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Scalable Blockchain for 5G Enabled Networks

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Abstract: The future of networking and communication is being completely changed by the revolutionary combination of 5G and blockchain. With the use of 5G, networks will be able to link billions of disparate objects while maintaining high network capacity, improved system throughput and high quality of service. Even with all of these benefits, there are still a number of important problems that require resolution, such network privacy and security, data provenance and administration, decentralization, transparency, and data interoperability. The problems facing by 5G networks can be successfully resolved with the help of blockchain-a new age disruptive technology. However use of blockchain for 5G hampers high throughput of transactions, high scalability, and the processing of transactions in real time. Scalable blockchain will address these issues while integrating with 5G networks. In this paper, we address the topic of scalability and offer a synopsis of current research on scalable blockchain systems. First, we address the issue with scalability from the viewpoints of storage, networking, and Throughput. Then, scalable blockchain systems, current enabling technologies are showcased, provides detailed survey about integration of scalable blockchain with 5G networks, comparison of scalability solutions, survey of various approaches to integrate blockchain with 5G, methods to improve blockchain scalability. Also outlines the contributions and open challenges that can aid the research community in advancing knowledge in this field by a careful analysis of the body of existing literature.

Keywords: *Blockchain, 5G networks, Scalability, Blockchain Throughput*

1. Introduction

5G stands for fifth generation of cellular technology. Its goals are to boost wireless service flexibility, lower latency, and increase speed. Due to its capacity to offer broader network coverage, dependable network connections, and quicker data transfer, it has promised a rise in wealth creation potential. Unlike previous mobile network technologies, 5G is intended to connect everyone and everything, rather than just individuals. The demand for 5G is essentially driven by two general demands: the first is a capable wireless ecosystem underpin and manage a range of IoT applications, and the second is High-speed data rates (peak data rates of 100 gbps, for instance), exceptionally quick latency, such as 1 ms or less, global connectivity for a large number of equipment, immersive VR/AR application experience, decreased bit costs and low operating costs, and improved QoE are all expected characteristics of 5G networks [1]. .In reality, the goal of 5G is to integrate 500 billion or more mobile devices by 2030 using complicated networks and heterogeneous device connections (Internet of things 2016)[2]. In addition, it is anticipated that the rapidly developing Massive Machine Communications (MMC) and the Internet of Things (IoT) would establish more than 80 billion connections by 2020. The incredibly compact tiny cellnetworks, a crucial part of the infrastructure for 5G Will offer connectivity and efficient energy radio connections with fast data rates and low latencies in such a situation [3]. But it raises issues with secure interoperability and trust among intricate sub-networks. Consequently, offering trustworthy cooperation networks in this sense, blockchain can allow for distributed massive communication with high security and dependability thanks to its immutable and decentralised transaction ledgers. The necessity to ensure a system that is open, transparent, and secure amid the extraordinarily large resources available and mobile users presents a significant problem for current 5G platforms. With its distinct decentralized operation principles, blockchain technology can offer a high degree of immutability, transparency, security, and privacy for data when it comes to the storing of 5G heterogeneous data. Network slicing is also a major enabler for 5G networks and services in the future, particularly when combined with other cutting-edge technologies like Network Function Virtualization (NFV), Device to Device (D2D) connectivity, and cloud/edge computing [4]. Thus, it is anticipated that blockchain will be a crucial instrument for achieving the performance requirements for 5G systems with the least amount of expense and administrative burden [5].

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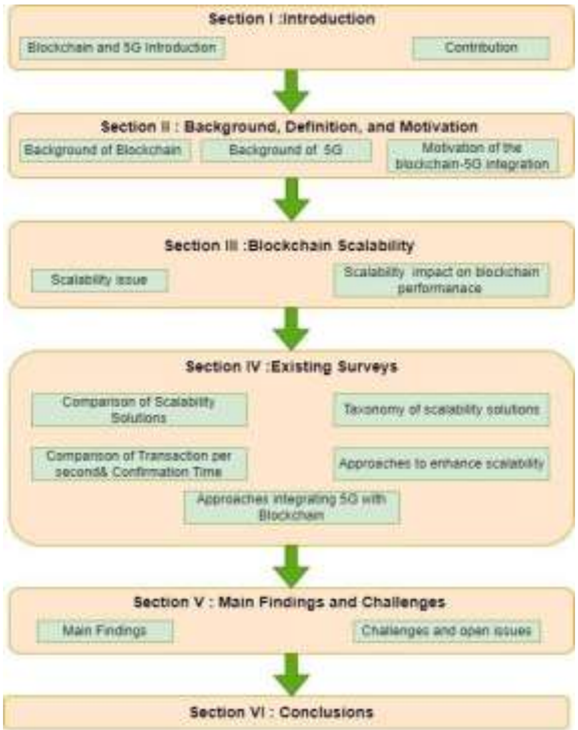

Fig 1 Structure of Paper

This paper adds to expanding body of research on scalability issue of blockchain implementation. Scalability solution classification in several layers, comparison of scalability solutions, various approaches to enhance scalability. It also gives detail review of various approaches integrating 5G with Blockchain. This review paper will surely guide researchers in the field of enhancing scalability of blockchain. The section of paper is as shown in Fig.1. Section II presents a quick review of background of Blockchain and 5G. The major scalability issue of Blockchain is explained in Section III. Section IV demonstrates the survey on exiting solutions to improve scalability of Blockchain for 5G. Section V discusses the new obstacles in improving scalability of Blockchain, as well as some relevant research to address these issues. The paper comes to a close with section VI.

2. Background, Definition, Motivation

2.1. Blockchain

Blockchain is an immutable, decentralized database that simplifies asset management and transaction recording inside an enterprise network. Intangible assets include things like intellectual property, patents, copyrights, and brand recognition, while tangible assets include things like a home, car, money, or a plot of land [3]. In a blockchain network, almost anything of value may be recorded and sold, reducing risk and increasing efficiency for everybody involved. Information is a crucial component in company, thus it is better if it is delivered swiftly and accurately. Blockchain provides real-time, shareable, and fully transparent data that is stored on an immutable ledger and available exclusively to users of a permissioned network, making it the perfect technology for distributing this kind of information. A blockchain network can be used to track orders, payments, accounts, and production, among other things. Furthermore, because everyone has access to the similar interpretation of reality, you can watch every facet of a transaction from start to finish. This increases your self-assurance and opens up new possibilities.

2.2. Essential elements of a blockchain

a) Making use of distributed ledger technologies the access to the distributed ledger and its immutable transaction record is granted to any network user. By simply recording transactions once, this shared ledger removes the effort duplication found in traditional business networks.

b) Immutable records no participant may change or tamper with a transaction once it has been added to the shared ledger. To repair a mistake in a transaction record, a fresh transaction needs to be established before both transactions are displayed. c) Smart contracts a smart contract, or set of instructions, is stored on the blockchain and automatically carried out to speed up transactions. A smart contract can set terms for corporate bond transfers and travel insurance costs, among many other things.

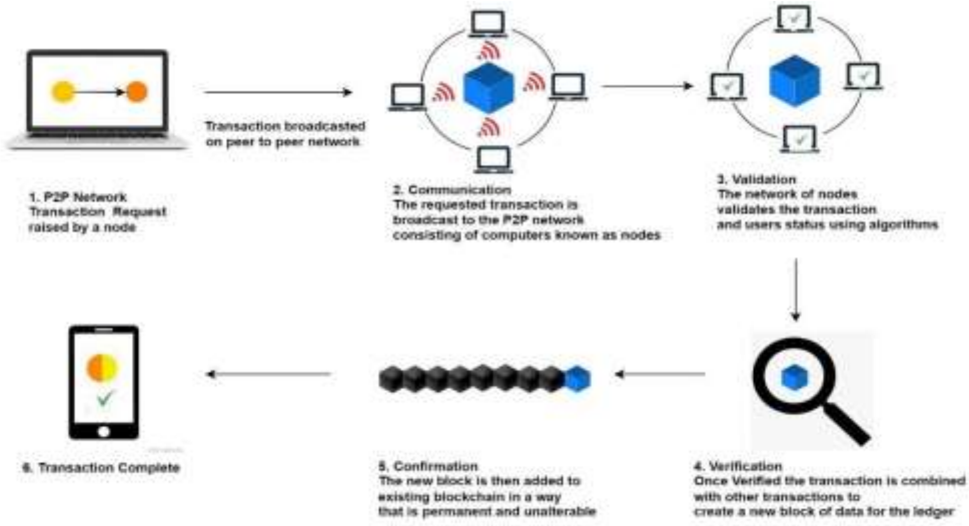

Fig 2 Blockchain Transaction Flow

2.3. Workings of blockchain

As each transaction occurs, a "block" of data is kept track of it.These transactions show the transfer of an asset, which could be a tangible good or an intangible one like intellectual property. The data block can be used to store information on who, what, when, where, how much, and even the condition, like the temperature of a food shipment. There are connections between each block and those that came before and after it. A data chain is formed by these blocks as an asset is moved from one place to another or ownership changes. The blocks securely link together to prevent any blocks from being added or altered between two existing blocks. The blocks attest to the exact timing and sequence of transactions. A blockchain is a block-joined, unbreakable sequence of transactions. Each new block improves the prior block's verification and, by extension, the blockchain overall. As a result, the blockchain gains its fundamental strength of immutability and becomes tamper-evident. By doing this, you and other network users may create a trustworthy transaction ledger and eliminate the chance that bad actors will alter the data. This ensures that data is transferred securely.

