The Potential of Blockchain for 5G Technologies: Opportunities and Challenges

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***Abstract*—Blockchain is decentralized data management technology developed for financial and non-financial smart contracts. Its evolved as an enabling transformational technology adopted across industry vertical domains. Meanwhile, 5G is mobile network that promises to be 20x more faster than current technology. Its low latency, more coverage and high data rate add more benefits to the technology. However, it comes with its own technical issues related to authentication and resource management. Integration of 5G with Blockchain technology give solutions to many such challenges. This paper provides potentials of Blockchain technology for 5G technology. We present working of blockchain and its applications in various fields. We also summarize potentials opportunities with integration of blockchain and 5G technologies. Finally, we discuss research challenges of combined technology.**

Index TermsClass: Blockchain; 5G technology; Healthcare; Internet of Things.

I. INTRODUCTION

A blockchain is a distributed database, designed to maintain continuous growing list of ordered records. The records are commonly known as blocks. All the blocks comprise of link to previous block and a timestamp, which are resistant to modification of data, cannot be altered or modified. They are protected from tampering, revision, and deletion [1]. The technical definition of blockchain is a collection of records, transaction of a particular type or contracts between two parties known as ledger, which can be programmed to trigger transactions automatically. These contracts are embedded in digital code and stored in a shared database. All the agreements are digitally recorded and signature of which in turn identified, validated, shared and stored to replace intermediates such as banks, lawyers, and brokers.

The blockchain technology can be successfully applied to financial as well as non-financial applications. Non-financial applications include healthcare [2], utilities [3], real estate [4], Internet of Things, Agriculture, Supply chain management and government sector [3].

The technology is exploited to replace the trusted inter-mediator third parties such as banks for financial transactions, email service providers or it can be social networks which can be hacked, compromised or manipulated anytime. In the mean time, the technology operates in decentralized fashion gives a provision to verify its digital assets anytime without compromising the privacy of the data.

One more cutting-edge technology is 5th Generation wire-less cellular network. Commonly known as 5G technology. It is faster, reliable, and able to handle maximum connected devices than any other existing technology, 20x faster than current technology. It shows huge impact on accessibility via connected latest remote applications. Its potential speed and usage capacity make new future for the world. 5G technology support various applications of heterogeneous networks and machines with high quality of services, huge system throughput and high network capacity. It supports new business opportunities in several fields such as enterprise, government regulators, mobile operators, and infrastructure providers. 5G is known for low latency, more coverage, high data rates and high processing speed which will be standardized soon. Meanwhile, technology lacks in resource management, security challenges, decentralization, and risk of data interoperability and authentication handover [5], [6]. However, blockchain is used to authenticate, register, validate transaction and assets, manage identification in a trusted decentralized network. The main contribution of this work is:

- Brief introduction of blockchain technology, its working, and applications in various fields.
- Brief introduction of 5G technology.
- Potential opportunities with integration of blockchain with 5G networks.
- Research challenges and opportunities of blockchain with 5G technology.

The reminder of this paper is organized as follows. Section II focuses on working of blockchain by exploring creating a valid signature and calculating difficulty value. Section III gives potential applications of blockchain in the field of Healthcare, Agriculture, Internet of Things and Supply Chain Management. Section IV discusses requirements of 5G and how blockchain technology fulfils it. Section V briefs on research directions and challenges. Finally, paper is concluded in Section VI with future work.

II. WORKING OF BLOCKCHAIN

Blockchain is chain of blocks, or distributed data structure where data is shared and replicated among the members of the

