Blockchain-based Traceability in Agri-Food Supply Chain Management: A practical Implementation

Miguel Pincheira Caro , Muhammand Salek Ali,
Massimo Vecchio and Raffaele Giaffreda

Agenda

- What is a Blockchain?
- How does it work?
- Benefits of Blockchains to the Internet of Things
- Use case: from-farm-to-fork
- The proposed architecture
- Implementations
- Performance analysis
- Conclusions

What is a Blockchain?

What is a Blockchain?

- the technology behind the Bitcoin cryptocurrency.

What is a Blockchain?

- the technology behind the Bitcoin cryptocurrency.
- immutable, time-stamped “chain of blocks”.

What is a Blockchain?

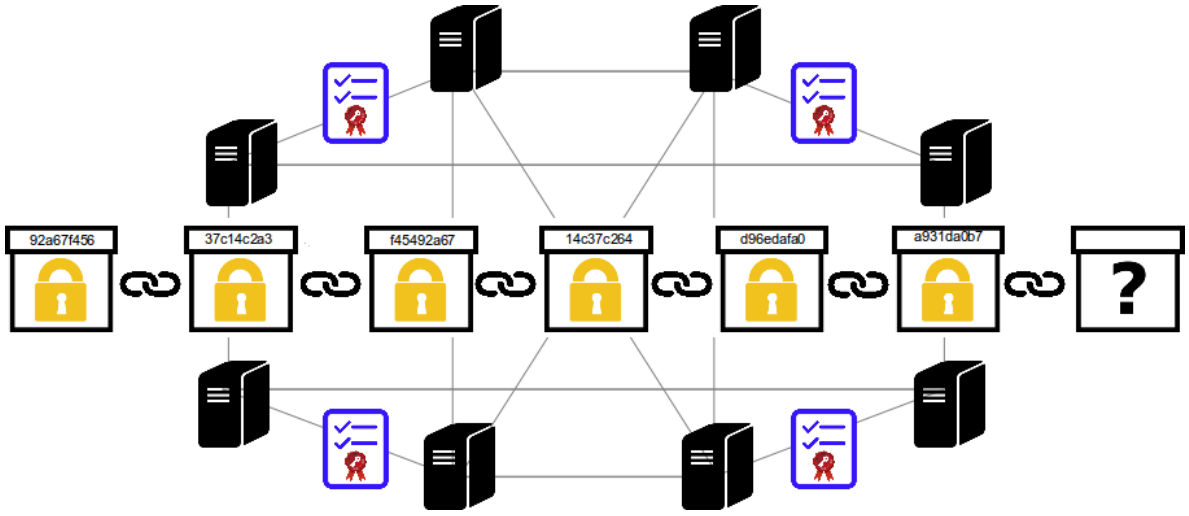
- the technology behind the Bitcoin cryptocurrency.
- immutable, time-stamped “chain of blocks”.
- smart contracts provide scripting capabilities.

What is a Blockchain?

- the technology behind the Bitcoin cryptocurrency.
- immutable, time-stamped “chain of blocks”.
- smart contracts provide scripting capabilities.
- several implementations and variations are available.

What is a Blockchain?

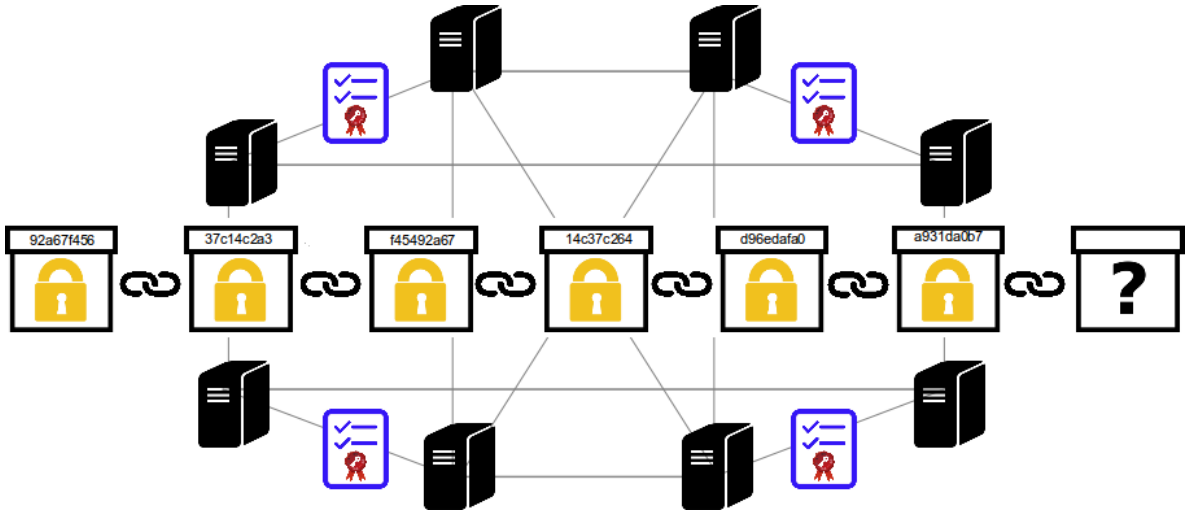
- the technology behind the Bitcoin cryptocurrency.
- immutable, time-stamped “chain of blocks”.
- smart contracts provide scripting capabilities.
- several implementations and variations are available.



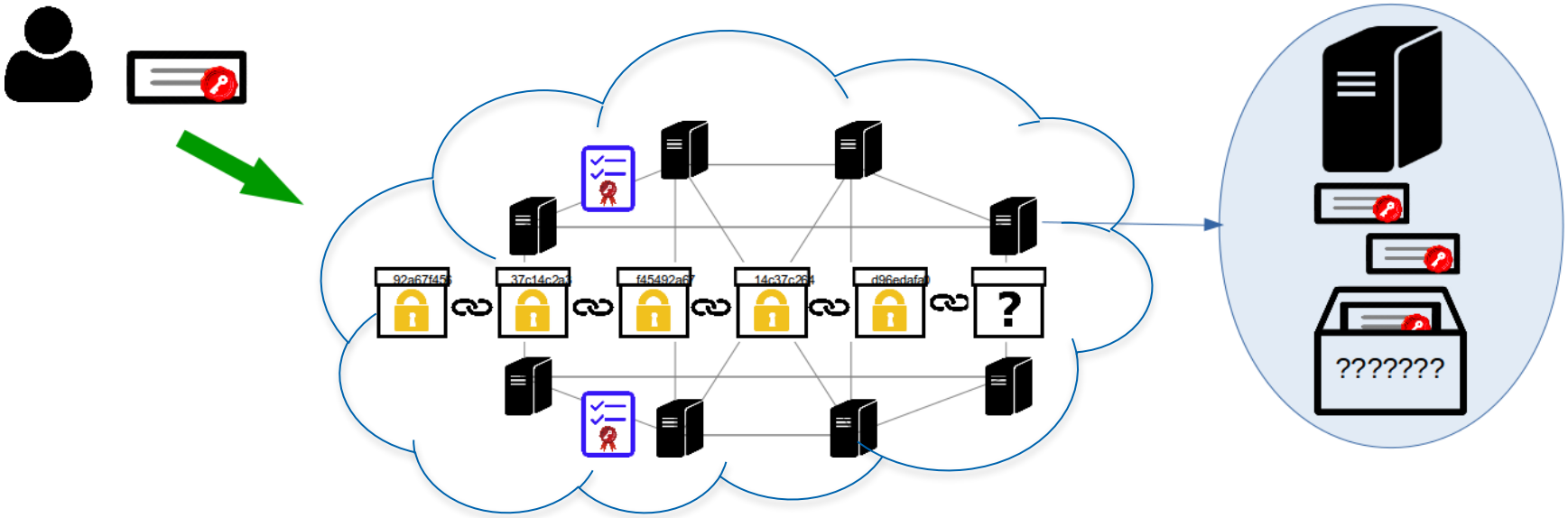
What is a Blockchain?

- the technology behind the Bitcoin cryptocurrency.
- immutable, time-stamped “chain of blocks”.
- smart contracts provide scripting capabilities.
- several implementations and variations are available.

