Blockchain-based payment for supply chains

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Outline

Problem

- Hydrogen is a part of the Australian government's pivot towards clean energy.
  i. $540 million pledge for "clean" hydrogen.
  ii. Global market worth USD155 billion by 2022.
- To accelerate Australia's move towards a hydrogen market, can a blockchain solution be used to deliver trust into the renewable energy market?

Hydrogen Energy

- Hydrogen is a clean fuel that produces only water when consumed.
- Harvested from sources of renewable energy: solar and wind.
- Commonly harvested through natural gas reforming and a technique referred to as *electrolysis*.

Aim

- Is there a usable blockchain solution that will develop 'trust' in the hydrogen market.
- *Why?* Because customers are wary of the reliability and quality of hydrogen energy.
- *How?* Using a permissioned blockchain to help develop trust without a centralised authority.

General Theory

- The level of output is determined by the level of *effective demand*.
  1. Effective demand is made volatile by the presence of investment spending and *expectations* in the market.
- A change in aggregate industrial wide income Y is impacted by a multiplier with investment and savings (I and S).
  1. $\Delta I \rightarrow \Delta S$.
- The government can play a role in spurring *effective demand* using fiscal tools in the hydrogen market.

[1] Keynes, John Maynard. 2021. *The General Theory Of Employment, Interest And Money*. London: Palgrave Macmillan.

Taxation

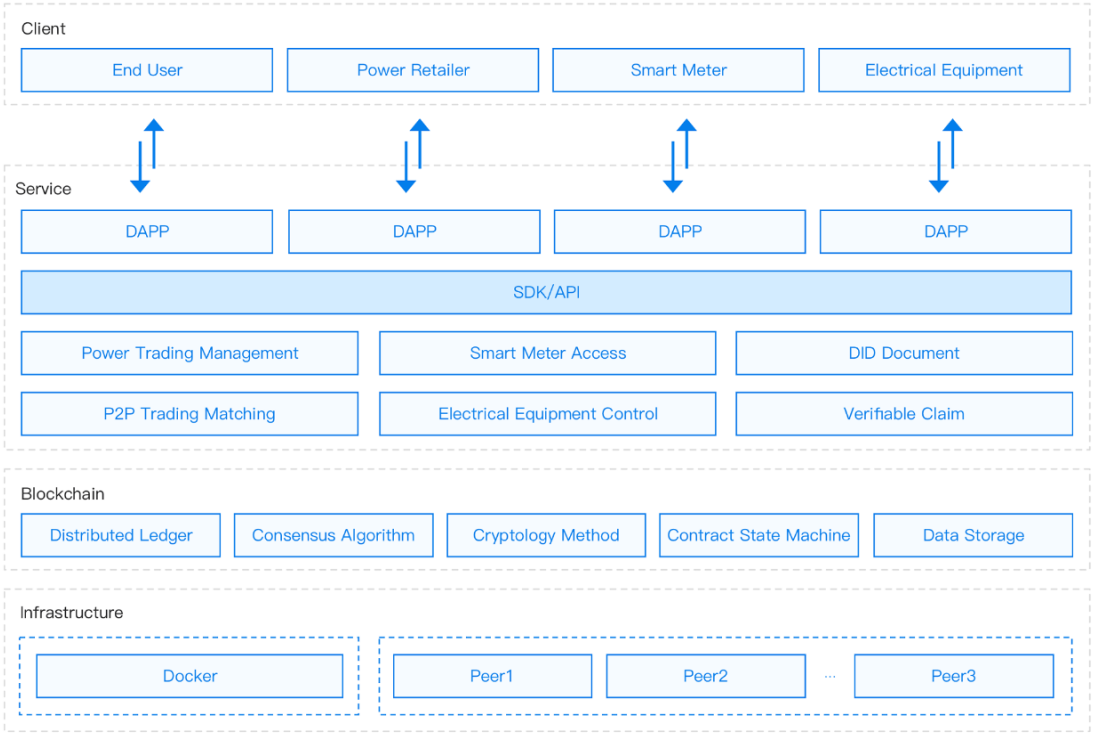
- The use of *smart contracts* can 'nudge' consumers of hydrogen to use cleaner hydrogen.
  1. A 'carbon tax' enforced by a player in the system.
- Punishing non-clean sources of energy through smart contracts can accelerate the removal of negative externalities.
  1. Rapidly adjust to 'cleaner' equilibria inside a market.

Hydrogen Certificates

- An approach for formally attesting the level of cleanness in a produced unit of hydrogen.
  1. Shared across the supply chain.
  2. Can attest to standards related to Hydrogen safety and quality.
- An agent in the blockchain can act as the certification body.

Distributed Energy System

- *Li et al., (2019)* developed a blockchain architecture for the energy market using smart contracts with non-cooperative game theory.



[1] Li, Yinan, Wentao Yang, Ping He, Chang Chen, and Xiaonan Wang. 2019. "Design And Management Of A Distributed Hybrid Energy System Through Smart Contract And Blockchain". *Applied Energy* 248: 390-405. doi:10.1016/j.apenergy.2019.04.132.

