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Blockchain as a Service for IoT

Cloud versus Fog

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***Abstract*—A blockchain is a distributed and decentralized ledger that contains connected blocks of transactions. Unlike other ledger approaches, blockchain guarantees tamper proof storage of approved transactions. Due to its distributed and decentralized organization, blockchain is beeing used within IoT e.g. to manage device configuration, store sensor data and enable micro-payments. A key challenge in the deployment of blockchain technology is the hosting location. This paper evaluates the use of cloud and fog as hosting platforms.**

Keywords—IoT, Virtual Resource, Software-Defined IoT, Edge Computing, Multi-Tenancy

I. BLOCKCHAIN AND IOT

A blockchain [1,2] is decentralized ledger that contains connected blocks of transactions. The fundamental concept behind the blockchain is that of tamper-proof storage of approved transactions.

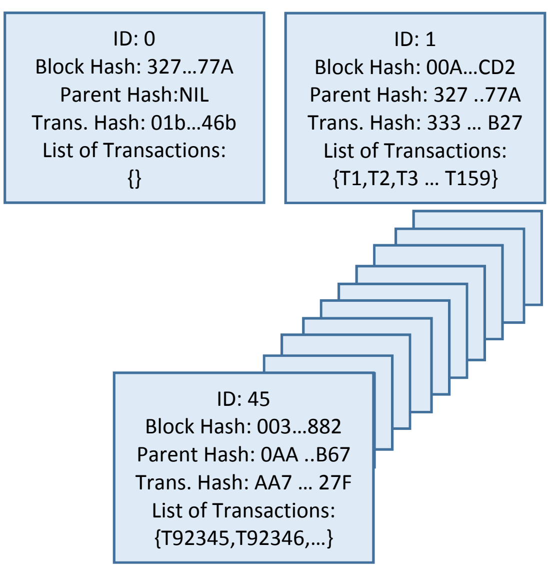

Figure 1. Sample Blockchain.

As shown in figure 1, valid/verified transaction are stored in the form of a block (lists of transactions) that is linked to the previous one. A blockchain starts with an initial or genesis block. Upon creation of a new block it the hash value of the preceding block is entered. Once a new block is formed, any changes to a previous block would result in different hashcode and would thus be immediately visible to all participants in the blockchain. Consequently, blockchains are considered tamperproof distributed transaction ledgers. Originally designed as the distributed transaction ledger for BitCoin [3], the idea of using blockchains has spread.

The ability to create/store/transfer digital assets in a distributed, decentralized and tamper-proof way is of a large practical value for IoT systems. While micro-payments in IoT may be the most obvious use of blockchain technology, we consider the storage/sharing of data & code the most useful at the current state of IoT deployments. IBM's ADEPT system [4] that is built on Bluemix is an excellent example of early blockchain use within IoT. ADEPT showcases scalable storage of IoT configuration data and provides a platform for micro-payments.

II. BLOCKCHAIN AS A SERVICE: CLOUD VERSUS FOG

While there is growing consensus on the potential of linking blockchain technology to IoT, a key question remains open:

- Where should the blockchain be hosted?

Hosting the blockchain directly on resource-constrained IoT devices is unadvisable due to the following three reasons:

- lack of computational resources
- lack of sufficient bandwidth
- need to preserve power

However, the fog and the cloud are two equally suited hosting platforms for a blockchain as a service. Cloud and fog are mirror images of each other regarding computational resources and latency. While the fog has limited resources, it exhibits low latency. On the other hand, cloud hosted applications can scale out and thus overcome resource constraints at the price of significant latency issues.

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III. EVALUATION

To evaluate the use of fog (local cluster) and cloud computing, a simple experiment was conducted. As IoT devices, we use Intel Edison Arduino boards. As shown below (figure 2), these boards consist of an Uno R3 compatible Edison breakout board and an Intel Edison module. The Edison module is a System on a Chip (SoC) comprising a 500 MHz dual-core, dual threaded Intel Atom and a 100 MHz 32-bit Intel Quark microcontroller.

Figure 2: Edge Device

The Edison board is connected via a dedicated wifi hotspot with three standard workstations that host python servers that interact each with a multichain node.