2.4. Advantages of blockchain

Benefits of blockchain operations include avoiding the routine time and resource waste associated with maintaining duplicate records and requesting third-party validations. Records management software may be susceptible to fraud and cyber-attacks. Data verification could be more challenging if there is a lack of transparency. Additionally, the number of transactions has expanded since the development of the Internet of Things. We need a better solution because all of this slows down business and damages the bottom line. As a result, blockchain offers the following advantages.

• Greater trust

You can use blockchain to make sure the information you receive as a member of a members-only network is accurate and timely. Your private blockchain records will only be accessible to network participants who have been specifically granted access.

• Greater security

All network users' transactions must be permanently saved and unchangeable. Nobody can erase a transaction, not even the system administrator.

• Greater efficiency

Time-consuming record reconciliations are avoided by using a distributed ledger shared by users of the network. The blockchain can also be used to store and automatically execute a smart contract, which is a compilation of guidelines, to speed up transactions.

2.5. Blockchain Applications

• Internet of Things

A network of interconnected devices having communication capabilities and gather information that can be utilized to make insightful decisions is called the Internet of Things. Blockchain is required to give this widely dispersed system security.

• Healthcare using smart contracts, blockchain can significantly impact the healthcare industry, which is one of the main uses for the blockchain technology. • Crypto currency one of the numerous benefits of utilizing blockchain technology for crypto currencies is its lack of regional restrictions. Consequently, crypto currency coins are used for international transactions.

• Asset Management

The processing and trading of various assets, including fixed income, real estate, stocks, mutual funds, commodities, and other alternative investments, are all part of asset management for an individual. Standard asset management trading procedures can be highly costly, particularly when dealing with transactions involving several nations and cross-border payments. Blockchain can be quite helpful in these kinds of scenarios since it eliminates the need for middlemen like custodians, brokers, settlement managers, and brokers. Rather, the blockchain ledge offers an error-free, straightforward approach that minimizes the possibility of mistakes.

• Government

Government organizations have several different blockchain applications, including those related to voting and identity security. Blockchains can store digital IDs, certificates of any kind, and even passports since they are typically impossible to counterfeit or change. The transparency of this data's accessibility and viewing at any time will support the global travel and tourism sectors.

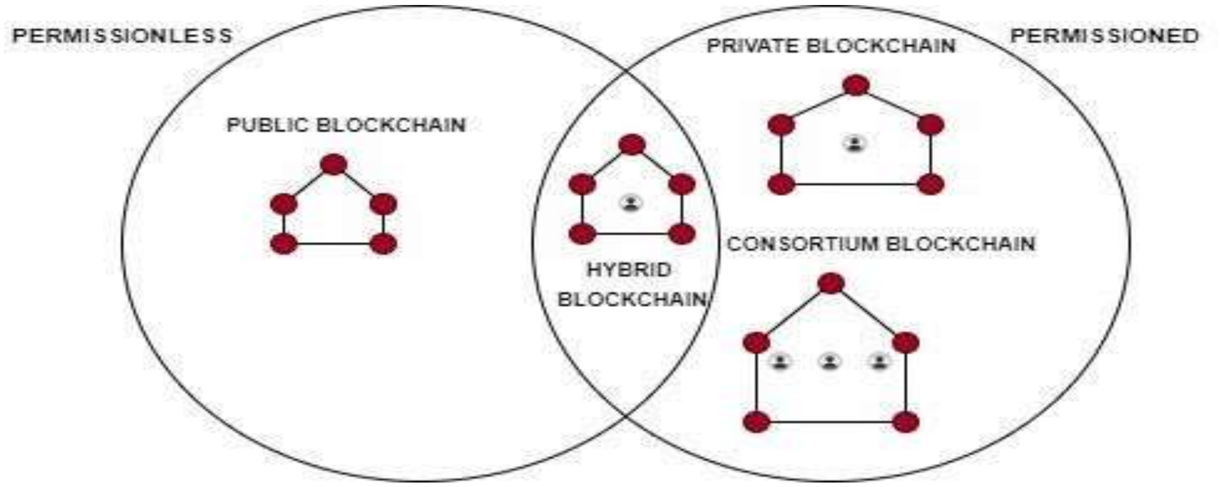

Fig 3 Blockchain Network Types

2.6. Blockchain networks types

Different methods can be used to build a blockchain networks shown in figure 3. They could be made by a collaboration and could be private, public, or permissioned.

• Public blockchain networks

A public blockchain, such as the one that one used by Bitcoin. The requirement for a lot of computational power, the absence of transactional privacy, and the poor security are some disadvantages. These are essential considerations for blockchain use cases in commercial settings.

• Private blockchain networks: The decentralized peer-to-peer nature of both public and private blockchain networks makes them similar. However, a single entity is in charge of network governance, carrying out a consensus process, and overseeing the shared ledger. This has the potential to greatly increase participant trust and confidence depending on the use case. There are more alternatives, such as hosting a private blockchain on-site or operating it behind a company firewall.

• Permissioned blockchain networks Companies that build private blockchains frequently build permissioned networks. It's important to remember that public blockchain networks might additionally offer licenses. As a result, there are restrictions on the kinds of transactions that can be made and the users of the network. Participants must have an invitation or authorization in order to participate.

• Consortium blockchains the upkeep of a blockchain may be divided among numerous businesses. These pre-selected organizations determine who is allowed to submit transactions or view the data. A consortium blockchain is the best choice when every party involved in a commercial transaction needs to have access to and share ownership of the blockchain. Blockchain is a system for distributed ledgers that allows user interaction and transactions (saving and retrieving data). It guarantees the validity, immutability, and non-repudiation of data. Block chain's decentralized nature eliminates the need for centralized operations by enabling data communication between industrial organizations and numerous 5G/IoT devices. Accountability, data provenance, and non-repudiation may all be provided for each user via the blockchain supported 5G ecosystem. The initial block in a blockchain is called the genesis block, is empty of transactions.[6].

Fig 4 Evolutio**n** of 5G

2.7. Evolution of 5G

The development of mobile networks has seen several generations of technology, each bringing significant improvements in speed, capacity, and functionality. Here's a brief overview of the major developments in mobile network since the introduction of the first generation of mobile networks in the 1980s, as Figure 3 illustrates,

• 1G (Generation I):

1G networks, introduced in the 1980s, were analog and offered only voice services. The main technology used was AMPS (Advanced Mobile Phone System), which provided low-speed data transmission

• 2G (Generation II): When 2G networks were first deployed in the 1990s, they provided voice and rudimentary data capabilities. The Global System for Mobile Communications (GSM), Code Division Multiple Access (CDMA), and Time Division Multiple Access (TDMA) were the primary technologies employed. The emergence of SMS messaging and rudimentary mobile internet access was made possible by these networks.

• 3G (Generation III): The first to provide high-speed data services, 3G networks were launched in the early 2000s and enabled more sophisticated mobile internet access, video calling, and mobile TV. The two primary technologies utilized were CDMA2000 and UMTS (Universal Mobile Telecommunications System).

• 4G (Generation IV): With the advent of 4G networks in the late 2000s, advanced mobile applications like virtual reality, online gaming, and video streaming were made possible by their increased capacity and higher data speeds. LTE (Long-Term Evolution) and WiMAX (Worldwide Interoperability for Microwave Access) were the primary technologies deployed.

• 5G (Generation V): 5G networks, introduced in the 2010s, represent the latest development in mobile network technology. They offer notably faster data speeds, reduced latency, and higher capacity as compared to previous generations, which makes it possible to develop new applications like remote surgery, driverless cars, and smart cities. The main technologies used are NR (New Radio) and mmWave (millimetre Wave).Communication networks have advanced significantly. Since then, successive mobile network generations have continuously been driven by more services and faster throughputs, including GPRS/EDGE, HSPA/HSPA+, LTE/LTE-A Pro, and now the fifth generation network, also known as 5G or New Radio (NR).In order to fully utilise the offered services, it is crucial to keep in mind that intelligent gadgets, such as smartphones, wearable's, and sensors, complement this evolution. The transition from basic voice and data services to cutting-edge time-sensitive and mission critical services like V2X, IIoT, IoMT, robots, gaming, and AR/VR is regarded as being facilitated by 5G in particular. This creates the perfect foundation for 6G technology and beyond, enabling native AI use-cases and futuristic ones that will develop over the next ten years.