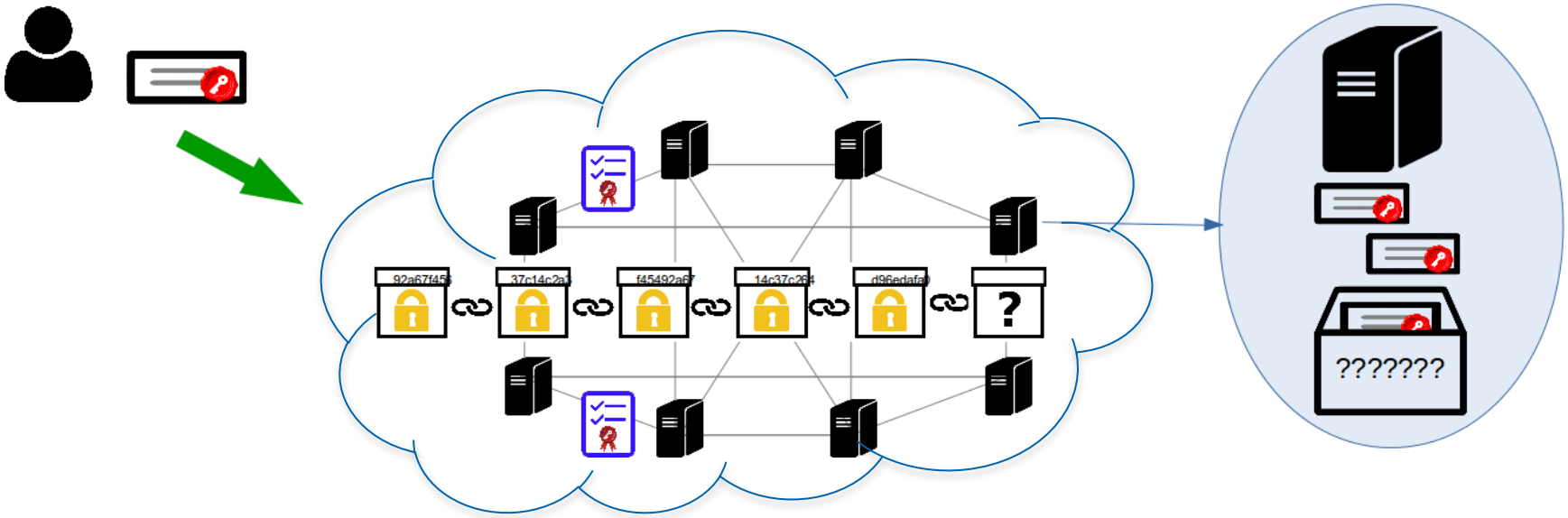
Is a peer to peer network, maintaining a distributed record of cryptographically signed transactions.



How does it work?

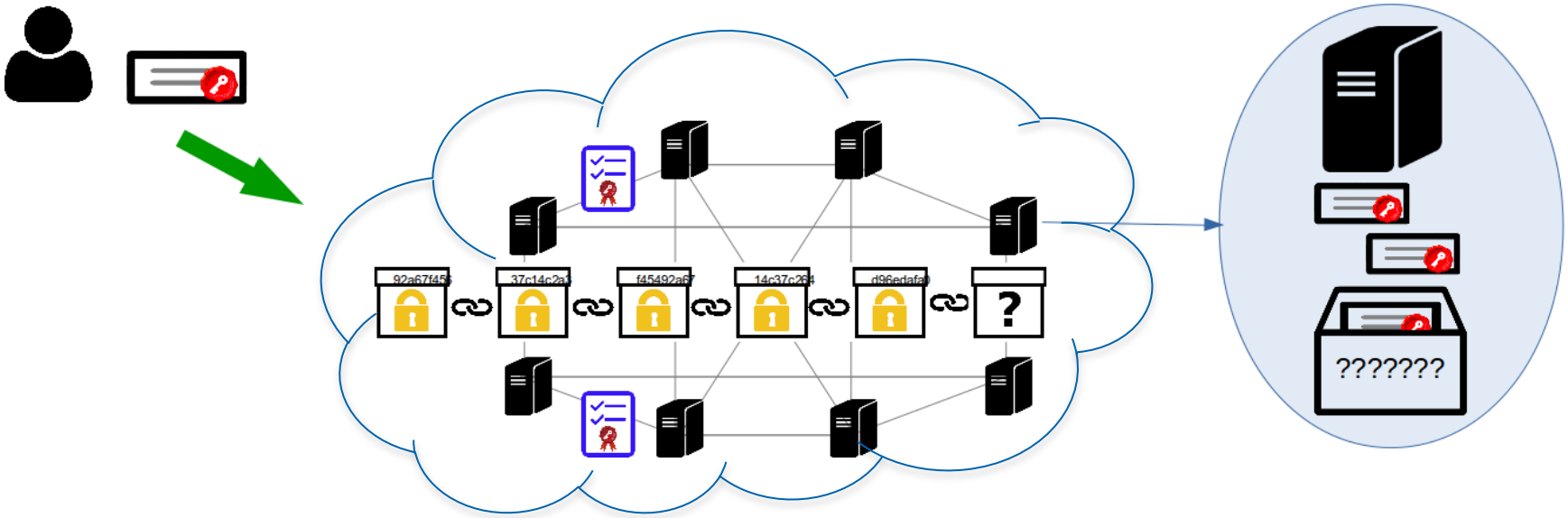


How does it work?



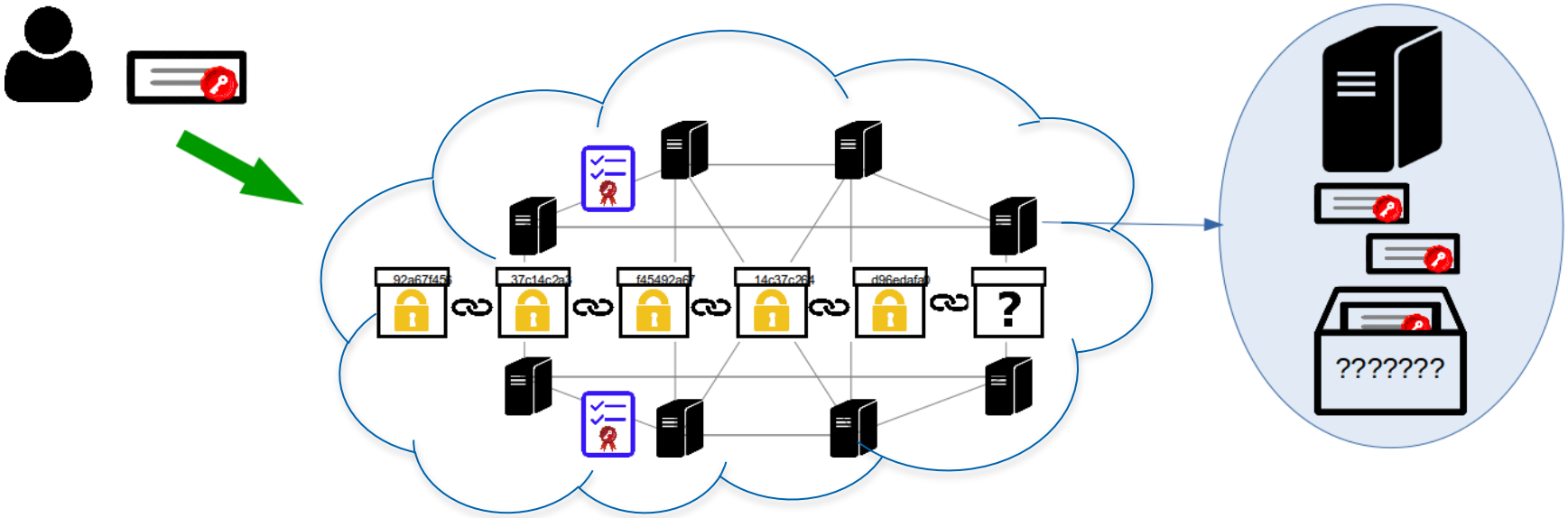
- A user signs a transaction and sends it to the network.

How does it work?



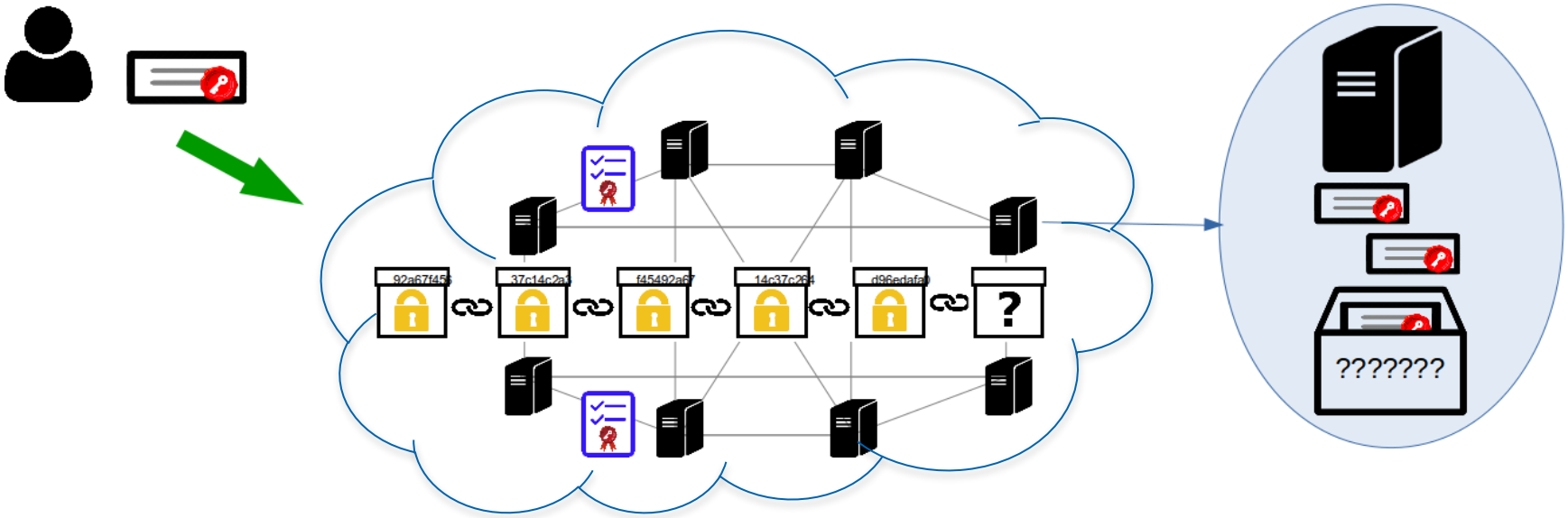
- A user signs a transaction and sends it to the network.
- The nodes perform basic validations (signatures, timestamp, etc.)

