Green-Ride Architecture

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Abstract—Ridesharing or carpooling has a valuable potential in large cities that suffer from traffic jams and congestion especially in places with poor public transportation infrastructure and fuel trip expenses are too high. By increasing the level of vehicles occupancy; colleagues who share the same workplace can smoothly hop into each other's vehicles to reach their destination. In this research paper we utilize the decentralization nature of the blockchain to build a smart ridesharing application – GreenRide - through incentivizing its users via token rewards. Our work investigates boosting ridesharing efficiency through utilizing the blockchain merits of decentralization, trustless, and scalability. We also emphasize on the application's environmental impacts where it promotes carbon emission reduction, and enhances air quality. Moreover, the research paper identifies GreenRide's economic and social impacts as per it helps road users to share the costly fuel expenses and to create friendships between like-minded people respectively. The research findings unlock the tremendous potential of the blockchain technology in other business-related fields not only limited to finance and cryptocurrencies.

Index Terms—Keywords: blockchain; distributed ledger; ridesharing; decentralized application..

I. Introduction

The world is currently undergoing a rapid change where it is becoming more driven by data. The digital transformation is encompassing all societal systems; government, logistics, power, health, traffic, and marketing where data is being more qualitative, efficient, and more transparent and accountable. It is crucial to build an infrastructure that maintains healthy, efficient, and safe data systems to guarantee that our highly networked world is not being held in poorly-secured repositories. Blockchain is one promising solution that offers a high resilient architecture and distributed nature to adopt the needs of dynamic datadriven network and self-regulating systems as well .

Since its early application the Bitcoin in 2009 ; number of large industrial key players are exploring the blockchain to expand their product portfolios. Through smart contracts, blockchain is now applicable in sectors as transportation,

healthcare, and government. They set number of parameters upon agreement among parties where terms of the agree-ment are interpreted into lines of codes in smart contracts

. Consequently, transactions are transparent, traceable, and irreversible. However, there are still issues and challenges in blockchain execution that must be tackled to ensure its smooth integration with different sectors. It is imperative to consider education within industries, consistent blockchain frameworks, collaboration across industries, and verifying its public bene-fits. Consequently, promoting the concept of sharing economy that has been a transformative force for a wide industries.

In this paper, we consider the blockchain as a disruptive technology to revolutionize the transportation sector as per its massive impact on environment, air quality, and pollution. We demonstrate the specifications and technical features of Green-Ride; a semi decentralized blockchainbased application that promotes social responsibility towards the environment. The application illustrates a feasible integration of the blockchain to orchestrate the rewarding mechanism among users to incen-tivize them to share their rides with colleagues. Consequently, users will collaborate to decrease carbon emissions while being rewarded by GRTs (GreenRide Tokens).

A. Blockchain and its Structure Overview.

Blockchain in a nutshell is a sequence of blocks where each block encompasses records of transactions and held in a public database/ledger . What makes the blockchain unique is that each block is signed by the hash of its transactions plus the hash of the previous block. As depicted in Fig. 1, each block is composed of a block header and body where the header has several fields that maintain blockchain decentralization, persistence, accountability, and anonymity.

Currently, there are three main types of blockchain plat-forms; public, consortium, and private blockchain . Public blockchain represents the ultimate spirit of decentralization and the trust-less public ledger where all participants have the same value to determine the next block to be added. On the other hand, the decision regarding the next block in consortium blockchain is only limited to specific entities or pre-selected nodes. While reading/writing permissions are either public or restricted to certain participants. Whereas private blockchain keeps the write/read permissions restricted and only pre-selected nodes can be authenticated to participate in the network .

Blockchain technology is still immature and evolving. It has several challenges that must tackled in order to guarantee its efficient utilization. For instance, scalability is a major issue that is related to the capacity of transactions in each block. There are boundaries for each block size and time to commit a new block that would bound to validate 7 transactions per second in a Bitcoin network for example . Off-chain scaling solution ensures that specific transactions to be committed without mining and few information to be synchronized.