2.8. 5G

The following-generation of mobile networks is 5G, will be a watershed moment in wireless communication. Three primary 5G services have been established by the International Telecommunication Union (ITU) Radio communication Sector: improved Mobile Broadband (eMBB), massive Machine Type Communication (mMTC), and Ultra Reliable and Low Latency Communications (URLLC) [7]. To support such a broad range of services, 5G has extremely low round-trip latency (about 1 ms), a high data rate (about 10 Gbps), and amazing scalability (about 100x coupled devices). Network Slicing is a major enabling technology for 5G. (NS), MEC (Multi-access Edge Computing), NFV (Network Function Virtualization), SDN (Software-Defined Networking), millimetre-wave communications, huge Multiple Input Multiple Output (MIMO), Device to Device connection (D2D),Non Orthogonal Multiple Access (NOMA), Heterogeneous Networks (HetNet) and so on. IoT will undoubtedly be one of the most significant 5G use cases, requiring the adoption of mMTC and URLLC services [8]. Together with a greater spectral bandwidth per frequency channel, the 5G technology is anticipated to offer new (far wider than the previous one) frequency bands. Current generations of mobile technologies have demonstrated a huge increase in peak bit rate. What makes 5G different from earlier technologies, especially 4G? The answer is that 5G is more advanced than 4G in terms of not only bit rate but also a number of other areas. 1. An elevated peak bit rate. 2. An increase in data volume per area (high spectral efficiency of the system). 3. High support for new devices, continuous communication. 4. Less battery consumption. 5. Increased connectedness, wherever you are in the world. 6. Additional auxiliary tools. 7. Lower construction costs for infrastructure. 8. More reliable communications. The 5G system paradigm, which is totally IP-based and created for wireless and mobile networks, is represented as it appears in Fig. 3. 5G architecture is designed to provide a more robust and flexible network infrastructure than its predecessors. The following are the main elements of the 5G architecture:

User Equipment (UE): The term "user equipment," or "UE," describes the end-user's mobile device or terminal that connects to the 5G network. Smartphones, tablets, and other Internet of things devices are among these. • Radio Access Network (RAN): The Radio Access Network, or RAN, is required to link the user equipment to the core network. It is made up of distributed units (DU), which assist in managing network traffic, and the 5G base station, also referred to as the gNodeB. The radio resource management and high-speed data delivery to the user equipment are the responsibilities of the RAN.• Core Network: The core of the 5G architecture, the Core Network, is in charge of delivering numerous network services like authentication, billing, and mobility management. It includes a number of network functions, such as the 5G core, which acts as a centralized control unit for the network, and the network slicing function, this enables the creation of many virtual networks.

•Network Functions Virtualization (NFV): An integral part of the 5G architecture is Network Functions Virtualization (NFV). \It involves the use of virtualized network functions (VNFs) to provide network services such as routing, firewalling, and traffic management. The use of virtualization enables the network to be more agile and flexible, and allows operators to deploy new services and functions more quickly. Service providers may develop and manage network services more affordably and effectively thanks to NFV.

• Software Defined Networking (SDN): Another essential element of the 5G design is Software Defined Networking, or SDN. One way to increase the network's programmability and adaptability is to divide the control and data planes. This makes it possible for operators to launch new services and functions more quickly and to control network traffic more effectively and flexibly. The system is made up of several independent and autonomous radio access technologies, as well as a main user terminal. All radio technologies are considered IP links to the external internet environment. The sole purpose of IP technology is to guarantee adequate control data for proper IP packet routing linked to sessions between client applications and servers dispersed over the Internet. SDN can also improve network performance and reduce costs. In order to enable automatic traffic rerouting, device reconfiguration, and bandwidth allotment to improve performance and lower complexity, SDN virtualizes IoT networks at a low cost. Compared to traditional networking, it offers flexibility, scalability, and efficiency.

2.9. 5G applications

Some of the important uses include creating a single, universal global standard for everyone. Thanks to ubiquitous network availability, people will be able to use their laptops and other mobile devices whenever they want and wherever they are. A mobile visitor’s IP address will be assigned thanks to IPv6 technology based on the connected network and location. By using it, the entire planet will be covered by a genuine Wi-Fi zone. Numerous radio technology variants will be able to successfully share the same spectrum thanks to its cognitive radio technology. Due to its adoption, people will be able to get radio signal at higher altitudes. Innovative Elements The advancements of 5G over earlier radio technology include the following

1. It is conceivable to access the super speed of 1 to 10.

2. 1,000,000x bandwidth per square inch. Possibility of connecting 10 to 100 devices. Coverage on a global scale.

3. Energy use on the network is reduced by almost 90 4. The entire planet will be in a Wi-Fi zone

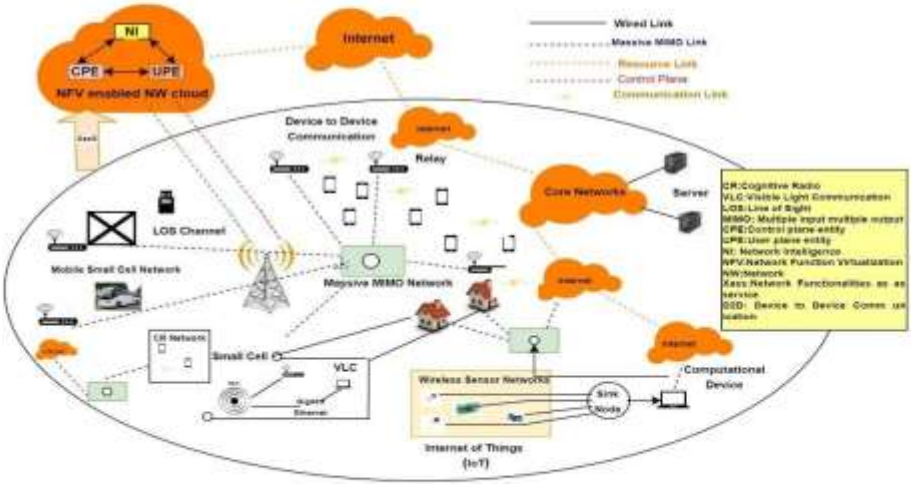

Fig 5 5G Architecture

2.10. General Challenges of 5G

• Scalability IoT and 5G are both require cloud-oriented infrastructure for management and control. To put it another way, a centralised cloud analyses the data generated by network nodes before sending control returns signals to the nodes to carry out tasks like fault management, resource (re)allocation, traffic engineering, routing, and other similar tasks. However, due to the massive volumes of data produced by IoT devices and the growing number of them, centralised cloud servers will need to enhance their capacity and computational power [9].

• Network Congestion Furthermore, in both IoT and 5G possibilities, cloud connectivity for devices via a gateway or an edge node, which is connected to the cloud via a succession of networks known as fronthaul, midhaul, and backhaul. Frequent congestion occurs in the fronthaul, midhaul, and backhaul networks around gateway nodes due to the volume of devices trying to connect to the cloud. Lack of data sharing/usage auditability and control a massive amount of data is generated in an IoT network, and it is generated through devices that are unique to numerous businesses. As a result, all parties involved frequently have little control over this data. It might refer to all manufacturers whose products make up network nodes, all service providers who use the same physical network infrastructure, or all customers who use the same cloud platform [10]. Because of this, it is difficult to manage and monitor this data in terms of who owns it, where it comes from, and potential uses. Data silos Data created in networks, as was indicated in the article before it, has several owners and is quite non-coherent, making it challenging to trace and audit. There are other circumstances in which data cannot be transferred among devices held by different companies because there are no established standards or procedures. Furthermore, data may be locked in or not work together across several organizational divisions as a result of trust issues [11].

3. Blockchain Scalability

3.1. Scalability Issue

Scalability issues arise when a system or technology is unable to handle an increasing workload or user demand. Scalability in computers and technology refers to a system's capacity to manage growing volumes of data, traffic, or users without noticeably lowering its performance or dependability. Here are some common examples of scalability issues in different domains: Software Applications: Scalability issues can arise in software applications when the number of users or quantity of data being processed surpasses the capability of the system. For example, an e-commerce website may experience scalability issues if it is unable to handle a sudden surge in traffic during a sale event.

Cloud Computing: Scalability problems arise in cloud computing systems when they cannot handle an increasing number of users or when resource consumption surpasses their capacity. This can result in slow response times, downtime, or a decrease in overall performance. Database Management Systems: Scalability issues can arise in database management systems when the volume of data exceeds the system's capacity to process and store it. This can result in slow query times, database crashes, or other performance issues.

Networking: Networking systems can experience scalability issues when the number of devices and users on the network exceeds its capacity. This can result in slow internet speeds, dropped connections, or other connectivity issues. Hardware: Hardware systems can experience scalability issues when they are unable to accommodate the processing power required for a particular workload. For example, a computer may experience scalability issues if it is unable to handle the demands of running multiple applications simultaneously. In order to address scalability issues, systems and technologies can be designed with scalability in mind from the outset. This may involve using scalable hardware and software architectures, implementing load balancing and distributed computing techniques, and ensuring that the system is easily expandable and adaptable to changing demands

3.2. Scalability Impact on Blockchain Performance

There are many aspects of scalability, including networking, throughput, cost, and capacity. The throughput of the Bitcoin blockchain, at seven transactions per second, is incredibly low when compared to PayPal or VISA.