How does it work?



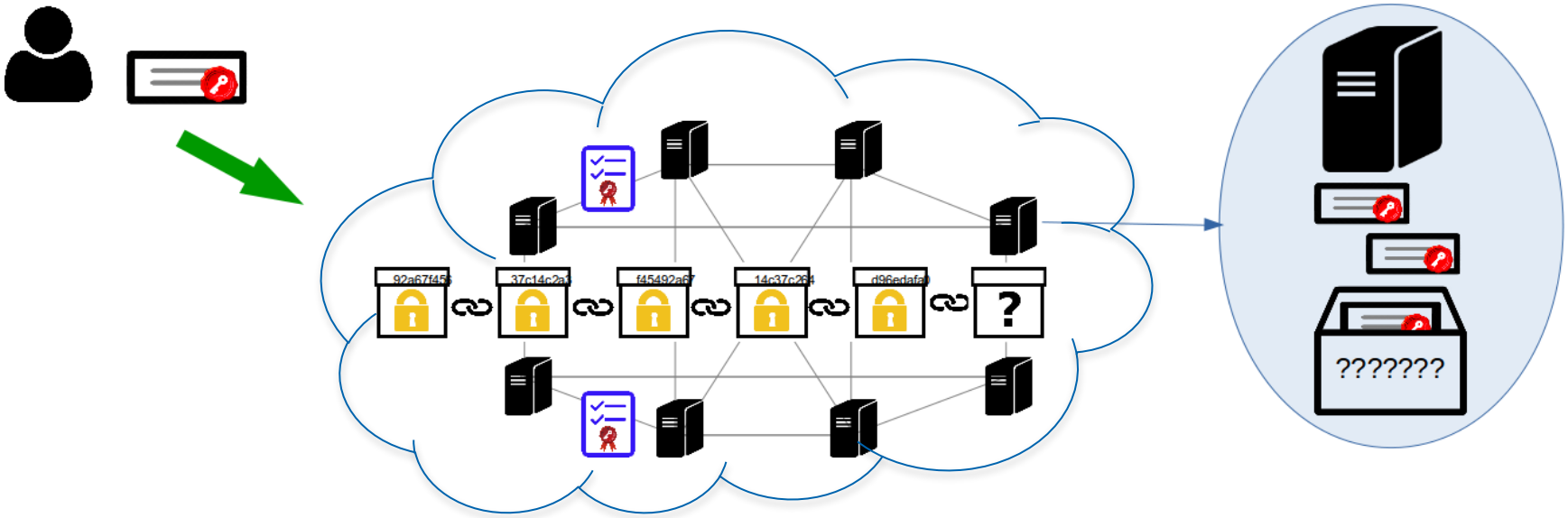
- A user signs a transaction and sends it to the network.
- The nodes perform basic validations (signatures, timestamp, etc.)
- Smart contracts perform programmed logic (validations, calculations)

How does it work?



- A user signs a transaction and sends it to the network.
- The nodes perform basic validations (signatures, timestamp, etc.)
- Smart contracts perform programmed logic (validations, calculations)
- A miner work to create a valid block for new transactions (consensus algorithm)

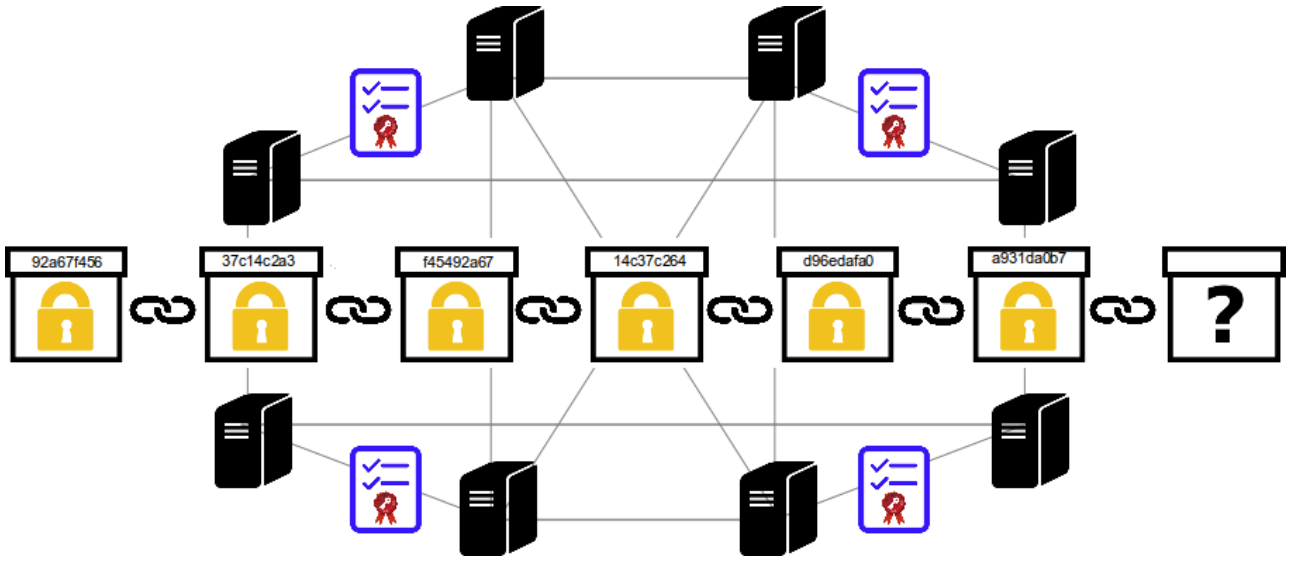
How does it work?



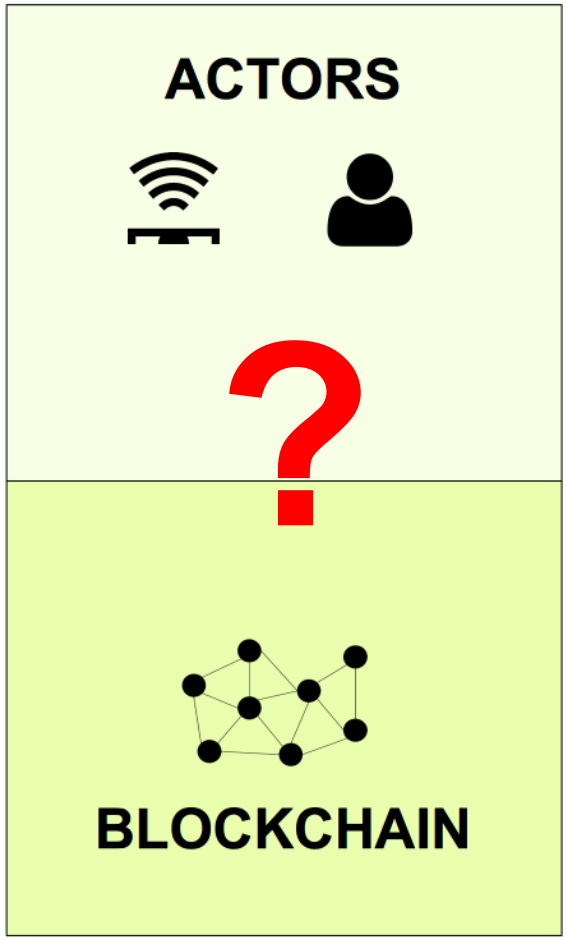
- A user signs a transaction and sends it to the network.
- The nodes perform basic validations (signatures, timestamp, etc.)
- Smart contracts perform programmed logic (validations, calculations)
- A miner work to create a valid block for new transactions (consensus algorithm)
- The new block is appended to the blockchain

What is a Blockchain?

