WHITE PAPER

IoT and Blockchain

Securing data pertaining to IoT devices is becoming important. With traditional client-server architectures being vulnerable to cyber-attacks, Blockchain distributed ledger technology can be used to store records of transactions between devices in a secure manner. By providing the ability to verify the origin of a physical device, Blockchain can curtail fraud and enable the customer to enter into genuine transactions.

Blockchain platforms are either private or public or private. Ethereum™ is a popular public Blockchain platform with tools that can be used to build Blockchain applications for IoT.

THINXTREAM®

Introduction

As IoT deployments increase across industries worldwide, securing data pertaining to IoT devices is becoming important. Traditional client-server architectures are vulnerable to cyber-attacks due to their single point of security intelligence on the server. A decentralized and distributed alternative provides a verifiable, secure and permanent method of recording data generated by these smart devices. Businesses that relied on expensive, complex data security systems can now rely on open source and vendor-neutral technologies like Blockchain.

Blockchain is a distributed ledger technology that secures the transaction between two end-users without the need for intermediaries. While it has been used extensively to store cryptocurrency transactions, it can also be used to store records of transactions (financial and non-financial) between devices in a secure manner.

In this white paper, we examine the challenges faced by IoT industry concerning data security, how it can be solved with Blockchain and some use-cases of Blockchain in IoT.

IoT Security Challenges

In 2016, distributed denial of service (DDoS) attacks on as many as 100,000 IoT devices exposed the inadequacy of IoT security. Distributed client-server designs that use a central authority to manage IoT devices, along with all the data generated across an IoT network offered a single point of security failure. Architectural limitations prevented IoT devices from making security decisions without the support of the central authority, leading to a single point of decision-making that is prone to security failure. This calls for a distributed and decentralized security architecture that is resilient to failure.

While traditionally transactions have been maintained and validated with the help of intermediaries, this is an expensive proposition for the massive scale of operations in IoT. This calls for a scalable technology solution which can algorithmically validate the transaction and automatically determine fraudulent sources at zero or minimal fees.

When data is held by a single business entity there are chances that it can be manipulated and falsified. It is quite important to maintain the integrity of the data so that any modifications of original data can be algorithmically and independently derived, agnostic to who owns the data.

As IoT deployments involve devices and software from multiple vendors, it is often impractical to agree on a single solution or a vendor for implementing security. Such implementations will lead to silos, replication and maintenance chaos. This calls for a standardized, vendor-neutral, democratized (no single owner) approach that can be easily integrated into these devices and software.

Last but not the least, to reap the benefit of a truly connected and self-reliant IoT system, we need to empower devices/applications to execute commercial transactions on behalf of humans. The system should handle responsibility issues when devices/applications take actions based on an operation that is automatically executed by a chain of linked applications from different vendors.

Blockchain Benefits

Blockchain is a decentralized design that creates a secure, democratized platform independent of all involved entities. Blockchain removes the single point of decision-making and hence a single point of security failure by enabling networks to protect themselves by allowing participating nodes to form group consensus about what is normal and abnormal, and quarantining any nodes that behave unusually.

Use of encryption and distributed storage would mean data can be trusted by concerned entities. Machines will autonomously and securely record details of transactions that take place between devices, with no human intervention. These records will be immutable once recorded.

Data here is automatically replicated in many nodes and access to it can be controlled. It can be publicly accessible as well as it can be a private permission-based Blockchain. All data stored here is signed and each device is accountable for its actions.

There is no single entity holding the records as data is replicated in multiple nodes owned by multiple entities. No one entity can modify or delete the data. All participating nodes have an

identity secured by a public key. This ensures protected communication and builds trust in the overall network.

Most of the data associated with IoT is personal and this has to be shared with external applications to derive value from it. This, unfortunately, increases opportunities for hackers to attack. Blockchains provide an additional level of security as they are built on top of robust encryption standards available today.

In the IoT environment, we need to empower devices to make transactions on behalf of humans. Blockchains allow the creation of agreements called 'smart contracts' which get executed when specific conditions in the contract are triggered. These conditions could indicate delivery of a service and on the execution of a contract, one system could make a payment to the other securely without any human intervention.