The confirmation time is approximately 10 minutes, and each block is approximately 1 MB in size. The maximum number of transactions per second can be calculated by dividing the maximum block size by the normal bit coin transaction size of 250 bytes [12].

Cost and capacity: Large amounts of data must be recorded on the Blockchain, starting with the genesis block and going all the way down to the most recent block transaction. Each node on the blockchain has a finite amount of storage and resources.

Networking: Prior to any transaction being completed, it is initially broadcast to all nodes. A block is propagated to all nodes once again when it is mined, using up network resources and increasing propagation time. Therefore, more effective data transmission systems are needed [13]. However, the Blockchain is being utilized to build many different applications.

3.3. Privacy and Security

Both the Domains of 5G and IoT use devices that are often portable, light, and have simple form factors. Even more power-efficient devices are available. in specific IoT application scenarios, with the ability to operate for extended periods of time on battery power. As a result, these devices' security is periodically compromised [14].Security features on these devices are minimal to non-existent. Furthermore, due to intense deployment competition, both equipment makers and network service providers jeopardise security scalability is a big drawback [15]. Scalability is affected by the following factors: digital signature, block size, chain size, and transaction per second [16]. Numerous techniques, such as on-chain, off-chain, child chain, and interchange numerous components, can be used to tackle the scalability problem. Standards and conventions for communication sometimes, different organizations will not communicate or interposes similar types of data, such meteorological and climatic data, in order to reach a consensus judgment [17]-[18].

3.4. Device resource heterogeneity

Nodes in a 5G/IoT ecosystem can have varying computing capacity, with some having a few megabytes of memory and a few watts of power from a battery. This depends on the application and network segment. This is problematic since some gadgets may end up functioning for a very short time. One node close to the gateway, for instance, might be unable to handle a large volume of packets or have a short battery life and be turned off, rendering the sensor network worthless.[18].

3.5. Key Challenges to achieve Blockchain scalability

One of the biggest issues facing the blockchain industry is blockchain scalability. Here are some of the key obstacles that must be overcome in order to achieve blockchain scalability.

Network congestion: One of the biggest challenges of blockchain scalability is network congestion. Considering that the number of transactions on the blockchain network increases, it can become difficult for the network to handle the traffic, leading to delays, slow transaction times, high transaction fees. Limited transaction processing capacity: Another challenge is the limited transaction processing capacity of blockchain networks. This is due to the design of blockchain, which requires all nodes on the network to process every transaction. This can lead to a bottleneck in the system and limits the quantity of transactions that can be handled in a single second. Blockchain size: The size of the blockchain can also become a scalability challenge. As the blockchain grows in size, it becomes increasingly difficult for nodes to store and process the data, which could result in security risks and delayed processing times.

Energy consumption: The energy needed for transaction validation is another difficulty for blockchain scalability. This is particularly true for consensus methods based on Proof of Work (PoW), which demand a large amount of energy in order to solve intricate mathematical issues.

Decentralization: Scalability issues arising from the decentralized nature of blockchain technology might also be problematic. Every node on the network must verify each transaction in order to preserve consensus.

, which can be difficult to scale without compromising on decentralization. Security concerns: As blockchain networks become more complex and handle larger amounts of data, there is an increased risk of security breaches and vulnerabilities. This can be a challenge for blockchain scalability, as maintaining security and integrity is critical to the success of the network. To address these challenges, the blockchain industry is exploring a variety of approaches, including sharding, layer 2 solutions, and new consensus algorithms, as well as improvements in hardware technology. In general, attaining blockchain scalability continues to be a significant difficulty, but the sector is aggressively seeking to provide creative answers to get over these barriers. The scalability of blockchain-based solutions is one of the primary concerns that could limit blockchain's potential as a disruptive technology, despite its recent surge in popularity. This section focused on representation of the analysis of previous and current research on the scalability issue [19]. Through our literature survey, it is came to know that, scalability is composed of Horizontal and Vertical scalability. We have defined this various dimensions of scalability. 3.1 Horizontal scaling more nodes (i.e., machines) are added to an existing system's framework as part of horizontal scaling. Horizontal scaling involves following [20].

a) Client Scaling: The ability of a blockchain system to accommodate an increasing number of clients without compromising overall performance is known as client scalability. Application programs that submit transactions on a user's behalf are known as clients.

b) Node Scaling: The ability of a blockchain system to accommodate more nodes without seeing a decline in overall performance is known as node scalability. A network can be extended vertically by raising the power and memory of the system's central processing unit. There are numerous sub-dimensions of vertical scalability that can be further deconstructed, including throughput, block production rate, latency, and storage scalability. These are outlined below: a) Throughput: Seven transactions are processed in the Bitcoin blockchain per second, which is incredibly slow when compared to VISA or PayPal. Each block is roughly 1 MB in size, and the confirmation time is around 10 minutes. The maximum block size is divided by the typical bitcoin transaction size to get the number of transactions per second, which is 250 bytes [21].

b) Block Production Rate: Depending on the block size, several transactions are typically bundled together to form a block in a blockchain environment. The frequency with which new blocks are mined, created, and added to the blockchain is referred to in this context as the block generation rate (BGR). Transaction mining's resource-intensive process of creating blocks is reliant on block size and consensus effectiveness [22].

c) Latency: The time it takes a blockchain network to verify that a transaction has been accepted is known as network latency [23]. When more blocks are added following the initial confirmation, the transaction becomes more conclusive.

[24].Low network latency is crucial for a payments system that wants to be widely used. If it takes too long, the interval between paying at the cashier and receiving the confirmation of the payment can cause user annoyance.

d) Storage: The scalability of blockchain storage systems guarantees that the nodes can perform the essential functions even as the volume of blockchain data increases, maintaining the features of blockchain

e) Block Size: Block size in blockchain technology refers to the volume of transactional data that a single block in the chain can store

f) Chain Size: The blockchain is a decentralised ledger where transactions have steadily increased in number. Before joining the network, a node needs to have adequate storage to download the chain and get a full picture of it. As the Bitcoin blockchain has already grown to be larger than 280 GB, a miner has to download a significant amount of data locally in order to be able to use the network [25]. The blockchain scalability solutions can be categorized into on-chain and off-chain solutions as shown in Table I.

On-chain solutions Blockchain Pipelining: The sequence of data processing stages that take place while processing Blockchain data is known as the Blockchain data processing pipeline. This consists of a few essential components, such as a data source, the actions taken during data analysis, an inference drawn from the data, and a final destination for the findings and inferences [26].

Blockchain delivery networks: Through our research, we have found solutions that use delivery networks, like cloud delivery networks or cut through routing-enabled gateways. These techniques aim to maintain the decentralized nature of blockchain while boosting transaction throughput or scaling storage through the use of a cooperative cloud storage system.

Block Size Adjustment: Scalability can also be attained by changing the block size. These methods must be tuned according to the requirements of each application because they are application-specific. An excessive increase in block size, for example, results in more transactions per block but also longer propagation times.

Off-chain: outside-chain solutions can increase the scalability of the Blockchain by handling transactions outside the Blockchain. Among the off-chain solutions is the lightning network. A scalable off-chain quick payment network is called the Lightning Network. To manage multi-signature transactions, off-chain micropayment channels are constructed between nodes; only final transactions—if any node executes transactions frequently—are carried out on the Blockchain. The lightning network for the Ethereum version is called Raiden. However, it compromises security. All transactions made over the off-chain micropayment channel were lost as a result of the attack.

