Blockchains and Authorization in Constrained IoT Environments

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Motivation and challenges

- Why constrained IoT environments ?
- Why or why not blockchains ? Which type of blockchain ?
- Goal: identify and quantify tradeoffs in terms of **transaction cost, transaction delay, trust, and privacy**

Challenges

- Transaction cost and delay
- Fully decentralized solution
- Ensuring that IoT devices actually provide promised access
- Constrained client devices & constrained IoT resource devices

Single public ledger not enough

Blockchain interaction with real world is a challenge

Why constrained IoT environments?

- Because many IoT devices are constrained in terms of
  - processing and storage resources
  - network connectivity

Reducing usage also ***reduces power consumption*** & ***security threats***

Scalability of IoT systems ***can be addressed*** by utilizing device-to-device communication

Device-to-device technologies ***exist*** and are ***becoming mature***

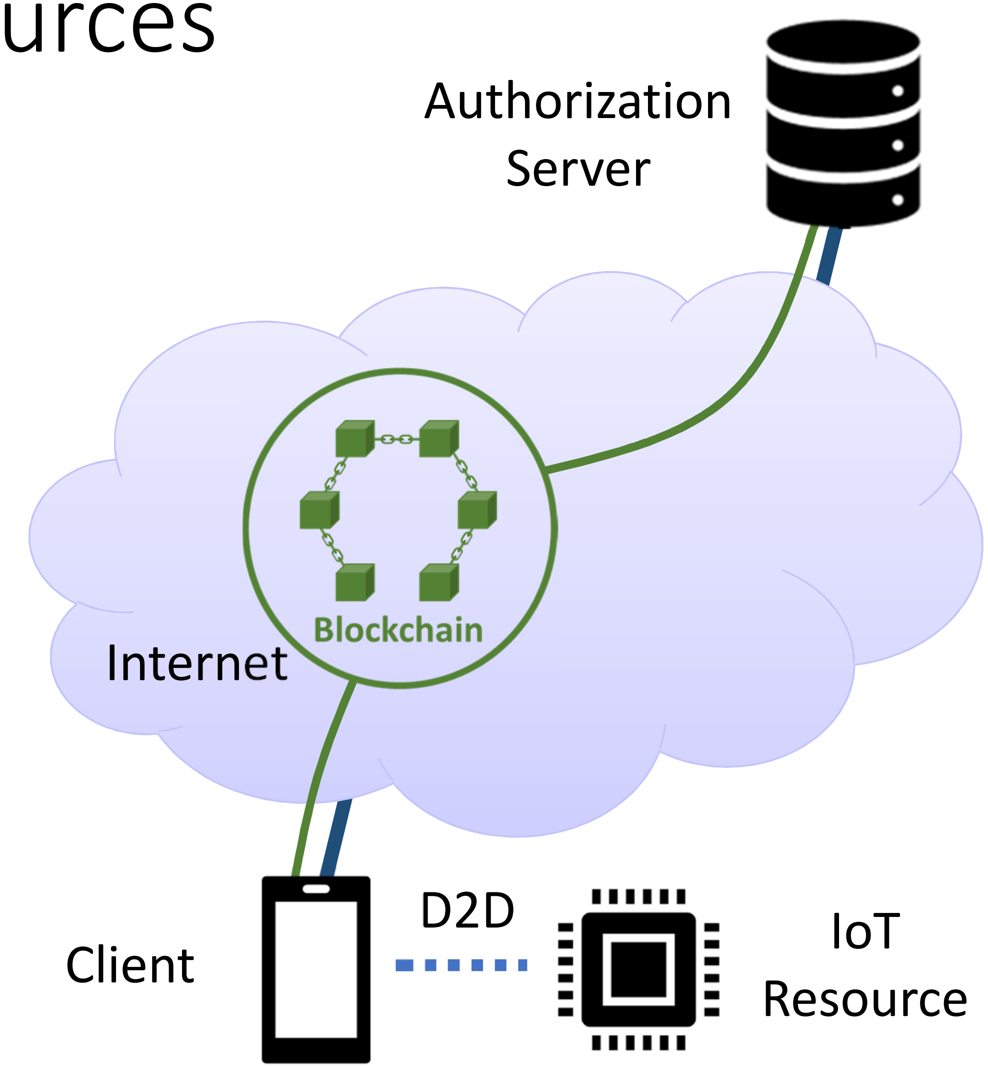
New challenge: how to achieve ***trusted*** device-to-device communication

Why/which type of blockchains?