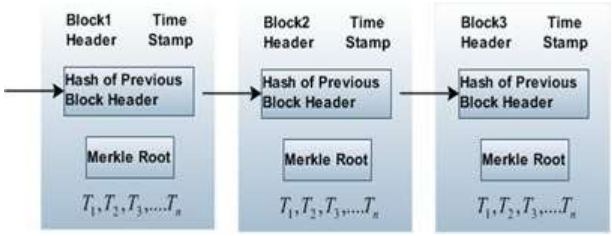

Fig. 1. Blocks connected in the form of chains

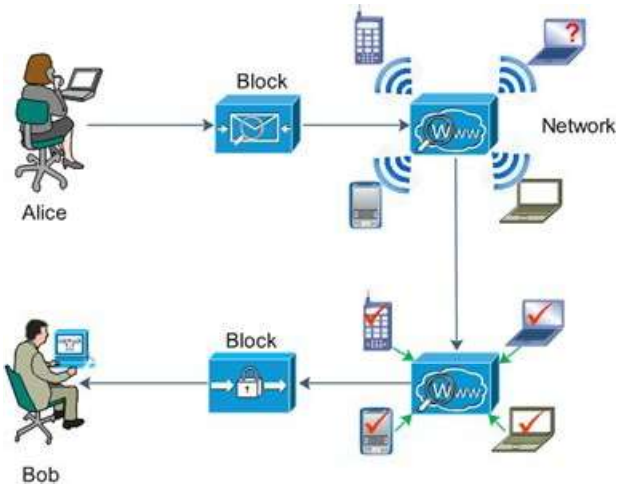

Fig. 2. Working of Blockchain technology

network. The blocks in the chain follow the singly linked list structure by storing the hash of the previous block and all the blocks are connected to each other in the form of chain [7]. The first block of the chain is called genesis block and has no parent node.

Each block in blockchain comprises of four major fields as shown in the Figure 1, a hash of the previous block, Merkle hash, timestamp, and transactions (smart contracts). Hash establishes a link between blocks by creating chain of blocks. As the hash field contains hash of the previous records, change of an entry leads to change of all subsequent records which is very difficult to change.

Figure 2 shows working of blockchain in financial transactions. Let Alice and Bob are two entities in the blockchain. Alice wants to send currency to Bob. The transaction is represented online as a block. This block is broadcasted to every node in the network and is recorded in public ledger. The new block of transaction need to be validated, verified and approved by miners. Miners are network members who perform mining process . The valid signature is required to link the block into chain of previous blocks. Process needs to ensure two things, Alice owns cryptocurrency required digital signature verification on the block and Alice has sufficient cryptocurrency in her account which is verified by checking Alices personal account by her public key. Now the transaction is successful and currency is transferred from Alices account to Bobs account. [1] [2]

Identification of Alice and Bob accounts are through public/ private-key pair. Receivers account is identified by public key and senders account must be signed with private key [8]. However, transactions are identified by their double SHA-256 hash key. Usually, miners gather all the transactions together, calculate their hashes with current header number of the blockchain for cryptographic problem. They solve the problem and create mined block which contains group of all the transactions present in the calculation. The process of mining and calculating Merkle root is shown in the Figure 1. Merkle tree is a binary tree in which every leaf node is a hash of the transaction and the main root node is known as Merkle root. Let miner M calculates the Merkle root for the transactions in the block by using block header values. Suppose *S is* the Merkle hash (double SHA256 hash) which is given by,

$$S = SHA256(n + h + sj) \quad (1)$$

Where$h$ the block header and n is is the random nonce value or time stamp, '+' symbol in the equation denotes string concatenation. The final value of S is specified with approximately 64 leading zeros. If it is not 64 leading zeros, then the value of S is recomputed by updating random nonce value n. Once the mining process is completed, block is included to the blockchain network. The common steps to upload a new transaction block into blockchain are:

Step1: Generate a public/private key pair.
Step2: Hash the new transaction. .
Step3: Encrypt the new transaction with private key for digital signature.
Step4: Append the signature with new transaction block.
Step5: Place new transaction into blockchain network.

The difficulty is defined as a measurement of how difficult to find a hash of a given target, where target is a 256-bit number, leading 32 bits are zeros and remaining are the ones. The difficulty is calculated by,

$$Difficulty\ of\ a\ block = \frac{Difficulty\ of\ one\ target}{current\ target} \quad (2)$$

The value of difficulty will increase or decrease depending on how much time it is taking to find 2016 blocks, which is directly proportional to network hash rate. When more computing power is added to the network, more tries are performed per second, leading to the faster block finding. As the mining power increases in the network, the blocks would get faster and faster. Then it is said that difficulty readjusts automatically for every 2016 blocks.

