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Blockchain based Application to Electric Vehicle in IoT environment

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Abstract

Recently, research is being conducted on the rapid service provision and reliability of the instance-based rather than the existing IP-based structure. Research is mainly conducted through Block cloud, a platform that combines service-centric networking (SCN) and blockchain. In addition, the Internet of Things network has been proposed as a fog computing environment in the structure of the existing cloud computing. Fog computing is an environment suitable for real-time information processing. In this paper, we propose a new Internet network structure based on fog computing that requires real-time for rapid processing of IoT services. The proposed system applies IoTA, the third-generation blockchain based on DAG, to the block cloud. In addition, we want to propose a basic model of the object block chain and check the application services of electric vehicles.

Keywords: *Block Cloud, Fog Computing, SCN, Blockchain-based Internet of Things, Tangle*

1. INTRODUCTION

Currently, various studies on Internet of Things are progressing to build such system and have attracted significant and strong attractions[1-6]. However, A structure that receives a large amount of information in real-time and processes it at centralized server makes load concentrate to a server and places limitations on scalability, cost and size of a structure to process information [7, 8].

Service provided in a network is also changing and being diversified from a traditional host-oriented environment. In the previous method, a server searches and provides a requested service, based on network information including an IP and a port number of a supplier. SCN (Service-Centric Networking) that provides information based on service IDs and instances allows rapid searching and processing of service to be requested in real time because a router searches, based on service instance, rather than a location of specific host that providing service[9, 10].

Recently, Block Cloud announced an IoT network integrating SCN and blockchain technology, called as Block Cloud. Block Cloud provides portability and scalability of a network, adopting SCN based network structure. In addition, the technology uses the blockchain system to verify trustiness of service through a distributed trust system[12].

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This paper introduces and uses Block Cloud and applies DAG based third generation blockchain IOTA to Block Cloud to quickly process IoT service. Then, it a proposes a new architecture to operate Block Cloud in a fog computing method, which is more suitable for IoT network structure as IoT requires real-time interaction. Furthermore, the study presents a basic model of IoT blockchain and proposes electric vehicle application process based on the basic model[12].

In chapter 2, relevant researches forming the environment of this study such as SCN and blockchain are explained. Chapter 3 describes proposal of this study for DAG type IoT blockchain. Chapter 4 presents a service model that applies the proposal to electric vehicles. In the conclusion, importance of this study and future direction of research are presented.

2. RELATED WORKS

2.1 SCN(Service-Centric Network)

SCN is a new network structure that changed host address based service to non-host-centric service in a large network. SCN provides network users with a solution of QoS restrictions, high bandwidth and latency in communicating with a certain host to have service. Therefore, SCN allows users to request and use a service under the best demand and communication environment for them. It is also important to note that clients can use service, without connection with a certain host that provides service [9, 10].

2.2 BlockCloud

Blockcloud refers to a new type of cloud server platform that combines features of SCN and blockchain. Host centric service processing in an existing network has been improved to a network that can provide service instances with mobility and scalability using SCN. Trust to unclear service and service providers has been improved by adopting blockchain structure where trust can be obtained by consent of network participants.

In this study, we propose a new block cloud model based on fog computing using the previously studied block cloud architecture. The proposed system solves the bandwidth and delay problems inherent in the existing cloud computing network structure, and provides a physical environment for the IoT service architecture that requires real-time interaction.

The basic model consists of IoT devices, a data owner, a blockchain (and fog) network and cloud.

