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Blockchain-based Emissions Trading with Automatic ESG Reputation

Oscar Golding (z5160173)
Supervised by: Dr. Sherry Xu, Dr. Qinghua Lu

Thesis C: UNSW

November 7, 2021

Outline

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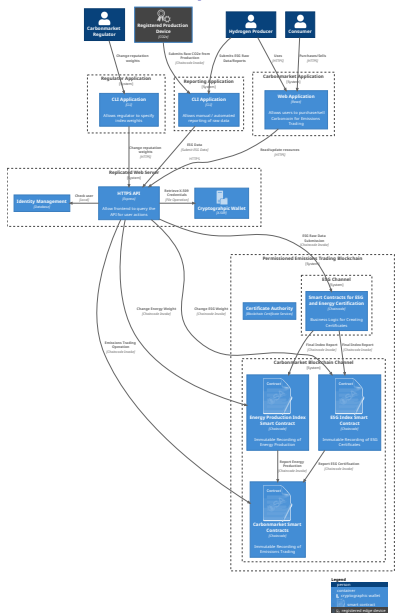
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Overview

- Issue: emissions trading is politically contentious and lacks *trust*.

- Trade the right to emit carbon on the blockchain.

- Increase market quality through an analysis of the 'reputation' of carbon market participants.

- Employ Environmental, Social and Governance (ESG) certificates on the blockchain.

- Blockchain-based ESG certificates driving the automatic operation of a carbon market.

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Expected Outcomes

- A complete Emissions Trading Scheme (ETS) application running on the permissioned blockchain *Hyperledger Fabric*.

- The ability for energy producers to effortlessly interact with an on-chain ETS.

- Allow market participants to trade carbon in a trustful manner.

- An inuitive notion of market *reputation* driven by automated ESG certificates on the blockchain.

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Complete Architecture

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On-chain Currency Brief Overview

- Creation of an on-chain currency to facilitate carbon trading amongst energy producers.

- Policy contract pattern specifies how to trade *Carboncoin* amongst other users.

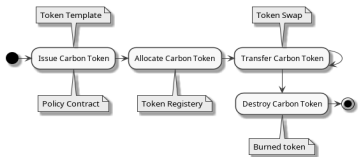- Optionally purchased with a *fiat* currency such as Australian dollars.

Figure: Carboncoin

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Blockchain Patterns

- Token template - offers, *Carboncoin*, reputation
- Policy contract - sale finalisation, offer creation, reputation
- Token registry - *Carboncoin*, reputation
- Token swap - *Carboncoin* sales
- Burned token - carbon dioxide emissions
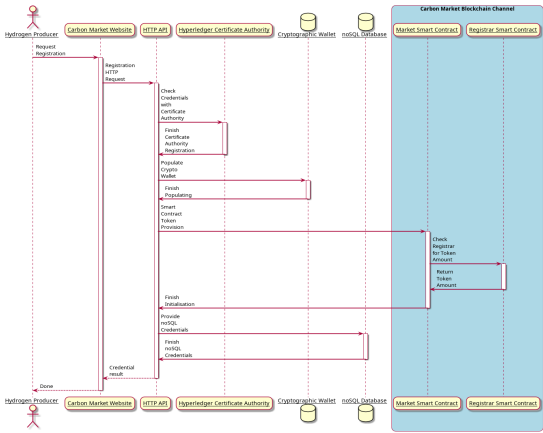
Figure: Token Patterns for Carboncoin

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Account Creation

- Producer creates account, the quantity of energy production created by the firm is checked on-chain to allocate *Carboncoin*.
- Simple heuristic - amount of energy production is recorded by a regulator and *Carboncoin* is distributed to producers based on the on-chain recording.
- *Hyperledger Certificate Authority* generates a *X.509* certificate to facilitate blockchain invokes for a user.

Figure: Policy Contract for Token Allocation

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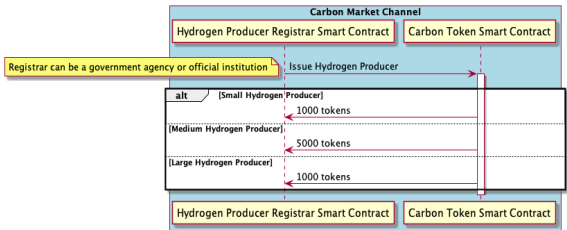
Account Creation Architecture

Figure: Account Creation

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Decentralised Offer Creation

- Policy contract pattern - requires producer role.
- Sale offers constrained by the amount of *Carboncoin* in their account minus the quantity they are offering on the open market.
- Visibility open to all other users.

