Carbon Credits on Blockchain

Dhiren Patel
Computer Engineering
Veermata Jijabai Technological Institute
Mumbai, India
dhiren29p@gmail.com

Sanidhya Sharma
Information Technology
Veermata Jijabai Technological Institute
Mumbai, India
sanidhyarsharma@gmail.com

Yash Dusing
Information Technology
Veermata Jijabai Technological Institute
Mumbai, India
yashdusing145@gmail.com

Benita Britto
Information Technology
Veermata Jijabai Technological Institute
Mumbai, India
benita.k.britto@gmail.com

Kaustubh Gaikwad
Information Technology
Veermata Jijabai Technological Institute
Mumbai, India
kaustubhgaikwad1998@gmail.com

Mrinal Gupta
Information Technology
Veermata Jijabai Technological Institute
Mumbai, India
mrinal.jmu@gmail.com

***Abstract*—This paper proposes a token based economy for carbon trading using blockchain as a means of ensuring decentralization and transparency at a global level. It explores digital tracking of carbon emission permits. It also proposes a safeguard against the hoarding of carbon credits.**

***Index Terms*—carbon trading, blockchain, CERs, carbon credits**

I. Introduction

A. Current scenario in carbon emissions

Green House Gases (GHG) emissions are the leading contributor to climate change globally [1]. Countries aim to reduce their emissions to foster better and cleaner practices. This is the fundamental step towards making Earth habitable for future generations.

New Zealand, U.K. and Scotland recently announced their plans for net zero carbon emissions by 2050 [2]. This seems to be a step in the right direction as countries try to look for efficient mechanisms to create products. India has pledged a 33-35% reduction in the "emissions intensity" by 2030 [3]. India also has set a reasonable expectation from the 'three-stage nuclear power programme' which is supposed to enter its third stage that aims for Thorium-based reactors. While this looks to be promising, India's carbon dioxide (CO2) emissions are growing at a faster rate than in any other major energy-consuming nation. In 2018, CO2 emissions in India rose 4.8% from the previous year, according to a new report by the Paris-based International Energy Agency. Emissions from India accounted for 7% of the global CO2 burden in 2018, compared with the US's 14% [4]. The increasing emissions are due to the fact that the country has been leaning more on fossil fuel based energy.

B. Clean Development Mechanism

The Clean Development Mechanism (CDM) allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, henceforth referred to as carbon credits, each equivalent to one tonne of CO2 [5], [6]. These carbon credits can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol [7].

The mechanism stimulates sustainable development and emission reductions, while simultaneously giving some flexibility to nations trying to meet their emission targets. Ultimately, such a scheme tries to bridge the gap between the amount of carbon dioxide equivalents produced and the amount of carbon dioxide equivalents reduced or sequestered.

In order to make this mechanism successful, a cap-and-trade scheme (Emission Trading Scheme) needs to be followed. First, an upper limit or cap is set on the amount of pollutants a participant can produce and then allow the participants to trade between the excess and deficiency. Over time this cap is reduced so as to make participants find cleaner and more efficient processes and reduce the overall global emissions. This scheme has the added advantage of allowing a smooth transition to stringent policies of pollution control which causes minimal disruption in the market. This is because the cap is adjusted gradually, thus providing enough time for the participants to adjust their internal processes and plan for future reductions. This is the fundamental idea behind the cap-and-trade scheme [8].

If established with a sound economical foundation, trading of carbon credits can push countries and industries towards environmentally friendly practices and bring about reduction of pollutants from the atmosphere.

C. Blockchain overview

Ever since the publication 'Bitcoin: A Peer-to-Peer Electronic Cash System' by 'Satoshi Nakamoto' [9], decentralized databases and research have seen a huge boost. The underlying technology behind Bitcoin - Blockchain has spun multiple variations, each having an improvement over the last iteration.

The core motivation behind Blockchain are the ideas of decentralization, immutability and transparency. Blockchain is a ledger sharing among the participating entities. Because of these advantages, Blockchain has been employed in various fields from government autonomy to education and business

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decisions. We propose one such use case in the field of carbon trading.

D. Carbon trading overview

The trading of carbon credits is currently tracked by the Clean Development Mechanism registry as stipulated in the first session of the Conference of Parties to the Kyoto Protocol [10]. According to the report, some of the pertinent tracking requirements are as follows:

- "A standardized electronic database which contains, inter alia, common data elements relevant to the issuance, holding, transfer and acquisition of carbon credits"
- Accounts with specific responsibilities such as a pending account used to store issued carbon credits, one each for hosting a CDM activity, one for cancelling carbon credits, one for holding and transferring CERs corresponding to the share of proceeds which will be used for administrative purposes.
- Each carbon credit shall be held in only one account in one registry at a time.
- Each account within the CDM registry shall have a unique account number.
- Each carbon credit must have a unique serial number.
- The CDM registry shall make non-confidential information publicly available and provide a publicly accessible user interface through the Internet that allows interested persons to query and view it.