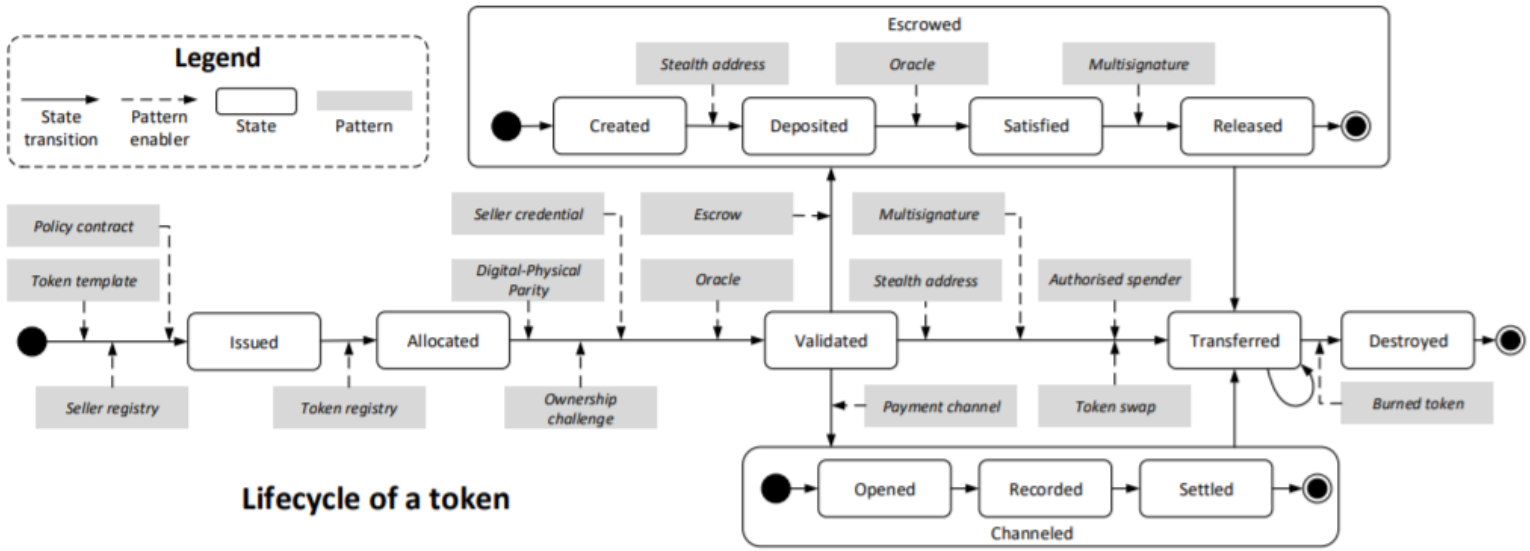
CertifHy

- A European certification scheme for clean hydrogen.
- 75,000 digital certificates issued.
- Software system.
- Allows for registration, issuing and transfer of certificates.

[1] "Certifhy". 2021. *Certifhy.eu*. https://www.certifhy.eu/.

Patterns

- Token template pattern
- Token registry pattern
- Escrow

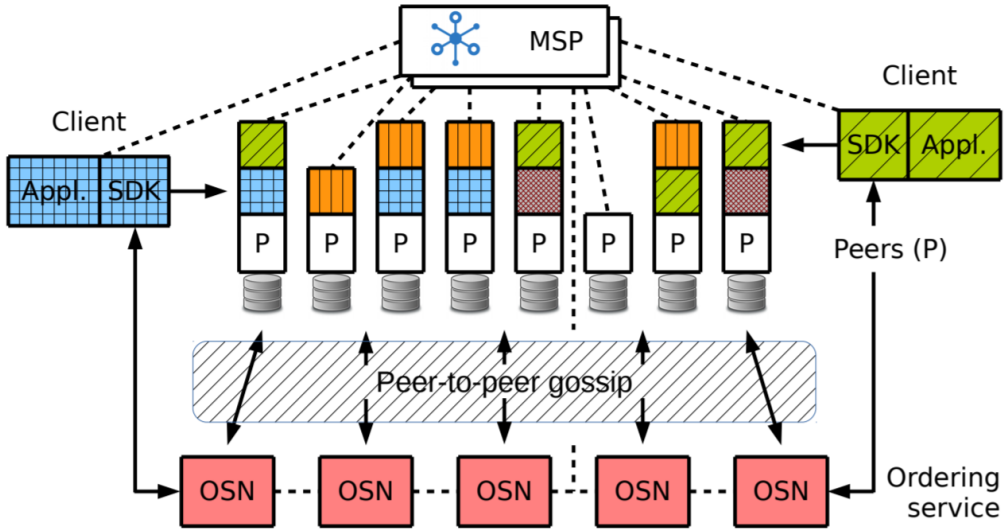


Lifecycle of a token

[1] Lu, Qinghua, Xiwei Xu, Dilum Bandara, Shiping Chen, and Liming Zhu. 2021. "Design Patterns For Blockchain-Based Payment Applications". *ACM*. doi:10.1145/1122445.1122456.

