Managing Smart Home Appliances with Proof of Authority and Blockchain

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Overview

- Introduction
- Problem Statement
- Motivation
- Related Work
- Proposed Mechanism
- Experimental Setup
- Results
- Conclusion

Smart Homes

- With advance in technology and growth in standard of living smart homes are becoming a reality.
- Consists of home appliances and IoT devices that communicate with each other to address residents need.
- Devices generate, share and consume large volume of data that are private and sometimes safety critical to the residents.

Source : https://www.helpnetsecurity.com/2015/10/23/smart-home-security-and-privacy-checklist/

Problem Statement

- Current state of the art cloud based smart home services have availability and privacy issues.
- Users have no control over how their data is being utilized by the service providers.
- Less transparency.

Source : https://www.helpnetsecurity.com/2015/10/23/smart-home-security-and-privacy-checklist/

Motivation

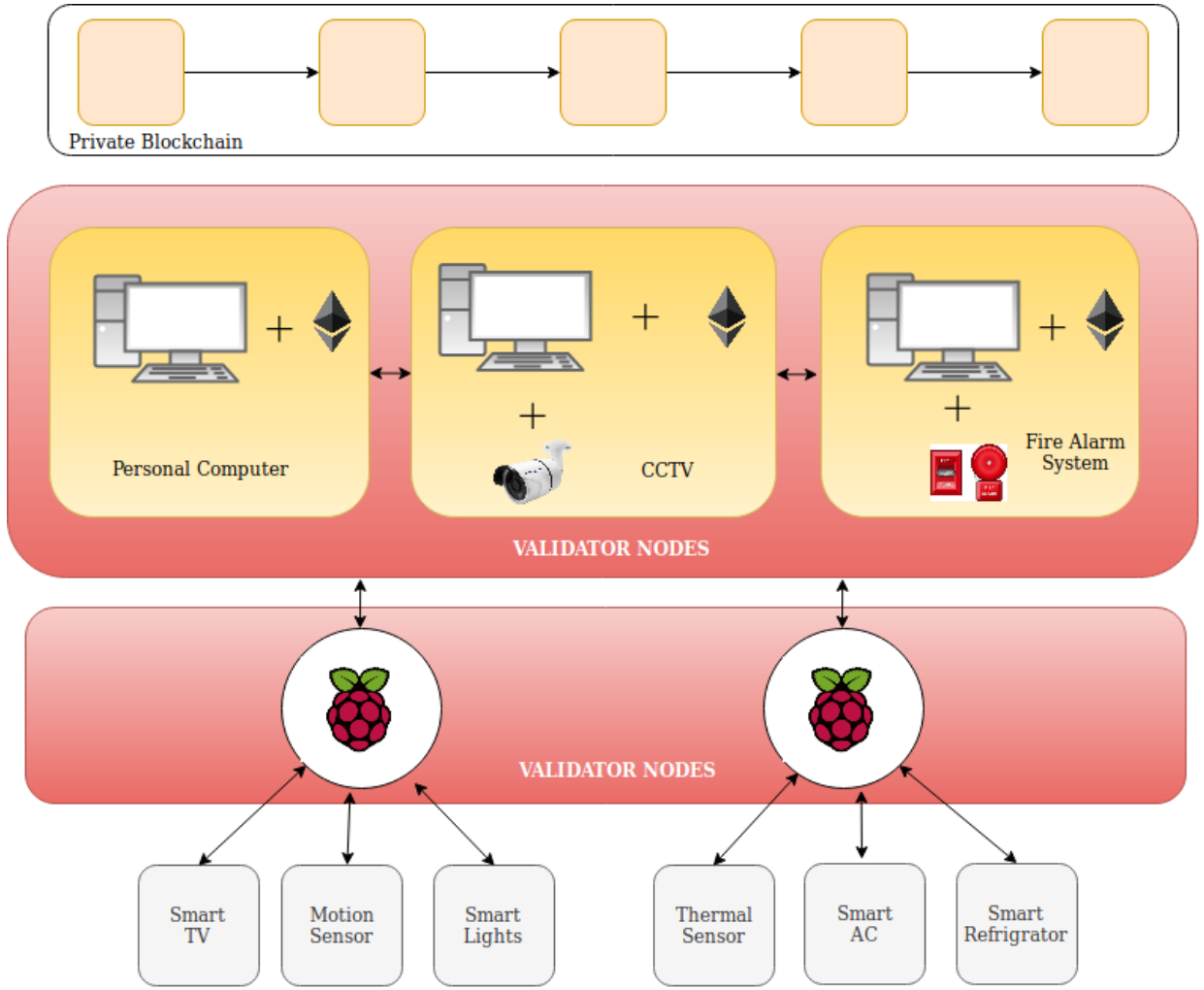
- Implement a smart home system to provide
  - High availability.
  - Efficient way of monitoring and auditing the in home happenings.
  - Preventing from non-repudiation of devices; identifying compromised and malfunctioned devices.
- Implementing low power consuming Proof of Authority(PoA) as the consensus mechanism for increased system performance .
- Removing the need of trust on untrusted cloud service providers.

