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Using Blockchain for Flow Measurement of 5G Base Station

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Abstract. 5G is a hot area for its high speed data transmission by millimetre wave. Thus a huge amount of 5G base stations are required to be established, which brings heavy burden to 5G operators. In this paper, we propose a new flow measurement system based on blockchain to settle accounts for base stations belonging to different operators securely and fairly. For the base stations can verify the data flow for each other, only real data transmission can be recorded by blockchain. The proposed system can utilize existing consensus mechanism to make it stable and distributed. A concrete scheme is constructed and the scheme is proved to be secure. With this system, the base stations can be encouraged to be setup by different 5G operators and other companies to gain incentive by transmitting data service. This system can solve the problem of huge demand of base stations, and it's secure, fair, and suitable for real deployment in practice.

1. Introduction

With the development of the mobile Internet, IoT and its applications, wireless data traffic demands are expected to increase 1,000 fold by 2020 [1] and 10,000 fold by the year 2025 [2]. The fifth generation (5G) cellular networks will be used not only for communication between people, but also for communication between people and objects, as well as between things and things. At present, 5G services can be roughly divided into three scenarios: eMBB (Enhanced Mobile Broadband), mMTC (Massive Machine Communication), and uRLLC (Ultra Reliable Low Delay Communication). It provides high speed data transmission for end nodes.

With the increase of access equipment and the increase of communication bandwidth demand, higher requirements are put forward for the number of base stations and the quality of service. At the same time, due to the low penetration of millimeter wave, more micro-base stations will be built in each cell to provide stable data connection for mobile terminals, which makes infrastructure providers spend a lot of money to establish a sufficient number of base stations. To make matters worse, there are usually many 5G operators. In the construction of 5G base stations, different operators will build their own 5G base stations, resulting in a huge amount of base station construction, and excessive consumption of resources, a large number of base stations occupy a large amount of space.

If the 5G base stations built by various operators can be used in common with each other, the above problems will be effectively solved. However, this will lead operators to blame each other in the process of 5G construction, or make their base stations lazier in providing 5G data services for users of other operators. If we can provide a credible settlement mechanism in the 5G universal process, so that the services provided by the base stations built by operators can be effectively recorded, and the use of base stations can be settled between different operators within a fixed period, the above problems will

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be effectively solved. Therefore, there is a lack of a fair and credible technology for uniform traffic settlement between 5G base stations across operators.

Blockchain is the core supporting technology of the digital encryption currency system represented by Bitcoin [3]. Bitcoin is a peer-to-peer network of nodes that distributes records, and every node collects transactions from the broadcast network. Blockchain can use the encryption, time stamp, digital signature and distributed consensus technology to achieve decentralized architecture [4]. Data on blockchain is untampered, public and traceable, ensured by cryptography, without any help of any third-party organizations. Blockchain is an append-only bulletin board maintained in a distributed fashion by nodes in networks [5].

Similar to the block chain network architecture, 5G base stations have the characteristics of large number and point-to-point communication. Therefore, connecting 5G base stations belonging to different operators into block chain system, trustworthy recording of their transmission data and providing certain incentives for their builders can effectively solve the data settlement problem of 5G base stations. Using this technology, 5G base stations can be built by different operators to provide services together, to gain benefits according to the number of services, and to ensure the fairness and feasibility of the process. Even in the future, private users can build 5G base stations by themselves and make profits after providing data services.

The organization of this paper is as follows. In Section 2 we describe our contributions in this paper. Then in Section 3 we show some related work. Section 4 provides the system model. Section 5 provides the concrete work flow of the proposed scheme. And after this, a security analysis of this scheme is given in Section 6. Finally, Section 7 concludes this paper.

2. Our Contributions

In this paper, we propose a new flow measurement system of 5G base station based on blockchain. Our contribution can be summarized as follows.

Firstly, we design a new blockchain system model for 5G base station. The architecture of this system is described. The system is divided into five layers, data collection layer, communication layer, distributed storage layer, consensus layer and application layer. Distributed storage layer is proposed to store all data flow data, which is hash locked periodically on blockchain to ensure untampered.

Secondly, the concrete scheme is provided. In this system, we utilize the communication data between different base stations to calculate data flow for each other. In this way, the data transmitted by each base station is measured fairly.

Finally, the system can be built based on existing consensus mechanism, e.g. Proof of Work (PoW), Delegated Proof of Stake (DPoS), etc. Due to the limited source of base station, the DPoS can be achieve by the method that different 5G operators set up different nodes as miners.

The security of this system is analysed. The proposed system can provide data flow measurement of 5G base stations fairly and securely, and it can be deployed in practice.

3. Related Works

5G technology has developed for several years [6][7][8][9], and the technology of 5G base station has also been developed since then. Qian et.al. proposed the base station based centralized network architecture for 5G mobile communication systems [10]. Feng et.al. summarized the approaches and challenges for base station on-off switching in 5G wireless networks [11]. Chen et.al. proposed base station switch-off with mutual repulsion in massive MIMO networks [12]. Yang et.al. proposed relay base-station handover in 5G [13].