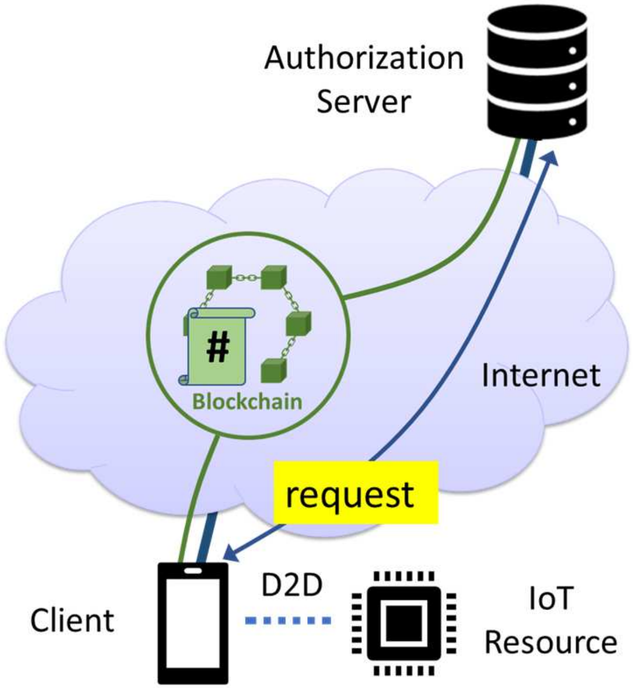
- **Decentralized trust,** i.e. no single trusted third party
  - Public ledgers: *wide-scale decentralized trust*
  - Permissioned ledgers: *degree of trust* determined by permissioned set
- **Immutability**
  - related to first point, majority of nodes need to agree to change state
  - depending on scenario, can be achieved by other means
- **Transparency**
  - not only a feature but a *requirement* for decentralized trust
  - tradeoff with *privacy*
- **Availability**, through *decentralized storage and execution*
  - can be achieved other ways

Constrained IoT resources

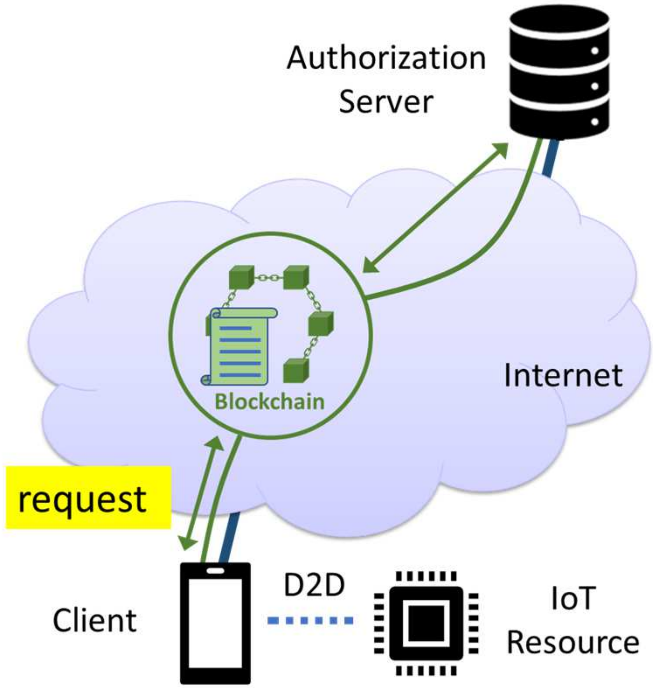
- IoT resource has limited processing, storage and only D2D connectivity
- Authorization Server (AS) handles requests on behalf of IoT resource
  - OAuth 2.0 authorization framework
  - Based on access tokens
- Client and AS always connected and can interact with blockchain



