Uppsala University

Computer Systems with Project Work

1DT003

CarbonGuard - A distributed Validation of Carbon Offsetting

Group: Dadel

Authors:
Jonna Bauer
Daniel Djärf
Fredrik Hammarberg
Theo Karlsson
Hanna Lindmark
Felix Ljungkvist
Björn Westerlund

April 19, 2024

Abstract

An application was built and it worked well!

Contents

1 Introduction

Every ton of greenhouse gas emitted increases the global warming of our planet [11]. Aligning with the Paris Agreement [10] and maintaining the warming well below two degrees requires the net greenhouse gas emissions to be zero by 2050 [9]. To achieve net zero emissions, a voluntary market for climate offsetting has emerged [6] where individuals can support projects that reduce greenhouse gas emissions [7].

However, the voluntary carbon market faces issues [4] with ensuring that the support of a climate project reduces the promised amount of emissions. A common problem within the carbon market is double counting, meaning that the same sources of carbon offsets are claimed by more than one entity, thereby not contributing to offsetting the accounted carbon emissions. Another problem is the integrity of project and validation organizations[8] and one way to improve the voluntary carbon market would be a more transparent and verifiable market [3].

To present a solution for improving the voluntary carbon market, CarbonGuard was implemented where consumers can purchase traceable carbon offsets accounted on a blockchain through a distributed validation process. The goal of the application was to present traceable carbon offsets available in an easy-to-use application, making it easier to verify the reduced emissions in the voluntary carbon market.

1.1 Product Questions

- How can blockchain technology be used to ensure traceability of carbon offsets and prevent the issue of double counting?

- How can complex concepts related to carbon offsets and blockchain be presented to a user in an engaging and easy-to-understand way?

1.2 Related Work

Ethereum[5] and Bitcoin[2] are two of the most well-known cryptocurrencies today, both using blockchain technology to facilitate communication and consensus without the need for a centralized authority. In 2021 Ethereum made the jump from using the consensus algorithm “Proof of Work” to “Proof of Stake”[12] which ended up decreasing the energy consumption by over 99.9 percent. Instead of relying on the computation-heavy Proof of Work consensus algorithm, Ethereum makes use of Stake to dissuade validators, who verify the validity of new transactions, from being malicious on the blockchain.

Climate Trade[1] is a company who have created a market for climate compensation available to the general public. Climate Trade keeps transparency and tractability through the use of blockchain technology. Via their REST API, existing projects can also integrate with their marketplace. Another project is the *Climate Action Data Trust*[13], abbreviated to *CAD Trust*, which has created a decentralized meta-data system using a blockchain for tracking and keeping carbon offset transactions transparent. By connecting to the CAD Trusts data system, information of carbon offset projects is made available to everyone and solidified by the nature of the blockchain.

2 System Description

The system consists of three main parts, see Figure 1, the server, the clients, and the blockchain. Since a blockchain is a type of distributed ledger it is part of both the server and the client in the form of nodes, and is not a standalone unit. The clients and server communicate via a process-oriented client/server TCP connection. This is also how the nodes communicate with each other.

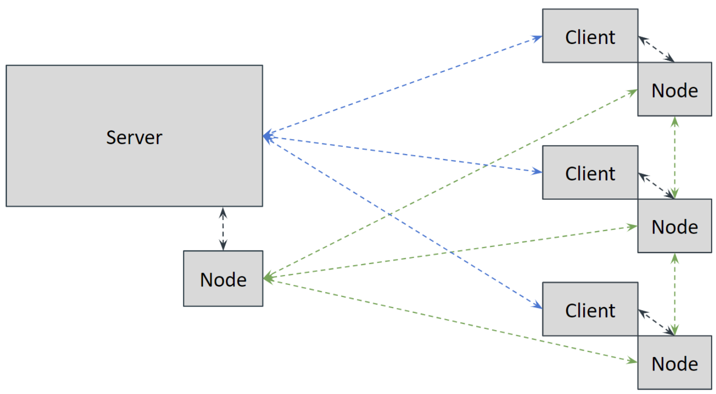

Figure 1: Overall System Architecture

2.1 Server and Database

To facilitate the clients with up-to-date information and to coordinate purchases, the application uses a cloud-based server setup which can be accessed with a TCP connection. The server manages all connections in a single process, creating a new thread and socket pair for each client that makes a request. After a period of inactivity from a client, the connection is closed and resources are retrieved.