B. GreenRide Architecture Overview

GreenRide - through incentivizing its users via token rewards.A work investigates boosting ridesharing efficiency through utilizing the blockchain merits of decentralization, trustless, and scalability. It also emphasize on the application's environmental impacts where it promotes carbon emission reduction, and enhances air quality. Moreover, the research paper identifies GreenRide's economic and social impacts as per it helps road users to share the costly fuel expenses and to create friendships between like-minded people respectively.

II. RELATED WORK

This section is a study of few of the most popular existent proposals of Peer-to-Peer Ride Sharing Architecture.

1) B-Ride acquaints a reputation model which rates drivers built on prior behavior, allowing riders to select based on the collection of interactions of the drivers. The confirmation is done using zero-knowledge proof to protect rider/driver privacy. To ensure fair payment, a pay-as-you-drive philosophy is presented.

2) PEBERS model, utilizes fog computing nodes as authorized nodes. Fog computing nodes are road side units with storage, computing and communication capabilities. These nodes are semi trusted and are distributed area wise in the network. This feature will overcome centralized server concept and bring about benefits such as location awareness, low latency to our design. Furthermore, they serve as the agents to find and match passengers and drivers.

3) O-Ride, a privacy-preserving system optimizes SHE so that bandwidth requirements and processing overhead are lessened using ciphertext packing and transformed processing. It includes features such as credit-card payment, contacting drivers in the event of missing belongings, and traceability in the event of criminal activity.

4) Block-VN is a distributed vehicle network architecture. It examines how the network of vehicles evolves with paradigms. The department of vehicles transmits details to the revocation authority each time a vehicle registration is issued. The revocation authority then informs the distributed blockchain of all information about ordinary and miner vehicle nodes.[4]

III. TRANSPORTATION SECTOR AND RIDESHARING

The magnitude services of road transportation increase the number of mobility cars which increase the traffic jams, air pollution, and carbon emission.

The potential negative impact of transportation on environment are degradation of air quality, increasing carbon emission, increasing the threat of climate change, and degradation of water resources[2]. In 2016 greenhouse gas emission from transportation was about 25gt and expected to increase by 400% by 2050. The inefficient use of vehicles around the world which projected to reach the two billion by 2040 has an obvious negative impact on economic, environment, health, and social sectors. Transportation is the primary factor of climate changes (Fig. 2). More than a quarter of totally energy use is allocated to the transportation sector; causing 22 % of global energy endues related to CO2 emission.[3]

By raising the occupancy level of private vehicle; ridesharing will decrease the number of vehicle and present enormous potential for positive societal impact with respect to pollu-tion, congestion, and energy consumption. Ridesharing is a promising solution for cities with poor public transportation and fuel expenses are high. Shared modes in transportation has a potential in reducing traffic jams and the use of parking slots. With an average of occupancy rate of 2 riders per car for a short distance and 3 riders per car for long distance in France for instance; less vehicles are needed to move the same number of users.[2]

IV. GREENRIDE: DESIGN AND SPECIFICATIONS

In this Section we will detail our proposed application – GreenRide – and its related specifications, configurations,, operation management, and explain justifications for the ap-proach deployed.

A. Objective & Motivation

As mentioned in Section III, transportation is a primary factor in increasing the global greenhouse gas emissions and affects environment and health negatively accordingly.

We introduced the GreenRide not only to overcome the dilemma of traffic jams and congestion through ridesharing, but rather to promote our environmental obligations toward the nature and to guarantee a better tomorrow with what we do today. The main objective is to empower corporate, universities, and governmental institutions with a mean to contribute to their annual carbon footprint target.