Two approaches with one blockchain



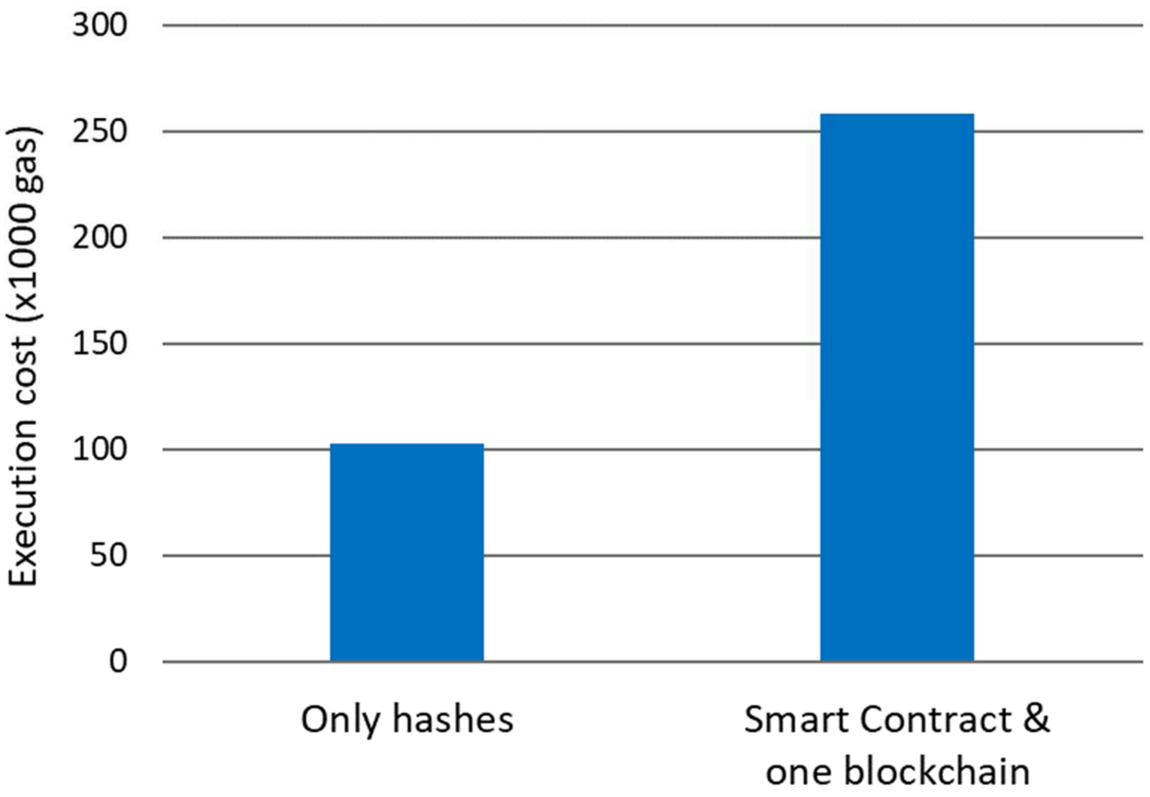
1. Record only hashes



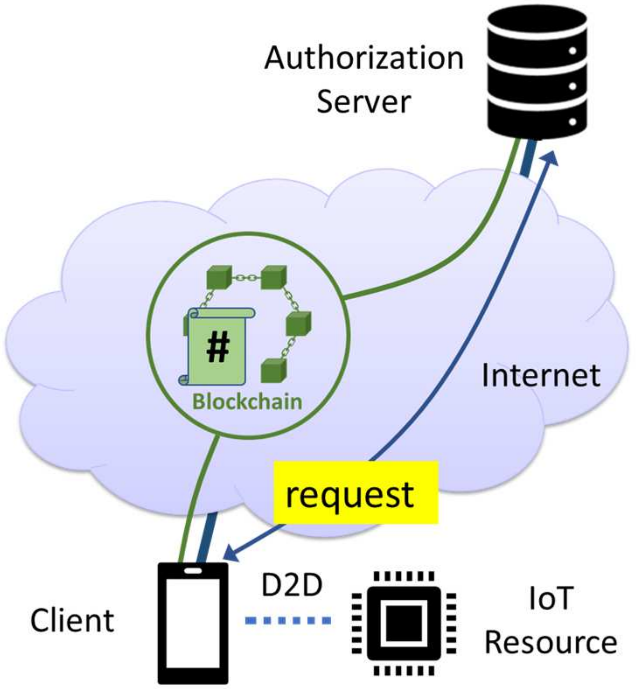
2. Smart Contract

Single blockchain: execution cost

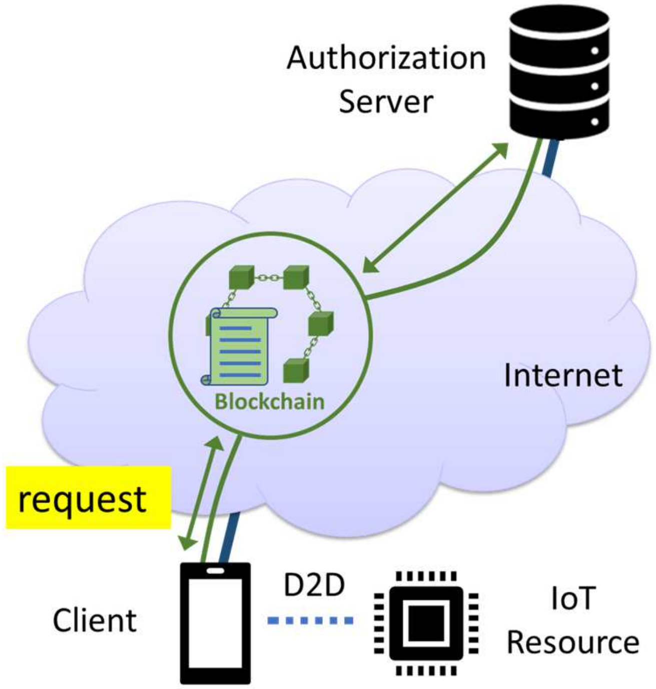
- Smart contract requires 2.5 times EVM gas compared to simply recording hashes
- Only write transactions cost gas
  - Reading data has zero cost
- Quantifies cost for higher functionality of smart contracts
  - Authorization policies & logic