All relevant data a client might query for is stored in a SQLite database instance, seen in Figure 2, hosted locally on the server hardware. When the server is initiated, an object tasked with interacting with the database is created establishing a connection to the database as part of its construction.

All threads share this object to gain access to the database, which allows for coordination between clients even during complicated procedures.

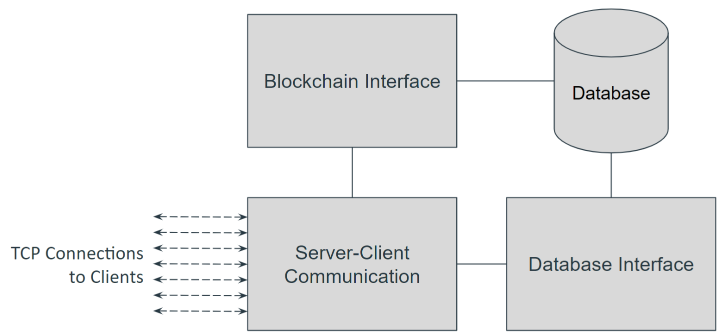

Figure 2: Server Architecture

The server will also function as a node that keeps a version of the blockchain ledger. It too is stored in an SQLite instance, but is kept separate from the client-related data and is operated on using a separate interface that is connected to the blockchain application. In fact, it follows the same structure as the local nodes that are bundled with the client application, the only difference being the amount of transaction information stored.

2.2 The Client Application

The client provides a mobile application where the user can interact with the server to buy and trace climate credits. To help the users make informed decisions about the purchase of climate credits the client has functionalities for calculating emissions and information about different climate projects as well as transaction history.

As can be seen in the graph above, Figure 3, the client consists of a UI front-end and a UI back-end. The front-end includes the elements of the application that the user can interact with and is integrated with a Google API for signing in and managing user data. When the user has signed in, multiple different app functionalities that communicate with the application's back-end are presented. The three main functionalities are lookup in blockchain, searching for projects, and creating a transaction. When the user requests

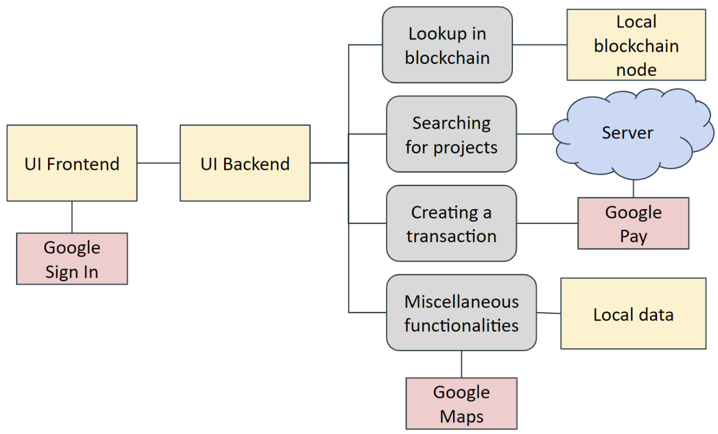

Figure 3: Client System Architecture

a lookup in the blockchain, information from the local blockchain node is fetched which is then displayed in the GUI. When searching for a project a request is sent to the server for search results which are then displayed to the user. When creating a transaction, a Google Pay API is used to manage the transaction and communicate with the server to complete the purchase. Lastly, several miscellaneous functionalities exist. These include carbon credit calculators, app settings and profile information which require locally stored data, as well as a Google Maps API to view the location of projects.

2.3 Decentralized Climate Compensation Ledger

To store purchases of climate compensation, a decentralized blockchain is used to keep transparency and traceability as well as prevent double counting. Each user who is running a client application on their mobile phone, also have a validator node running in the background, making sure that the blockchain does not get corrupted by malicious parties. These nodes together with the node connected to the server, makes up the blockchain network.