Blockchain technology is
NOT
only for Fintech!!!

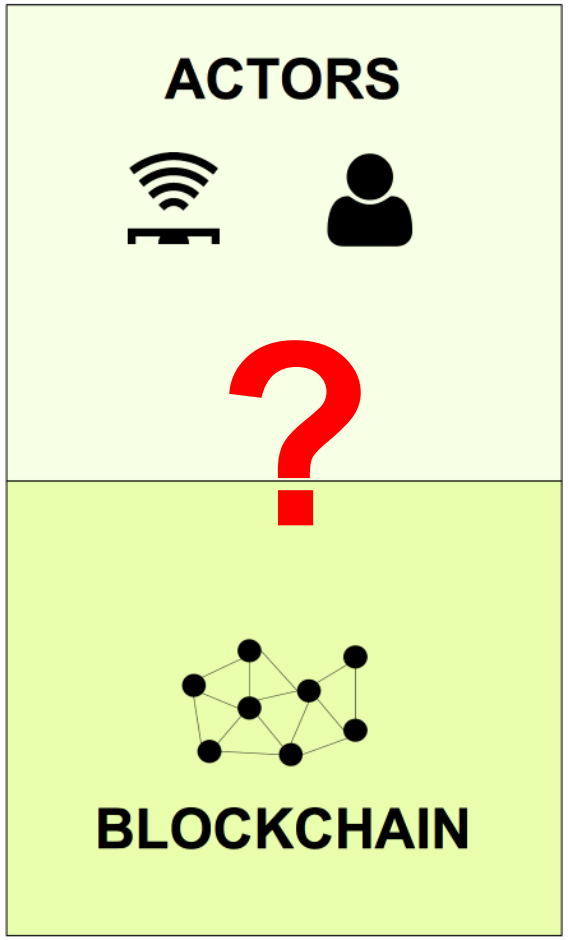


Benefits of Blockchains to the Internet of Things

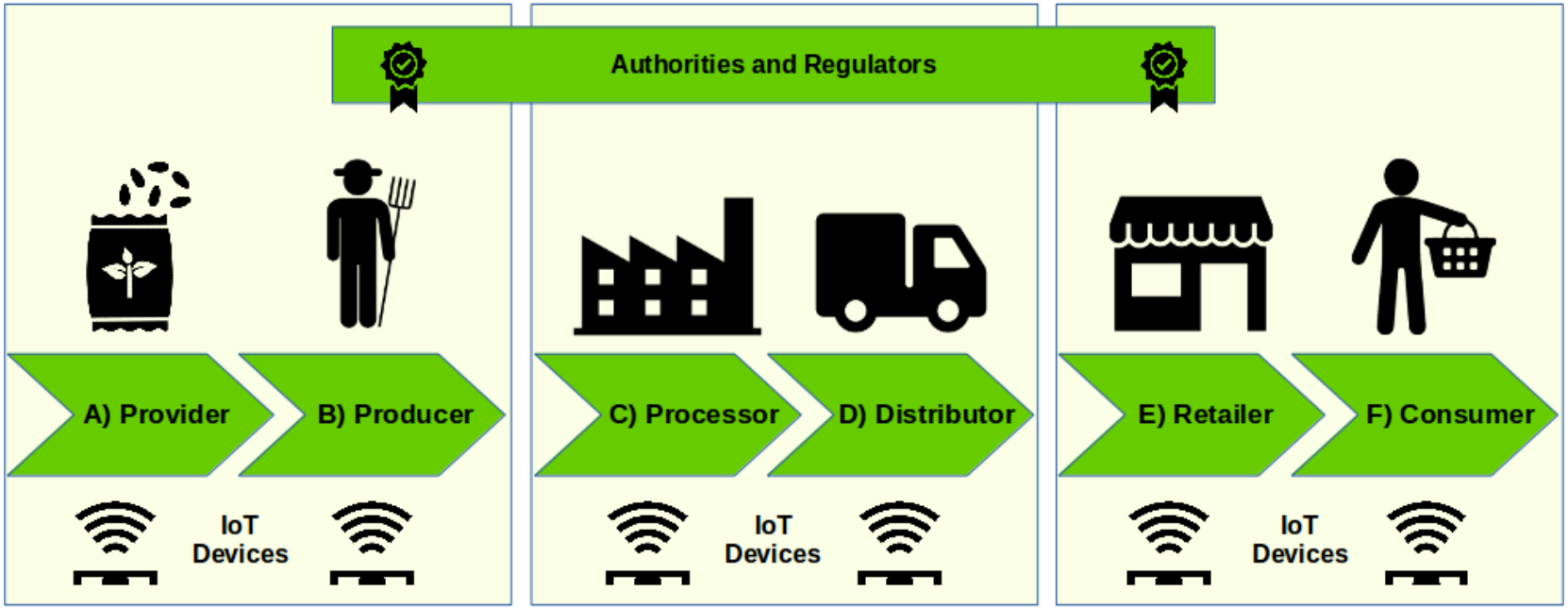


Benefits of Blockchains to the Internet of Things

- **Decentralization.**
  - Peer to Peer Network.
- **Transparency.**
  - Immutable distributed records.
- **Authenticity.**
  - Cryptographically signed transactions.
- **Autonomous transactions**
  - Smart contracts

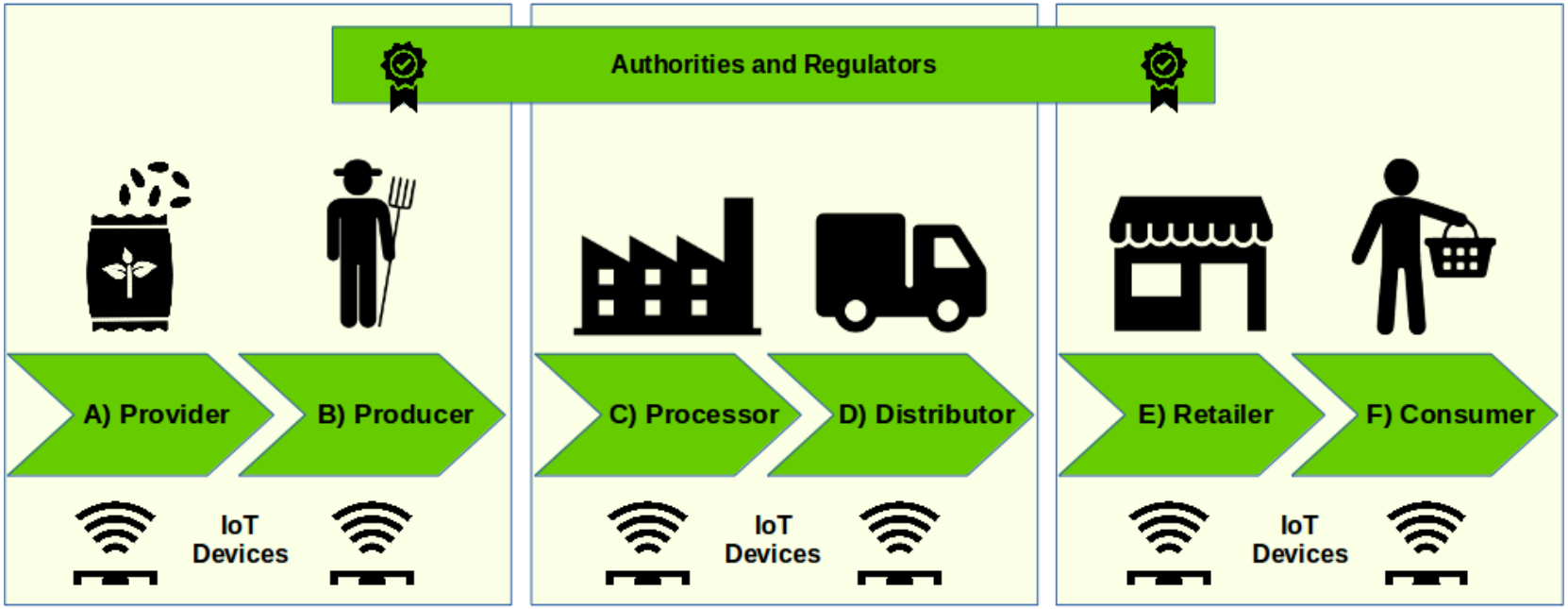


Use Case: “from-farm-to-fork”



