LoRaCoin: Towards a blockchain-based platform for managing LoRa devices

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***Abstract*—We propose LoRaCoin, a decentralized blockchain-based service to manage the generation and storage of sensor data generated by IoT devices. A novel feature of LoRaCoin is that it rewards both IoT devices that generate data and gateways that offer the Internet connectivity to the sensor nodes. With such double rewards, LoRaCoin aims to incentivize individuals to host sensor nodes and gateways and contribute to the growing need of the society for environmental monitoring applications.**

***Index Terms*—LoRa, Blockchain, Web3.**

I. Introduction

LoRa is a wireless communication technology used in the IoT to establish long range communication links of several km between the sensor nodes and gatways [1]. Most LoRa IoT applications use the LoRaWAN architecture [2].

Environmental monitoring is a kind of IoT application that helps to know about the environmental impact of cities, industries and societies. Such applications are important for the growing need to assess climate change and to attest environmentally sustainable operations. With sensors having become cheaper and techniques becoming available for affordable calibration of sensors [3], the path is open for a large number of individuals to contribute in the provision of sensing hardware and environmental data.

A prominent example of a large worldwide LoRaWAN deployment is The Things Network (TTN) [4]. While anybody can register her sensor nodes and gateway at *The Things Stack Community Edition*, the focus is to build personal IoT applications which leverage the centralized backend sevices managed by *The Things Industries*. More recently, Helium [5] has appeared to provide *people-powered* LoRaWAN networks. Helium is designed as a decentralized solution based on the Helium blockchain which rewards the provision of hotspots with HNT tokens. For users with specific applications, the wireless infrastructure offered by Helium may be a cheap alternative to using 5G, making it worth for them to reward gateway owners. Data provision, however, is not considered an asset valuable to be rewarded.

In this paper we introduce a new concept to give value both to infrastructure provision *and* data provision. Specifically, we propose to incentivize the provision of data by LoRa sensor nodes and the provision gateways. We suggest a blockchain-based architecture, which without centralized management is able to track the users' contributions, both of LoRa gateway provision and of data from sensor nodes. We implement a proof-of-concept prototype to show the feasibility for building the proposed system applying current technologies.

II. Architecture

The LoRaCoin architecture has five layers (Fig. 1).

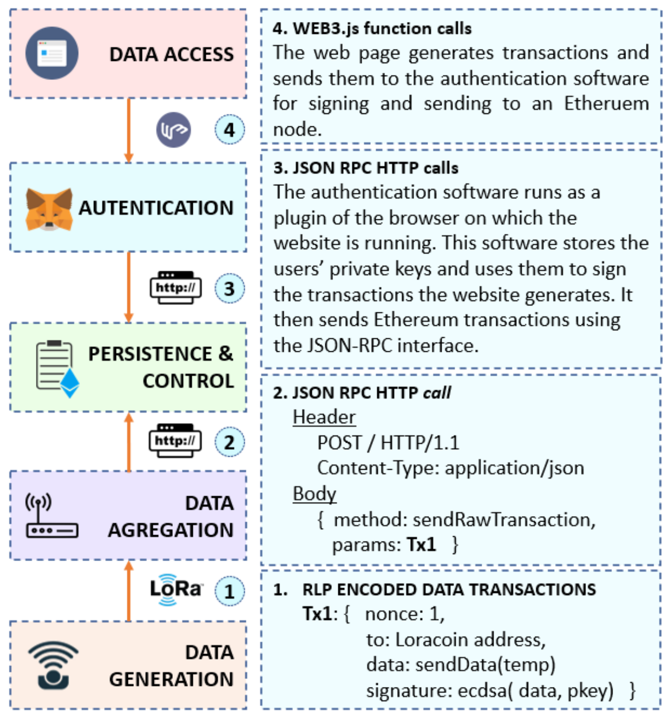

Figure 1. LoRaCoin architecture.

At the data generation layer are the LoRa sensor nodes. They capture information from the environment and have a LoRa radio communication interface. Each node has a pair of public and private keys that are used to generate transactions. For sending sensor node information, a node builds a transaction, signs it by its private key and encodes the data using the RLP serialization algorithm. It then sends the data packet through the LoRa interface to be received by the gateways in its coverage area.