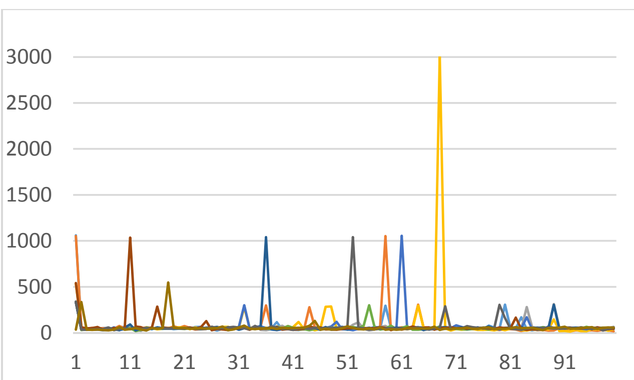

Figure 3: 0 milliseconds delay

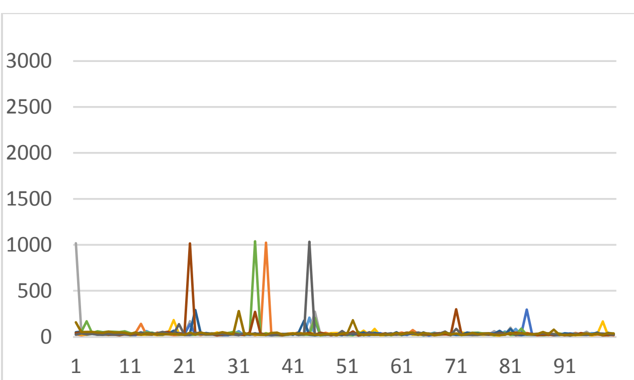

Figure 4: 50 milliseconds delay

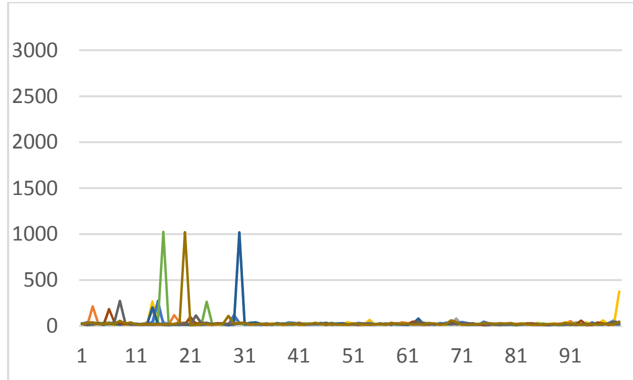

Figure 5: 100 milliseconds delay

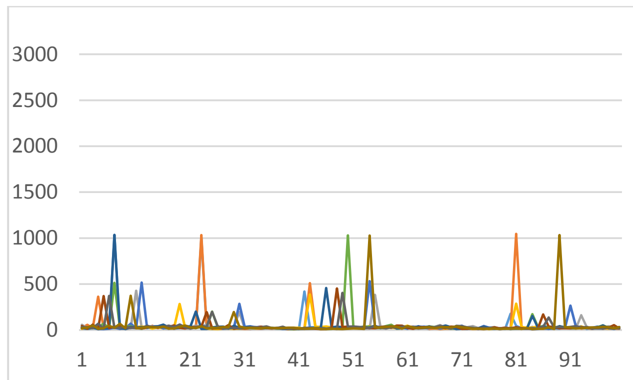

Figure 6: 150 milliseconds delay

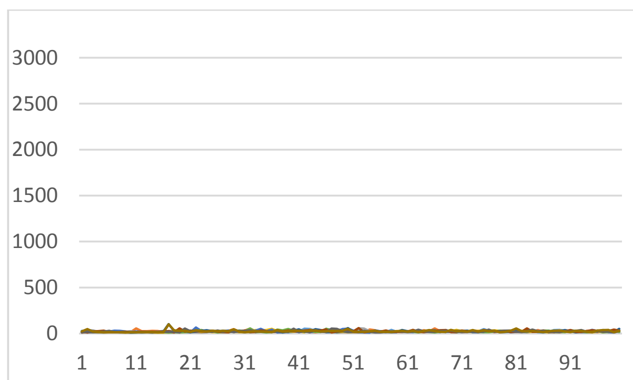

Figure 7: 200 milliseconds delay

In the experiments, an Edison board executes ten concurrent clients that perform writes (720 bytes) to the multichain (via python server). In the runs shown we vary the arrival rate of the write requests by adding a delay. 0, 50,100, 150,200, 250 and 300 milliseconds are used.

Please also see Samaniego et al. [5,6,7] for more experiments and evaluations.