- **IoT Device.** T IoT devices collect and send data to the network layer (e.g. cloud or other applications). IoT devices also conduct data collection, preliminary processing, encryption (if supported) and transmission. IoT devices generally allow remote access grant and order processing. If it is required to request data from other devices, such request should be published to the cloud or the data owner.
- **Data Owner.** T Data owners are classified as administrators and general data owners. Therefore, there are many data owners. Administrators have responsibility to investigate participants. When a data owner has access data request from other IoT devices, he/she should authenticate ID before making a response.
- **Blockchain & Fog Network.** T the average time for an attacker to solve an issue is significantly less than the time for information to be distributed through a network. Consensus Algorithm of the system is Practical Byzantine Fault Tolerance (pBFT), rather than Proof-of-Work, which is used for bitcoin[13]. A fog network is a method to realize IoT proposed by CISCO. A fog network has a node to process data created at a device in real-time, like a station, and transfers only data that requires computing power to a cloud. If every data needs to be uploaded to a cloud through a network to process it, it is impossible to take an immediate action to provide users with valuable service because of latency. While fog computing can control data, it is difficult to verify whether a device is certified or not. To deal with this issue, an

authentication code for each type of devices can be uploaded to blockchain to verify a device. In addition, security can be improved through attribute-based encryption, proxy re-encryption and distributed encryption method.

- **Cloud.** A cloud saves data of an encrypted device, transfers a transaction to a blockchain network and searches authority of a device, if requested from an IoT device. In other words, a cloud monitors a blockchain network and makes a response to data requested.

3. APPLICATION OF DAG IOT BLOCKCHAIN

3.1 DAG Blockchain

While the first and the second generation of blockchain has linear structure, IoTA has non-linear blockchain. Due to the non-linear structure, it can process all transactions in parallel. Therefore, transaction speed increases if there are more issuers. Particularly, all previous blockchains had both miners and issuers. In IoTA, all issuers can equally approve and issue transactions. IoTA operates a transaction system based on DAG structure, which is called as Tangle [14].

- **DAG.** A DAG (Directed Acyclic Graph) is a non-cyclic graph. Tangle uses the DAG's directionality among the transactions accumulated over time to select the tip based on the weight and reliability of the specific transaction [14, 15].
- **Tangle.** For issuers to request a transaction in Tangle, they should approve two previous transactions. A transaction is selected by Tip Selection Algorithm (TSA). According to TSA, a transaction is randomly selected by its accumulated weight. To approve a selected transaction, a user who requests a transaction should have PoW (Proof of Work), Although the calculation process is similar with that of blockchain, actual amount of calculation to be required is not much. In addition, all issuers can proceed a transaction without a fee because one of the conditions to approve a transaction is no fee. Therefore, this is a transaction structure optimized for M2M and micro payment, which do not require high calculation capacity and any fee[14].

Currently, IoTA Foundation does not disclose the number of traders who are participating in and the amount of transactions happening in a Tangle network. Transaction units are small and processing time is short when the number of participants in a network is small. If a malicious user takes an advantage of this factor and take a certain percentage of transactions happening in the network, transactions between other users could not be properly approved. Therefore, IoTA Foundation generates a certain transaction called as Milestone every two minute at a coordinate node to find whether transactions happening in a network is properly approved.

It removes a part of Tangle network when a certain period of time passes and saves a necessary part of user information for the removed network.

As a result, an issuer does not need to save all status information of Tangle network. This paper creates a new type of service structure that allows rapid change from fog computing based blockcloud model, as described in Chapter 2, to IoT centric service requiring real-time transactions, adopting DAG based third generation blockchain IoTA.

3.2 Application Models

In this chapter, the third generation blockchain DAG based IoTA is applied to blockcloud and IoT centric network structure is designed, based on fog computing.

The structure must meet the requirements of scalability of transactions, real-time processing, no fees, service-based communication, and offline processing services. First, IoTA allows unlimited transactions, so the scalability of transactions is met. Creating and authorizing transactions on the blockchain requires a special process, but IoTA is advantageous for high-volume transactions. Second, fog computing can process services by immediately accessing them from a nearby location, unlike existing cloud-based services. Third, you need to approve other transactions in order to get transaction approval from IoTA. However, one of the conditions for approval is a fee-free role and no complicated calculations are required. Therefore, it is an optimized system for micropayments. Fourth, with service-based communication, service-based communication through the SCN network expands the range of hosts to provide services and enables quick search. Fifth, IoTA can create off-chain tangles. It can handle large amounts of transactions without uploading to the main tangle. Therefore, it enables fast processing of IoT services.