The rest of the paper is organised as follows: Section II discusses problems with the existing carbon trading implementations. Our Blockchain solution is highlighted in Section III with advantages of using Blockchain technology being discussed in Section IV. Section V concludes the paper with future scope and references being mentioned at the end.

II. Problems associated with carbon credit trading implementations

A. Centralization

A centralised authority in any system controls the entire system. In carbon credits scenarios, this is undesirable as there can be cases of fraudulent conduct by central authority with no repercussions. There is also a chance that the carbon credits system will be controlled by few powerful entities who possess the majority of carbon credits.

B. Insufficient motivation for participants

In a cap-and-trade system, carbon credits are allocated to polluters for free based on historical emissions and the emissions cap for the industry. This gives the polluters an incentive to not reduce their emissions, because if they do reduce their emissions they will receive fewer carbon credits in future. According to Preston Teeter and Jorgen Sandberg [11], because of the complexity and uncertainty of this system, fewer organisations try to innovate and comply.

C. Susceptibility to Fraud

A carbon credit trading system is vulnerable to frauds and carbon cheaters who persuade the common public into investing in worthless or fake permits [12]. The reason for such frauds is the underlying complexity of the system as well as the lack of transparency. A decentralised and transparent blockchain system prevents such cases by making the data publicly available. By tracking the path to the source of the carbon credits, many frauds such as major banks turning a blind eye to theft [13] could be tracked easily and a suitable punishment could be imposed on the cheating party.

D. Hoarding

A carbon credit trading system is also prone to the problem of hoarding [14]. Hoarding is the storing of purchased carbon credits for an indefinite period of time so as to sell them when their demand and price is higher. This decreases the supply of credits along with the liquidity of the market and makes the transition of a participant to lower emissions more difficult. This in turn could drive away the participant if the price of the carbon credits matches the penalty imposed by the government on carbon emission violations. The problem of hoarding of carbon credits must therefore be effectively discouraged for the economy to be sustainable and effective in lowering pollution.

III. The Blockchain Solution: Our Proposal

A. Introduction

On close inspection of the requirements (Section I-D) one can clearly see a fitting application of blockchain technology in the tracking of carbon credits. Properties such as immutability, single ownership of carbon credits, trust are present in the requirements and thus warrant the use of blockchain as a possible solution for tracking carbon credits globally. The following sections explain how blockchain technology can be implemented and how it can provide numerous advantages over the current implementation of Clean Development Mechanism registry.

B. Actors

- Participating Entities: There exists 3 participating entities in the system,
  1) Generator
  2) Consumer
  3) Issuer
- **Generators** are entities who are awarded permits for offsetting carbon. These permits can be achieved either by carbon offsetting or using an efficient mechanism such that carbon credits consumption is less than the limit imposed by the cap-and-trade scheme. Carbon offsetting can be done in various ways such as planting trees, setting up windmill farms and performing other activities that benefit the environment. Any corporate entity who has a surplus amount of carbon credits can also function as a generator.