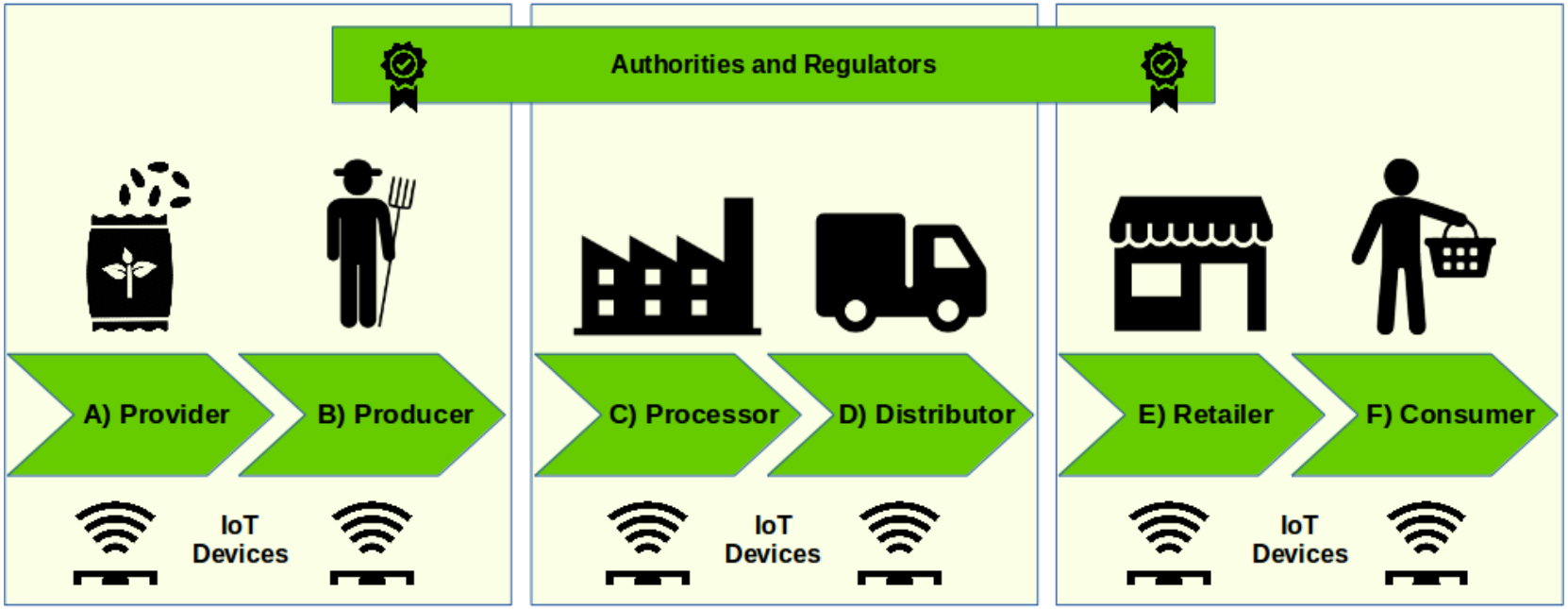
Use Case: “from-farm-to-fork”

- **Actors** benefit from a **decentralized** and **trusted information** repository.



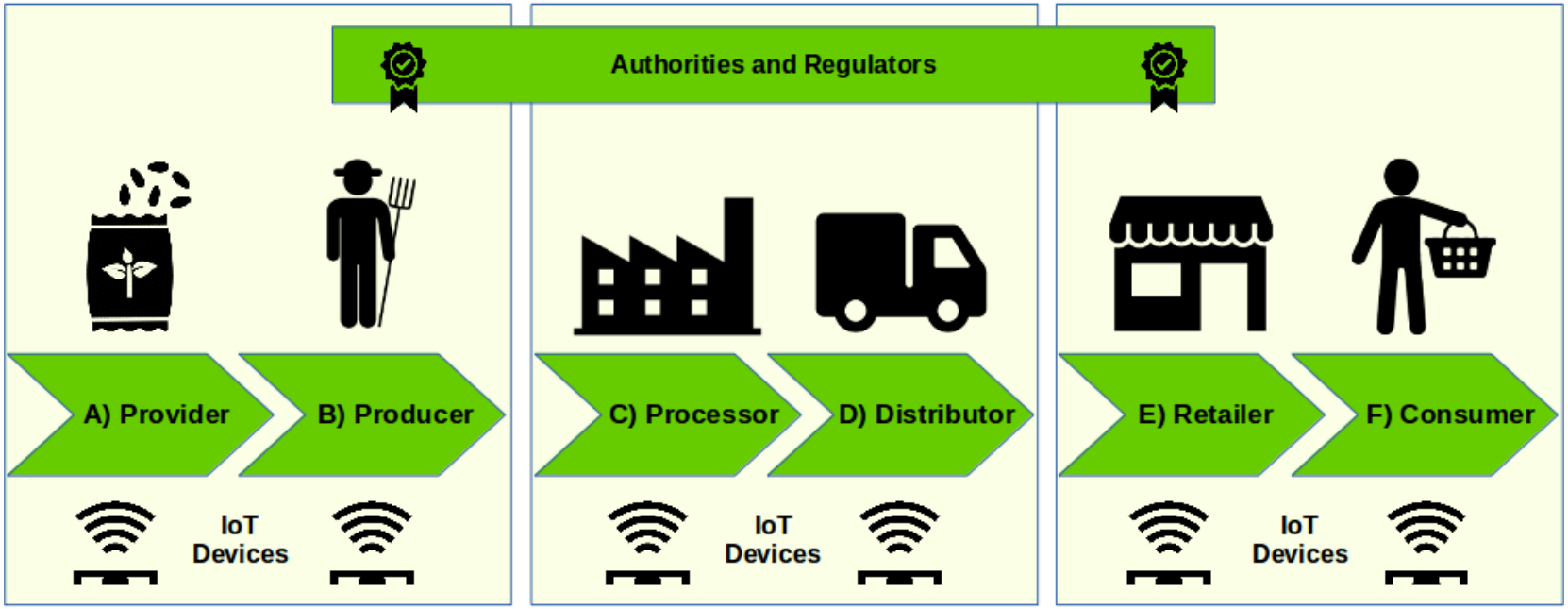
Use Case: “from-farm-to-fork”

- **Actors** benefit from a **decentralized** and **trusted information** repository.
- **IoT** devices take advantage of a **decentralized infrastructure** and provide **cryptographically signed** representation of physical assets.



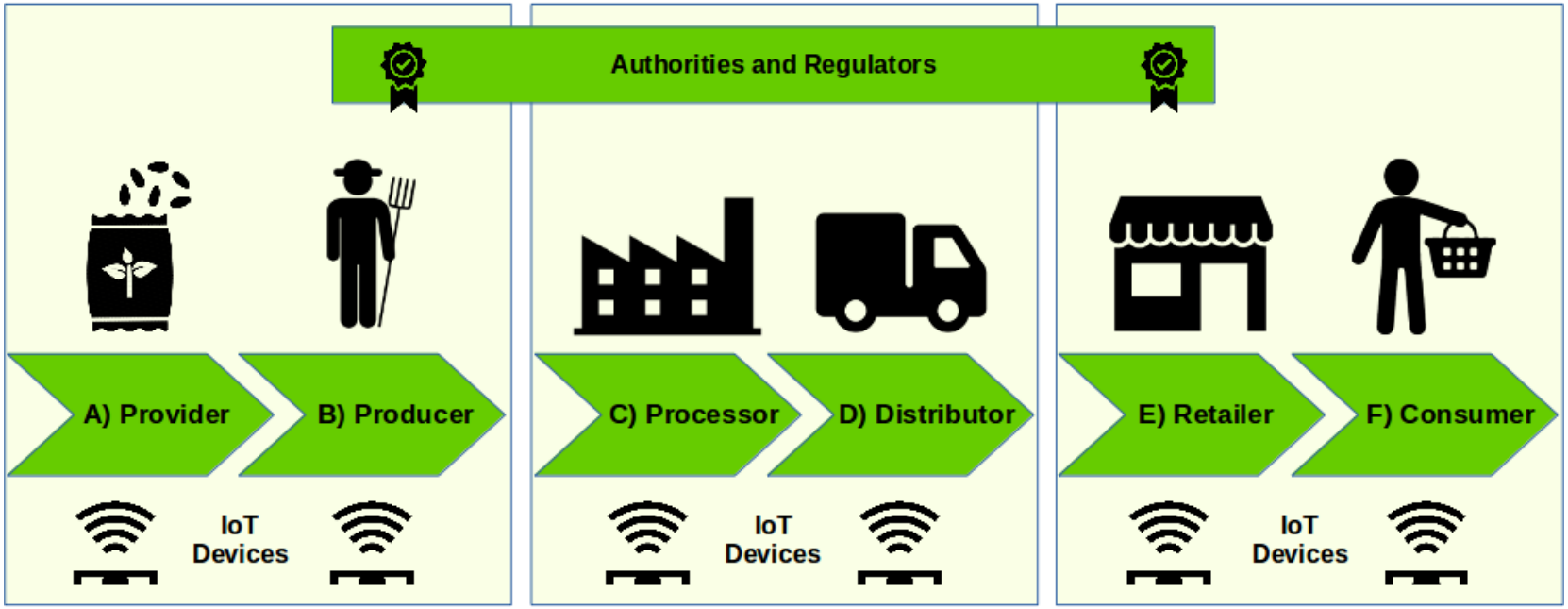
Use Case: “from-farm-to-fork”

- **Actors** benefit from a **decentralized** and **trusted information** repository.
- **IoT** devices take advantage of a **decentralized infrastructure** and provide **cryptographically signed** representation of physical assets.
- **Smart contracts** enable **autonomous transactions** (eg. certifications for organic products, alarms in case of cold chain anomalies, etc.)

