Using Blockchain to Improve Security of the Internet of Things

Josh Quist
University of Minnesota, Morris
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Introduction

- Alarm clock data wipe

  More sinister example:

- Intentional alarm data manipulation

https://www.bestbuy.com/site/amazon-echo-spot-smart-alarm-clock-with-alexa-black

Internet of Things Example Cont.

- Clearly important security risk
- Peloton Data breach
  - User info was exposed
  - Joe Biden Peloton Data was viewable
  - Weight is a socially sensitive issue, while birthdays are commonly used in passwords
- Devices like this need to be secure

https://www.npr.org/2022/01/24/1075326738/the-ins-and-out-of-peloton-culture

Talk Outline

1. Background Information
    a. Introduction to Internet of Things
    b. Discussion of current IoT implementations
    c. Introduction to blockchain
2. Blockchain IoT example 1
3. Blockchain IoT example 2
4. Blockchain Implementation Difficulties
5. Conclusion

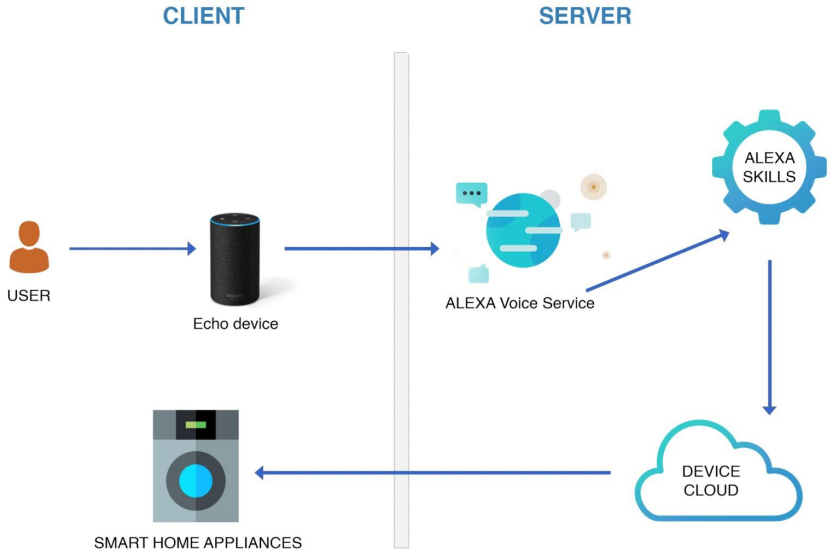
Internet of Things Introduction

- Internet of Things (IoT) definition
- Examples: Smart home security system, wearable health monitors, smart appliances.
- Automate tasks for convenience

https://builtin.com/internet-things/iot-internet-of-things-companies

Current IoT Implementation

- Alexa system design
  - Always-online
  - Amazon uses its servers for software functionality
  - Stores all data on its own cloud server
  - Typical of most IoT systems; data sometimes stored by third parties



https://www.qsstechnosoft.com/how-does-amazon-alexa-works

IoT Implementation Security Concerns

- Complete separation from your data
- Devices communicating with system not monitored
- Third parties often trusted with data
- Blockchain can help with these concerns