Figure: Offer Creation
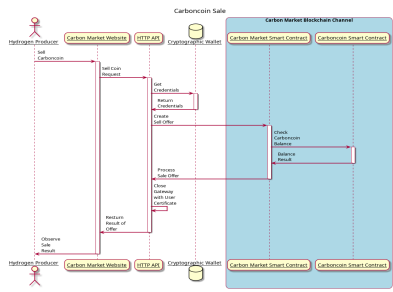
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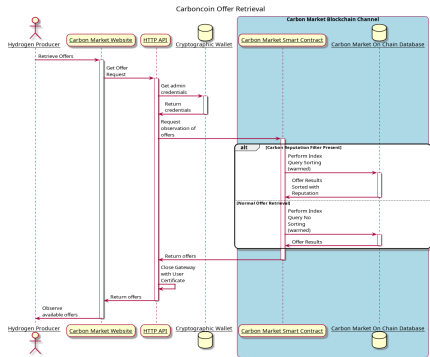Market

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On-chain Order Book

- On-chain order book.

- A template token pattern is utilised to place all *Carboncoin* sale offers on-chain.

- Generates trust in the market at the expense of chaincode performance.

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Offer Retrieval

- Offers are retrieved from an on-chain *couchDB* database with a warmed index for performance.
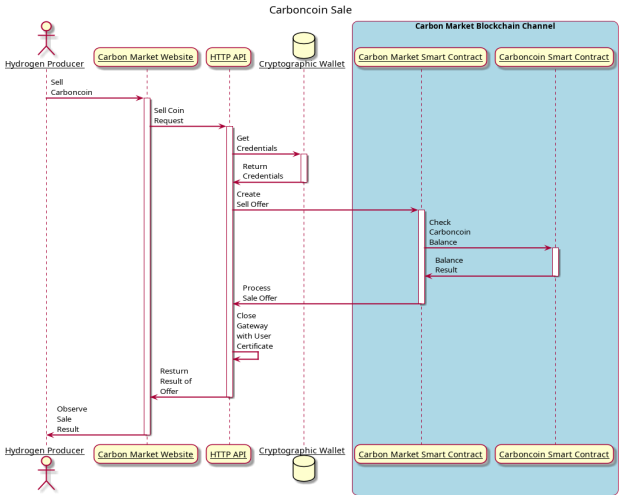
Figure: Offer Retrieval

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Decentralised Sales of Carboncoin

- Users sell *Carboncoin* - and therefore the right to produce emissions to one another - on the open market.

- Purpose built offer finder to help users find *Carboncoin* to fit a budget.

- A token swap pattern is used to facilitate the sale of *Carboncoin*.

- A sale results in the offerer receiving Australian dollars in exchange for *Carboncoin*.

- Policy contract attached to chaincode:
    - Active offer is required
    - Seller must have enough *Carboncoin*

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Sale Architecture

Figure: Decentralised Sale

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Direct Market Interaction

- A producer can directly purchase *Carboncoin* outside of the open market at an *extra cost*.

- A policy contract pattern requires the price per Carboncoin to reflect a price threshold.

- The user is given an on-chain offer token to purchase *Carboncoin*.

- The price per token is calculated using the maximum offer on the open market (see Equation 1).

- Each x_i in Equation 1 represents an active offer in the market in Australian dollars.

$$\text{Direct Offer} = \max\left(\langle x_1, x_2, \ldots, x_n \rangle\right) + 50 \qquad (1)$$

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Direct Offer Creation Example

Figure: Direct Offer Creation
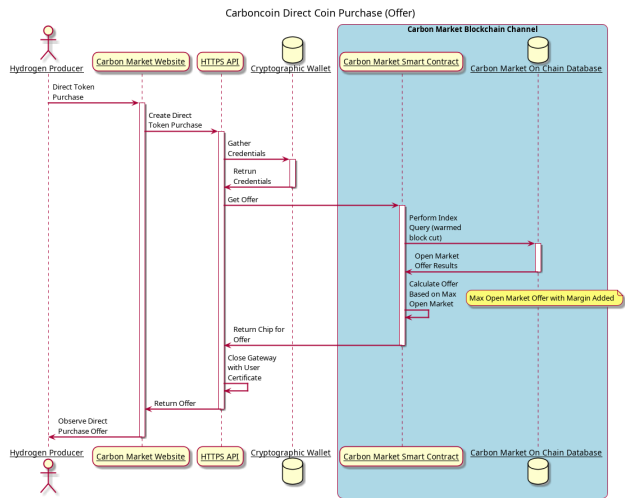
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On-chain ESG Data Compiling

- Carbon market requires the viewing of Environmental, Social and Goverance certificates to automatically expense *Carboncoin* and record reputation.