Sharding: This is a useful method for making a blockchain more scalable. The nodes are divided into fragments. Each shard contains a portion of a transaction, which is processed in parallel [27].The transaction is verified within the shard using a Byzantine consensus mechanism. Elastico and Omni ledger are two examples of Blockchain sharding systems. It's challenging to pick the right shard size. Byzantine Consensus Algorithm Performance the scalability of the Blockchain is determined by the shard size; nevertheless, the shard size has a negative impact on the scalability of the Blockchain. The significance of nodes in blockchain sharding can make it simple for you to comprehend the technique [28]. Decentralized networks allow for the storage of vital data such as account balances and transaction histories by nodes. To ensure security, blockchain networks disseminate data and transaction information among a number of nodes. However, the model makes significant scaling concessions. Blockchain networks' distributed ledger technology provides security and decentralisation. The massive volumes of data linked with the transactions might cause network congestion, and blockchain networks are unable to handle a significant volume of transactions. As a result, the network may eventually operate slowly or with delay. Ethereum, for instance, can handle 10 to 20 transactions per second. Does it apply to a blockchain network that is quickly becoming the top option for blockchain applications? Successful blockchain projects that use sharding give an impression of how nodes can be set up to handle a lot of transactions. The blockchain network can horizontally split its workload, preventing all nodes from having to handle or process every transaction. Therefore, the efficient and compartmentalised node design in a blockchain network can illuminate the significance of nodes in sharding [29]. The network of nodes is not physically divided in order for crypto currency sharding to function. The horizontal segmentation of the blockchain network or database, on the other hand, aids in the creation of distinct rows in sharding. The horizontal architecture, which consists of rows known as"shards," contributes to the development of a highly dynamic ecology. According to their characteristics, it has aided shards in completing a variety of specific actions. For instance, a shard might keep track of both the transaction history and the current state of a particular address. On the other side, a shard might potentially carry out functions like working with other shards to complete transactions. Imagine a large database that has six rows. The table can be divided into three smaller, horizontal rows, making it simpler to process the vast table of data. Sharding a blockchain horizontally allows for the conversion of a larger database into smaller, more effective copies of the original while keeping the core functionality. However, there are other ways to achieve scalability than horizontal division. You can also find other options for transaction processing, such as layer 2 scaling programmes or vertical scaling options. In actuality, splitting the work into several shards aids in the effective allocation of the burden for a blockchain network [30]. Horizontal Shrading the splitting of larger databases' rows and columns into smaller ones is known as blockchain sharding. Larger data tables are also divided into smaller ones and added to sharded tables in a similar manner. Horizontal sharding is the process of adding new tables that all share the same schema. The goal of horizontal sharding is to reduce the workload on each node in the network, allowing them to process transactions more efficiently and with lower latency. By breaking the network into smaller, more manageable pieces, horizontal sharding enables the network to scale horizontally, adding new shards as needed to accommodate increased transaction volume.

4. Existing Survey

Table I show as the details about Comparison of scalability solutions for different Technologies. The Big Block [31] is a technique that raises the upper limit for blocks. Block chain networks create blocks, which include a list of transactions, on a regular basis. A block size determines how many transactions can be processed at once; as a result, as the block size rises, more transactions are able to be processed at once, increasing throughput. Larger block sizes may lead to unacceptable block propagation delays even while they cause longer block transmission delays. Merkle Trees and Abstract Syntax Trees (ASTs) are combined in MAST [32]. One type of data structure is the Merkle tree is useful for determining whether the data being stored is accurate. Merkle Trees are now employed in Bitcoin to effectively preserve the blockchain's transaction history. An update to the Bitcoin network called SegWit [33] to address the scalability and malleability issues. Making an existing transaction's identifier (id) malleable is the method of doing so. The proposed block structure modification is part of the network upgrade. While non-SegWit blocks, sometimes referred to as legacy blocks, have a total size of 1 MB, SegWit employs large 4MB blocks. SegWit does indeed increase block sizes. SegWit blocks are made up of a base transaction block that is 1 MB in size and an extended block that is 3 MB in size. Sharding is a network architecture that divides the network into smaller units called committees or shards [29]. Throughout the text, committee and shard are used interchangeably. Each committee is concentrating on a distinct set of transactions, rather than the network as a whole processing the same transactions. The Lightning Network for Bitcoin is an example of an off-chain solution [34]. For high-volume, rapid micropayments, a decentralized, scalable system known as the Lightning Network eliminates the danger associated with giving third parties custody of your money. In theory, Lightning uses the smart contract capabilities of the blockchain to speed up user payments within a network. Numerous advantages of the Lightning network include: The main purpose of the speedy, inexpensive, and scalable Raiden Network is an Ethereum token transfer. It offers instant payments, measured in milliseconds to seconds, high throughput (the Lightning Network can handle millions to billions of transactions per second across the network), and low cost (the Lightning Network allows for incredibly low fees because of off-blockchain transactions). [35]. For Ethereum, the Raiden Network is an off-chain scaling solution that enables almost instantaneous, inexpensive, and scalable payments .It functions with any ERC20 compatible coin and complements the Ethereum blockchain. The ERC20 token standard outlines the features and actions that an Ethereum token contract must provide scaling off-chain protocols is a specific goal of Plasma [36]. It is a method for carrying out off-chain transactions in a very scalable manner. A lot of chains, referred to as child chains, leading back to the parent chain is the fundamental concept of Plasma. Blockchains within blockchains can be created by child chains, which can spawn more sub chains. These chains are capable of functioning as standalone blockchains, with sporadic updates to the parent chains (as required). They may have their own consensus building processes. Table II gives the brief about Scalability solution classification in several layers, To enable communication between distributed ledgers without relying on a single server, the Cosmos blockchain was created. The founders of the Cosmos network, who aimed to build an open-source interoperable platform of blockchains that could accelerate transactions between them, quickly came to refer to it as the Internet of blockchains. Polkadot[42] is a protocol that connects blockchains, allowing money and data to be transferred between networks that were previously incompatible (like Bitcoin and Ethereum). It is also intended to be quick and flexible. The DOT crypto currency, which can be purchased or sold on Coin base and other exchanges, is used for governance and staking. It is possible to think of True bit [43] as a marketplace where Task Givers (composed of Task Owners and Task Submitters) invite Solvers and Verifiers to do computations on their behalf. Tasks are carried out by Solvers, who subsequently hand them off to Verifiers for solution verification. If the Verifier reports a mistake, he turns into a Challenger. Arbitrum [44] executes transactions in batches, off the main Ethereum chain, and stores the confirmation on the main chain using optimistic rollup technology. Due to its Virtual Machine, it provides a more established ecosystem of dApps and sophisticated smart contracts as compared to other Layer 2 systems like zkSync.

Through a Bitcoin blockchain network hard fork, and it has subsequently grown a separate ecosystem. The next-generation blockchain system known as Bitcoin NG [50] has a number of benefits over the original Bitcoin protocol. By raising the block size limit and allowing more transactions to be completed per block, it enables faster transaction speeds and better and less expensive to use. The asset was produced scalability. A group of very effective layer 1 blockchains that enable security, scalability, privacy, and transaction finality are provided by Algorand's [51]. Snow technology. A layer-1 blockchain is a collection of improvements to the core protocol that increase the system's scalability The Cardano and Polkadot blockchains use a series of

Table 1 Comparison of scalability solutions for different Technologies

Mechanism	**Blockchain Solution**	**Algorithm of Consensus**	**Throughput**	**Cost**	**Capacity**	**Pros**	**Cons**
On Chain	Big Block[31]	PoW	High	Low	High	Spamming Won't longer be an affordable practice.	Bitcoin full nodes are compelled To consume additional non-Bitcoin resources.

	MAST[32]	PoW	—	—	Low	More reliable larger smart contract	Insufficient privacy
	SegWit[33]	PoW	High	Low	—	High transact speed	Increases us-age resources as capacity
	Sharding [29]	PBFT/PoS	High	—	Low	Low transact fees/Low capacity bur-den	Bandwidth in-creases More protocol comp lexity
Off Chain	Lightning [34]	—	High	Low	Low	Multiple Processing It might lessen Blockchain traffic	It is onlyintended for modest and medium pay ments.
	Raiden [35]	—	High	Low	Low	Low transaction costs enable the transfer of small values.	Some ofthe tokens required byRaiden Network must be permanently locked.
Child Chain	Plasma[36]	PoA	High	—	Low	Quicker and less Expensive	Security challenges need to be address to maintain immutability
Interchain	Atomic Swap [37]	—	—	—	—	Worse in Privacy	

Table 2 Scalability solution classification in several layers

Blockchain Layer	Class	Solution
Blockchain Layer 2 **Non on chain**	Payment channel Network (PCN)[38]	Bitcoin's Lightning network,[34] Raiden network[35], NFT sprites
	Side Chain [39]	2 way Peg side chain, Plasma Chains [36], LQD Liquidity network
	Cross chain Technology[40]	Cosmos SDK [41], Polkadot Network Protocol[42]
	Off chain data and computation	True bit Protocol[43], Eth Layer 2, Arbitrum[44]

Blockchain Layer I On Chain	Block data	Compact Block Relay (BIP152) [45] ,Bitcoin-Cash(BCH)[46],Segregated Witness(SegWit)[33], Txilm Protocol[47], Consensus Unit-Based Storage (CUB)[48], JidarProtocol[49]
	Consensuses Mechanism	Bitcoin-NG-scalable Blockchain Protocol[50], ALGO (Algorand)[51],Protocol Snow white[52], Cardano OuroborosProtocol[53]
	Sharding Technology	Elastico, Sharding Protocol [54], Omniledger-A secure ledger[27], Full Sharding Protocol: Rapidchain[55], Protocol monoxide[56]
	Directed Acyclic Graph(DAG)	Inclusive Blockchain Protocol [57],Crypto currencyProtocol, SPECTRE[58], Cryptoand NFT wallet: PHANTOM[59], Network Conflux[60], Cryptocurrency:Dagcoin[61],Internet of Things Application(IOTA)[62], GBYTE Coin(Byteb) all[63], Lightweight cryptocurrency: Nano[64]
Blockchain Layer 0	Data Propagation	A bitcoin transaction relay protocol: Erlay[65], Protocol Kadcast[66], Velocity Network Blockchain[26] , bloXroute Blockchain[67]

Proof-of stake consensus mechanisms called Ouroboros [53]. Be run on it. ELASTICO [54], a novel distributed agreement protocol for blockchains without authorization. The number of transaction blocks selected per unit time rises as the network's processing capacity rises in ELASTICO, which scales transaction rates approximately linearly with available computing power for mining. When sending network communications, ELASTICO can handle byzantine adversaries that use up to 25% of the system's processing power.