Related Work

- In [10], the authors hacked into a variety of IoT enabled smart home devices
- In the past, numerous centralized solutions have been proposed
- Most of the solutions from industry deploy their proprietary solutions and serve as a centralized trusted third party.
- The major challenges with the centralized solutions are
  - Heavy communication and processing overheads on centralized server [3]
  - Transparency
  - Trust and privacy-related issues,
  - Access control and
  - Single point of failure.
- Various researchers [5,6,11,12,17] have turned-out the attention towards distributed framework and proposed popular blockchain based solutions

Proposed System Architecture

- **Home Owner :**
  - Configures home appliances,
  - Registers home residents to the system,
  - Deploys smart contract.
- **Validator Nodes:**
  - Devices having sufficient computing and storage capabilities.
  - Responsible for sealing of the blocks; and maintain the blockchain.
- **Smart Contract:**
  - Contains appropriate logic for interaction among the devices.
  - Specifies privileges of home residents.
- **Home Residents :**
  - Uses home appliances,
  - Make changes to the appliances; as per the privilege provided by the home owner.



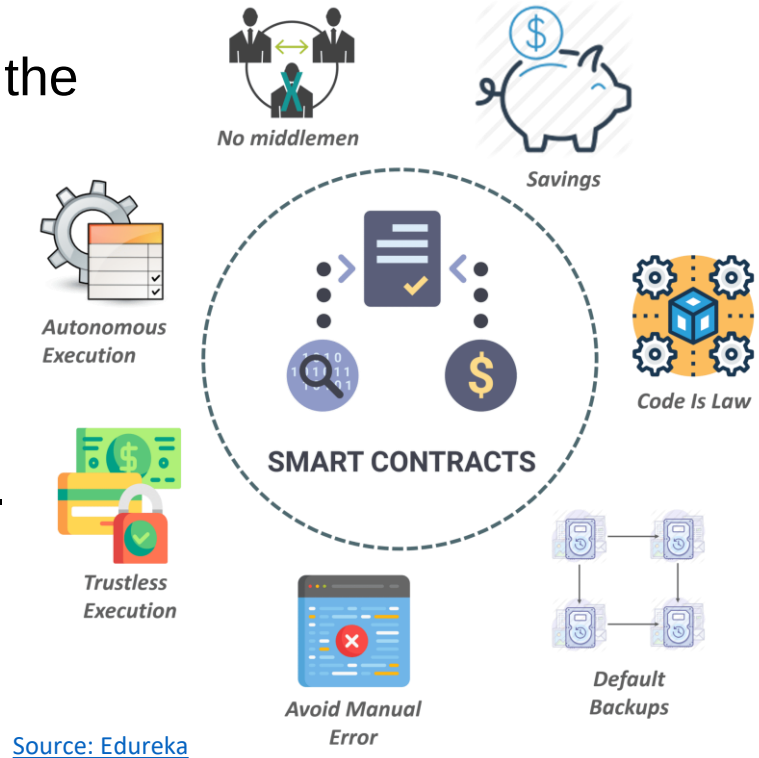
Blockchain Technologies Used

Ethereum:

- Public permissionless blockchain platform allows to setup a private and permissioned instance of the chain.
- Supports smart contracts (application specific code deployed on the blockchain).