- Offload responsibility for on-chain transformation of ESG raw data to a useable index onto a 'ESG Channel'.

- Raw data can be manually/automatically submitted to chaincode in the 'ESG Channel' which authenticates and verifies to produce a final index.

- Motivated by recent work from Liu et al in 2021.

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ESG Index Compilation Example

Figure: ESG Index Compilation

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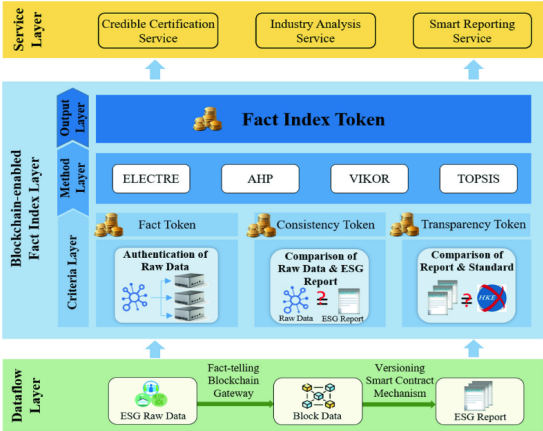Representation
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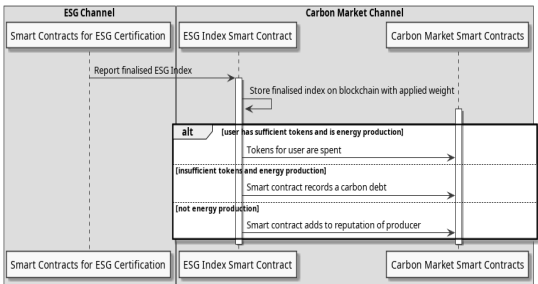Performance

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ESG Integration

- A carbon market regulator specifies unique weights for each ESG category used by energy producers.

- As an example, energy production as carbon dioxide equivalence is given a negative weight of one whilst good quality water used in production is given a score of positive two.

- The carbon market can weigh ESG data outside of the environment - such as the female employee rate found inside a company's Annual Report.

- The baseline weight is for carbon dioxide equivalence (CO2e), it always has a weight of negative one reputation.

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ESG Integration Architecture

- The carbon market has specific chaincode for communicating with the 'ESG Channel', which receives ESG index scores.

- Market chaincode applies a weight specified by the regulator to provide to the *Carbonmarket* smart contract.

Figure: ESG Architecture Interaction

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Automated ESG Reputation

- The carbon market smart contract uses the weighted index score to generate a reputation breakdown for all energy producers on the platform.

- Can be viewed mathematically as a weighted sum - where each x_i is an ESG index value and w_i is a weight for the index category x_i in Equation 2. Applied to all n ESG index scores for a producer.

- Once added the reputation is persistent.

- Reputation is automatically updated for each user when a new ESG index is made in the 'ESG Channel'.

$$\text{Reputation} = \sum_{i=1}^{n} x_i \cdot w_i \qquad (2)$$

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Reputation Blockchain Patterns

- Token template - each ESG index instantiates a token template with fields for the original statistic, weight and reputation breakdown.

- Policy contract - reputation can only be added by the 'ESG Index Smart Contract' on the Carbon Market Channel.

- Access control - reputation breakdown is viewable for each user with the producer role in the system.

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Architecture Gaps

- The focus of the thesis was to create a carbon market motivated by automatic ESG certification.

- The architecture for an 'ESG Channel' researched by Liu et al in 2021 needs to be further explored and implemented in detail.

- Although payment settlment happens on-chain, further work is required to explore how a producer could pay for production in a currency outisde of Australian dollars.

  - Trust could be further generated by allowing payment in cryptocurrencies such as *Ether* or *Bitcoin*.

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Transactions Per Second

- The decision to move the order book on-chain comes at the price of a significant performance loss.

- Generally, on-chain order books suffer from low TPS due to *phantom read conflicts* - a blockchain phenomenon where assets are read in the same block of transactions where they are written to.

- To scale the carbon market for a large number of producers a sensible architecture would be having an off-chain order book with sale finalisation happening on-chain.

- Alternatively, a specialised blockchain and protocol such as *Solana* and *Serum* could be used at the price of using a more unstable technology compared to *Hyperledger*.

- The issue of where to put the order book is contentious, and depends on the scale the carbon market is expected to reach.

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Thank You

- Questions?

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In Steffen G. Scholz, Robert J. Howlett, and Rossi Setchi, editors, *Sustainable Design and Manufacturing 2020*, pages 403–413, Singapore, 2021. Springer Singapore.