Work-in-Progress: Integrating Low-Power IoT devices to a Blockchain-Based Infrastructure

Kazım Rıfat Özyılmaz
Bogazici University
Bebek
İstanbul 34342, Turkey
kazim@monolytic.com

Arda Yurdakul
Bogazici University
Bebek
İstanbul 34342, Turkey
yurdakul@boun.edu.tr

ABSTRACT

The ever-increasing number of IoT devices necessitates a secure and scalable infrastructure to store and process generated data. Blockchain is an ideal choice with its decentralized, trustless architecture. However, low-power IoT end-devices do not possess enough horsepower to run a software client for intensive blockchain calculations. The purpose of this paper is to create a proof of concept to enable low-power, resource-constrained IoT end-devices accessing a blockchain-based infrastructure. To achieve this aim, an IoT gateway is configured as a blockchain node and an event-based messaging mechanism for low-power IoT end-devices is proposed. A demonstration of such a system is realized using LoRa nodes and gateway in a private Ethereum network.

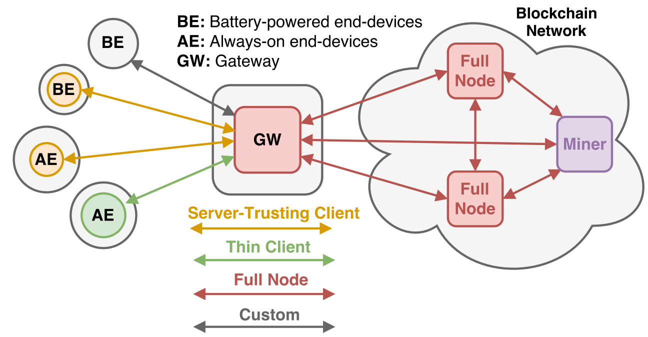

Figure 1: Blockchain Integration Methods

CCS CONCEPTS

• **Security and privacy → Distributed systems security**; • **Computer systems organization → Embedded systems**; *Dependable and fault-tolerant systems and networks*;

KEYWORDS

IoT, Blockchain, LPWAN, LoRa, Ethereum, trustless, decentralized

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1 INTRODUCTION

According to Gartner Research, the total number of connected Internet-of-Things (IoT) devices will reach twenty billion by 2020 [7]. Ericsson predicts that low-power wide-area (LPWA) technologies like LoRa and cellular-based NarrowBand IoT (NB-IoT) will be the great enablers for mass deployment of low-power end-devices [5]. The current paradigm of short-range (NFC, Bluetooth), mesh-topology communication, which limits the coverage area of IoT devices is challenged by the low-rate, long-range communication paradigm with star topology [17]. This shift in wireless communication technology may bring the possibility of implementing software solutions on IoT gateways.

IBM is emphasizing that blockchain technology will make a great impact on IoT [15] and there are ongoing efforts to create various products and services that integrate both worlds. Examples may include an on-demand manufacturing platform [1], an API-based service (IOTA) [10], an IoT security solution [12], or even a physical product called *smart locks* [16]. Our approach in this paper is creating a proof-of-concept implementation for an LPWAN-based IoT deployment to blockchain infrastructure. We also propose methods of integration for various types of end-devices. Our software solution at the gateways makes use of blockchain functionality to (a) facilitate a decentralized IoT platform, (b) standardize the way to handle data transfer between the end-devices and the IoT infrastructure, (c) connect any type of IoT end-device to a blockchain-based IoT platform.

In order to achieve these goals, we have investigated how a peer-to-peer network may be used to store both data [8] and code fragments and interact with each other by means of a unified interface. As a proof-of-concept, an event based communication mechanism between LoRa gateways and backend servers on a private Ethereum blockchain is implemented.

2 BLOCKCHAIN AND IOT INTEGRATION

Blockchain is a distributed database deployed in a peer-to-peer network where *nodes* in the system create and broadcast *transactions* continuously [13]. Predictably, blockchain consists of *blocks*, which are cryptographically linked and time-stamped collections of transactions. Blocks are constantly verified by nodes in the system to stand against malicious attackers. Integrating IoT end-devices and

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gateways to a blockchain-based IoT infrastructure can be accomplished in following ways:

Gateway as a full blockchain node End-devices communicate with the gateway where gateway operates as a full blockchain node i.e. routing data and verifying integrity.