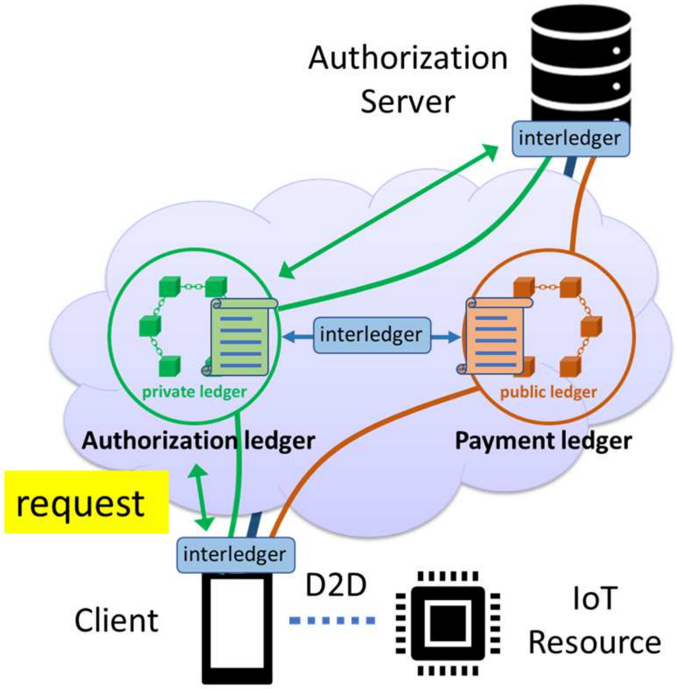
Smart contracts and two blockchains



1. Record only hashes



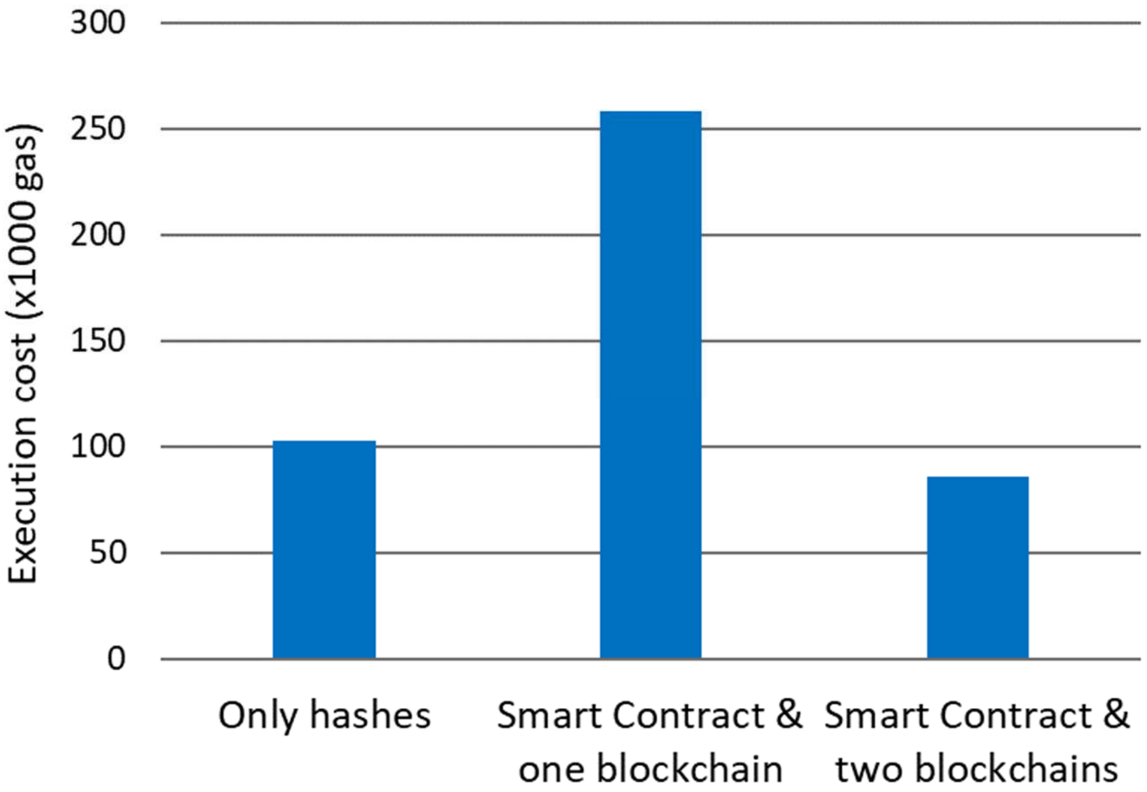
2. Smart Contract



3. Smart Contract & two blockchains

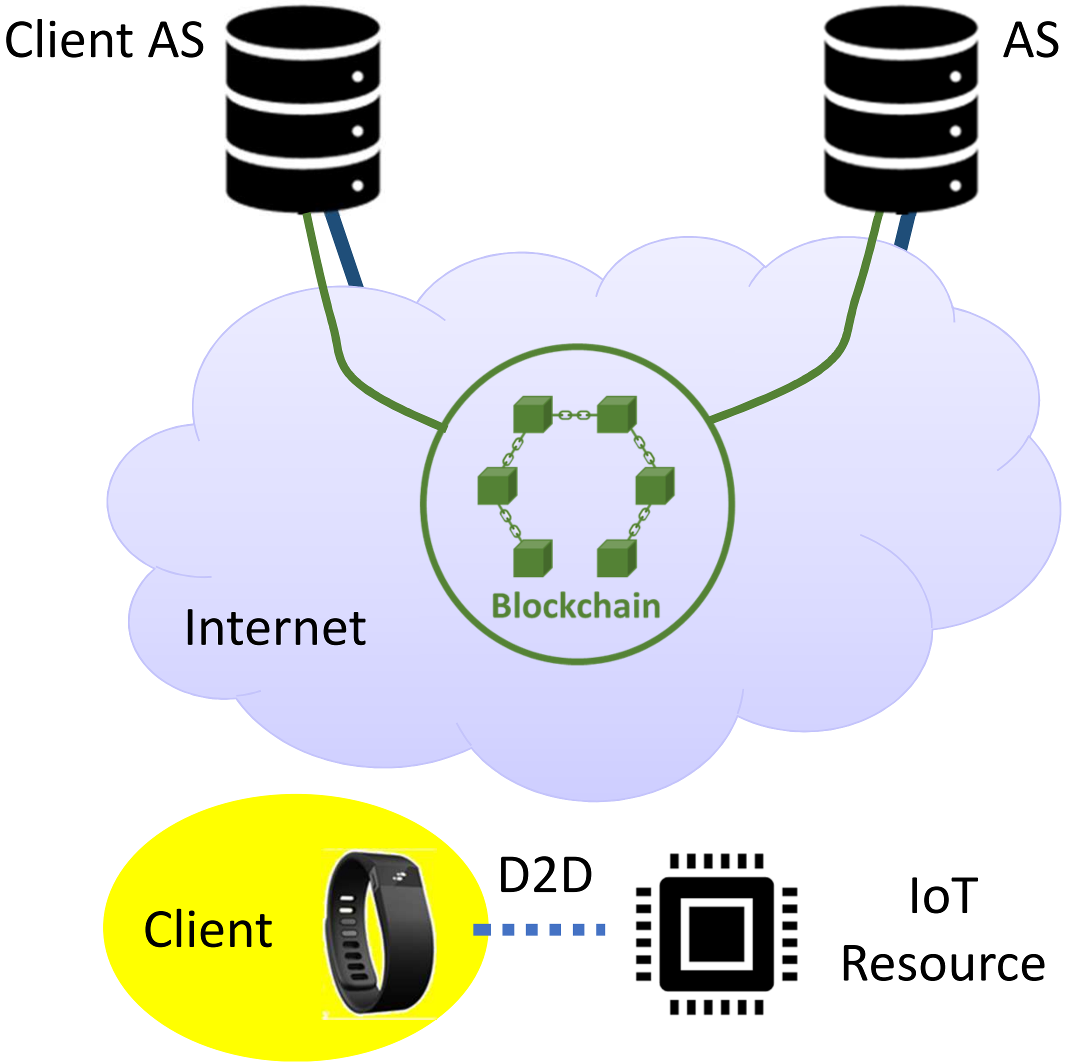
Execution cost

- Two blockchains achieve lower cost compared to one
  - Only payment transaction on public ledger
- Tradeoffs
  - Two ledgers: **trust, transparency, and privacy** for authorization transactions determined by **permissioned node set**
  - Public ledger: **wide-scale decentralized trust and transparency**



Disconnected resource & ~~connected~~ disconnected client

- Up to now assumed that client
  - has continuous connectivity
  - Interacts directly with blockchain
- Client AS can, on behalf of client,
  - interact with ledger
  - Interact with IoT resource AS
- Client must obtain authorization information from client AS at some prior instance (asynchronously)