Blockchain Programming

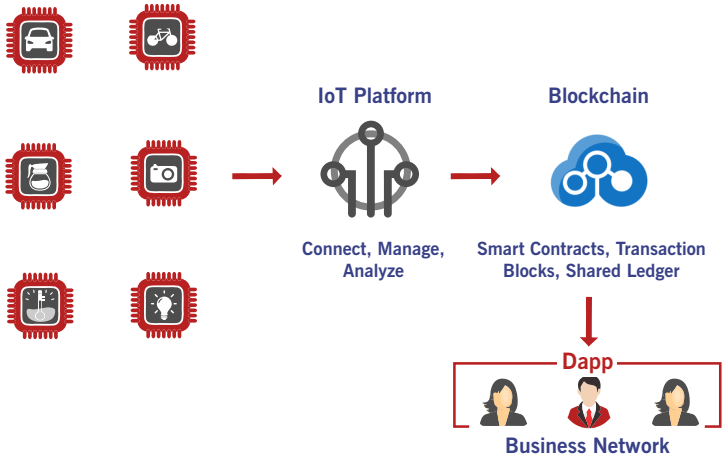

Figure 1. Decentralized Blockchain based IoT Application

Programming Terminologies

- Dapp™ is a decentralized application that runs on a decentralized peer-to-peer network owned by multiple entities in a trustless protocol setup. It is not controlled by any single entity on the network. BitTorrent®, Popcorn Time, Bitmessage, Tor®, are all decentralized applications that run on a peer-to-peer network, but not on a Blockchain. A smart contract connects decentralized apps to Blockchain. Traditional Web apps and decentralized Blockchain apps differ as below when it comes to software development:
  - Traditional Web apps: Front End → API → Database
  - Dapp enabled Web apps: Front End → Smart Contract → Blockchain

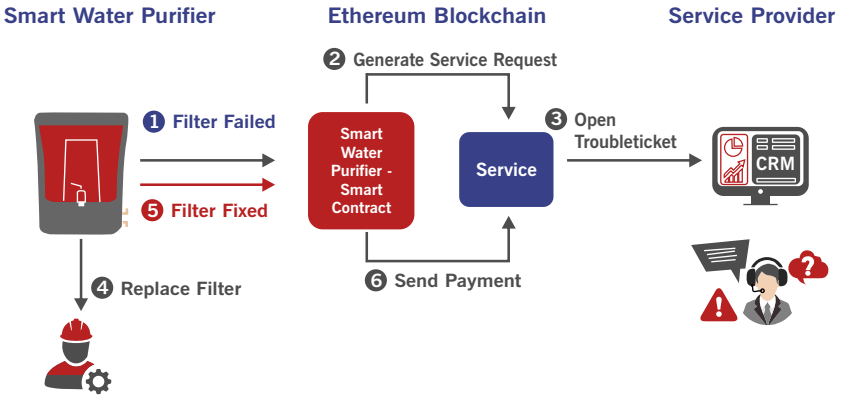

Figure 2. Smart Contract and Field Service

- Smart Contract is a software program on the distributed ledger, allowing an immutable, verifiable and secure record of all contracts and transactions. The typical lifecycle of a Smart Contract includes:

  - It records the terms of a contract between two direct entities on a Blockchain shared between all participants and validated by validators. Regulators and auditors keep a tab on the system through read-only access to Blockchain.
  - It connects with the external world to collect trigger points e.g., account balance, stock prices, etc.
  - It waits for external triggers to evaluate pre-defined conditions. When the conditions are met, this contract self-executes. Transactions are recorded on Blockchain.
  - It provides data for compliance and reporting when needed.

Platforms & Development Tools

Blockchain platforms are either private or public or private.

Private platforms are for limited and defined number of users. They are more useful in industrial and niche sectors where a limited number of entities take part.

In public platforms, all users and applications share the entire ledger. There are currently three main public Blockchain platforms: Bitcoin, Hyperledger™ and Ethereum. Most applications are built on these.

We will restrict our discussion here to only Ethereum.

