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Towards Application Portability on Blockchains

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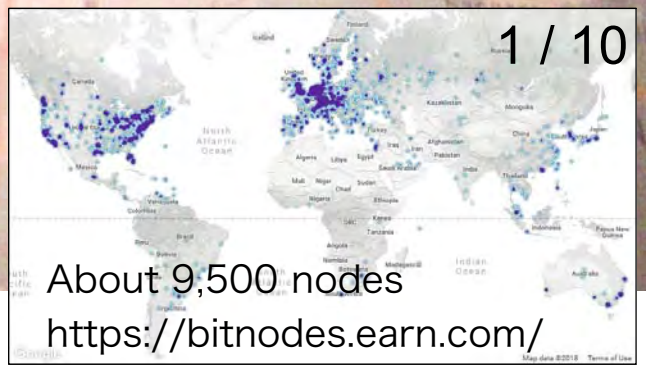
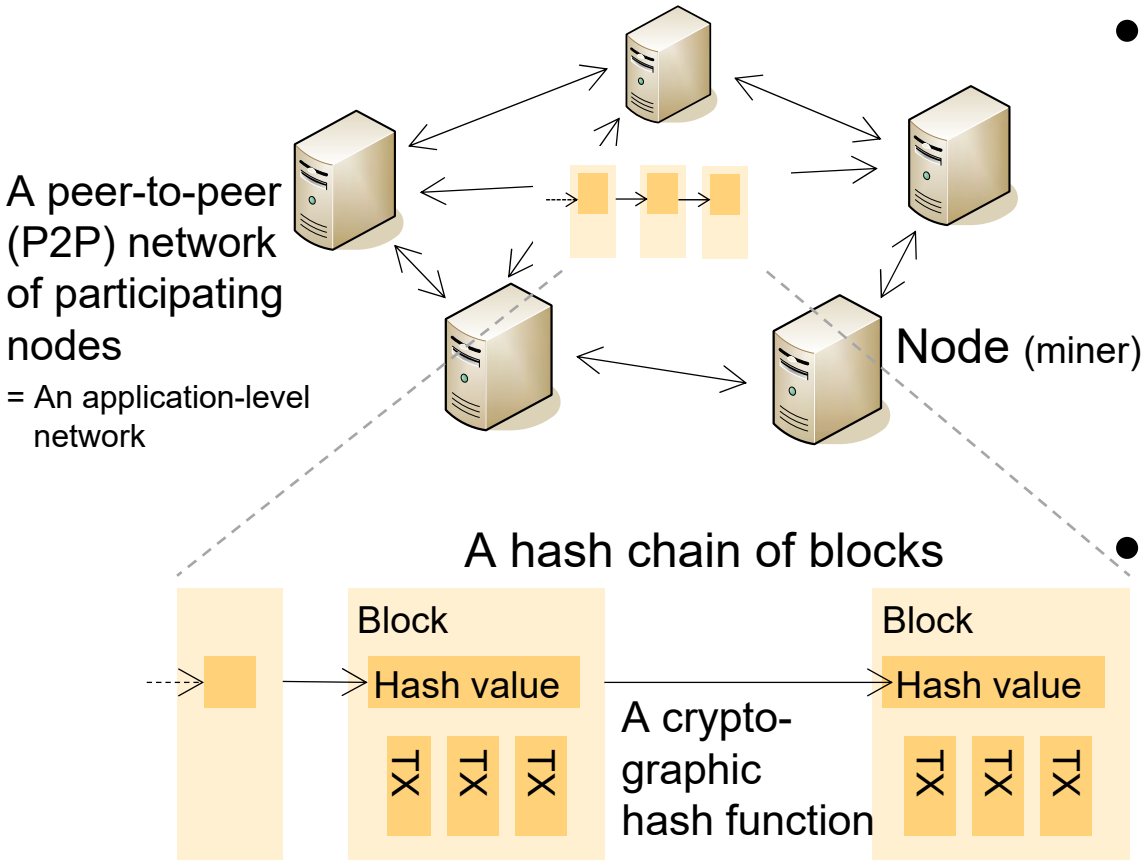
Background: (Public) Blockchain

