IoT-Fog: A Communication Framework using Blockchain in the Internet of Things

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Abstract: In big cloud structures or large data structures, fog computing could be interpreted, referring critically to the growing issues and problems in accessing the information among Internet of things (IoT) devices. Fog computing can be used to compute, store, control and connect smart devices to each other. IoT is an architecture of uniquely identified interrelated physical things, these physical things are able to communicate with each other and can transmit and receive information. This research presents a framework of the combination of the Internet of Things (IoT) and Fog computing. The blockchain is also the emerging technology that provides a hyper, distributed, public, authentic ledger to record the transactions. Blockchains technology is a secure technology that can be a great benefit to the next generation computing. The confluence of fog, blockchains and IoT in this area introduces a new incentive. In this research work, the author mentions the convergence of blockchain, fog and IoT technological innovations to present an effective communication framework. The framework is implemented and tested using different scenarios.

Index Terms: Internet of Things (IoT), Fog Computing, Cloud Computing, Blockchains, Communication.

I. INTRODUCTION

The blockchains technology (BT) and IoT are pondered emerging approaches that can change our lives in the next generation computing. BT is much secured and authentic than other technologies. It can be optimistic to provide us high trust in the secure transactions in the heterogeneous network where everything with connecting and talks to each other [1]. Fog computing is an essential technique to compute, store and control the transaction in the integration of IoT and BT. The IoT is the ongoing research to connect the physical objects, machines and embedded devices to wireless communication and the internet. In the Statista report [2], the IoT communicated smart devices will reach more than 75 billion up to 2025. This report shows us the importance of the proposed framework. The blockchain is considered as validating and selecting a chain of blocks. Every IoT node is able to perform validation and selection criteria. The transactions fired by the IoT node are converted into blocks. The blocks are transmitted to the public network and this block will reach every IoT node but this block will be selected by the valid node and verify the hash code. The hyper ledger stores the transaction records publicly with security. Every transaction is digitally signed before transmitting to the network.

Figure 1. Statista report of connecting devices between 2015-2025 [1]

So, the transactions are much more secured that shows its authenticity and integrity of the Hyperledger. The following points can be considered for the blockchain:

i) A blockchain is a decentralized, public, distributed and secure database among IoT nodes.
ii) Each IoT node has the ability to validate the blocks.
iii) Sometimes some IoT nodes (Miners) are considered as a controller in the block chains.
iv) The peer-to-peer topology is used in blockchains.
v) The hyper ledger stores all recorded transactions. The blockchains update after recorded.
vi) BT is always on. No any IoT node off the BT.
The above are the positive points about blockchains but there are a lot of challenges such as:

i) The processing speed of the IoT device and BT
ii) Time durability
iii) Storage the big data
iv) Real-time connectivity
v) IoT device Intelligence power
vi) and so on...

The aim of this research is to introduce the new area of research where the top emerging technologies combined together and form a group for the ultimate goal of our proposal. It enhances the area of IoT and provides secure and authentic communication among physical things.
II. LITERATURE REVIEW

Fog Computing is also represented as fogging that is a term created by Cisco. The role of fogging is exploring the cloud into edge computing. Fogging is supported by the IoT network that is the main idea to develop this term. The Fogging has improved the efficiency of the framework and the quality of the services. It can support the physical things that are connected together. In 2015, Cisco represented fogging for cloud computing in the edge of the network to process the information in a more accurate way. It is used to reduce the workload of cloud computing [3]. Flavio Bonomi et. al. was presented the role of fogging and its characteristics in the internet of things [4]. Fog computing is used to minimize the information transmitted to the cloud to process, analyze and store. It is also improved the efficiency and security of the framework. In 2017, Jianbing Ni has presented an article on secure fogging for IoT. In this paper, the authors were focused on many issues related to the transaction’s security in fogging [5]. In 2017, Joy Dutta and Sarbani Roy have published an article [6] on IoT-Fog framework for smart cities. In this paper, they presented the smart building structure with the use of fog and IoT networks. In 2017, Muhtasim M., et. al. was published the thesis report [7], they have presented the security of transmitted data transactions in the internet of things network by using the blockchains technology. In the article [8], various consensus algorithms discussed and compared. They compared the algorithms such as Proof-of-Works (PoW), Proof-of-Importance (PoI), Proof-of-Capacities (PoC), and Proof-of-Weights (PoW) etc. [9].