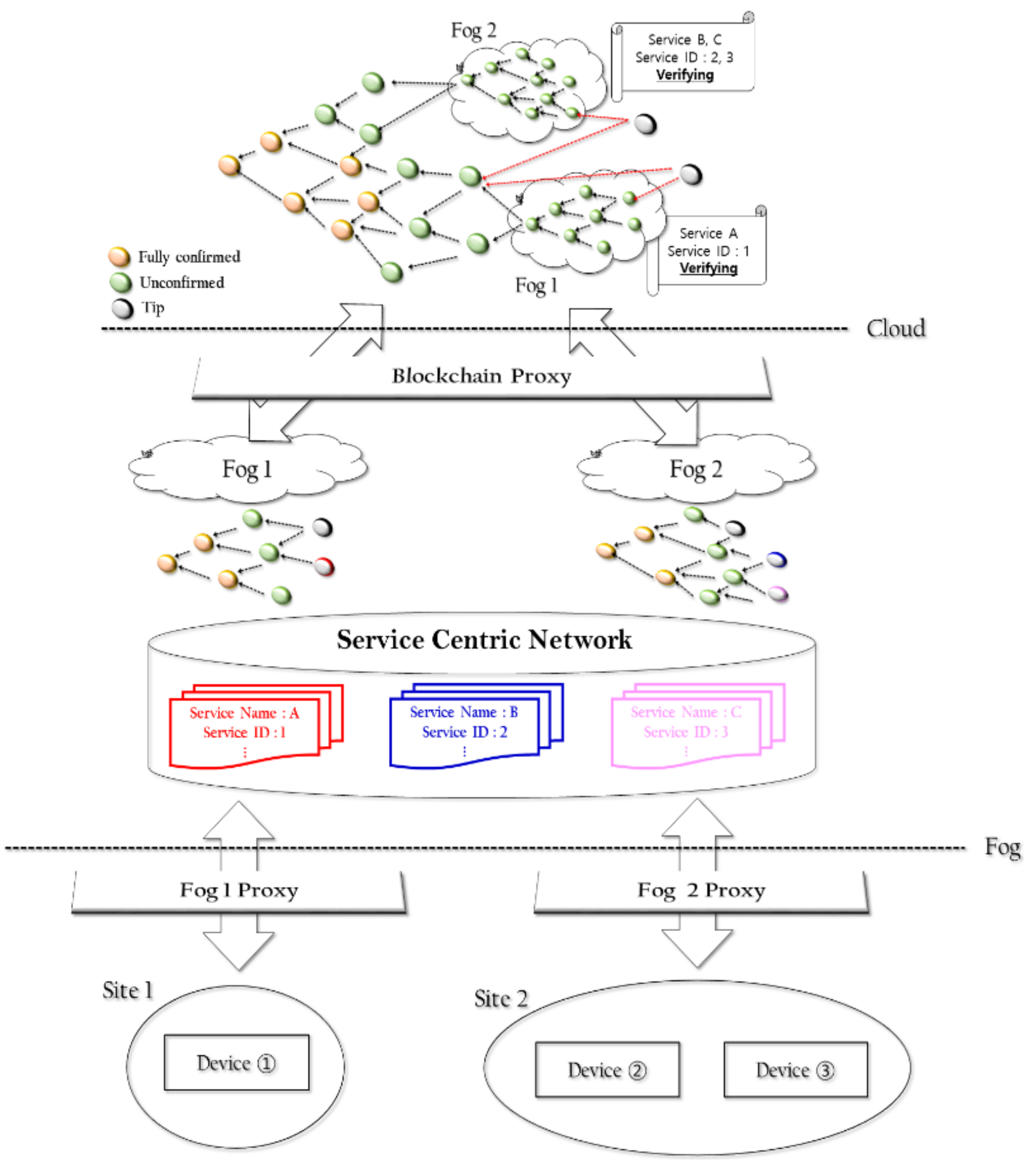

Figure 1. Model Overview

For overall process in Figure 1, when a device in IoT, a sensor node, requests service, service is transferred to a fog node that is searching a signal of sensor node through a near fog proxy. The service is delivered through SCN network in a form of packet that containing the service name and ID and saved as Tangle network transaction in a fog node. Once trustiness of service is verified, a sensor node prepares to receive service from a service provider's node, on the basis of routing information. After that, Tangle information formed at a fog node is transferred to blockchain of a cloud server through a blockchain proxy. Then, service processed at a fog node moves to the final approval and validation stage.

4. SERVICE APPLICATION MODEL

A user is now riding an electric vehicle and notices that a vehicle's battery is going to be flat in the middle of driving. The user searches a cheap charging station among near charging stations and pay charging price to the station in advance. Then, the user visits the station and charge electricity for his vehicle, without making additional payment.

4.1 Service Transfor

To transfer a service in a SCN network, an autonomous vehicle should be allocated to a single node and request a service, In the data plane, which manages a service, a service is renewed at a service table. In the control plane, a service controller refers to service information and route to a path containing a node that can provide a service earliest.

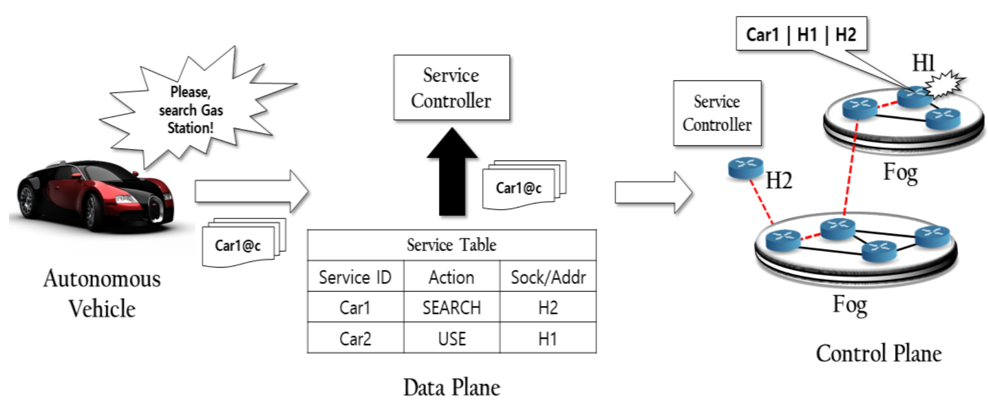

Figure 2. SCN Network

Figure 2 shows the service environment. In the SCN network, the service ID is defined as Car 1 before the autonomous vehicle delivers the service to the fog node in the region. The name of the service that finds a charging station is defined as 'c'. Services are stored in the services table. The service route from Node H1 to Node H2, where the