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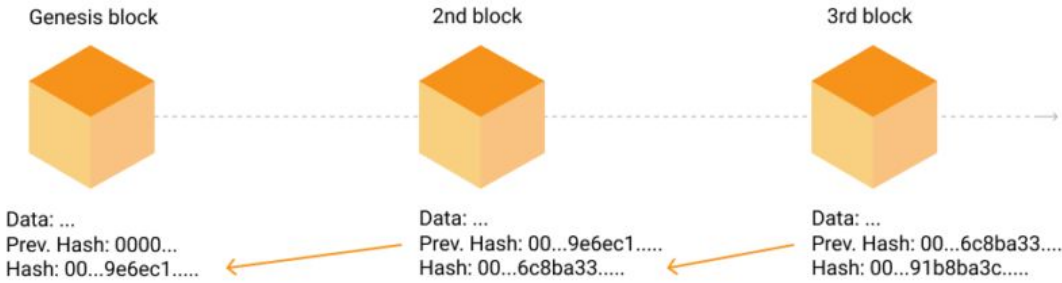
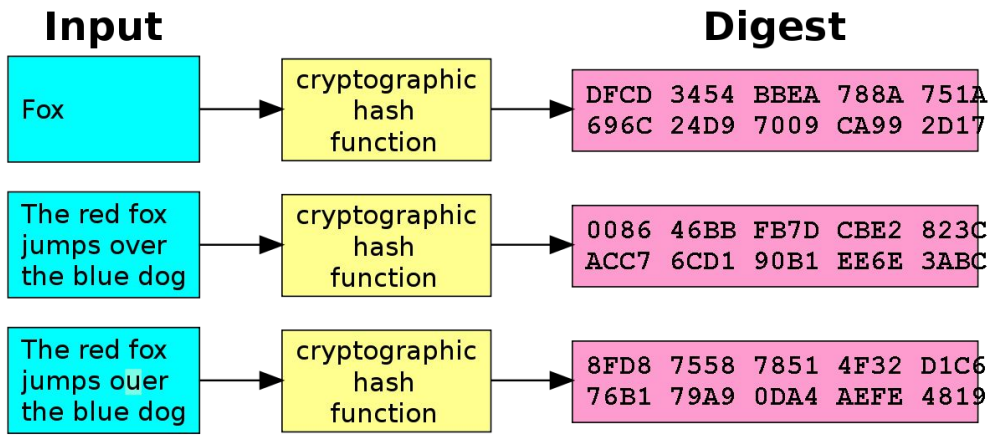
Introduction to Blockchain

- What is a blockchain?
  - Database containing records, or “Blocks”
  - Each block contains hash of previous block, hash of next block, timestamp, and data contained within
  - Blocks are “chained” because each contains information about the previous block



Hashing

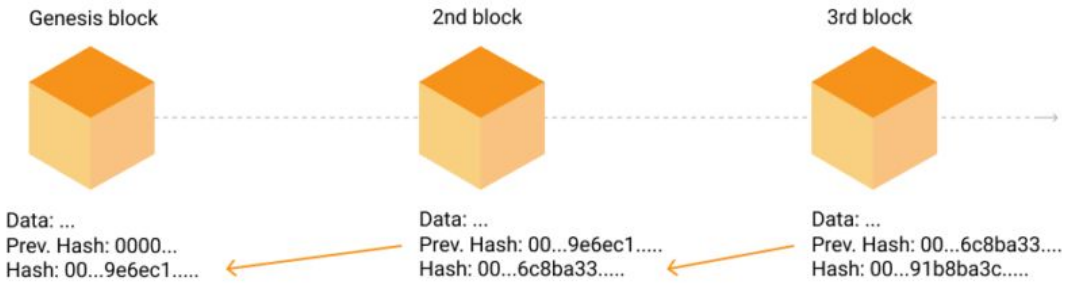
- Mathematical function, converts input to fixed length digest, or output
- One change alters entire output
- “One-way” - simple example



https://en.wikipedia.org/wiki/Cryptographic_hash_function

Hashing in Blockchain

- All information in the block hashed, points to the next block
- Data unable to be altered without breaking the chain
- One way functionality means data is secure



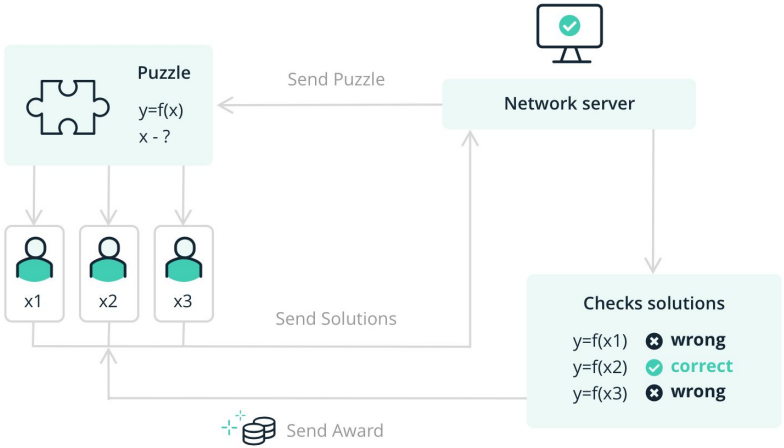
Bitcoin Blockchain Example

- Bitcoin most well-known implementation of blockchain
- Decentralized, digital currency, or Cryptocurrency
- Blockchain stores transaction information
- Anonymous way to send and receive money
- Bitcoin’s blockchain grows by incentivizing miners