[1]Timestamp is the current time of event, tells the time of the transaction.

[2]Mining is the process of collecting the valid transactions into blocks and are later added to the network by linking them to the blocks which are accepted previously through hash signature.

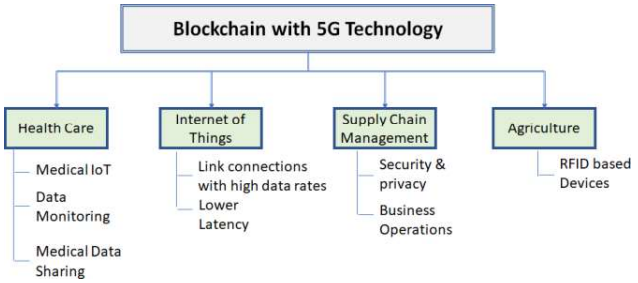

Fig. 3. Taxonomy for Blockchain and 5G Technology

III. Blockchain's Applications and Challenges

There are several applications of blockchain technology. In this paper some of the typical applications of the blockchain are summarized in the areas such as Healthcare, Agriculture, Internet of Things and Supply Chain Management. Applications are shown in the Figure 3.

A. Blockchain in Healthcare

Electronic health records were never designed and maintained in a distributed network as a life time record. Usually patients leave their medical data across various health centers or individual providers. Time to time the medical records are shifted manually from one health center provider to other, leading to data lose and ease of access as data is stored with separate providers. Blockchain provides best deployment plans in healthcare and data science. The most exciting project is MedRec, to store medical records of the patients [9]. This is a MIT-Forde project created on blockchain to serve as a digital history and family medical records. The block (on blockchain) of family medical record history is created that can be passed from one generation to other. Researchers, doctors and public healthcare authorities are the in the system. The system enables MedRec data economics by supplying big data to researchers to release metadata. This is the big gift from network industry to health information technology and research Integrated Blockchain learning model for health- care data users provides provisioning of parallel computing. Medical dataset from various healthcare centers is trained and smart contract is used for international collaboration using 5G networks. Blockchain with 5G technology provides security, privacy, decentralization, lower operational costs, and service efficiency. The technologies incorporate with Software Defined Network, cloud and edge computing for better healthcare facilities.

B. Blockchain in Agriculture

Feng Tian worked on Agri-based supply chain traceability system [10]. The system is based on blockchain and RFID technology. The system gathers the data and information from agri-food supply chain. This system monitors and traces the safety and quality of agri-food from source to destination. The trust of the products and logistic industry with the application cost. The conceptual design of the system is designed as shown in the Figure 4.

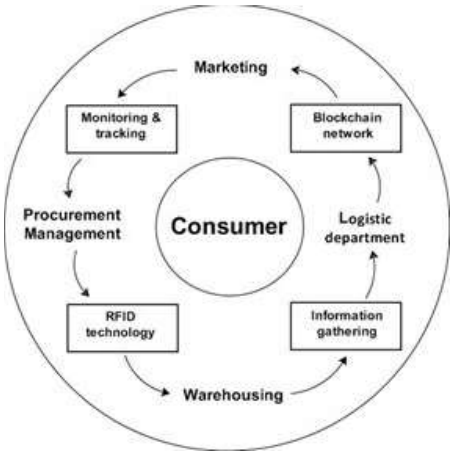

Fig. 4. Framework for agri-food supply using RFID and blockchain

C. Blockchain in Internet of Things

Recently people are monetizing their things by many applications with the implementation of distributed application using Internet of Things and blockchain technology [11], [12], [13]. This facilitates the sharing of electronic devices, buildings and vehicles with the help of network connectivity and sensors. These embedded things enable interchange of data among themselves with the help of Internet. The data can be shared without the trusted third party. The applications are shared in a decentralized peer-to-peer (P2P) network to embed a blockchain technology in IoT industry [14]. Stock.it is a combined application of IoT and blockchain, where Ethereum system is the IoT device that grants access to the code, acts as an interface between universal sharing network and the physical world. [3] [4] Integration of Blockchain with 5G has lots of applications in Internet of Things technology. In fact, IoT devices are predicted exponentially more connections by 2025. In such situation 5G networks provide link connection with low latency and high data rates.