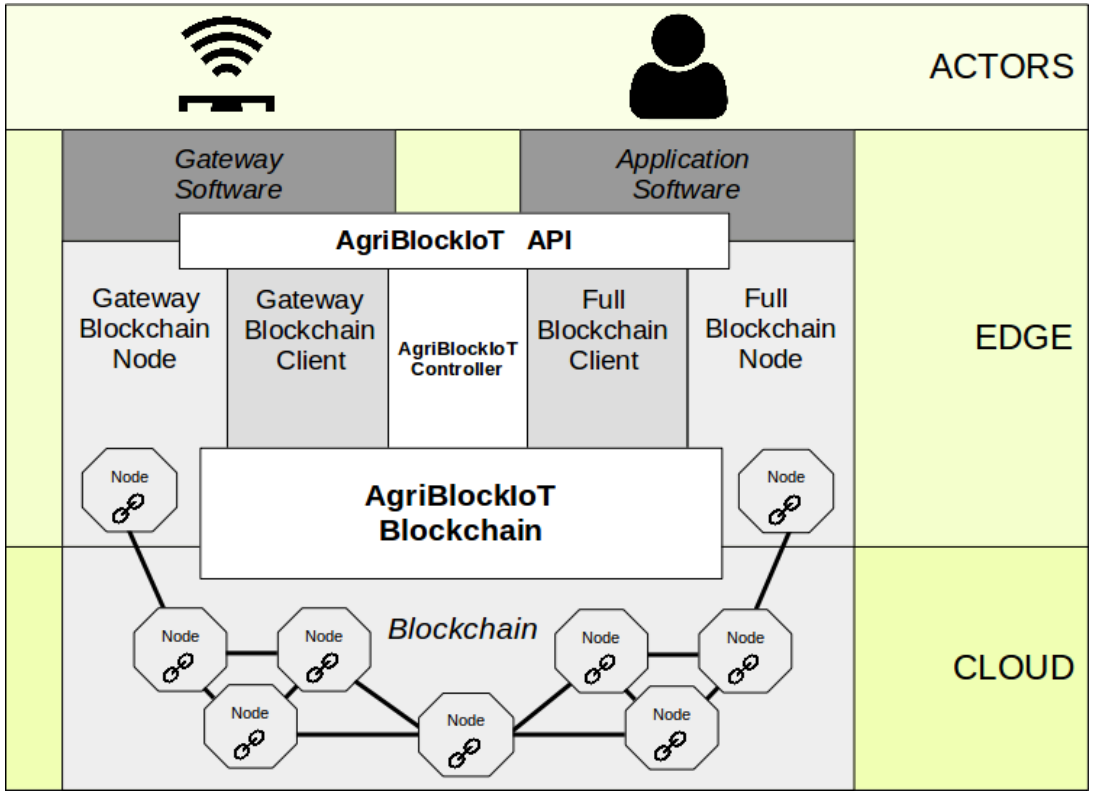


Use Case: “from-farm-to-fork”

- **Actors** benefit from a **decentralized** and **trusted information** repository.
- **IoT** devices take advantage of a **decentralized infrastructure** and provide **cryptographically signed** representation of physical assets.
- **Smart contracts** enable **autonomous transactions** (eg. certifications for organic products, alarms in case of cold chain anomalies, etc.)
- **Consumers** benefit from an **immutable, transparent history** of the product.