Smart Contract:

- A bunch of self-executable code sitting on top of a blockchain.
- Consists of well-defined conditions and their corresponding actions.
- Triggered by the Transactions.

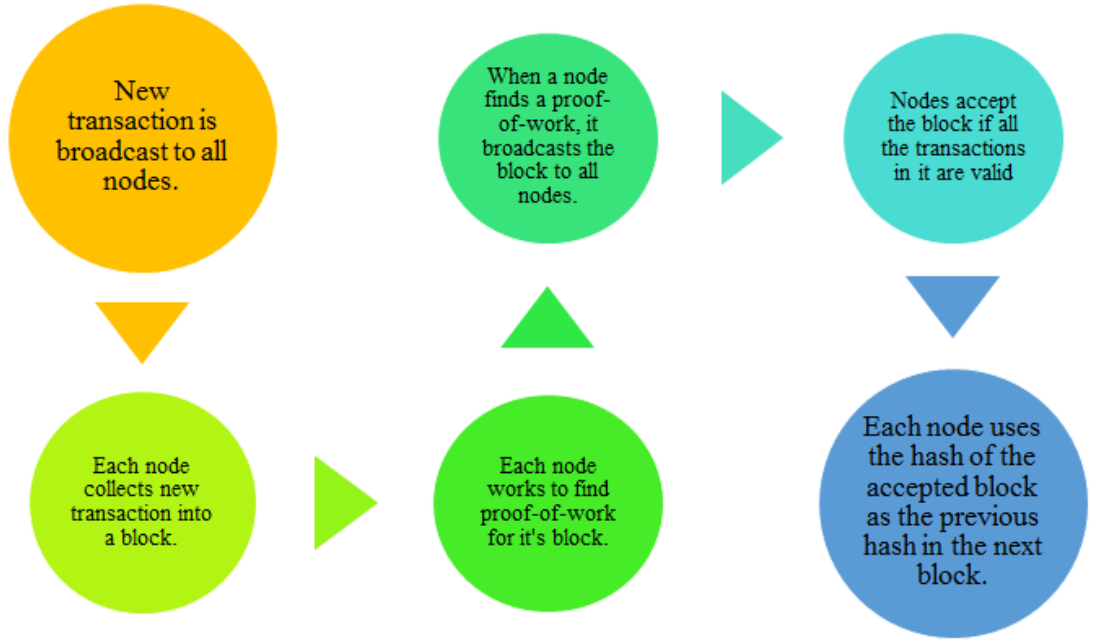


Source: Edureka

Consensus Mechanism

➢ Proof-of-Work (PoW):

- ❑ Have a variety of nodes such as full node, miner node, light node.
- ❑ In PoW mechanism, miners are responsible for maintaining the blockchain.
- ❑ Miners perform cryptographically hard and computationally resource intensive operations.



Source: EtherWorld.co

Consensus Mechanism Used

➢ Proof-of-Authority (PoA):

- ❑ A BFT consensus mechanism for private and permissioned blockchain.
- ❑ A set of validator maintains the blockchain,
- ❑ Run in rounds; A validator proposes a block in its respective round,
- ❑ Other validators verify the block and adds it onto the chain; reaching a consensus.

Source : https://cryptocurrencyhub.io/proof-of-authority-poa-b8faad1c768e?gi=cb0cc2a33d27