D. Blockchain in supply chain management system

Blockchain ensures security, trust and transparency in supply chain management with global facilities such as tracking, transfer and payment. The main goal is end-to-end tracking solution. Blockfreight is supply chain management with blockchain technology, which gives solution for international trade while sea shipping and national trade while truckload shipping. The three major fields that include blockchain technology in supply chain are traceability, smart contracts and safe transactions. In food sector, origin of goods and ingredients are the essential factors for trustworthy business.

The main challenge process of traceability is automated and accelerated by blockchain technology with tracking system

[3]Ethereum system is the Internet of Things device that grants access to the lock. The work is conducted on the agri-food such as fruits and vegetables, and meat. RFID technology helps in data acquisition and processing, warehousing, logistics and marketing. The system enables food safety and quality supervision.

[4]USN is the universal decentralized autonomous application that runs on the Ethereum platform to unlock the smart lock.

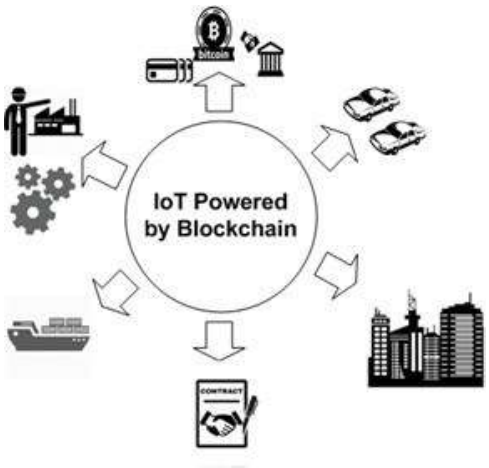

Fig. 5. Areas across which Blockchain enables IoT

such as RFID. Potential applications are tracking of quantity and transfer of materials from manufactures to customers, the technique is smart tendering. Electronic contracts on automated actions are the added advantage for supply chain management. These smart contracts automatically execute payment system in case of on time delivery by executing fully automated order calls in multi stakeholder contracts. The existing technology is ERP based private clouds. With a valid timestamp, blockchain technology tracks the journey of data such as shipping documents, confidential business documents and order confirmations. The main objective is for getting reliable and transparent documentation of transactions, communication between manufactures to customers (end-to-end communication). In fact, best role is by focusing specifically on payments and invoice

IV. BLOCKCHAIN FOR 5G TECHNOLOGY

Currently, 5G data traffic is showing rapid growth in day-to-day activities, such as increased usage of smart phone devices, laptops with embedded SIM cards, YouTube down streaming, NetFlix usage, social cloud platforms, 5G targets to support enhanced mobile broadband low latency, massive machine type communication, high quality of service, system throughput and network capacity. 5G cellular networks provide immediate impacts on business stake holders and customers. It promises for revolutionizing global industries by providing advanced and customized user centric values. The main objective is meeting the rapidly growing demands of emerging services by enabling human/machine interconnections.

However, rapid growth of 5G networks face security issues and conventional methods are not sufficient to handle security challenges. It has its own technical issues in repeated authentication handover, resource management which leads to increased latency and delay. Meanwhile, Blockchain technology enables transformational and disruptive technology by adopting industry domains. Main features of blockchain include registration, validating transactions and assets, interaction governing, managing identification by recording data. Blockchain combined with Software defined networks remove reauthentication of repeated handover in heterogenous networks by accessing minimum delay [15].