2.3.1 Communication Methods Between Nodes

The most prevalent connection and communication method used in the blockchain between nodes is TCP. Before a node has ever connected to the network, the address and public key of the server is known. By connecting to the server node via TCP, information about other validator nodes on the network are sent from the server node to the connecting node.

2.3.2 Implementation Of Transactions

When a climate compensation is purchased by an client on the market place, the server node will create a transaction reflecting the purchase made. All climate compensation are separated into projects where each project is able to distribute a set amount of carbon offset given at the creation of the project. This amount is divided into equal parts that the user is able to purchase. The transaction stores the information of which project, how many shares in that project that has been purchased and by who it was purchased by.

Due to the nature of the blockchain and its transparency with transactions, it hinders the possibility of overspending or double counting purchases of carbon credits by building a ledger where each new transaction builds on previous "unspent" carbon credits, documented in validated and solidified transactions on the blockchain. These tranactions are referenced as inputs to the transaction, showing where the unspent carbon credits are taken from.

2.3.3 Addressing nodes in transactions

in order to determine to who a transaction should be given to, an address is created using the receiving nodes public key. The address is compirsed of three main parts. First a hash of the public key, ensuring that only the public key of the given node could generate the same hash. Second is the transaction type, indicating what type of transaction is taking place. The last part of the address is the checksum, ensuring that the public key and transaction type have not been tampered with. the checksum is generated by hashing the hashed public key with the transaction type and taking the

30 first bits of the resulting hash to indicate the integrity of the address.

2.3.4 Verification of transactions

In order for transactions to be valid, it has to align with a set list of criteria. For a transition of carbon credit to a client after a purchase, the first criteria is that the transaction comes from the server node. Due to how the blockchain works in direct correlation with the CarbonGuard, the only viable node to initiate a transfer of carbon credit to another node is the server node. When the transactions is first created an sent out into the network, the transaction is signed with the private key of the server node. the server node's public key is then used to verify that the transaction originate from the server node.

References

[1] *About Us*. https://climatetrade.com/about-us/. Visited on 2024-04-17.

[2] *Bitcoin home page*. https://bitcoin.org/en/. Visited on 2024-04-11.

[3] Christopher Blaufelder et al. *A blueprint for scaling voluntary carbon markets to meet the Climate Challenge*. https://www.mckinsey.com/capabilities/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge. visited on: 2024-04-18. Jan. 2021.

[4] Allegra Dawes, Cy McGeady, and Joseph Majkut. *Voluntary Carbon Markets: A Review of Global Initiatives and Evolving Models*. https://www.csis.org/analysis/voluntary-carbon-markets-review-global-initiatives-and-evolving-models.

[5] *Ethereum home page*. https://ethereum.org/en/. Visited on 2024-04-11.

[6] World Economic Forum. *How the voluntary carbon market could help us get to net zero*. https://www.weforum.org/agenda/2022/03/voluntary-carbon-market-net-zero/. Mar. 2023.

[7] Wikimedia Foundation. *Carbon offsets and credits*. Apr. 2024. URL: https://en.wikipedia.org/wiki/Carbon_offsets_and_credits.

[8] Patrick Greenfield. *Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows*. https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe. visited on 2024-03-28. Jan. 2023.

[9] United Nations. *For a livable climate: Net-zero commitments must be backed by credible action*. www.un.org/en/climatechange/net-zero-coalition. visited on 2024-03-18.

[10] United Nations. *Paris Agreement*. https://www.un.org/en/climatechange/paris-agreement.

[11] United Nations. *What Is Climate Change?* visited on 2024-03-28. URL: https://www.un.org/en/climatechange/what-is-climate-change.

[12] *The Merge*. https://ethereum.org/en/roadmap/merge/. Mar. 2024.

[13] Climate Action Data Trust. *How blockchain solves the challenges of transparency in carbon credit data*. https://climateactiondata.org/the-role-of-blockchain-technology-and-robust-digital-infrastructure-in-shaping-the-future-of-carbon-markets/. Aug. 2023.