Fabric

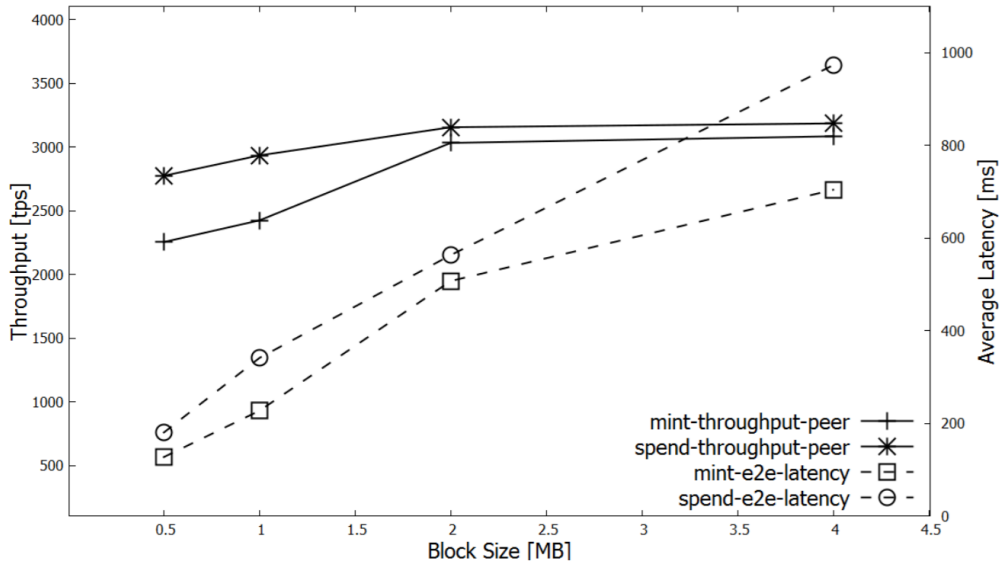
- A modular and extensible open-source system for developing blockchain applications.
- Pluggable consensus algorithms.
- *Chaincode* in general programming languages.
- Channels for enterprise confidentiality.



[1] Androulaki, Eli, Artem Barger, Vita Bortnikov, Christian Cachin, et al. 2018. "Hyperledger Fabric: A Distributed Operating System For Permissioned Blockchains".

Fabric Architecture

- Novel *execute-order-validate* architecture supporting high throughput transactions.
- Dedicated ordering nodes.
- Support for up to 3560 TPS (lab environment).



[1] Androulaki, Eli, Artem Barger, Vita Bortnikov, Christian Cachin, et al. 2018. "Hyperledger Fabric: A Distributed Operating System For Permissioned Blockchains".

Fabric Projects

- GoDirect Trade introducing trust into the supply chain for used aeroplane parts.
- OrgBook British Columbia helping small businesses find critical information about business partners.
- A permissioned blockchain as a 'trust machine' for organisations.

[1] "Orgbook Case Study – Hyperledger". 2021. *Hyperledger*. https://www.hyperledger.org/learn/publications/orgbook-case-study.

[2] 'Case Study: Honeywell Aerospace Creates Online Parts Marketplace With Hyperledger Fabric'. 2021. Blog. *Case Studies*. Accessed April 14.

Summary

- The government can use the blockchain to deliver trust and growth in hydrogen energy.
- Smart contracts can be applied for verification of hydrogen quality.
- Previous blockchain energy solutions rely on centralised parties or use the blockchain to act as an ‘auction house’.

Overview

1. Establish requirements for actors in the system.
2. Formalise authorities in the Hydrogen market as nodes in Fabric.
3. Express business logic for actors as 'chaincode'.
4. Develop a user interface for actors to interact with the blockchain.

Architecture Details

- Crash Fault Tolerant consensus algorithm: *Raft*.
  - Ensures high throughput transactions.
- Utilise Fabric channels to keep pricing information related to Hydrogen suppliers confidential.
- API endpoints to interface with the blockchain.
- Web application for users to query and modify the blockchain.

Solidity Example

```
1  pragma solidity >=0.8.3;
2
3  contract Certificate {
4    function purity() constant returns (uint256) {
5        return ...;
6    }
7  }
8  contract CarbonIntensity is Certificate {
9    function purity() constant returns (uint256) {
10       return ...;
11   }
12     function intensity() constant returns (
           uint256) {
13         return ...;
14     }
15 }
```

Current Progress

1. Problem has been defined.
2. Deep-dive on Hyperledger.
3. Learning about smart contracts and Fabric's novel approach using 'chaincode'.
4. Literature review on previous blockchain solutions in the energy market and supply chains employing Hyperledger.

Research Timeline