https://bitcoin.org/

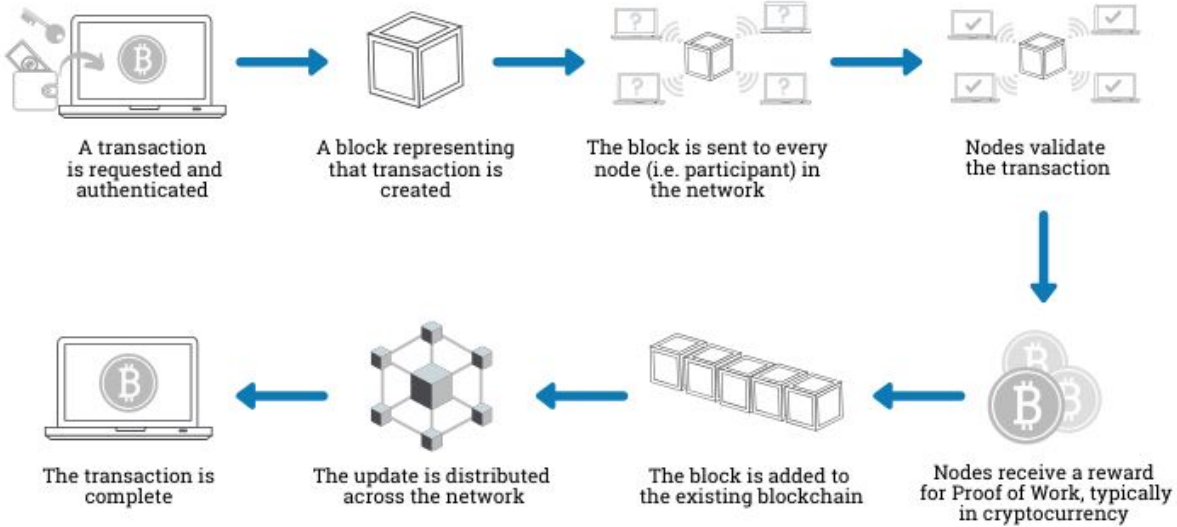
Bitcoin mining

- Bitcoin generates new block every 10 minutes, including a target digit and the hash for the next block
- Bitcoin miners calculate the hash of the next block to verify
- The solution to the hash is a mathematical problem
- Finding the solution, or “proof of work” essentially guesswork
- Reward for solving this “proof of work” is Bitcoin



https://www.ledger.com/academy/blockchain/what-is-proof-of-work

Completing Transaction



https://support.coinigy.com/hc/en-us/articles/4408831413915-What-is-Bitcoin-

Mining Ensuring Authenticity

- The mining process ensures that entries are authentic
- After a miner posts the solved hash, all other miners verify its correctness
- Data in blockchain unable to be modified

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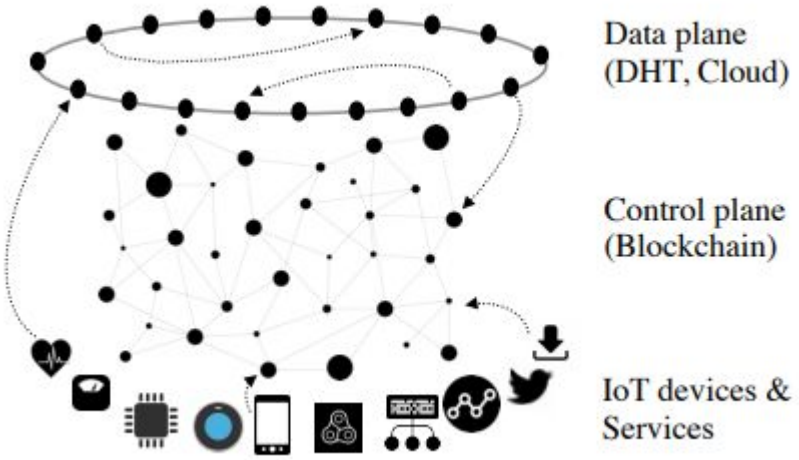
IoT Implementation Security Concerns