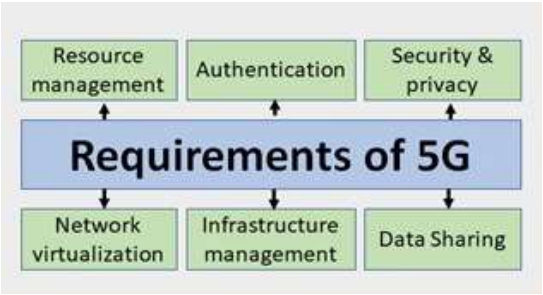

Fig. 6. Requirements of 5G

In this section we explain the integration of blockchain and 5G network. Figure 6 Shows the components involved in fulfilling the requirements of 5G using blockchain. It has evolved as a boon to 5G technology by proving efficient service to users as well as network. The most powerful mobile resources such as computation, bandwidth, memory, and storage are growing rapidly by increasing network complexity in terms of resource management. Handling such issues in mobile service is critical challenge. However, blockchain is efficient technology to solve these issues by enabling distributed resource allocation schemes.

Strong data sharing capacity of 5G to cope up with high user demands is still under research. Blockchain provides features such as traceability, transparency and immutability to improve efficiency of data sharing. Added requirement of 5G is network virtualization of wireless network. This provides coverage, energy efficiency and capability of network. Blockchain providing immutability secures wireless networks. In 5G, edge computing, parallel computing, cloud computing and fog computing play significant role to improve quality of service and increased computing capabilities. 5G is suffering from security and privacy issues such as data sharing privacy, end to end data privacy, and trust issues. Blockchain with decentralization and trust capability solves such issues [16].

V. RESEARCH DIRECTIONS AND OPEN ISSUES

Due to emerging technology block has multiple challenges in scalability. Day by day there is a rapid growth in number of transactions, by making the blockchain heavy. Current Bitcoin storage is more than 100 GB [17]. Number of transactions processed per second is nearly 7 transactions which indicates the time of processing of millions of transactions is far more to imagine. One more scalability problem is capacity of the block is very small. The delay in processing leads to high minor fee. The problems are proposed with two type of solutions which are storage optimization of blockchain [18] and redesigning the architecture of blockchain [19], [20].

Blockchain transactions cannot guarantee security and privacy since value of all transactions (public key) is publicly visible. In the network node trust over 51% computing power is accepted, but it is not 100% sure that the node is blocked in the blockchain, miners may delay it for private charging.

Integration of 5G with blockchain technology is still its infant stage. Many researchers are working to overcome the challenges of 5G by integrating blockchain technology research with new features such as decentralization and security.

However, there are still several critical issues that need to be resolved. There is lack of infrastructure, standardization, and regulations in current 5G blockchain system. It is difficult to adopt 5G with blockchain with any standardization. One of the major promises of 5G is high throughput. And blockchain has lower throughput and long queuing time.

On the other hand, if 5G network using Internet of Things devices, they generate huge data with that ultra-dense network of 5G have limited resource. This leads to issues such as data storage, resource management and data sharing by increasing computation burden. Blockchain requires high computation cost, high bandwidth, high mining power but current network is computationally expensive because maximum computation power is used by miners (When new block is created, miners run mining puzzles on it to approve the block. This utilizes maximum computation power). Still network is suffering from latency, bandwidth demands, energy consumption and network congestion [16]. The combined technology has opened various challenges to both academicians as well as industrialist and motivates them to work on several issues like this. The research is still in its early stage and has provided wide scope for research.

VI. CONCLUSION AND FUTURE WORK

Blockchain and 5G network technology are cutting edge technologies, both have drawn significant attention in industry as well as academic researchers. This paper explores potential of blockchain in 5G network. We discussed working of blockchain with brief mathematical equations and pseudocode. We presented integration of 5G with blockchain. Applications in various fields are given with brief introduction. At the end gave research directions and challenges. Though, this is a survey type paper, we would like to propose future work. Implementation of the combined technologies by considering real 5G network data.

REFERENCES

[1] M. Crosby, P. Pattanayak, S. Verma, V. Kalyanaraman *et al.*, "Blockchain technology: Beyond bitcoin," *Applied Innovation*, vol. 2, no. 6-10, p. 71, 2016.