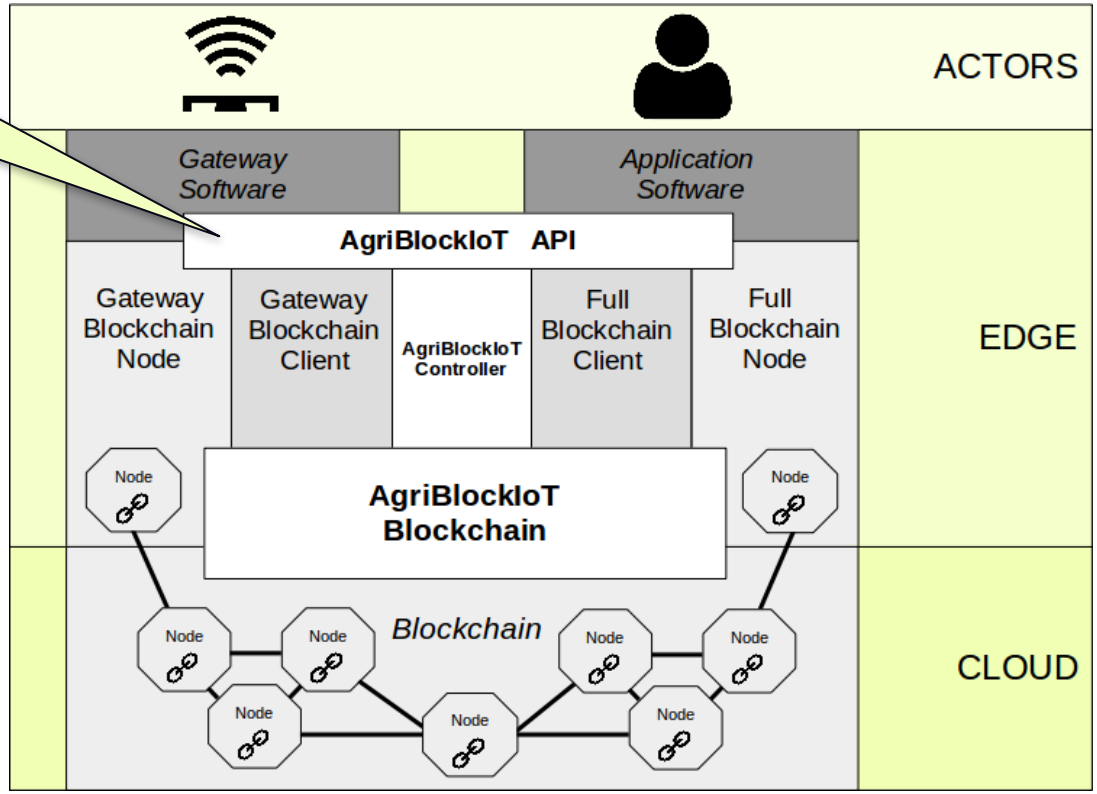


AgriBlockIoT - 3 Layer Architecture



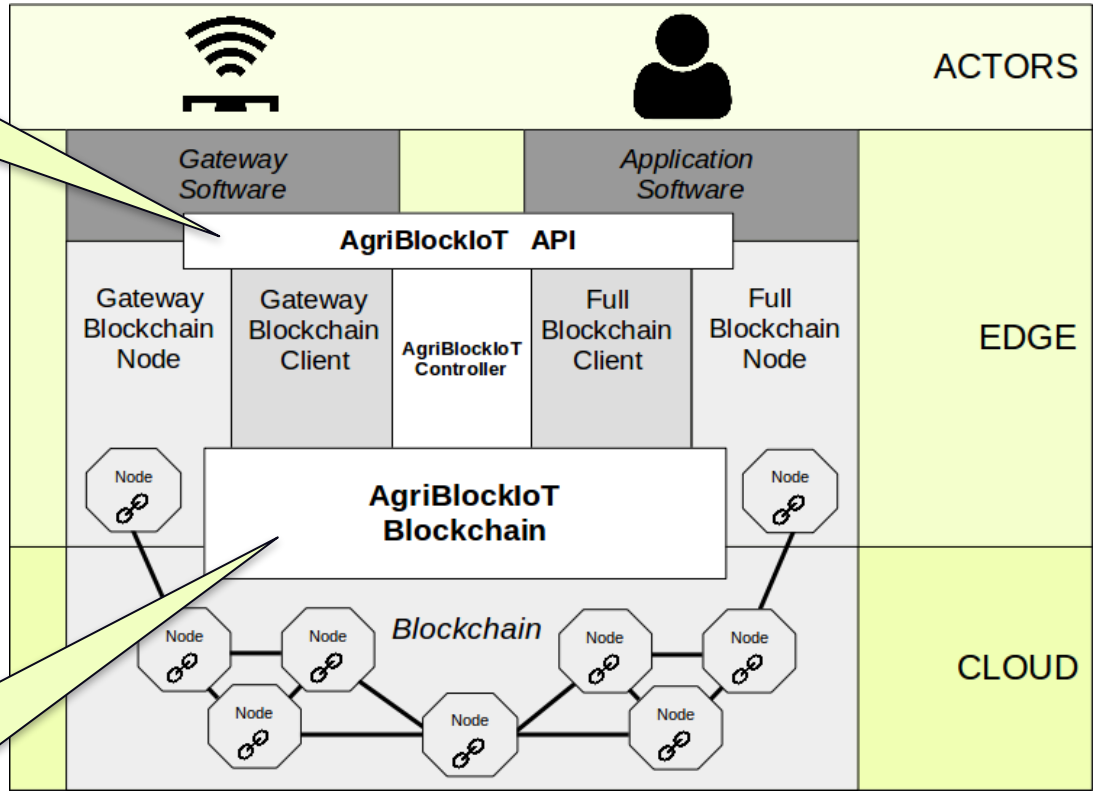
AgriBlockIoT - 3 Layer Architecture

API: Provides a high level interface for devices and users



AgriBlockIoT - 3 Layer Architecture

API: Provides a high level interface for devices and users



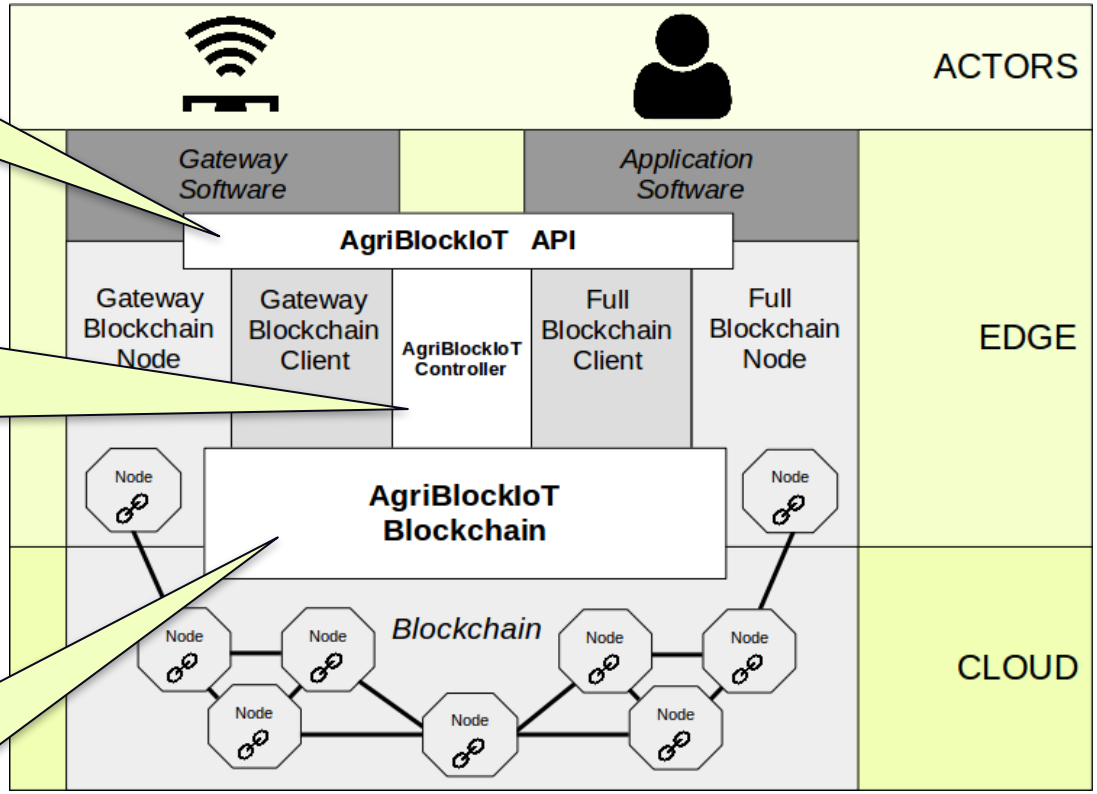
Blockchain: smart contracts implementing the business logic for autonomous events

AgriBlockIoT - 3 Layer Architecture

API: Provides a high level interface for devices and users

Controller: Transform all the high level calls to blockchain transactions

Blockchain: smart contracts implementing the business logic for autonomous events

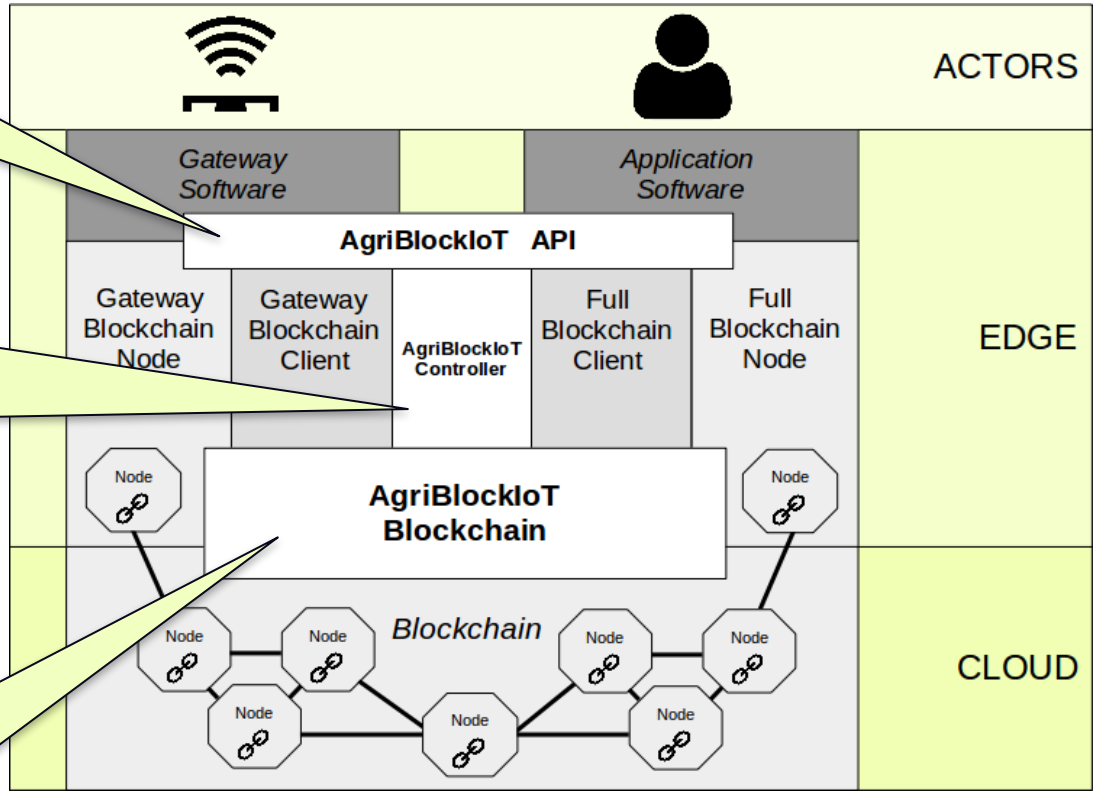


AgriBlockIoT - 3 Layer Architecture

API: Provides a high level interface for devices and users

Controller: Transform all the high level calls to blockchain transactions

Blockchain: smart contracts implementing the business logic for autonomous events



Edge devices may be also nodes on the peer to peer network and not just clients

Implementations

- **“Traditional” blockchain**
- Focused on improving Bitcoin’s smart contract capabilities
- Available since 2013
- Maintained by Ethereum Foundation
- The transaction is a fixed structure
- Storage on LevelDB

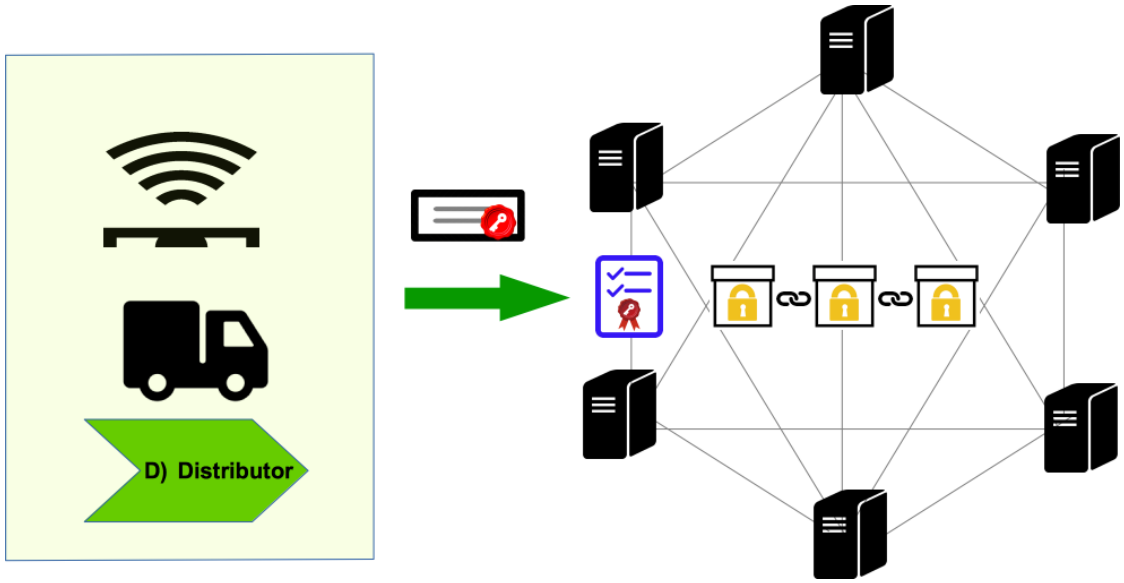
Implementations

- **“Traditional” blockchain**
- Focused on improving Bitcoin’s smart contract capabilities
- Available since 2013
- Maintained by Ethereum Foundation
- The transaction is a fixed structure
- Storage on LevelDB