autonomous vehicle requested the service, is provided after confirming that the service can be provided from Node H2 in another region through the service controller. The system does not communicate with the service using an address, but allocates a unique number to the service task to provide a P2P type service instance, so it distributes redundant services through a distributed network and maintains the most effective network use of the service requested by the client.

4.2 Service Processing

Figure 3 shows the processing based on fog computing. A user uses a fog proxy to access to a fog node near him/her when requesting a service. When a fog node in an area where a client belongs to is connected, a service requested by an autonomous vehicle is encoded and uploaded to a Tangle network of a fog node in a form of transaction. A transaction shall have approval of network participants. To obtain approval, two previous transactions in a Tangle structure should be approved. Once approval is obtained, modified Tangle information is recorded at a status device of a fog node through a service chain processor. Then, a service provider and price are confirmed and saved in a form of smart contract, referring to the service management table and the market place. In the inside of fog, a service based on service routing information requested by an autonomous vehicle is requested to a Tangle network as a transaction for validation and implementation. When validation is completed, electricity price is confirmed, referring to the market place. Then, a smart contract is issued, with the condition that a service user shall transfer a token to an account address of a service provider. If the contract conditions are met, a service provider provide an autonomous vehicle with a corresponding service. A user charges electricity at a station notified by the service. Then, data is processed at a fog node and service information is transferred to a cloud server.