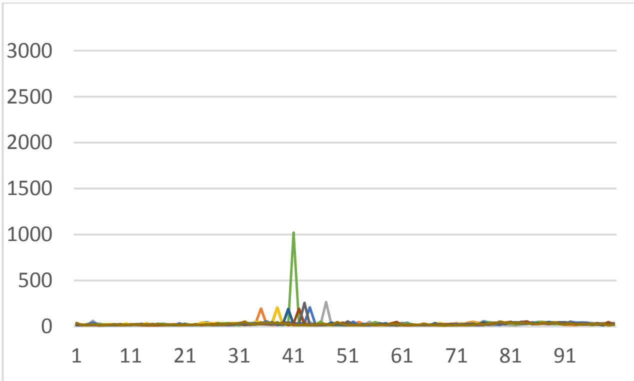

Figure 8: 250 milliseconds delay

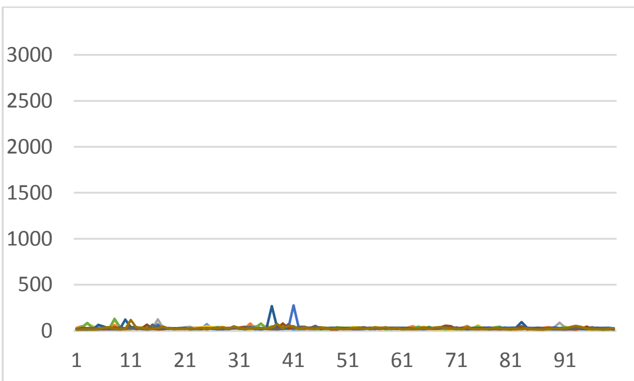

Figure 9: 300 milliseconds delay

Figure 3 shows that having ten clients writing without delay to the multichain leads to a few spikes. This is expected since the network component of the Edison is pushed to its maximum. Adding a modest delay of 50 milliseconds reduces the network traffic and consequently fewer and smaller spikes emerge. Increasing the delays leads to an expected decline as can be seen at 200 milliseconds. We can conclude that the local private multichain is not a bottleneck and that it is primarily the network card and traffic on the Edison chip that determines the performance.

Having established the basic behavior of writing to a private blockchain hosted close to the edge devices the impact of cloud latency needs to be evaluated. The next set of experiments focusses on the use of IBM's Bluemix blockchain.

Please also see Samaniego et al. [5,6] for more experiments and evaluations.