Again, specific security concerns with current system designs:

- Complete separation from your data
- Devices communicating with system not monitored
- Third parties often trusted with data

Shafagh et al. System Design

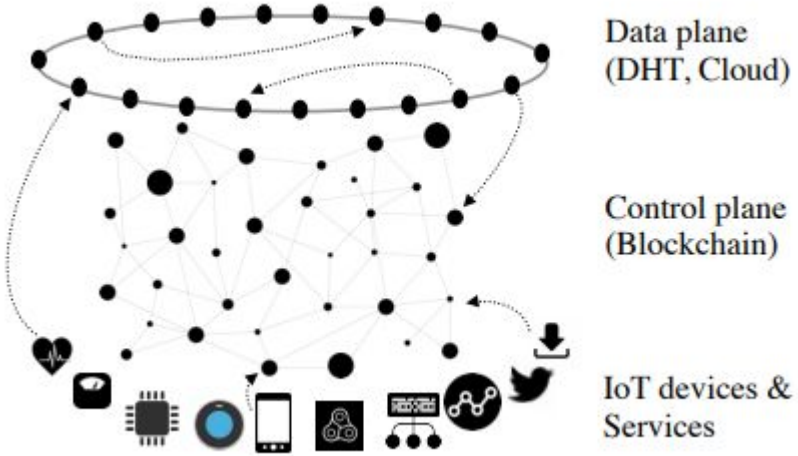
- System designed to provide access control
- Built on top of Bitcoin's blockchain system



Source: Shafagh (2017)

Control Plane and IoT Devices

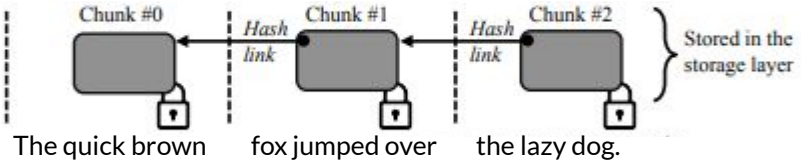
- IoT Device layer
  - Each device contains the private key for the IoT network
  - Private key is essentially system's password
- Control Plane: blockchain containing authenticated device ID's and the private key
- Data Plane: data chunked and stored on a third party server



Source: Shafagh (2017)

Example 1 Chunking Visual

- Data is chunked, then sent to data plane
- Each chunk encrypted



Source: Shafagh (2017)

Ex 1 Example of attack this system prevents

- Peloton Example
  - Leaky API
  - Data chunking
- DDoS Attack
  - Low power devices typically used as part of “swarm”
  - Access control

Performance Evaluation

- 10% slowdown in request throughput
- “Moderate overhead” due to the system hardware requirements
- Future work will include optimizing that overhead, and building more expansive IoT system for more testing

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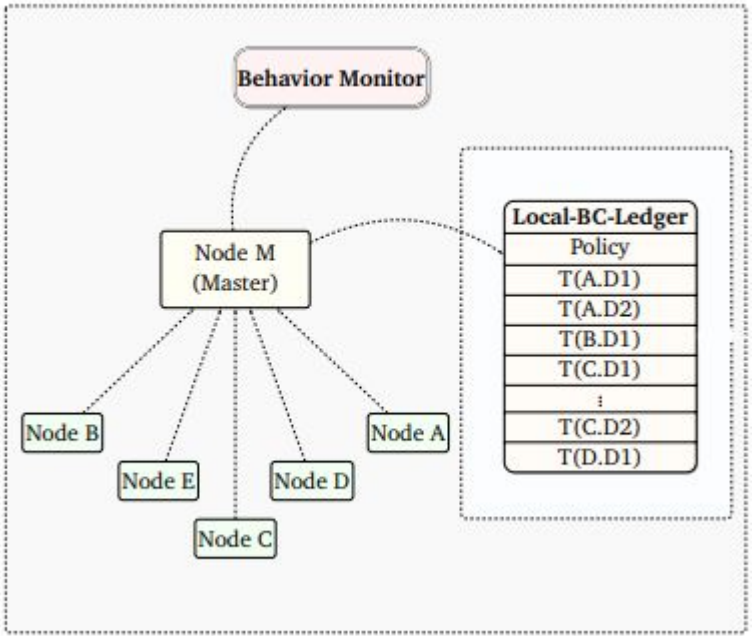
Ali et al. System