Blockchain is an emerging technology, which is widely used in bitcoin [3]. In the blockchain system, the last block contains the hash value of its previous one, which ensures the data untemperable [14]. Due to the valuable property of blockchain, several blockchain-based applications have been developed [15][16]. Zyskind et.al. used blockchain to protect personal data [17]. Huh et.al. proposed a blockchain platform to manage IoT devices [18]. Yuan et.al. proposed blockchain-based intelligent transportation systems [19]. And Mettler summarized the future application of blockchain in healthcare [20]. Dorri used blockchain to ensure security and privacy in IoT [21]. It also has several applications in bank industry [22] and sharing services [23]. Blockchain technology achieves secure

and fair system for decentralized architecture, and it has important influence in lots of application scenarios.

4. System Model

There are five layers in this system, as shown in Figure 1, including Data Collection Layer, Communication Layer, Distributed Storage Layer, Consensus Layer, Application Layer.

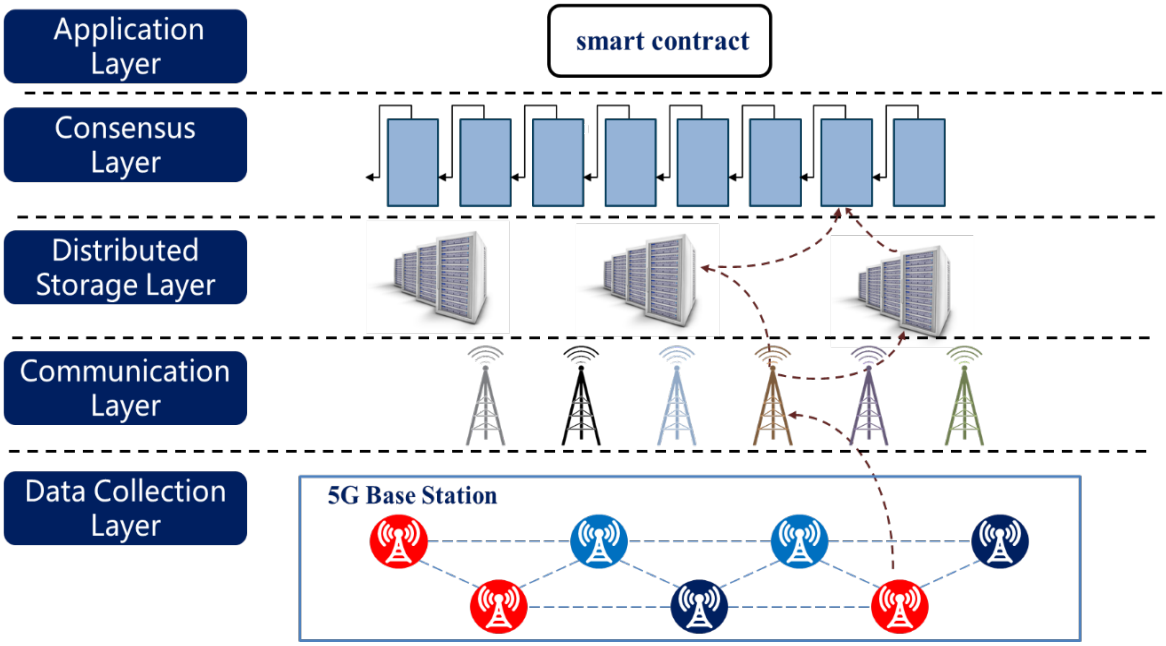

Figure 1. System Model

- The Data Collection Layer is built on the 5G base stations, and there are huge amounts of based stations in this system, which belong to different 5G operators. When the data transmitted from one base station to another, the base station would add its digital signature at the end of the data package, and the next base station would verify its validity. Due to the base stations deployed in the whole 5G network, all data is transmitted by all base stations on the route from data sender to receiver. Thus the base stations can collect all the transmitted data and identify the data route. Then all base stations would record the work of each base station that the related data it transmitted. Finally, the base station would send the result of data flow measurement to the network and the result that verified by other base stations would be recorded in distributed storage layer.
- The Communication Layer is built by the base stations and network routers. The base stations in the Data Collection Layer are linked with each other as a peer-to-peer network by wireless connection. Through this layer, the collected flow data will be spread in the whole network.
- The Distributed Storage Layer is composed of secure storage devices, and the flow date collected by the base stations can be stored in this layer securely. The system will generate a message digest for each segment of flow data which is collected by a base station over a period of time.
- The Consensus Layer is the core algorithm of the blockchain system. All base stations have the same consensus and they are combined as a blockchain system. The base stations in the system will check the correctness of the flow data. And the message digest of correctly collected data will be recorded in the blockchain. And it can assure the flow data adopted by blockchain is trusted or agreed by the most of the base stations.
- The Application Layer is carried out by the Consensus Layer. Correct flow data emerging in all stage of the system is recorded in the block and thus there can be many smart contracts

based on the blockchain to process the data according to flexible rules. For example, the smart contract can periodically calculate flow data from different base stations, and settle accounts between different 5G operators.