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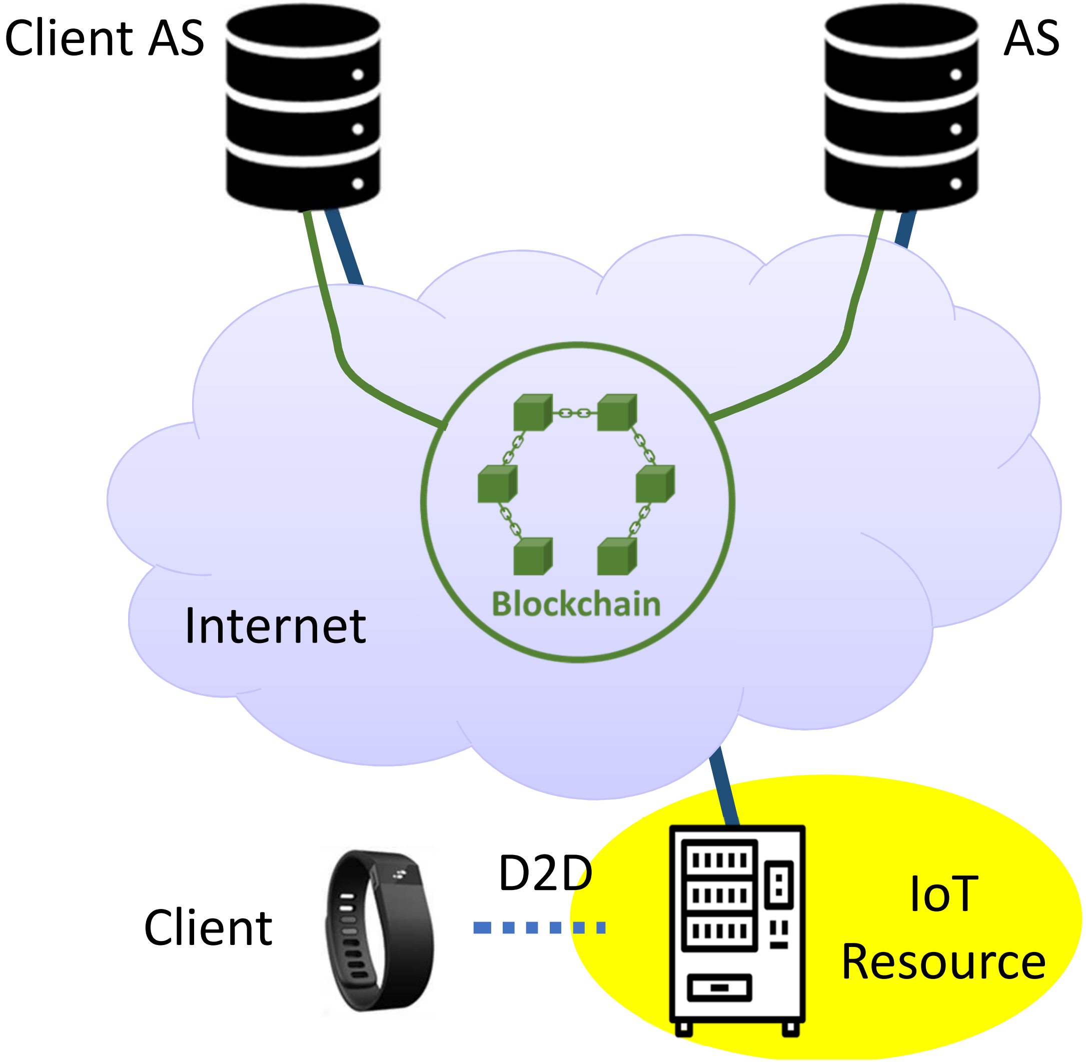
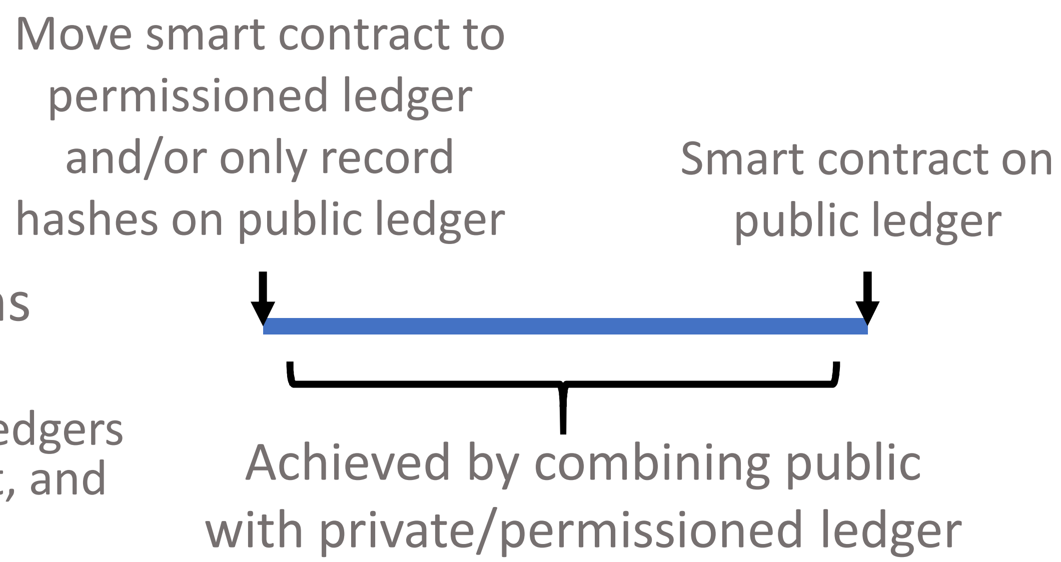
Connected resource & disconnected client

