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Blockchain-based payment for supply chains

Oscar Golding
Supervised by: Sherry Xu, Qinghua Lu

Thesis A: UNSW

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Hydrogen Certificates

Problem

- Hydrogen is a part of the Australian government's pivot towards clean energy.
 - 1 \$540 million pledge for "clean" hydrogen.
 - 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?

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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*.

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- 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.

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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).
- The government can play a role in spurring *effective* demand using fiscal tools in the hydrogen market.

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

Economic Rationale

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- 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.

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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.

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Existing Work in Energy Domain

Distributed Energy System

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



¹Li, 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. 4 D > 4 P > 4 E > 4 E >

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CertifHy

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

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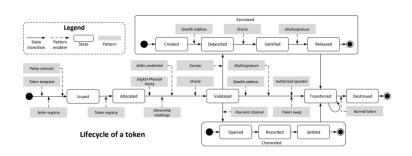
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Patterns

- Token template pattern
- Token registry pattern
- Escrow



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



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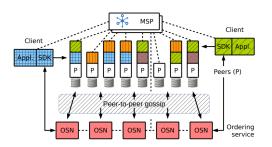
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Fabric

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



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

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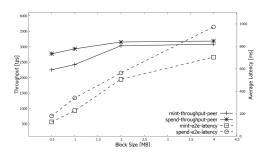
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Fabric Architecture

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



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

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Fabric Projects

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 &}quot;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. 4 □ > 4 □ > 4 □ > 4 □ >

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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'.

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- 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'.
- Oevelop a user interface for actors to interact with the blockchain.

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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

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

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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.

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