Experimental Setup

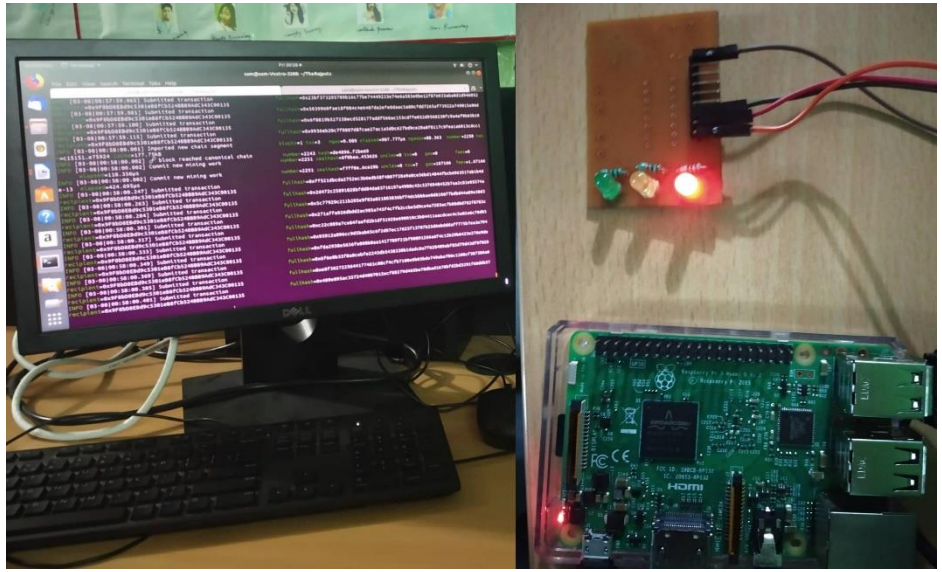


Fig. 1. Validator node & Processing Unit Setup

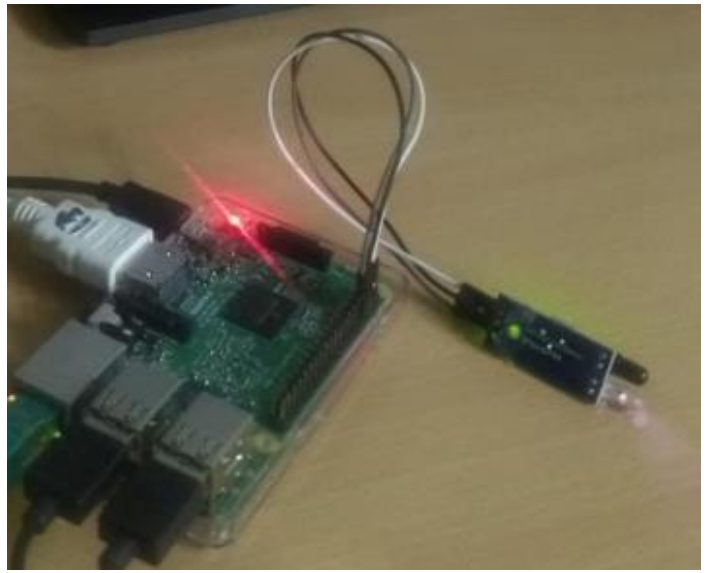


Fig. 2. IR sensor interfaced with Processing unit

Table 1. Devices and their role

Device name	No. of device	Geth version	Role
Dell-Vostro (8 GB RAM, i7-7700 CPU, 1 TB HDD)	1	v1.8.17-stable release	Validator
Raspberry Pi 3	1	geth 1.8.18 ARMv7	Validator (Processing Unit)
IR Sensor	1		Home IoT device
LED	2		Home appliance
nodeMCU	1		Home IoT device

System Characteristics

- Home resident can control the appliances via the smart contract.
- The activity is logged onto the blockchain.