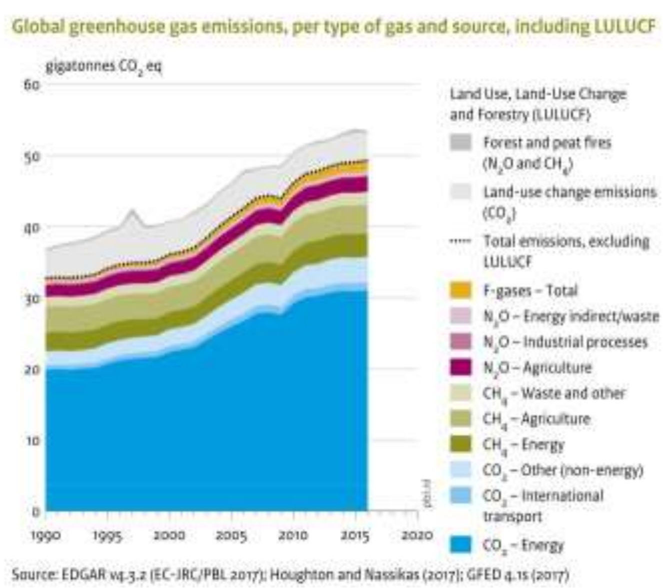

Fig. 1. Global Greenhouse Gas Emissions (2017) [3]

The application rewards its users via GRT for every kg of CO2 reduced via sharing rides. The organization is given the control over what this reward might mapped to. For instance, a day off, free cafeteria coupon, or even monetary reward. Incentivizing employees is of vital importance the organiza-tion is obligated with towards their social and environmental responsibilities.

We aim to target universities' students/employees, min-istries, governmental institutions, and corporate with large number of employees. One key merit of GreenRide is that it does not need for new regulations or long approval pro-cess from authorities since its only dedicated to universities, government institutions and large corporate. However, man-agement of large communities as in universities will need to allow a proper integration of their private database from which the application requests information. Hence, the application will not add extra risk layer to users' privacy as per security controls and countermeasures determined by the management of the community shall be deployed. The application's success depends on its users. The more the users are encouraged to use it, the more drivers are available and hence the application is feasible and worth trying. Users' feedback will be dominantly focused on its real-time response in finding the suitable ride and go; however, when number of drivers' web are not wide enough, the searching process of a ride would take a time to locate and this would make the user switching to another alternatives. In our case scenario; the incentive layer added is a promising solution but the reward itself is determined by the management of certain corporate. Consequently, we need to educate the management board on the importance of GreenRide implications on environment, pollution, and air quality.

B. Development Environment

As illustrated in Fig. 3, GreenRide application will consist of two main structures; centralized application code that will reside on Google Cloud App Engine (Platform-asa-Service PaaS) where it handles automatic instances creation when GreenRide volume is increasing. Hence, application's flex-ibility and scalability is maintained so that users services including searching and finding suitable rides are prompt-ness. Whereas the second structure is the decentralized re-warding GRTs that will be deployed on a private fork of Ethereum blockchain over Google Cloud Compute Engine (Infrastructure-as-a-Service IaaS). This requires manual net-work configuration to create Ethereum nodes (Geth clients) to enable users to create their GRT wallet (details are in subsection C).

GreenRide is well described as a hybrid blockchain ap-plication; it offers to overcome issues related to the public blockchain network where it only allows pre-selected nodes to authorize (mine) the next block in the blockchain. Conse-quently, token exchange is instantaneous with no scalability issues. However; for security and regulatory perspectives; GreenRide users' information will be kept in Google Firebase database that can be easily integrated with the corporate

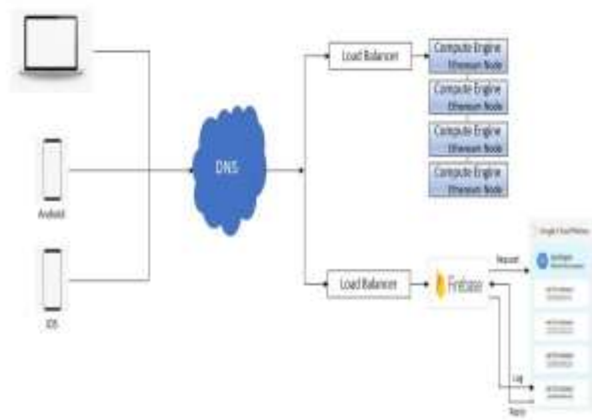

Fig. 2. GreenRide – Architectural Overview

database and hence, employees' data is not going to be hosted outside the premises of the corporate. Consequently, users will no longer be reluctant to share their routing information. On the other hand, the application is deployed over a private network to overlook any regulatory disputes in countries that ban cryptocurrencies as in Jordan and hence, the application is currently targeting large communities as in universities, ministries, and corporate with large group of employees. Also, GreenRide takes into consideration countries that ban using private cars to make money out of ridesharing.