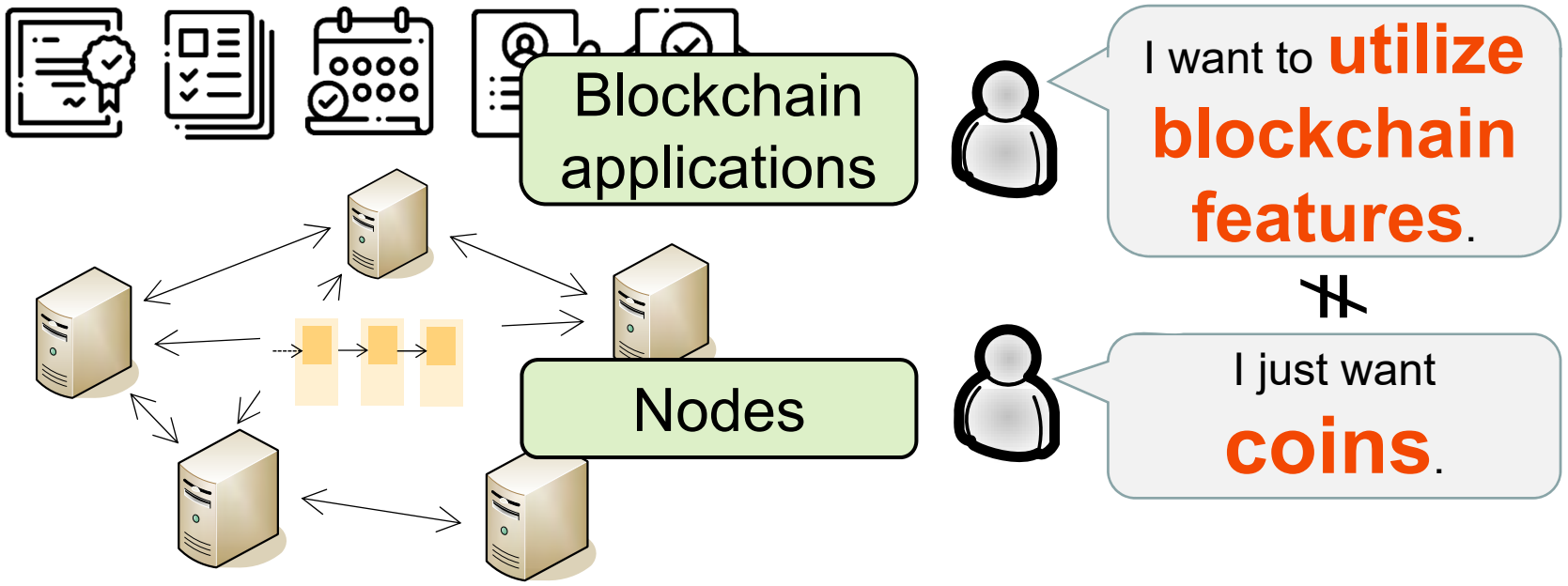




- A distributed system supporting Today's cryptocurrencies
  - Bitcoin's market capitalization is US$ 110B.
  - 9,500 Bitcoin nodes
- A block and transactions in the block are confirmed by Proof of Work / Stakes / Importance / Elapsed Time / … algorithms.
  - A winning node (miner) takes some new **coins**.

Problem: "Incentive mismatch" / インセンティブ (動機) 不整合

- Blockchain nodes and applications do not share common incentive.



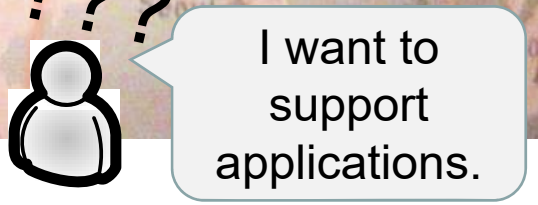
- If a public blockchain cannot provide sufficient economic incentives …

Problem: "Incentive mismatch" / インセンティブ (動機) 不整合

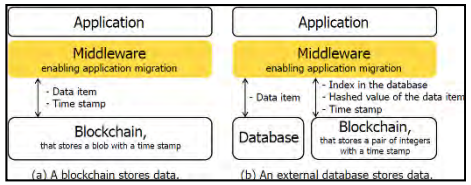
- If a public blockchain cannot provide sufficient economic incentives …
  - E.g. A fall in coin prices