Gateway as a thin client End-devices communicate with the gateway where gateway operates as a thin client by storing only relevant data fragments using protocols like SPV [3] or Light Client [6].

End-devices as regular sensors Battery-powered end-devices may be so weak that no blockchain client is integrated, IoT gateway will push transmitted data to blockchain infrastructure.

End-devices as server-trusting client A simple form of blockchain client utilizing an interface like BCCAPI [2] may be integrated to battery powered end-devices.

End-devices as thin client If end-devices are not battery-powered and always-on, they can operate as a thin client.

3 PROOF OF CONCEPT

LPWAN technology opens up a broad spectrum of possibilities for tracking people or devices in urban areas with kilometers of wide coverage. In this proof-of-concept implementation, a battery-powered IoT end-device sends position data to a LoRa gateway [17]. The LoRa gateway then routes this data stream through the official Go-lang-based Ethereum client *Geth* to a private Ethereum blockchain using a smart contract [14]. A LoRa end-device is built using a Raspberry Pi 2 connected to a Dragino LoRa/GPS Hat [4] and a LoRa gateway is built using a Raspberry Pi 3 connected to a LoRa concentrator board named iC880A from IMST [9].

In order to implement such a two-way LoRaWAN-Ethereum proxy, gateway should run both LoRa protocol software to communicate with end-devices and an Ethereum client to route data to the blockchain network. LoRa protocol software consists of a concentrator card driver and a network daemon to forward data packets to application servers [11]. Additionally, a private Ethereum network is created using an initial genesis block with an easy mining setting for faster response times, i.e, shorter mining times.

To enable gateway interaction with the blockchain, a smart contract should be deployed. After being compiled into a virtual machine bytecode, smart contracts are sent just like any other transaction, further to be mined by miners. When a smart contract is mined, i.e., deployed in blockchain, its address and application binary interface (ABI) are used to interact with it. Finally, a "smart proxy" is developed in order to capture all data from LoRa packet forwarder and feed it directly to Geth by means of its JSON-RPC interface and invoke the smart contract.

Our smart contract "Bridge" contains two events (*Process* and *Notify*) and two functions (*request()* and *activate()*) in addition to its constructor and destructor methods [14]. Whenever the gateway receives data, the blockchain client calls the *query()* method of the smart contract with the received data as an argument. A transaction that contains this action is sent, and after it's mined, it becomes a part of the blockchain. Peers listening to *Notify* event immediately get a callback from the blockchain client, which in turn may be used to take the necessary action. Similarly, other peers may send messages to gateways to remotely activate end-devices by using the *activate()* function with a data string as an argument. Gateways will always be listening to any *Process* event and only the addressed gateway takes an action to the received message (Figure 2).

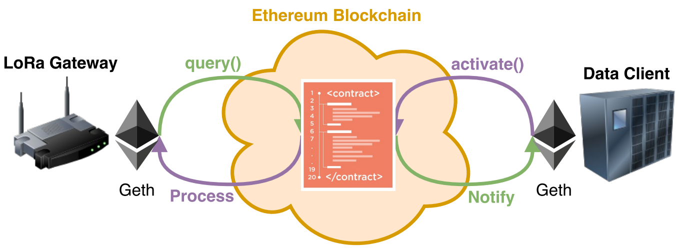

Figure 2: Smart Contract Execution in IoT Integration

In this proof-of-concept, a standard LoRa gateway is coupled with an Ethereum client. Using a smart contract, an event-based communication mechanism is built. Ethereum smart contract and LoRa proxy code used for this proof-of-concept can be found on the 'Blocky' [14] project page.

4 CONCLUSION

Once blockchain-based systems are widely used, application development and data processing can be massively conducted by using smart contracts as demonstrated with our proof-of-concept 'Blocky' [14]. Currently we are working on to show that, independent of their computing and storage capabilities, it is possible to integrate a blockchain client to any IoT device.

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