- Designed for IoT network
- Most powerful device designated as master node
- Transaction data stored in local blockchain on master node
- Behavior Monitor on top of master node



Source: Ali (2019)

Behavior Monitor

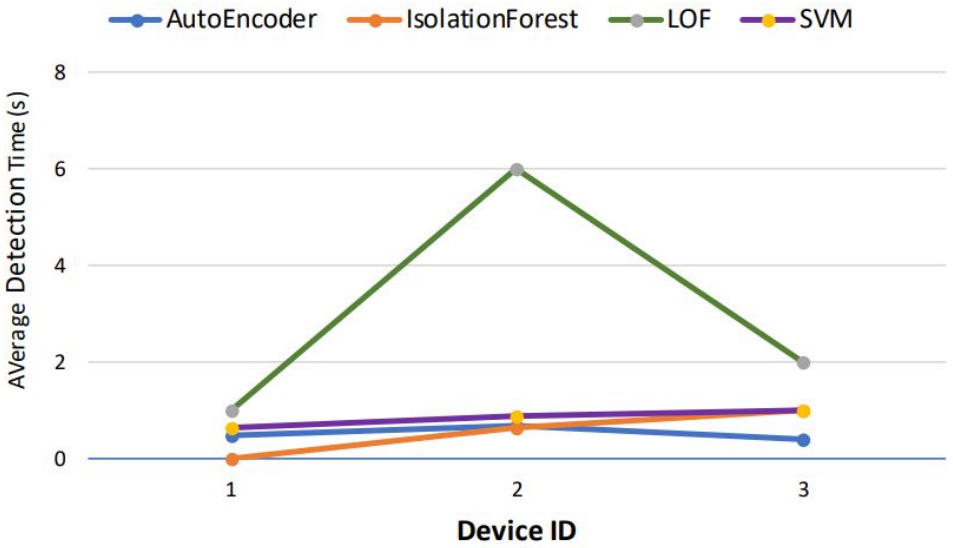
- Behavior monitor uses machine learning to identify bad actors
  - Machine learning is the process of training an algorithm on data in order to “teach” the machine patterns to look for.
- This system uses an algorithm which is trained on benign data to detect malicious behavior

What this system solves

- System does monitoring of IoT network
- Flags administrator of system when malicious behavior detected
- Takes care of IoT devices which provide advertised functionality, but in the background misuse your data

Performance Evaluation

- Performed tests comparing detection time to other popular anomaly detection algorithms
  - Isolation Forest
  - Local Outlier Factor
  - Support Vector Matrix
- AutoEncoder model produced similar detection times



Source: Ali (2019)

Blockchain Implementation Difficulty/Concerns

- Climate concerns
- Hardware limitations
- More involved on the user's side
- Scalability

Conclusion

- Current IoT has problems
- Blockchain can solve problems, but comes with some of its own
- More work is being done to address these

Sources

Jawad Ali, Toqeer Ali, Yazed Alsaawy, Ahmad Shahrafidz Khalid, Shahrulniza Musa. Blockchain-based Smart-IoT Trust Zone Measurement Architecture. (May 2019)

Hossein Shafagh, Lukas Burkhalter, Anwar Hithnawi, Simon Duquennoy. Towards Blockchain-based Auditable Storage and Sharing of IoT Data. (November 2017)

Questions?