- It loses the ability to confirm transactions securely.
  - Fewer supporting nodes -> Vulnerable to attacks
    - Majority (51%) attack, eclipse attack, …
- In May 2018, such attacks succeeded in a row.
  - Bitcoin Gold: 388,200 BTG = US$ 18,600,000 = 20 億 JPY/円
  - Monacoin: 23,832 MONA = US$ 93,500 = 1,000 万 JPY/円

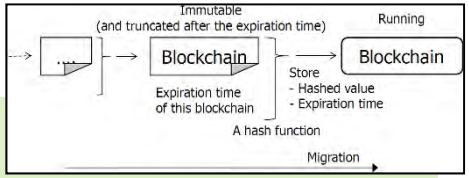
Possible solutions



1. Align their incentives ???
   - … Non-trivial and an open problem
2. Make applications **portable**
   - A potential (and next-best) solution



Middleware design



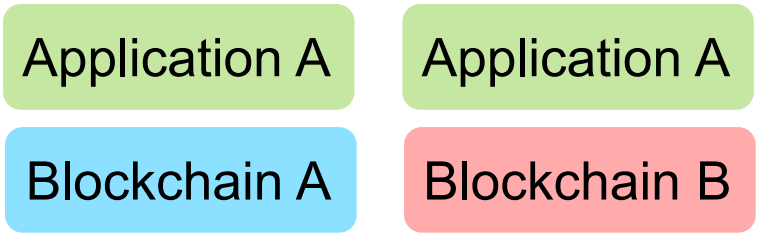
Migration process

- Our contributions
  - (Pointing out "incentive mismatch" problem)
  - A middleware design that enables application migration between blockchains
  - Migration process
  - Note: Implementation is part of future work.

Preparation:
Portability levels

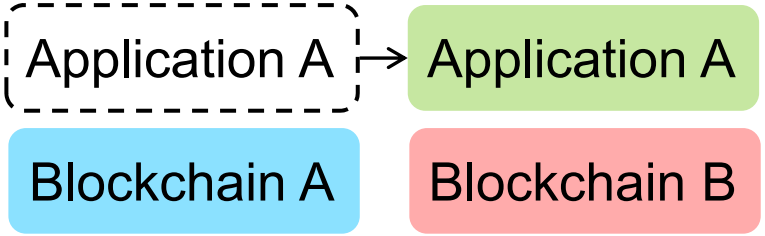
(1) *Runnable*

An application can run on both.



(2) *Migratable* Our target

An application can migrate.



- *Runnable*
  - A common API and smart contract language enable *runnable* portability.
  - Different blockchains running the same middleware also enable it.
  - It is unlikely to be useful because it requires application restart and loses fundamental blockchain features:
    - Proof of data existence
    - Verification of state changes
- *Migratable* – our target

Preparation:
Data to be migrated

In case of a cryptocurrency:

(1) Current state of the application ↔ ・ Account balance

(2) Logs ⟷ ・ Transactions

– Metadata of the states that describe state changes and their time stamps.

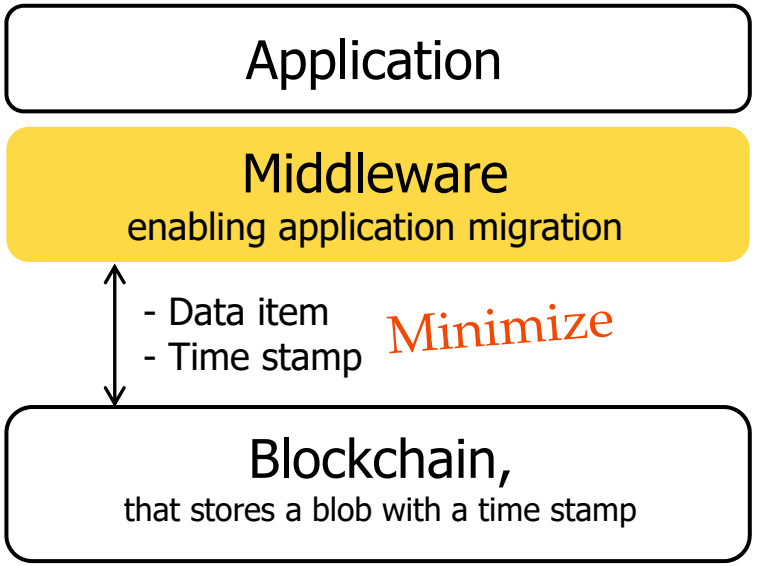
Fundamental blockchain features:

・ Proof of data existence	does not require logs.
・ Verification of state changes	requires logs.