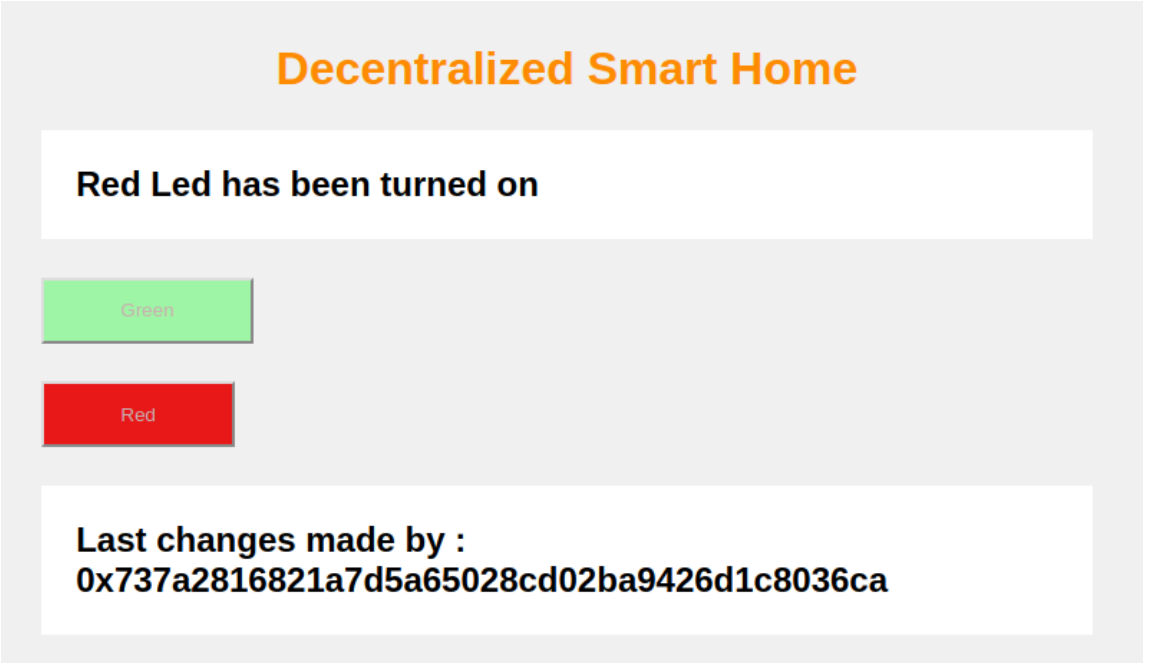


Fig. 3. User Interface

Results

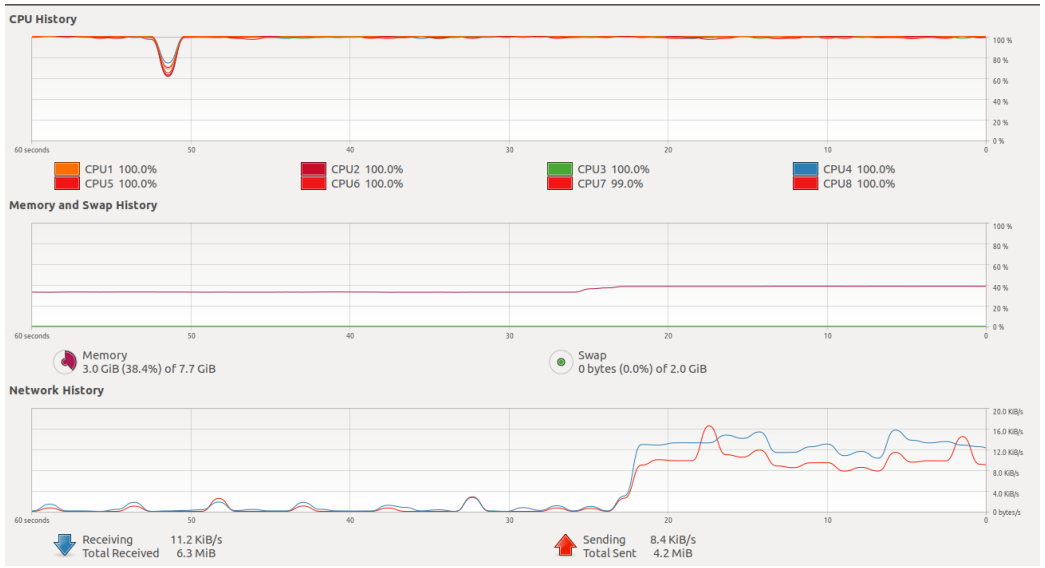


Fig. 4. Performance with PoW

Fig. 5. Performance with PoA

- We analyze the performance by evaluating the CPU utilization as the parameter
- Executed a set of 10,000 tx's for obtaining the plots.

Discussion

From the results, we can observe that

- The CPU utilization when using PoA as the consensus mechanism is far more lower in compare when the PoW mechanism is used.
- It shows that the PoA as a blockchain consensus mechanism can be one of the potential and lightweight solutions for IoT use cases such as smart homes.

Conclusion

- Our work presented a framework and a prototype implementation of a blockchain based approach for managing smart home appliances.
- Proposed system provides better, reliable and secure services to the residents.
- It also preserve the privacy of the user data, as it is not sent outside the home.
- The use of PoA over PoW not only increased the throughput but is also less expensive.
- The evaluation of the result demonstrates the feasibility of the system.

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