[2] Kar and I, "Estonian citizens will soon have the worlds most hack-proof health-care records," *Online, Quartz*, vol. 3, 2016, blockchain Bonus. [Online]. Available: https://qz.com/628889/this-eastern-european-country-is-moving-its-health-records-to-the-blockchain/

[3] M. Walport *et al.*, "Distributed ledger technology: Beyond blockchain," *1*, pp. 1–88, 2016.

[4] D. Oparah. (2016, February 7) 3 ways that the blockchain will change the real estate market. [Online]. Available: https://techcrunch.com/2016/02/06/3-ways-that-blockchain-will-change-the-real-estate-market/

[5] Hu, Su, B. Yu, C. Qian, Y. Xiao, Q. Xiong, C. Sun, and Y. Gao, "Nonorthogonal interleave-grid multiple access scheme for industrial internet of things in 5g network," *IEEE Transactions on Industrial Informatics*, no. 14, no. 12, pp. 5436–5446, (2018).

[6] Duan, Xiaoyu, and X. Wang, "Authentication handover and privacy protection in 5g hetnets using software-defined networking," *IEEE Communications Magazine*, vol. 53, no. 4, pp. 28–35.

[7] R. Dennis and G. Owen, "Rep on the block: A next generation reputation system based on the blockchain," *IEEE*, pp. 131–138, 2015, 10th International Conference for Internet Technology and Secured Transactions (ICITST).

[8] Decker, Christian, and R. Wattenhofer, Eds., *Information propagation in the bitcoin network*, vol. 978-1-4799-0521-8/13, IEEE. P2P Proceedings, 2013, pp1–10.

[9] Marvin and R, "Blockchain: The invisible technology that's changing the world. pcmag," Retrieved, 2017.

[10] Y.-P. Lin, J. R. Petway, J. Anthony, H. Mukhtar, S.-W. Liao, C.-F. Chou, and Y.-F. Ho, "Blockchain: The evolutionary next step for ict e-agriculture," *Environments*, vol. 4, no. 3, p. 50, 2017, multidisciplinary Digital Publishing Institute.

[11] S. Cuomo, P. De Michele, V. Di Somma, and A. Galletti, "A stochastic method for financial iot data," *Elsevier Procedia Computer Science*, pp. 491–496, 2016.

[12] S. Huckle, R. Bhattacharya, M. White, and N. Beloff, "Internet of things, blockchain and shared economy applications," *Elsevier procedia computer science*, vol. 98, pp. 461–466, 2016.

[13] Huh, Seyoung, S. Cho, and S. Kim, "Managing iot devices using blockchain platform," *IEEE International Conference on Advanced Communication Technology*, pp. 464–467, 2017.

[14] Ethereum. (2015) Ethereum frontier. [Online]. Available: https://ethereum.org/

[15] Yazdinejad, Abbas, R. M. Parizi, A. Dehghantanha, and K.-K. R. Choo, "5g vision: The 5g infrastructure public private partnership: the next generation of communication networks and services," *IEEE Transactions on Network Science and Engineering*, Aug 28. 2019.

[16] D. C. Nguyen, P. N. Pathirana, M. Ding, and A. Seneviratne, "Blockchain for 5g and beyond networks: A state of the art survey," *arXiv preprin*, no. 1912.05062, 2019.

[17] Z. Zheng, S. Xie, H.-N. Dai, X. Chen, and H. Wang, "Blockchain challenges and opportunities: A survey," *International Journal of Web and Grid Services*, vol. 14, no. 4, pp. 352–375, 2018, inderscience Publishers (IEL).

[18] Bruce and JD, "The mini-blockchain scheme," *White paper*, 2014.

[19] I. Eyal, A. E. Gencer, E. G. Sirer, and R. Van Renesse, Eds., *Bitcoin-ng: A scalable blockchain protocol*, symposium on networked systems design and implementation. 13th symposium on networked systems design and implementation, 2016, pp 45–59.

[20] Christidis, Konstantinos, and M. Devetsikiotis, "Blockchains and smart contracts for the internet of things," *IEEE Access*, vol. 4, pp. 2292–2303, 2016.