III. PROPOSED FRAMEWORK AND RESULTS

The proposed framework has represented the use of Fog computing with IoT devices on the edge of the network using the blockchain technology to connect, transfer and exchange information among the IoT nodes. The transactions in the proposed framework are transmitted in the point-to-point network topology. In the network, there are some special IoT nodes called Miners. They are generally used to verify the transactions in the network. If the transactions are verified then it converts into the block and added in the blockchains that previously exist and relayed to the network. The miners play an important role

| Algorithms | Blockchain Platform | Year | Languages | Smart Contracts | Advantages | disadvantages |
|------------|---------------------|------|-----------|----------------|------------|---------------|
| PoW        | Bitcoin             | 2009 | C++       | No             | 1. Minimize the attacks up to 50% or less  
2. improve security | 1. More power consumption  
2. centralized Miners |
| PoI        | NEM                 | 2015 | Java, C++XEM | Yes          | 1. Vesting  
2. Transaction partnership | 1. Decentralization Issue |
| PoC        | Burstcoin           | 2014 | Java      | Yes           | 1. Cheap  
2. Efficient  
3. Distributed | 1. Favoring bigger fishes  
2. Decentralization issue |
| PoWeight   | Filecoin            | 2017 | SNARK/STARK | Yes          | 1. Scalable  
2. Customizable | 1. Issue with Incentivization |
to adjust the newly created block in the blockchain.

In this research, we have evaluated the framework using several tests. The blockchains are implemented using Hyperledger IROHA tool. The docker and docker-compose are installed on the machine. The main parameters are described in table 1 [11].

Figure 3: IoT-Fog middleware architecture using Blockchain

Icov coverage testing tool is used to evaluate the IoT device coverage in the range of the network.

TABLE 2. Main parameters for performance evaluation.

| Parameter   | Possible values | Default | Description                                                          |
|-------------|-----------------|---------|----------------------------------------------------------------------|
| COVERAGE    | ON/OFF          | OFF     | Enables or disables lcov setting for code coverage generation        |
| BENCHMARKING|                 | OFF     | Enables or disables the build of the Google Benchmarks library       |
| TESTING     |                 | ON      | Enables or disables build of the tests                               |
| SWIG_PYTHON |                 | OFF     | Enables or disables the library building and Python bindings         |
| SWIG_JAVA   |                 | OFF     | Enables or disables the library building and Java bindings           |

The Hyperledger IROHA tool is included many facilities such as distributed Hyperledger, Proof of Work (PoW) algorithms, P2P network, etc., Sumeragi in Hyperledger IROHA algorithm is implemented to run blockchains. The Android and iOS packages in IROHA provide the facility to interact the IoT nodes to the blockchain. According to the Sumeragi algorithm, the IoT nodes request the transaction, and follow the following steps:

Step 1. Broadcasting: the leaders verify, orders and sign the transaction and transmit to the network.

Step 2: Verification and signing: It verifies, orders and sign the transaction and broadcasting to the authorized IoT node of the peer to peer network.

Step 3: Committed: Commit after signing.

In case of server failure, the algorithm adds one another step called error control. For controlling the errors, the algorithm works with the additional server to control the errors.

Figure 4: Sumeragi in Hyperledger IROHA algorithm [12]

We have evaluated the performance of 10, 50 and 100 IoT nodes using the different parameters in the proposed framework.

Figure 5: Sumeragi in Hyperledger IROHA algorithm with error control
TABLE 3: Performance of 10 IoT-nodes against searching, Examine and Selecting

| IoT-Node | Searching | Examine | Selecting |
|----------|-----------|---------|-----------|
| ON       | 0.11      | 0.01    | 0.01      |
| OFF      | 0.22      | 0.01    | 0.01      |

TABLE 4: Performance of 50 IoT-nodes against searching, Examine and Selecting

| IoT-Node | Searching | Examine | Selecting |
|----------|-----------|---------|-----------|
| ON       | 0.12      | 0.01    | 0.02      |
| OFF      | 0.23      | 0.02    | 0.02      |

TABLE 5: Performance of 100 IoT-nodes against searching, Examine and Selecting

| IoT-Node | Searching | Examine | Selecting |
|----------|-----------|---------|-----------|
| ON       | 1.81      | 0.53    | 0.24      |
| OFF      | 2.25      | 0.81    | 0.25      |

Figure 6: Performance of 10 IoT-nodes

Figure 7: Performance of 50 IoT-nodes
The proposed framework acted as a combination of the IoT and fogging. BT is used to create a hyper-distributed public authentic ledger to record the transactions. The research opened a new opportunity in this area. The framework is implemented using a different set of IoT nodes and tested. The results are found positive.

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