Table 3 Comparison of various solutions Transaction per second (TPS) and confirmation times

Scheme	Mechanism	Transactions per second	Confirmation Times
ByzCoin Protocol [68]	PBFT	1008	20 sec on a 1 MB,90 sec on 8MB block
Cardano Ouroboros Protocol [53]	PoS	250	1.8 min
Rapid Chain[55]	Sharding	7,300	8.7 sec
Algorand[51]	Byzantine Agreement	7500	3.3 sec
Conflux Network [60]	DAG	6,300	4.4-7.5 min

Monoxide[56]	Sharding	10,000	14-22 sec

The comparison of TPS and confirmation time between various solutions is displayed in Table III. Ouroboros[53] shows the least TPS with confirmation time of 2 minutes using PoS technology while Monoxide[56] shows highest least TPS with confirmation time of 13-21 seconds. Peer-to-peer transactions were made possible by the 2020 research that tested the Ouroboros Hydra protocol version, which employed"off-chain state channels" (also known as "heads") to do so. These "layer 2" protocols control transactions that take place outside of the primary blockchain, and each head may possess "up to 1,000 transactions per second" handling capacity. Theoretically, Ouroboros Hydra could run scores of heads to match the 30,000 simultaneous transactions provided by traditional payment systems like Visa. ByzCoin[68] is a brand-new, highly scalable Byzantine fault-tolerant (BFT) consensus system that offers solid consistency and scales to handle throughputs of hundreds of TPS among hundreds to thousands of decentralized miners. ByzCoin uses a PBFT modification and offers four significant upgrades over Bitcoin: The enhanced PBFT-like consensus method used by ByzCoin commits Bitcoin transactions irrevocably in a matter of seconds. ByzCoin preserves Bitcoin's open membership characteristic by dynamically creating hash power-proportionate consensus groups that reflect recently successful block miners. In order to further optimize transaction commitments and verification in normal operation while ensuring security and liveness in the event of Byzantine faults, ByzCoin leverages communication trees. ByzCoin, which was inspired by Bitcoin-NG, decouples the election of a new leader from transaction verification, allowing for even greater transaction throughput. With a special characteristic that sets it apart from other blockchains, Algorand[51] makes transactions final as soon as they are included in a block. The average wait time for a transaction to finish on Algorand for 3.3 seconds following the update to go-algorand 3.16. This is accomplished by keeping instant block finality while lowering block latency to 3.3 seconds. This improvement enables Algorithm-based applications can utilise the security and decentralisation offered by blockchain technology while yet offering users a similar user experience to that of customary Web2 applications. Rapid Chain is the first sharding-based public blockchain protocol. It processes transactions completely sharding the communication, compute, and storage overhead without requiring any trusted setup, and it is resistant to Byzantine failures from up to one-third of its user base. Quick Chain [55] makes use of a unique gossiping protocol for large blocks, an ideal intra-committee consensus method that makes use of block pipelining to achieve very high throughputs, and a strong reconfiguration mechanism that is probably safe. Our approach prevents transactions from being broadcast to the entire network by employing an effective shard transaction verification technique. With an expected confirmation delay of approximately 8.7 seconds, our empirical findings demonstrate that Rapid Chain can process (and confirm) over 7,300 transactions per second in a network of 4,000 nodes. The only scalable blockchain system that delivers the same level of security as Bitcoin and Ethereum is Monoxide [56]. It fully shards the consensus process, scales with minimal resource consumption, and upholds the decentralization guarantees of proof-of-work. Monoxide is the only scalable blockchain system that fully shards the consensus protocol, uses resources efficiently for scalability, maintains the decentralization guarantees of PoW, and offers the same level of security as Bitcoin and Ethereum. Two blocks are produced by the Conflux [60] network on average every second. Depending on the level of network congestion, a transaction should be packaged and performed within 20 seconds of being successfully sent. Table IV provides information on several methods to improve scalability. Lightning Network provides 1,668,000 TPS throughput is possible on a 2 Gbps network. The web service's public key infrastructure (PKI) provides 343 tX/s is the average transaction throughput. The scalability problem of controlling restricted device access in the Internet of Things is suggested to be addressed by a distributed access control system model [8] based on blockchain technology. The blockchain network's entire process is made simpler by the system model's adoption of a single smart contract, which also lowers communication costs between nodes. The results of the assessment and simulation have shown that the system has good scalability. Sharding is a viable solution to the low throughput problem in blockchains [12]. Cross-shard communication, however, makes it difficult to increase blockchain throughput effectively. To increase blockchain throughput, it is necessary to fairly distribute transactions among multiple shards. The majority of current research on blockchain sharding concentrates on the creation, configuration, and consensus of shards without taking into account the detrimental effects of blockchain throughput for cross-shard communication, seeking to boost the throughput of transaction processing. The Adrestus [13] system is a blockchain-based transaction system that can withstand Byzantine errors, scales without affecting system security, and uses a new consensus process. One of the main components of the Adrestus design is a consistent hashing method for efficiently assigning transactions across parallel regions, or zones, and for resolving load balancing problems. We contend that the Adrestus blockchain system scales linearly, accomplishes its objectives without the addition of extra overhead, and does so by cutting down on energy and computational waste. A framework for dynamic spectrum access for WSP [70] that prioritizes automated blockchain-based sensing and sharing. In this system, sensor nodes first assess the possibility of spectrum access before allocating the access right to the users after decentralized authentication of their transactions with the WSP. Another choice is to use blockchain as a reliable platform for autonomous spectrum sensing enforcement. Hyper ledger Fabric is an open-source blockchain platform hosted by the Linux Foundation. [25]. A vibrant and expanding development community exists there. Fabric networks are permissioned, which means that the identities of every participant are known and verified. The multi-block consensus technique based on Byzantine Fault Tolerance, which boosts throughput. The basic principle of the proposed method is that the primary propagates the disjoint-transaction sets to successive replicas [71].After receiving the propagated blocks, the replicas verify the content as well as the propagation of the blocks. As they exchanged the verification results, the replicas could add the valid blocks one by one to the blockchain. A highly effective distributed hybrid (multilevel) NoSQL caching system using FPGA and Redis to boost the scalability (throughput) of blockchain applications. Paper[23] analyse blockchain performance bottlenecks and develop a productive Gigabit Ethernet FPGA NoSQL caching architecture that collaborates with the Redis database via the Hiredis C client In order to communicate with the blockchain, Curl and Jansson are employed. A subset of nodes are chosen to serve as the root committee in Proteus [73], a new BFT-based consensus protocol. Proteus guarantees consistent performance in the face of numerous network failures and lowers the quadratic message complexity of traditional BFT-based protocols to O (cn) messages, where c n, for large numbers of nodes n. We tested our protocol against two other basic BFT protocols (PBFT and Bchain) on 200 Amazon EC2 instances for comparison. Our protocol outperformed the baselines in these tests by a factor of more than two for both throughput and latency. A distributed storage system known as IPFS [74] is used to increase throughput and avoid storage obligations. The dual-blockchain solution fulfils the fundamental requirements of the blockchain by replacing references to the initial block in the ledger with references to the main block. The investigation reveals that as compared to Bitcoin Core, our proposed technique can reach up to 25.8 times greater throughput and about 1685 times smaller ledger size. Table V shows various approaches integrating 5G with Blockchain. Euryale Suresh Babu [77] proposes a reliable blockchain system for 5G edge networks that can quickly identify edge devices, confirm their identity, and allocate addresses to them based on demand. Usama Arshad [78] gives cost-effective, scalable, secure blockchain based 5G vehicular network architecture.