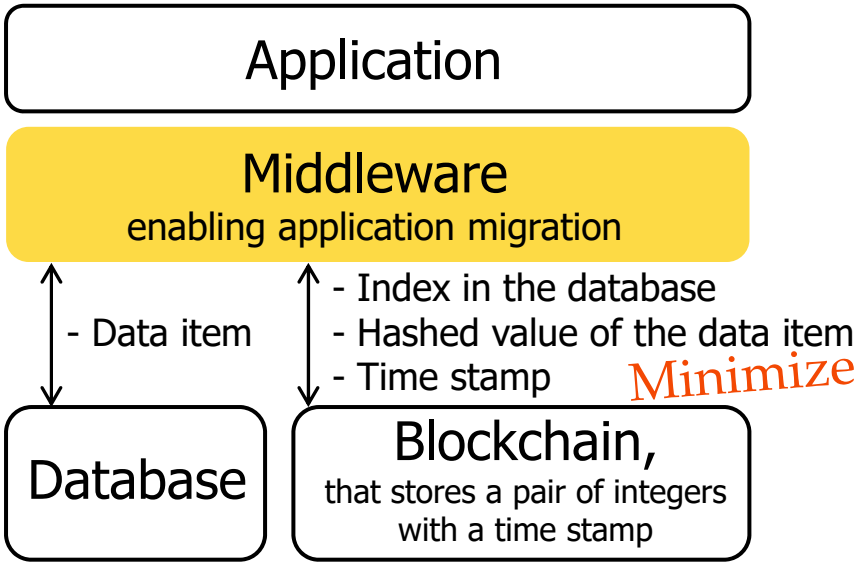
Middleware design

- Design principles
  - Minimize dependence on specific blockchain middleware
    - It stores simple data items, such as numbers or byte sequences, together with time stamps.
  - Do not expect to be able to retain trust in the original (source) blockchain
    - We cannot continue to rely on it in case of imminent collapse of it.

(a) A blockchain stores data.

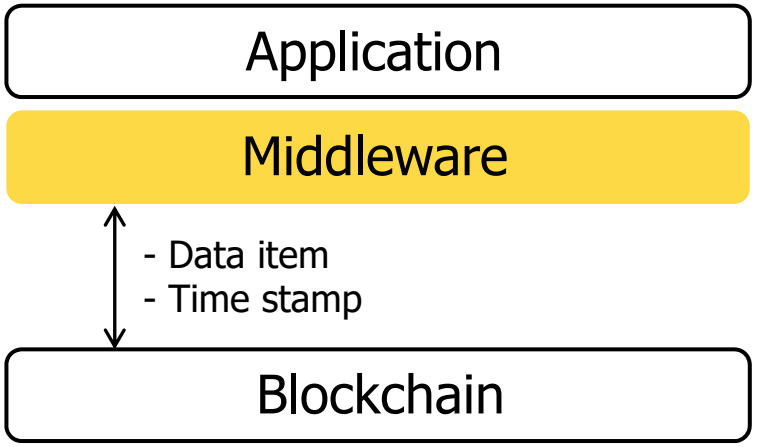


(b) An external database stores data.

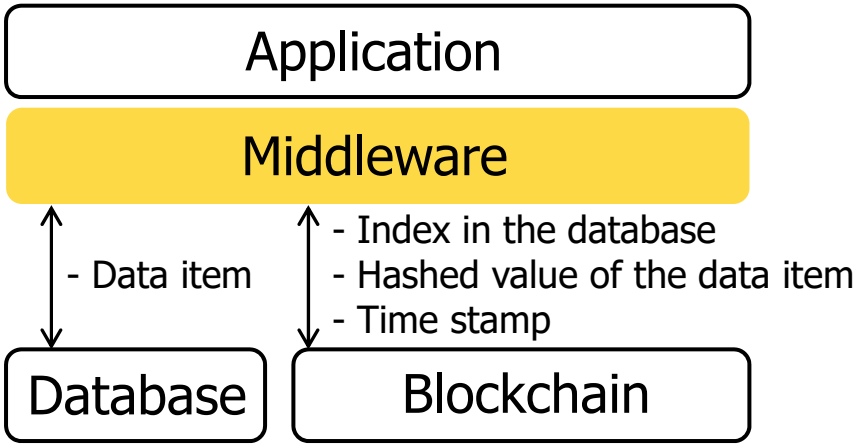


Middleware design (cont'd)

(a) A blockchain stores data.