- **“Modular” Blockchain**
- Focused on “Enterprise Level” blockchain.
- Version 1.0 avail. 01/2018
- Maintained by Linux Foundation, created by Intel
- Transactions can be forged by users
- Storage using LMDB

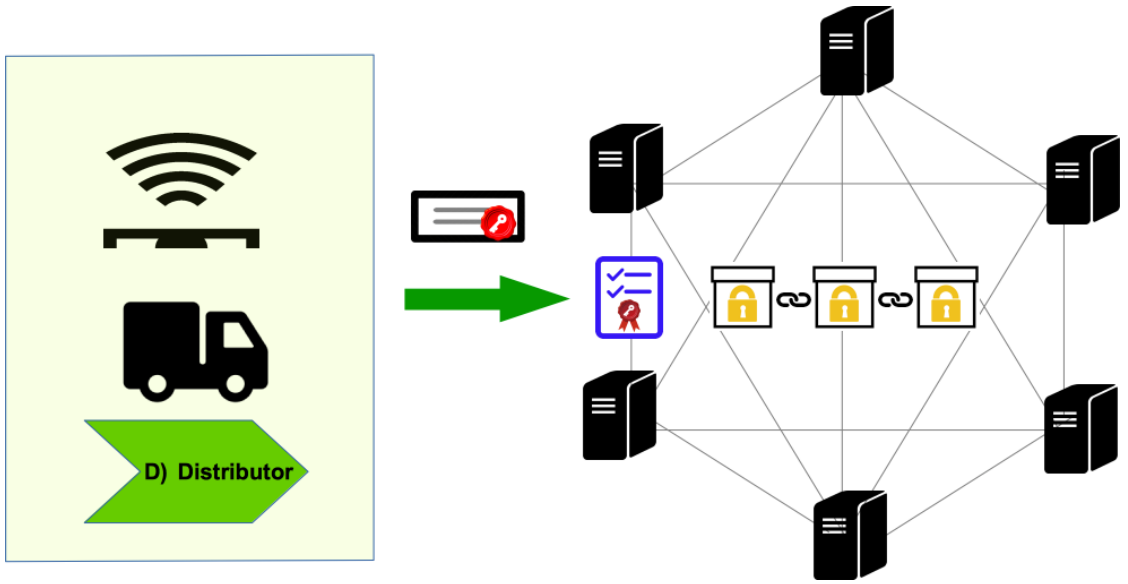
Performance analysis: metrics

A digital sensor updates its state on the blockchain through a smart-contract



Performance analysis: metrics

A digital sensor updates its state on the blockchain through a smart-contract



- Tested 100 times for each implementation (ETH and HL)
- Measured metrics:
  - Latency (Time to update the value on the network)
  - Network Traffic (transmitted and received)
  - CPU Load/Usage

Preliminary results: comparison

PERFORMANCE OF AGRIBLOCKIOT IN TERMS OF LATENCY, NETWORK TRAFFIC, AND CPU LOAD.

	latency [seconds]	**network tx [bytes]**	**network rx [bytes]**	**CPU load [%]**
Ethereum	16.55	528'108	682'415	46.78
Sawtooth	0.021	19'303	20'641	6.75

Preliminary results: comparison

PERFORMANCE OF AGRIBLOCKIOT IN TERMS OF LATENCY, NETWORK TRAFFIC, AND CPU LOAD.

	latency [seconds]	network tx [bytes]	network rx [bytes]	CPU load [%]
Ethereum	16.55	528'108	682'415	46.78
Sawtooth	0.021	19'303	20'641	6.75

- More mature platform
- Blocks are made even without transactions
- **Better consistency**
- Focused on a public, permisionless blockchain
- **Existing public network with cryptocurrency**

Preliminary results: comparison

PERFORMANCE OF AGRIBLOCKIOT IN TERMS OF LATENCY, NETWORK TRAFFIC, AND CPU LOAD.

	latency [seconds]	network tx [bytes]	network rx [bytes]	CPU load [%]
Ethereum	16.55	528'108	682'415	46.78
Sawtooth	0.021	19'303	20'641	6.75

- More mature platform
- Blocks are made even without transactions
- **Better consistency**
- Focused on a public, permisionless blockchain
- **Existing public network with cryptocurrency**

- More modular platform
- Blocks are made only when transactions arrive
- **Faster response**
- Adaptable to any type of blockchain (i.e. permissioned)
- **User most deploy network with customs transactions**

Preliminary results: comparison

PERFORMANCE OF AGRIBLOCKIOT IN TERMS OF LATENCY, NETWORK TRAFFIC, AND CPU LOAD.

	latency [seconds]	network tx [bytes]	network rx [bytes]	CPU load [%]
Ethereum	16.55	528'108	682'415	46.78
Sawtooth	0.021	19'303	20'641	6.75

ethereum

HYPERLEDGER SAWTOOTH

- More mature platform
- Blocks are made even without transactions
- **Better consistency**
- Focused on a public, permisionless blockchain
- **Existing public network with cryptocurrency**

- More modular platform
- Blocks are made only when transactions arrive
- **Faster response**
- Adaptable to any type of blockchain (i.e. permissioned)
- **User most deploy network with customs transactions**

Preliminary results: comparison

PERFORMANCE OF AGRIBLOCKIOT IN TERMS OF LATENCY, NETWORK TRAFFIC, AND CPU LOAD.

	latency [seconds]	network tx [bytes]	network rx [bytes]	CPU load [%]
Ethereum	16.55	528'108	682'415	46.78
Sawtooth	0.021	19'303	20'641	6.75

ethereum

HYPERLEDGER SAWTOOTH

- More mature platform
- Blocks are made even without transactions
- **Better consistency**
- Focused on a public, permisionless blockchain
- **Existing public network with cryptocurrency**

- More modular platform
- Blocks are made only when transactions arrive
- **Faster response**
- Adaptable to any type of blockchain (i.e. permissioned)
- **User most deploy network with customs transactions**

Conclusions

Conclusions

- Our architecture enables seamless integration of IoT devices into publicly available Blockchain implementations.

Conclusions

- Our architecture enables seamless integration of IoT devices into publicly available Blockchain implementations.
- Devices can be full fledged users of the blockchain, while smart contracts provides autonomous transaction executions.

Conclusions

- Our architecture enables seamless integration of IoT devices into publicly available Blockchain implementations.
- Devices can be full fledged users of the blockchain, while smart contracts provides autonomous transaction executions.
- Different Blockchain implementations provides different functional and non functional features.
  - Faster response time *vs* Better consistency
  - Existing cryptocurrency *vs* User defined transactions
  - Cost of use *vs* Cost of deployment

Conclusions

- Our architecture enables seamless integration of IoT devices into publicly available Blockchain implementations.
- Devices can be full fledged users of the blockchain, while smart contracts provides autonomous transaction executions.
- Different Blockchain implementations provides different functional and non functional features.
  - Faster response time *vs* Better consistency
  - Existing cryptocurrency *vs* User defined transactions
  - Cost of use *vs* Cost of deployment

Conclusions

- Our architecture enables seamless integration of IoT devices into publicly available Blockchain implementations.
- Devices can be full fledged users of the blockchain, while smart contracts provides autonomous transaction executions.
- Different Blockchain implementations provides different functional and non functional features.
  - Faster response time *vs* Better consistency
  - Existing cryptocurrency *vs* User defined transactions
  - Cost of use *vs* Cost of deployment

We plan to extend the performance analysis to **more constrained hardware architectures** and also to include other blockchain implementations into our reference architecture

thank you.

Miguel Pincheira Caro
mpincheiracaro@fbk.eu

PhD Candidate

OpenIoT Research Unit FBK CREATE-NET

University of Trento