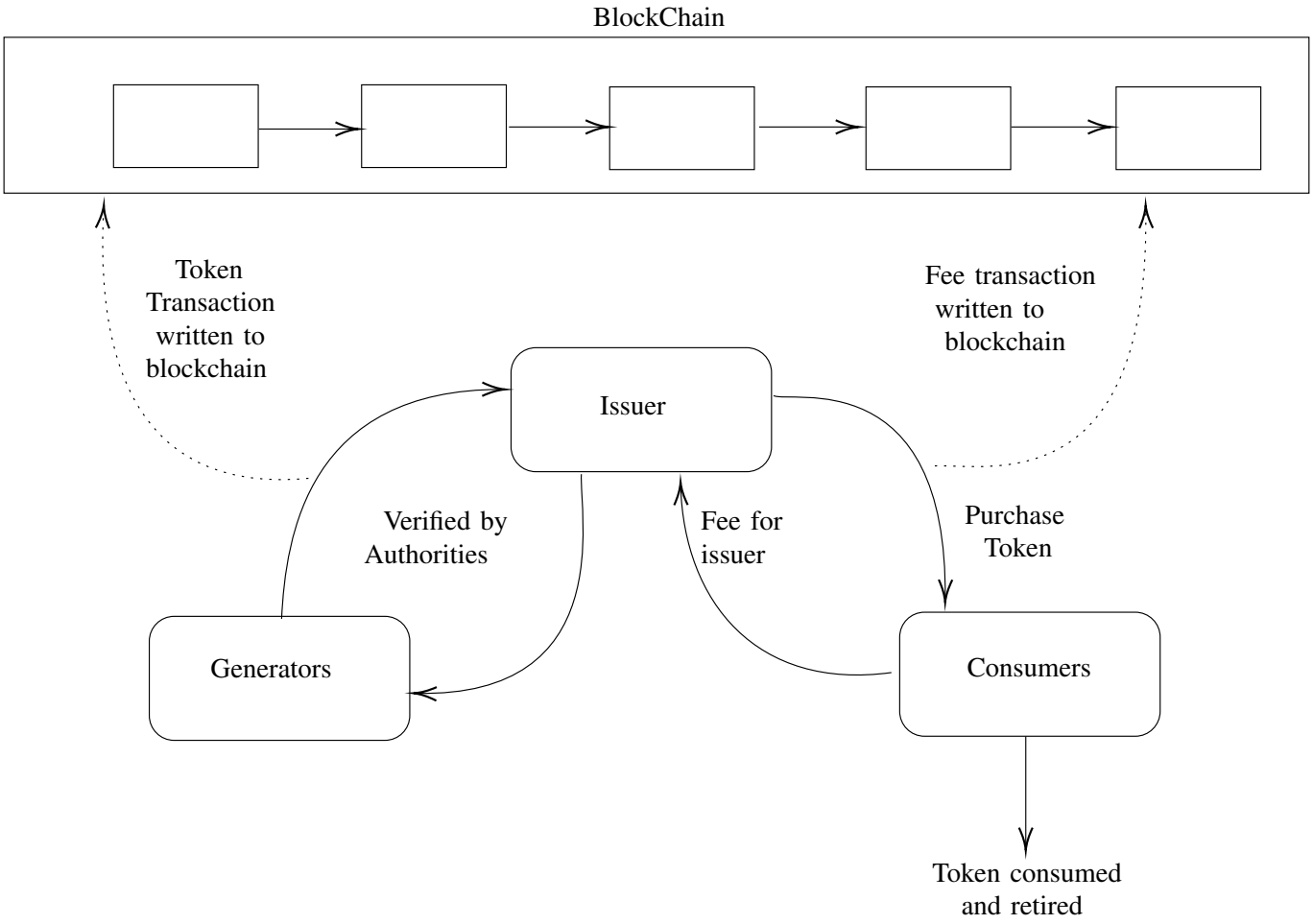

Fig. 1. Proposed Blockchain architecture for carbon credit trading

– **Consumers** are corporate entities who fall short of carbon credits given to them. Therefore, carbon credit consumers need to purchase permits from generators.
– **Issuers** are entities in the system that verifies the carbon emissions of each industry or organisation and decides the emission cap for each year. These are the one's who verify the carbon emissions of each industry, decides the emission cap for each year and also validate and verify the carbon offset of generator.

C. Workflow

The issuer decides the emission cap for the industry for a specific amount of time. This is done by independent auditing of the industrial process used during the manufacture. Then, these permits (which are less than the total cap) are distributed among the organisations. These permits can also be auctioned by issuer as an alternative and the funds received through the auction are utilized for sponsoring environment relation organisations or research for achieving efficient mechanisms. This ends the initial phase of the cap-and-trade scheme.

If the generator contributes positively towards the environment and submits the request for carbon credits from the issuer, the CER issuer after verifying the claims of the activity issues carbon credits to the generator. This CER certificate is attached to newly generated tokens in the economy and the transaction is recorded in the blockchain.

Now, if any consumers exceed their carbon emission limits, they can purchase CER from the generators via a unified trading platform. Once the CER permit is purchased by the consumer, an expiry timer begins. This timer signifies the lifetime of the permit. Once this timer is expired, the permit is retired. Meaning, the permit is worthless after the timer expires. This is done in order to prevent the hoarding of carbon credits. So, it is necessary for the consumer who buys these CER permit to use all these purchased carbon credits before the timer expires or return the excess tokens back to the seller.

As the cap emissions for the industry reduces every year, the quantity of these carbon credits reduces drastically. Organisations would therefore prefer to invest in researching and employing more efficient mechanisms rather than purchasing the costly CER permits. Breakthroughs in research would bring down the emissions far below the cap allowing the consumer industries to even generate carbon credits in the future.