Table 4 Various methods to address scalability issue

Authors	Year	Issue Addressed	Solution Type	Methodology	Implementation	Result	Limitations
Ade Ilham Fajri et al.[20]	2022	Throughput	On chain	Lightning Network	Geforce RTX 4080 GPU	Throughput can exceed 1,668,000 transactions per second on a 2 Gbps network.	Memory load on Storage Nodes
Wei Xiang et al.[8]	2022	Throughput	On chain	A distributed access control system model	Docker, vertigo / Ethereum, Golang, LibCOAP, Intel Core i7-950@3.07 GHz desktop running Ubuntu 16.04	900 queries are made every second with no more than 1000 customers active at once.	High Cost, Efficiency

Liping Tao et al [12]	2022	Throughput	On chain	Sharding			Dynamic submission of transactions is not addressed
Panagiotis Drakatos et al [13]	2022	Throughput	On chain	novel consensus mechanism	Amazon EC2 web services	Throughput is boosted upto 1200 TPS	More efficient algorithm required for storage requirements
Zhonghao Zhai et al [69]	2022	Throughput	Off chain	The web service's public key infrastructure (PKI).	Hyper ledger Fabric	343 tX/s is the average transaction throughput.	Needed to put the ordering auditors' dynamic selection into practice
Aqsa Ashraf Makhdomi et al [70]	2022	Throughput	Side Chain	dynamic spectrum access framework for WSP	Polygon test network, Rinkeby, Solidity	Throughput is 63000 TPS.	
Murat Kuzlu et al[25]	2019	Throughput	On chain	Hyperledger Fabric	AWS EC2	200 transactions per seconds	The throughput remains constant while the number of concurrent transactions rises.
Soohyeong Kim et al [71]	2020	Throughput	On chain	multi-block consensus algorithm based on Byzantine Fault Tolerance		Whenever a block contains 8,192 transactions, the block's maximum size is 2MB	Network capacity should be considered when calculating the delay
Abdurrashid Ibrahim Sanka et al[23]	2018	Throughput	On chain	customized SHA256 hash core	Jansson and Curl libraries ML605 Virtex 6 FPGA board	103 transactions per seconds	
Kaushik Ayinala et al [72] 2	2020	Throughput	On chain	PiChu	Java		
Mohammad M. Jalalzai[73]	2019	Throughput	On chain	Proteus, a new BFTbased consensus protocol	Amazon EC2 Golang		
MD. Soharab Hossain	2021	Throughput	On chain	A distributed storage system IPFS			

Sohan et al[74]							
Ke Wang et al [75]	2019	Throughput	On chain	FastChain	Blockchain Dynamics Simulator (BDSim)	30% higher	
Nasrin sohrabi et al [76]	2020	Throughput	On chain	ZyConChain			

Table 5 Various approaches integrating 5G with Blockchain

Authors	Year	Objective	Application	Blockchain	Pros	Cons
Ashutosh Dhar Dwivedi[71]	2021	Network scalability issue is solved using blockchain distributed network	UAV	Yes	Low Throughput issue solved	
Erukala Suresh Babu[72]	2022	Suggests a reliable blockchain framework for 5G networks that are edge-based.	Edge Computing	Yes	Can effectively locate the edge devices, verify the devices, and give the edge devices the addresses as needed.	The blockchain used is private
Usama Arshad[73]	2021	A full 5G vehicle network architecture based on blockchain	Vehicular Network	Yes	economical, scalable, and safe	handoff, interference, and coverage not addressed
Zaher Haddad[74]	2022	a blockchain-based pseudonym-based authentication system to provide security and privacy for 5G networks	5G networks	Yes	secure and preserves privacy	
Ziming Liu[75]	2022	A reliable cooperative power trading system for 5G-enabled social vehicular	Internet of Vehicles	Yes	power trading data	energy storage suppliers and prosumers

		networks based on block chain technology				not considered

In terms of functionality, blockchains are unable to deliver a 5G-enabled IoT-based network. The blockchain's network is what limits throughput. The P2P network's delayed transaction and block propagation prevents miners and verifiers from quickly mining and verifying new blocks, respectively. For this reason, the main problem with IoT-based blockchains is network scalability. In work [3], author used a distributed blockchain network to overcome the problem of network scalability, and to boost the throughput of the blockchain, author used the Raft consensus algorithm. Privacy is yet another crucial issue with IoT networks. Unfortunately, critical information is available on the network for everyone to see since the blockchain distributed ledgers are public. Key advantages of blockchain technology in 5G networks are discussed in the work [81] (i) Smaller infrastructure investors can construct cell towers that will be a part of the operator's overall infrastructure thanks to crowdsourcing for 5G infrastructure. When their towers are used, these smaller investors must be automatically maintained, registered, certified, and paid. A workable solution for tower registration, resource management, and automated charges, invoicing, and payment in crypto currency tokens in a decentralized, dependable way that also guarantees traceability and transparency can be found in blockchain technology and smart contracts. Instead of a centralized entity, distributed orchestration can be used to achieve this.(ii) With 5G, infrastructure sharing presents a clear commercial opportunity whereby a mobile network operator (MNO) uses all or some of its cellular towers to provide telecom services. Both of the aforementioned models are considered examples of active sharing. Examples of active components that an MNO provides in active sharing are the Radio Access Network (RAN), also known as the Multi-Operator Core Network (MOCN), or the Core network components, also known as the Gateway Core Network (GWCN). On the other hand, passive sharing occurs when a mobile phone company shares the cellular tower mast, as well as the space, air conditioning, and telecom rooms assigned to various buildings. Active sharing is thought to be the most effective technique because of the utilization of network virtualization. The physical and radio infrastructure resources must be divided and segmented into numerous virtual resources, each with its own features, services, and goals. To oversee and monitor the use of resources (the active and passive components of 5G), blockchain is expected to be very helpful. Smart contracts enable instantaneous, automatic agreement sharing and money disbursement without the need for middlemen. (iii) International Roaming: Due to the involvement of brokers and other parties in the negotiation of payment and charge policies, roaming is one of the more complicated challenges in the telecom industry. It goes without saying that many parties will be involved in using 5G networks. Multiple operators, intermediary international exchanges, and intermediary networks are a few examples of these parties. The roaming linkages are resolved in all circumstances either directly or through foreign exchanges. A single point of failure at the intermediate level, the profit-cut that these intermediaries regularly impose, and the potential for fraudulent activities (should roaming subscriber usage not be transferred directly) are some of the other major issues with foreign exchanges. To develop a blockchain-based roaming and payment system where fees and consumption are recorded and tracked, smart contracts are used. Following payments are automatically distributed among the parties involved in a trusted way in the form of crypto currencies or tokens without the intervention of local or foreign third parties, brokers, or exchanges. Smart contracts record, validate, and manage all of the parties' interactions so that they can be traced, tracked, and audited by all parties in an effective manner. They also capture the agreement conditions and logic from all parties.

Network Slicing: A "network slice" in 5G refers to an instantiation of the underlying network services and capabilities or the physical infrastructure. A 5G network slicer allows an operator to offer a variety of user services and applications using the same network architecture. Additionally, active infrastructure sharing and spectrum sharing are made possible by 5G network slicing. The slicing is often carried out by exposing the mobile operator network's service capabilities through a Network Slice Broker (NSB). Some or all of the NSB functions can be replaced with a blockchain smart contract with decentralized storage like Storj or IPFS. The restrictions of integrating Edge Computing, IoT, and 5G networks are removed by the proposed[77] trustworthy blockchain architecture for edge-based 5G networks. The suggested blockchain system effectively identifies edge devices, verifies their authenticity, and assigns addresses to the devices based on demand. Additionally, the proposed method offers secure edge device connectivity that can defend against DDOS and Side channel assaults. The suggested architecture [78] includes all necessary elements, including a reputation system, an incentive system, and priority-based strategies to address various shortcomings in the existing literature. The simulation results for several situations demonstrate that the transaction costs are represented as 130521, 109824, and 89195 gas values, while the high execution costs of a single controller node, minor node, and ordinary node are shown as 106305, 85864, and 65491 gas values, respectively. The results demonstrate the scalability, timeliness, and cost-effectiveness of the recommended design. For 5G networks to be confidential and safe [79] this article suggests an authentication methodology based on pseudonyms and blockchain. The proposed approach is safe and protects privacy from various threats, according to a security analysis. Additionally, performance evaluation shows how effective the suggested plan is in comparison to other schemes. This study proposes a blockchain-based trustworthy collaborative power trading scheme for 5G-enabled social vehicular networks, based on the establishment of trusted power trading through a distributed market mechanism [80]. This scheme eliminates the need for a centralized dispatch centre and is independent of it. In order to maximize societal welfare, construct the pricing and trade matching mechanisms for V2V power trading based on game theory. The paper [80] use smart contracts to match transactions and blockchain to store data on power trade for reliable pricing. The outcomes of the simulation confirm that the suggested plan is effective in enhancing social welfare and lowering grid demand