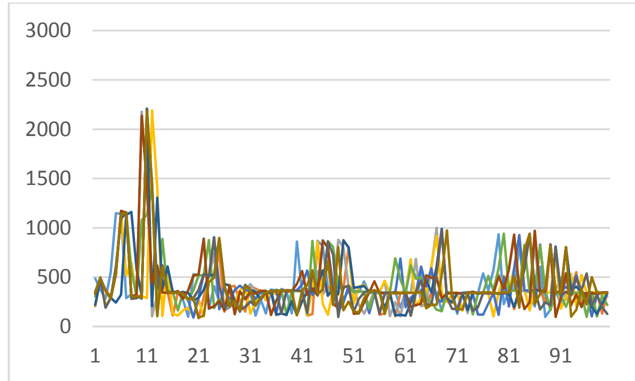

Figure 10: 0 milliseconds delay

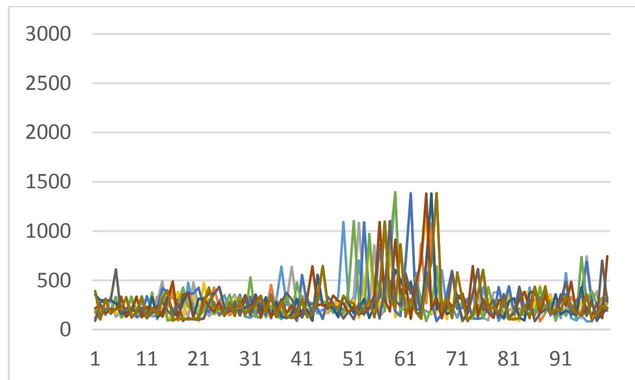

Figure 11: 50 milliseconds delay

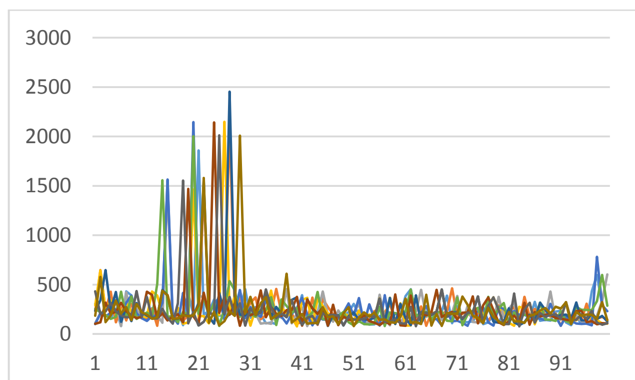

Figure 12: 100 milliseconds delay

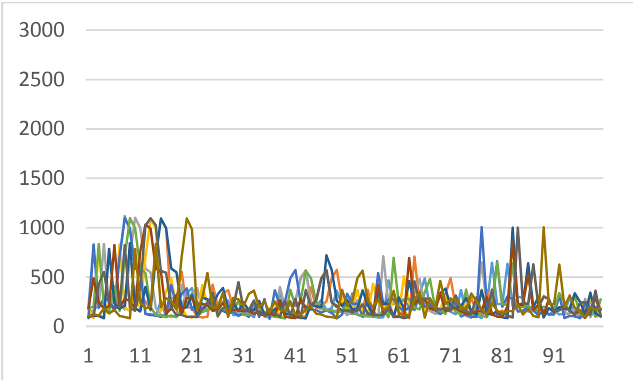

Figure 13: 150 milliseconds delay

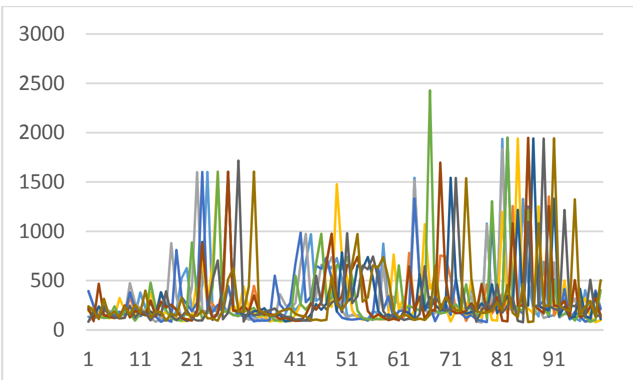

Figure 14: 200 milliseconds delay

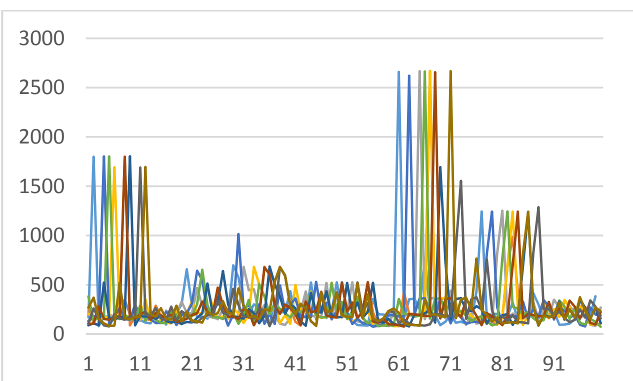

Figure 15: 250 milliseconds delay

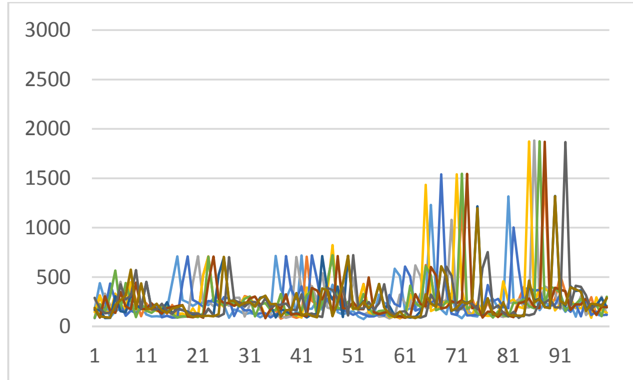

Figure 16: 300 milliseconds delay

Figures 10 – 16 show that the decreased arrival rate does not necessarily lead to better response times. We suspect that the network latency introduced by interacting with cloud services explains this behavior best. We would also like to point out that in some of the experimental runs (not shown here) we observed service failures and dropped messages. This indicates that the current Bluemix blockchain may not be the best choice for IoT blockchain technology.

IV. Summary & Future Work

A blockchain is a decentralized ledger that contains connected blocks of transactions. The ability to create/store/transfer digital assets in a distributed, decentralized and tamper-proof way is of great practical value for IoT systems. A key challenge in the deployment of Blockchain as a Service (BassS) for IoT is the hosting environment. Edge devices are often too constrained regarding computational resources and available bandwidth leading to cloud or fog as potential hosts. This paper evaluates the use of the fog and the cloud as possible platforms. The performance analysis clearly indicates that the network latency is the dominant factor. Consequently, the fog outperforms the cloud.

References

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