D. Incentive and transparency

The transactions are committed to the blockchain and a small reward is deducted from the transacted tokens and awarded to the member node as a fee for verifying the transaction. This serves two purposes. Firstly, it provides an incentive to member nodes to verify and commit blocks of transactions and secondly it reduces the effective amount of carbon credits generated for consumption.

Once the buyer emits enough effluents so as to match the amount of carbon credits it had purchased, the token is retired. This can be done by spending the equivalent token to a known dead account from which no tokens can be spent again. For example, if an account's private key is not known, all input transactions to it become locked and cannot be spent.

As specified in the requirements, any independent auditor can view the transaction history of a carbon credit and verify whether an account has sufficient amount of tokens. This would prevent the selling of bogus tokens on the market as a quick search on a web portal would reveal instantly the validity of a transaction and the authenticity of the carbon credits attached to the token. This can be done by attaching digitally signed certificates to tokens which can be verified by comparing with the issuer's signature. A buyer can thus verify the issuer's signature before purchasing carbon credits and avoid scams of this sort.

IV. Advantages of using blockchain technology

A. Improved Transparency

As described in the previous sections, a major reason for skepticism of various industries when it comes to participating in the Clean Development Mechanism stems from the fact that they do not trust the authenticity of the generated carbon credit. The various frauds which occur are mostly related to the fact that the carbon credits traded have no value as their sources were invalid. Such scams also discourage participation. However porting the registry to blockchain would ingrain the property of immutability and allow participants to instantly verify the authenticity and validity of any given carbon credit [15]. Awarded certificates will be digitally attached to the tokens in the economy and can be traced back to the generator by following the blockchain upwards.

B. Improved trust

Since the trading of carbon credits involves multiple distrusting parties, the introduction of a blockchain intermediary would infuse trust into the system and would foster participation from all over the world [15]. This is because the entire registry would be public and easily verifiable. Politics of nations would not affect the trading capabilities of participants. Moreover participating in carbon trading would improve the reputation of the member and any member would want to advertise their initiatives. This public registry would therefore be an incentive for participants to participate in the scheme and reduce their emissions according to the cap and trade.

C. Reduction in complexity

The digitization of carbon credits and their online trading would simplify the process and would become economical as more participants join. A simple verification of authenticity can be done by connecting to a node and verifying the digital signature on the certificate attached to the token. No complicated procedures would have to be followed in order to verify whether the credit is genuine and a cost of tracking the origin and validity of a token will be diminished.

D. Hoarding

In order to counter the problem of hoarding of carbon credits and their sale can be moderated by checking the requirements of the buyer and attaching an expiry timer to the token purchased. This would prevent a participant from buying and hoarding carbon credits as they would expire if not utilized within a reasonable amount of time. The time would be set in accordance with a report which would be submitted to a designated entity by the buyer which would verify whether the participant requires the carbon credits for the requested amount of time. If approved, the transaction can be verified and added to the pool of transactions after which it can be committed to the blockchain. This property can be introduced by the use of smart contracts which will enforce the timer on carbon credits and retire them as soon as the timer expires.

V. Conclusion and Future Scope

In this paper, we have presented a Blockchain solution for trading carbon credits. It is evident that tracking carbon credits using blockchain technology has tremendous benefits with respect to usefulness, participation and cost. Replacing the Clean Development Mechanism registry with a blockchain ledger will therefore support the growth of the carbon market and help direct the industries to a cleaner and more sustainable future. This is a work in progress.

If we gauge the effect of pollution based on location, it is easy to see that some areas are in a lot more danger than others. For example, a large city with many industrial plants would be more easily susceptible to pollution than a small underdeveloped village with an intact natural cover. It would make sense to make it costlier to pollute the city so as to not exacerbate the pollution and health hazards in the region. Therefore, the price of the token should be affected by the emitting location. A way must be found in order to make it harder to further pollute already suffering areas so as to alleviate the difficulties of areas which need serious attention.

The proposed implementation is viable at the industry level and is in progress. Tracking of emissions is an intensive task and with the available means, our goal is to focus at corporate level use cases. However, with the improvements in tracking mechanisms and technologies which would allow tracking at individual consumer level, the above implementation can be extrapolated to track and inhibit pollution at all levels. Carbon emission of humans could then be tracked and an accurate carbon tax could be imposed so as to instill environment friendly habits. For example, if a person takes

a flight from point A to B, a normalized carbon tax can be added to that person's ticket amount and such tracking would dissuade unnecessary pollution. Issues of scalability need to be addressed before a consumer level carbon tax scheme can be implemented. Currently, blockchains do not work well with a lot of small scale transactions as verification takes a lot of time. However, as the future brings adaptations to make the system accommodate these many transactions, consumer level tracking can be added to this system.

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