(b) An external database stores data.



- Pros and cons
  - **(b)** reduces the blockchain size, Instead, the database should be fault-tolerant. Replication or erasure coding work.

To be fault-tolerant

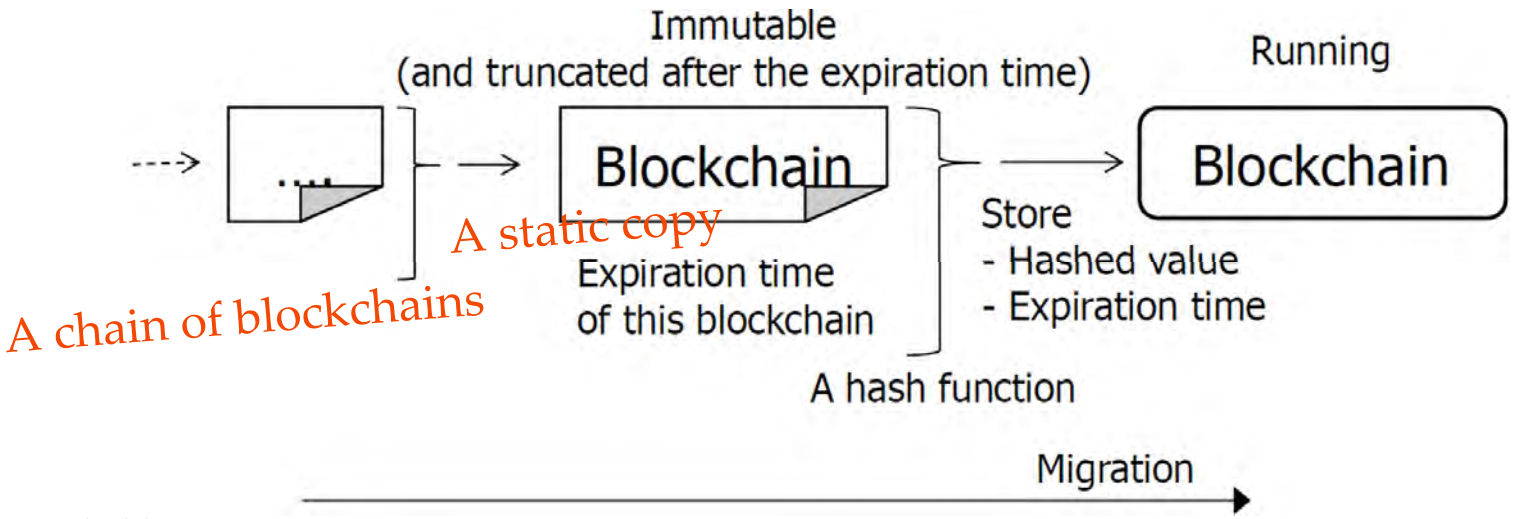
Reduced-size

- If verification of state (data) changes is
  - required: **(a)** must keep the original blockchains.
    (b) must keep all the versions of data.

    } In other words, **Logs** are required.
  - not required: **(a)** can abandon the original blockchains after copying metadata to prove the data exist.
    (b) can overwrite data.

Migration process

In case verification of state (data) changes is required



The middleware

- stores a static copy of the original blockchain, truncating it at the expiration time specified in block height.
  - Not rely on the original blockchain's middleware to still be running and accessible online.
  - Truncating allows us to stop trusting the original blockchain after the expiration time.
- makes a chain of the stored blockchains. It prevents tampering.
- accesses the stored blockchain. It requires a parsing library.

Summary

- "Incentive mismatch" problem pointed out
- Middleware design enabling application migration presented
- Migration process provided

- Future work
  - Proof of the design by implementation
  - Incentive-matched blockchain
  - Interoperability between heterogeneous blockchains

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