5. Concrete Scheme

To describe the concrete scheme in detail, we take the minimum system as an example as shown in Figure 2. Base stations $S_1,\ldots,S_n$ are deployed to transmit data and sign the data to mark its transmission work and verify the correctness of the mark from others.

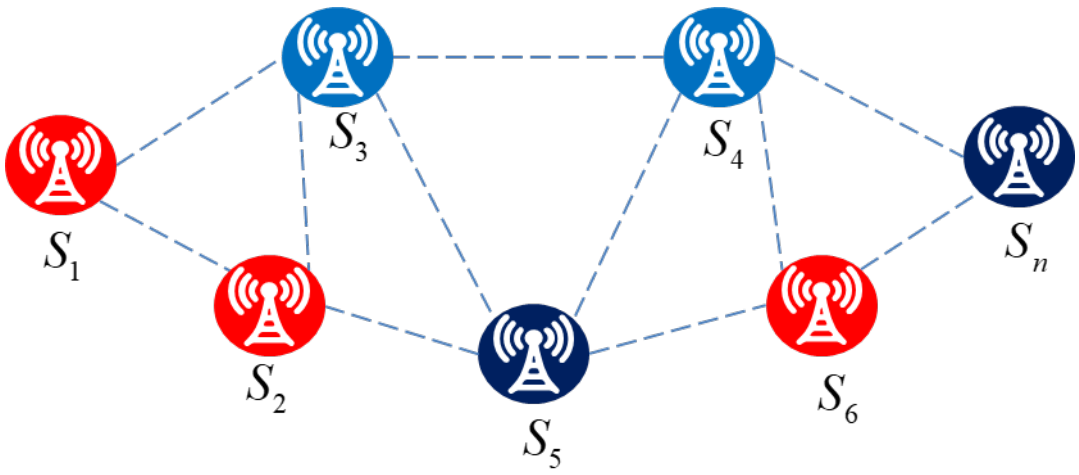

Figure 2. Concrete Scheme

The base stations in this system are also the miners of the blockchain and we adopt the existing Delegated Proof of Stake (DPoS) consensus mechanism. In DPoS, the miners are selected from the committee and generate new blocks one by one, and the current miner is named witness. While if the base stations are computing power limited, the miners can also be play by many high performance computers, which should also be produced from different manufactory or have different frameworks and run by different 5G operators. And the procedures of the system are as follows.

Step 1: Initialization. This algorithm is run at the first to setup the system at each layer of the system model. On input the security parameter λ , the system selects cryptography algorithms with relative security level, and the base stations build up the peer-to-peer network and the blockchain genies block between each other. The blockchain parameter is also initialized in this step including the number N of witness in the DPoS consensus mechanism.

Step 2: Data Collection. When a mobile sends data package from the base station S_1 and then the data goes to $S_2 \to S_5 \to S_6 \to S_n$, S_1 would mark the data package by its identity and using identity-based signature to sign the data. Then the data package with the mark and signature would be sent to S_2 , other base stations and distributed storage layer. After receiving the data package, S_2 would do the same as what S_1 does. This step ensures the transmission data is broadcasted to the whole network.

Step 3: Data Verification. After receiving the data package with mark from base station, all the other base station would check the correctness, e.g., the data marked by S_1 would then be marked by S_2 , which would also be broadcasted to the network. Then the other base stations would verify its correctness and if the data package is marked by S_2 , then it means the data is really transmitted from S_1 to S_2 . After verification, the base stations would send all the data to distributed storage layer. Periodically, the data is hash locked by generating a message digest. And thus the data flow is recorded. And this step ensures the collected data is trusted verified.

Step 4: Block Generation. When the flow data is verified to be correct, i.e. the data that is almost the same in more than half of the base stations, the witness will record the digest in the block. And then it will publish the new block to the whole system. This step ensures the data recorded in the distributed storage devices is secure and cannot be tampered, which serves for data audit.

Step 5: Smart Measurement. There can be many smart contract utilized based on the flow data. And based on data processing algorithm like Kalman Filter, the witness will calculate the difference value between each operator's base stations, and settle accounts between operators automatically. This step ensures the flow measurement is carried out honestly and fairly in the system.

Step 6: Block verification. When block published by the appointed witness of DPoS, the other miners will verify whether the data in the block is correct or the witness runs the smart measurement honestly. Once the block is not correct, each miner would reject the new block, and alert the operator. If the block is verified to be correct, the witness will add the block to the end of the existing blockchain.

6. Security Analysis

In this system, we utilize existing consensus mechanism of blockchain, which is verified to be secure in real deployment. The miners are run by different 5G operators, who must verify the flow data honestly, because they have to pay for the flow from other operators, and once some operators don't behave honestly or fairly, more than half of all operators would not record such flow data, and other operators would reject to give service to them. Besides, the signature algorithm and hash algorithm in this system are standard and proved to be secure. Above, the proposed system is secure and stable to record flow data for base station honestly and fairly.

7. Conclusion

In this paper, we proposed a new flow measurement of 5G base station system based on blockchain. The system model and concrete scheme were constructed with existing consensus mechanism and standard cryptography algorithm. It was proved that the system is secure and can provide fair flow measurement, which would have huge research and practice value in the future.

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