5. Main Fidings and Challenges

5.1. Blockchain Transaction Throughput

Blockchain Transaction Throughput significantly impacted by the growing usage of blockchain technology in both the financial and non-financial sectors, which calls for techniques and processes to increase both horizontal and vertical scalability. For a blockchain to scale to a high number of nodes and clients with little performance deterioration, increased throughput, an effective storage mechanism, and low latency are the most desirable characteristics. Many approaches have been proposed to develop scalable blockchain applications, taking into account the trade-offs between the most desirable but different DSS (Decentralization, Security, Scalability) trilemma. One of the most extensively used strategies to increase blockchain scalability is sharding, Elastico [54], Omni ledger [27], and other sharding-based techniques. Scalable storage, high throughput, and Byzantine fault tolerance can all be attained with minimal latency. Rapid chain [55] is best technique. With a message complexity of O, Rapid chain evolved as a protocol that offers higher scalability without sacrificing security (n). Reducing message complexity in sharding, and in blockchain in general, is the area that need more study. One of the secrets to blockchain scalability is the Communication Cost per Transaction (CCPT) [82]. Scalable blockchains are those with CCPTs of the order of O (n). Existing approaches either sacrifice reliability or the decentralised aspect of blockchain, rely on reliable hardware, or make the assumption that all nodes are motivated and act rationally in order to achieve O (n) CCPT. Byzantine adversaries can be tolerated by the Rapid chain [55] up to a third of the time, but only when working with crypto currencies. For blockchains that are not based on crypto currencies, a potent defence against byzantine opponents and shard takeover must be in place. Since the number of shards directly affects performance (throughput), having more shards also divides resources and processing capacity among the shards. Because of this, it takes a very small amount of resources for a hostile adversary to gain complete control of a shard. Maintaining atomicity in a cross-shard transaction can be challenging [83]. To validate the timing of these actions, a schedule must be followed when working on different shards. When a shard needs to deal with a lot of both legitimate and illegitimate cross-shard transactions, it might be investigated to introduce a load balancing system to cope with scenarios where miner nodes become exhausted and there is a denial of service. The development of several branches of blocks known as forks is another issue that restricts blockchain scalability and needs additional research from the research community. A fork is a metaphor for splitting off from or veering away from the norm or an established structure, policy, environment, etc. The process of mining creates blocks for the Bitcoin network, which contain valid transactions and require the solution of a Proof-of-Work problem. A blockchain fork happens when two miners independently find and publish a new block that has a reference to the previous block. Forks are a natural element of how the blockchain works and change the existing rules in favour of a new set of established rules, even though the inconsistency is only momentary and is fixed by the succeeding blocks. A few of the factors include delays, various mining strategies, opposing policy positions that lead to blockchain forks—the latter of which is also referred to as negative gamma and impacts the security of blockchain implementations—and ideas regarding network topology in a permission less setting. The forks that actually happened, as described in general, aid in understanding the causes of its genesis. A hard fork occurs when a blockchain upgrade is not backwards compatible with the current blockchain technology. The client software and virtual machines that validate transactions and blocks in accordance with the previous rule may view it as invalid and redundant, necessitating an upgrade of all the relevant nodes. The hard fork between Bitcoin and Bitcoin Cash, which was discussed in general assist to understand the causes that initially led to its establishment, is one of the best examples of this. A soft fork, as contrast to a hard fork, is an upgrade that is backward-compatible and allows upgraded nodes to connect with non-upgraded nodes. Only if the updated rule does not conflict with the previous one is this possible. Examples of this can be found in the blockchains of both Bitcoin and Ethereum, where the formation of each was influenced by modifications that were made public and then included [84] the longest chain rule is currently used to handle these forks. But in the absence of any fork avoidance methods, resource waste persists, which could have a detrimental effect on the blockchain's overall performance. Blockchain splits can have negative effects on the economy, cause confusion, and erode confidence. The author of [85] the piece develops a formal framework to investigate the emergence, persistence, and financial effects of blockchain splits. Author argues that process- or protocol based blockchain forks can occur accidentally or on purpose. The author also analyses the circumstances under which a chain split can become irreversible and offers a sub classification of protocol-based forks. It is shown that a fork's capacity to persist depends on the kind of modification made to the consensus rules and the proportionate allocation of resources relevant to the consensus. Several techniques, including [49], that rely on efficient network architecture and cut-through routing to lower latency were discovered during our literature review investigation. However, this necessitates a completely trusted configuration or trust management approach to prevent the network from becoming a bottleneck or an attack surface. Because they need an access control layer, permissioned blockchains offer an extra degree of protection over standard blockchain systems like Bitcoin. Because they need an access control layer, permissioned blockchains offer an extra degree of protection over standard blockchain systems like Bitcoin. Table 4 illustrates how using nimble or reliable hardware for mining and validation in a permissioned (consortium) blockchain system lowers BGR, which immediately impacts transaction throughput. But for it to be adopted in permission less (public) blockchain scenarios, there needs to be a compelling incentive system that encourages miners to use equipment with more processing, storage, and memory.

5.2 Challenges and Open Issues

The difficulties that could prevent blockchain technology from being widely adopted and used in 5G are outlined and discussed in this section. • Interoperability: It's still difficult to get several blockchain platforms to work together seamlessly. Currently, there are numerous blockchain systems that 5G stakeholders can connect to. This is a significant obstacle that researchers must face and conquer. A further difficulty is interoperability within 5G networks. MmWave, tiny cells, massive MIMO, full duplex, SDN, and beam forming are among the new technologies that come with 5G. These technologies differ from one another in how they function.

• Smart Contracts: Currently, there are roughly 10 million active smart contracts on the public Ethereum blockchain. The primary challenge is converting these massive volumes of contracts into smart contracts for the 5G ecosystem. Especially when taking into account the high degree of IoT device granularity that a standard 5G network will contain. An additional concern is the deployed smart contracts' legality. • Scalability: For payload and transported data, 5G networks aim to achieve an end-to-end latency of less than 1 millisecond [2]. This strict demand requires extremely high throughput rates for setup and configuration. Currently, 1014 Transactions per second (TPS) may be processed by public blockchain networks like Ethereum and Bitcoin, whereas up to 3, 00020,000 TPS can be processed by certain private blockchain implementations [35]. New blockchain topologies, sharding techniques, block size increases, and consensus algorithms are being researched to increase the throughput of today's blockchain networks.

• Data Privacy: Data privacy has grown to be a significant worry for people, companies, and governments. For 5G operators who handle sensitive consumer data, it is increasingly important. information that can contain credit card numbers, address information, service and usage logs, payment histories, and other personal and identifying facts. Since the introduction of the EU GDPR law, users' records and data have been subject to stricter privacy regulations that also grant them ownership and control over their data. The investigation led to the discovery of other projects that looked at how factors like block size and block production affected the creation of scalable block chains. However, the majority of these initiatives have been directed at the Bitcoin blockchain and are hence unique to the configurations used with Bitcoin. To highlight strengths and limits, particularly with regard to scalability, further work is needed to do similar analyses at a higher level of abstraction, i.e. within a specific platform like Ethereum or Multichain.

• Consensus algorithm: Because the blockchain software stack is decentralized, consensus algorithms are crucial to its operation. The first widely used blockchain application, Bitcoin, is based on the Proof of Work consensus mechanism, although other proposals include Proof of Stake, Proof of Authority, and Proof of Weight. However, in order to understand consensus algorithms and show that they are appropriate for specific application domains, a comprehensive empirical examination is required. Blockchain cannot realise its full disruptive potential without fully addressing the scalability issues. Our study of cutting-edge initiatives, however, reveals a number of their shortcomings that need for additional work on the part of the scientific community. We list the primary research roadblocks to creating scalable blockchains below. Off-chain computing is proposed as a solution for blockchain scalability when working with computationally expensive smart-contracts, in the same way as off-chain transactions (such as lightning networks) are proposed as a solution for blockchain scalability when working with financial transactions. As every peer carries out every smart contract on open, permissionless smart contract blockchains like Ethereum, a consensus is developed among all peers. To keep smart contracts from consuming excessive amounts of processing power, Ethereum implements a gas constraint that limits the number of instruction operations that a smart contract can perform. To enable more computationally intensive smart-contracts, all peers would have to agree on the result of the smart-contract execution, without every peer having to run the smart-contract. Potential solutions for this current research issue include trusting selected peers to execute smart contracts and using proof-of-stake voting to validate proposed execution results of smart contracts.

6. Conclusions

The previous several years have seen a rapid development of blockchain technology, which will soon find more uses across numerous industries. With the increasing adoption of blockchain technology, the user base has continued to grow. But the ongoing problem of network congestion has forced individuals to carefully investigate how to solve the blockchain's scalability issue. Many fresh alternatives have been put forth to this objective. In this paper, we first outline the blockchain performance issue with a focus on scalability, and then group the current popular solutions into a number of illustrative layers. In addition, we elaborate on some well-known methods, like sharding, side chains, and cross-chains, with the goal of providing a thorough justification. Aiming to address the scalability of blockchain systems, we also discuss several unresolved issues and potential research topics based on the shortcomings discovered, such as the enormous amount of blockchain data that needs to be reduced or pruned, the inefficient cross-shard transaction, and incomplete protocols to connect the current blockchain to cross-chain platforms. Also we have summarized research challenges in the integration of blockchain with 5G and the potential solutions, integration of 5G with the blockchain will revolutionize the way we communicate. We believe that by conducting this extensive study, our classification and evaluation of the available options will encourage more scholarly inquiry into improving the scalability of blockchains.

Author's contribution statement

Ravindra J. Lawande: Conceptualization, gathering and validating data, creating drafts and final manuscripts, analysing and interpreting the findings.

Sudhir B. Lande: oversight, ideation, interpretation of the findings, writing, review, and editing.

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