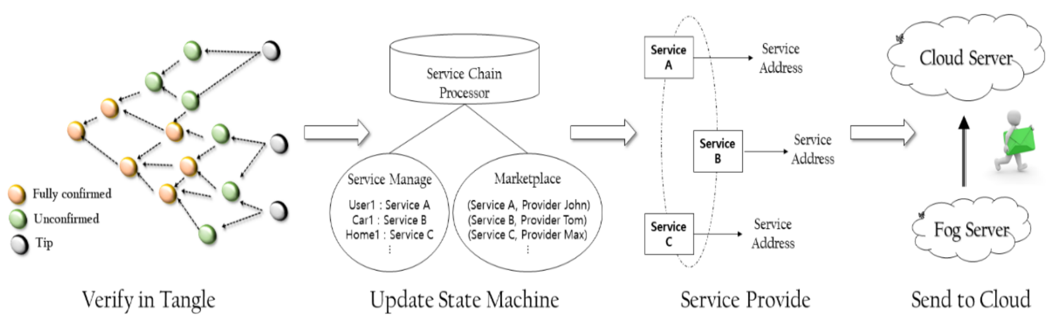

Figure 3. Process of Fog Computing

4.3 Service Validation

Figure 4 shows the transaction verification process of the cloud server. The final validation for service processed at a fog node is done at blockchain of a cloud server. Therefore, Tangle network information saved in a form of transaction is deleted in a certain period after the information is transferred. A server receiving information from several fog nodes verifies Tangle of a fog node as well when a new transaction validates previous transactions inside a server. It is important to note that transactions happening are invalid after a negative approval if there is negative approval given to a transaction with low trustiness among transactions validated in a fog node. Therefore, a fog node should refer to Snapshot, which contains information of overall Tangle in a cloud server, and account information, and a coordinate node in a fog node generates milestone transaction to prevent a negative transaction happening. A transaction with low trustiness shall have final approval at a cloud server.

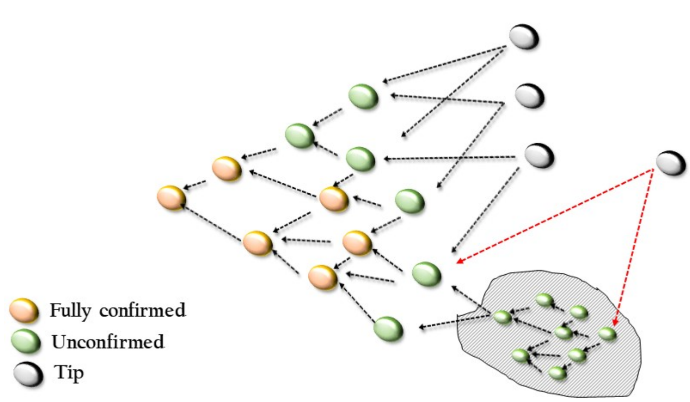

Figure 4. Validate Transactions in Cloud

5. CONCLUSION

This paper presents a new IoT model, combining characteristics of fog computing and blockchain. As the first and the second generation blockchain technology had transaction fee issues and limitations on processing speed, this study applies the third generation blockchain, IoTA, particularly, DAG based Tangle technology, which is the core technology of IoTA. However, current IoTA technology also has some issues. First, hardware design needs to be complete first. Second, there is a privacy management issue due to centralization of a certain node (coordinator). Third, there are also security issues including 34% attack. Therefore, these issues and limitation shall be dealt with before commercialization of the technology.

The possible future of IoT would be IDoT(Identity of Things) in which each device can make own decision, based on user's information. As the era of IDoT is coming, extensive studies on information security, as well as user's convenience should be conducted to ensure the era of safe and convenient.

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