The aggregation layer is formed by devices called gateways. These have the function of collecting all the messages generated by the sensor nodes and sending the information to the Internet. They have two communication interfaces:

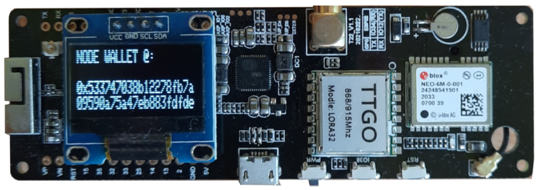

Figure 2. LoRa device: T-Beam board with LoRa radio.

a Lora radio and an Internet connection. When a gateway receives a transaction sent by a node, it builds an HTTP query to be sent to an Ethereum client.The request invokes the *sendRawTransaction* function with the transaction generated by the sensor node.

The data access and authentication layers are for the interaction with the LoRaCoin smart contract. The access layer is a web page that uses the web3.js library to generate transactions. A wallet software is represented by Metamask, which is responsible for managing the private keys, signing the requests and sending them to Ethereum.

The control and persistence layer corresponds to the backend of the information system and is transparent to the end user. This layer is in charge of managing and storing the information (IoT infrastructure and sensor data) in a decentralized way.

III. IMPLEMENTATION

We have built a prototype of LoRaCoin[1] integrating the blockchain technology provided by the Ethereum platform. For write transactions we use the JSON-RPC communication interface of the *Ethereum CLI*. We use Ethereum's asymmetric cryptographic algorithm called ECDSA which creates private and public key pairs, where the private key is used to sign a generated transaction and with the public key the authenticity of a signature is verified.

LoRaCoin leverages Ethereum's capacity to program smart contracts, i.e. code snippets programmed in Solidity that are stored on the blockchain and can be executed from outside the network using the *sendRawTransaction* call of the JSON-RPC. We apply a concept called tokens. Tokens can represent any virtual item within Ethereum. The use the ERC-20 standard, which defines an interface for creating smart contracts that manage fungible tokens [6].

Combining these concepts, LoRaCoin implements a smart contract that uses ERC20 functionalities to create an incentive system. Thus, when a gateway invokes the *sendData* function of the smart contract, it rewards LoRaCoin tokens to both the gateway address and the address of the node that generated the transaction.

Fig 2 shows a LoRa sensor node which we used for the functional validation of the implementation. It is the TTGO T-Beam board with an ESP32 microcontroller and the SX1276 LoRa transceiver chip. It can be seen that the LoRa device displays in its OLED screen the address generated using the ECDSA algorithm so it is accessible to the users.

[1]https://gitlab.fib.upc.edu/eloi.cruz/loracoin

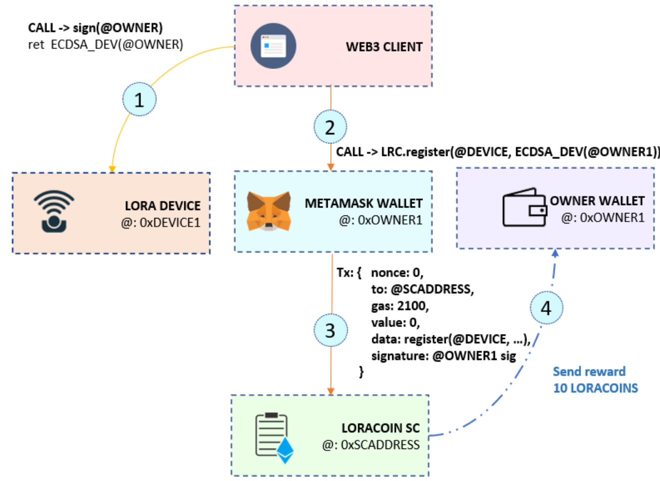

Figure 3. Sensor node registration steps.

Figure 3 describes the sequence of steps undertaken for the case of registering a device. This case shows the reward given to a gateway provider. Another important use cases (not shown here) is the reward given for data provision. In that case, in the final step, the smart contract sends the reward to the Etherum address corresponding to the owner of the sensor node.

IV. CONCLUDING REMARKS AND OUTLOOK

This paper introduced the idea to create a reward system based on blockchain for both data and infrastructure providers and thus incentize the contribution to publicly built IoT applications such as for environmental monitoring.

In order for LoRaCoin to be economically viable, the obtained sensor data must be converted, for instance by applying data analytics or prediction with machine learning, into a valuable asset for stakeholders (e.g. municipality, industry, society), in order to make it worth funding the rewards to both the data and infrastructure contributors.

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