- Connected IoT resource acts as relay for disconnected client



Challenges

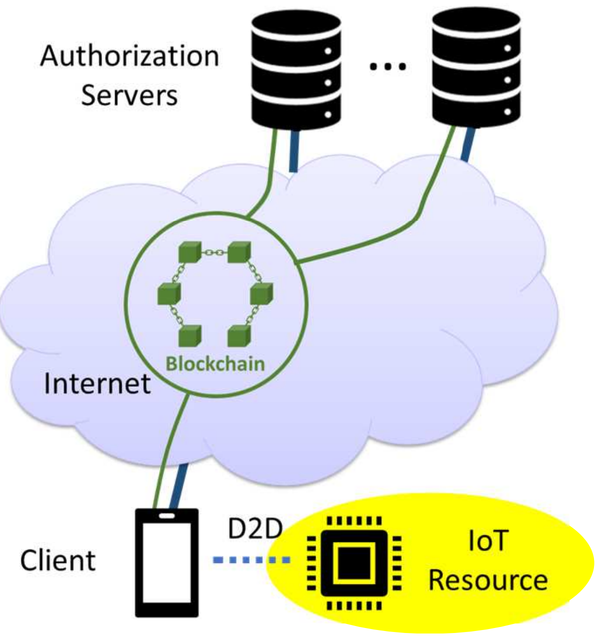
- High cost & delay incurred by blockchains
  - Due to public ledger
  - Combining public & private/permissioned ledgers can provide different tradeoffs of cost, trust, and privacy
  - Off-chain transactions: unidirectional payment channels sufficient for some IoT applications
- Single AS
  - Blockchain advantages are limited to assets & transactions residing in the blockchain
  - Once we traverse blockchain boundaries we loose these benefits
  - Solely adding multiple ASes not a solution because IoT resource not directly connected to blockchain
  - Need processing at client to reduce data & ensure trust with constrained IoT resource



Move smart contract to permissioned ledger and/or only record hashes on public ledger

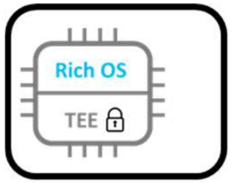
Smart contract on public ledger

Achieved by combining public with private/permissioned ledger

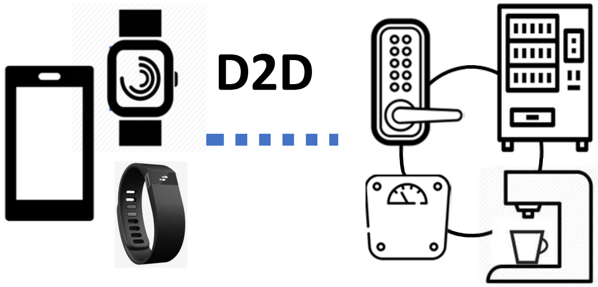


Challenges (cont)

- Trust that resource indeed provides access
  - Trusted Execution Environments (TEEs) such as ARM’s TrustZone, Intel’s SGX, Keystone (open source RISC V)
- Constrained clients
  - Need client proxy/agent (analogous to AS acting as proxy of IoT resource)



IoT resource with TEE



Further info: https://mm.aueb.gr/blockchains/

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