Ethereum provides developers with a foundation, which allows them to write a smart contract and decentralized applications. This enables developers to create their own arbitrary rules for ownership, transaction formats, and state transition functions. Smart Contracts are written in

either Solidity™, Serpent™, or LLL. The Ethereum development ecosystem typically comprises the following tools and technologies:

- A virtual machine that stores Blockchains and executes Smart Contracts.
- A Web-based IDE 'Remix' aimed at Solidity. This allows developers to check out code from GitHub and Swarm, compile, deploy and run Smart Contracts on customized environments like a JVM or Web3.JS.
- A test network/node like the popular Ganache™ CLI that offers a personal Blockchain on which developers can deploy Smart Contracts, develop applications, and run tests. (A test network/node is required as Blockchain is immutable by design and every Smart Contract update has to be deployed as a new instance.) Ganache is available for Windows®, Mac®, and Linux® flavors as both, a desktop application as well as a command-line tool. Using Ganache you can see the status of accounts, debug using logs and configure mining.
- A CLI based Ethereum development tool such as Truffle. It enables smart contract compilation, linking, automated contract testing, deployment, and binary management.
- As the code in Blockchain deals with money, analyzing code for security and storage is of paramount importance. Solium™ is a solidity code linter that works like an interpreter, continuously checking code for style and security issues.

- Browsers enable users to see a state of accounts, receipts, and transactions. Mist™ is one of the popular browsers and offers to create wallets, and deploy smart contracts, ability to send and receive transactions, and store ether. Metamask™ is another tool which turns Google Chrome™ into an Ethereum browser. It allows to fetch data from the Blockchain and enables users to securely send or receive signed transactions.
- In a recent advancement, as enterprises look to deploy the Blockchain technology, popular cloud platform vendors have launched Blockchain as a Service (BaaS) offerings that allow customers to leverage cloud-based solutions to build, host and use their own Blockchain apps, smart contracts, and functions on the Blockchain.

Blockchain in IoT

By providing the ability to verify the origin of a physical device, Blockchain can curtail fraud and enable the customer to enter into genuine transactions.

In the healthcare industry, tags on packaging and Blockchain can assure the viability of medical supplies along the entire supply chain as well as identify potential fraud and manipulation. Similarly, personal fitness and diagnostic data collected from wearables can be securely logged in Blockchains.

In the food industry, where products are sensitive to environmental factors like temperature, containers could carry thermometers whose values could be recorded in Blockchains at key locations. This can ensure that the maximum temperature is not breached on the way from producer to consumer.

In the case of the automotive and airline industry, Blockchains could be used to securely log performance and maintenance data. This data can be used for predictive maintenance and product improvements.

Insurance companies can use the data logged by sensors in cars in Blockchains before accidents to ensure fraud-free processing of claims by customers.

In 'chain of custody' applications such as logistics, where shipments move from one entity to another such as shipper to customs, Blockchains can quickly and accurately track a product.

Using smart contracts, smart devices could autonomously execute transactions with no human oversight. A vending machine could solicit bids from distributors and pay for the delivery of new items automatically. Smart appliances and vehicles could diagnose, schedule and pay for their maintenance. Home appliances could optimize their operations by syncing with lower grid prices and reducing the cost of electricity to consumers.

Conclusion

Blockchains are creating a revolution in the digital economy through cryptocurrency. With the increasing adoption of IoT, there is a challenge in securing collected user data and Blockchain is proving to be a good fit. The robustness of Blockchain results in applications like Smart Contracts wherein transactions are automatically carried out by devices when a specific condition is met with no human intervention. This enables innovative non-financial applications like tracking the origin of a good to prevent counterfeiting, recording environment factors of a perishable commodity from producer to consumer to ensure quality, chain of custody applications, feeding data for predictive maintenance, etc. Blockchains help in trust building, cost reduction, accelerated data exchanges and increased security. Popular Blockchain platforms like Ethereum, Hyperledger, BaaS provide the test and development infrastructure and tools to build Blockchain solutions.

As an IoT services provider, Thinxtream has the expertise to assess, architect and implement Blockchain use cases for IoT. We can help implement Blockchain applications for your current offerings and build decentralized apps on top of IoT platforms using available libraries, managed services and tools from Blockchain technology providers. By leveraging the IoT expertise built over a decade, Thinxtream ensures cost-effective, quality and timely delivery of IoT solutions.

References

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Thinxtream Technologies is a global software company with a portfolio of innovative software platforms, products, components, solutions, patents, competences and services for Internet of Things (IoT) across several industry verticals and applications, successfully enabling leading customers, including Fortune 500 companies, meet their application, product and business goals.

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