C. Specifications and Configurations

In this Section, we will briefly discuss forking a private net-work on Ethereum blockchain, creating GRT smart contracts, and deploying the application using Google Cloud Platform.

1) Forking Private Ethereum Network : In the development phase of GreenRide, a test network – Ganache – is deployed to run GRT smart contracts. It creates 10 accounts each of which has 100 Ether to pay the gas fees. The objective is to compile and run the code on a local network to refine it before pushing it into production via Google Cloud Compute Engine. However; in the production phase, we need to create at least two Ethereum nodes (aka two ubuntu VM instances) each of which run Geth client on Google cloud that are used to create GRT wallets for users. On the client side, users will communicate with their GRT wallets via MetaMask ; a browser extension that communicates with the deployed smart contracts on your Ethereum network via Web3 service provider. As per it is our private Ethereum network, the network will add pre-selected Geth clients and hence the network is not discoverable by other nodes. This would make our network more secure from malicious network attacks. Network architecture is demonstrated in Fig.

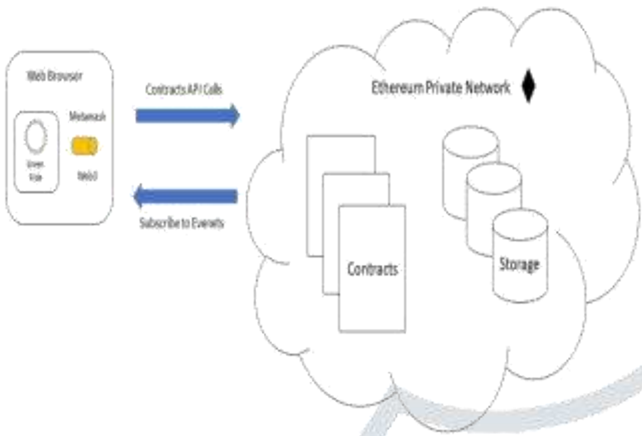

Fig. 3. GreenRide – Decentralized GRT Deployed on Private Ethereum Network

2) GRT Smart Contracts: The GRT is the GreenRide Token that is compliant with the ERC-20 standards . It has an infinite supply of tokens; service provider can mint as much as possible of tokens as per the token is mapped to kgs of CO2 reduced per each ride. GRT smart contracts are written in Solidity where they define all abstract functions needed to make GRT balance-related transactions as in mint, transfer, and approve. These smart contracts are compiled and deployed on the private Ethereum network. Calculations of GRT will be detailed in Section IV. This part of GreenRide is the only decentralized part where GRT circulation is maintained on private blockchain network. In our future direction, the appli-cation will be opened for the public and the GRT will be easily an exchangeable token as per it follows the ERC 20 token standards. Consequently, the application (decentralized part) can be deployed smoothly on the Ethereum main network. [2]

V. CASE STUDY: JORDAN

For estimating the environmental and economic impacts of using GreenRide, a deep analysis has been carried out for using private vehicles as a key source of transport in Jordan, due to the poor infrastructure of public transport. The statistics of the Driving and Vehicle Licensing Department in Jordan showed that, the total number of registered small private vehicles reached 862563 in 2013 . Knowing that the annual growth in number of private vehicles was in the average of 5.5 % annually for the past six years, thus by 2017 we estimate the number of private vehicles to reach up to 1.07 Million vehicles.

In our calculations, we assume that only 10registered vehicles (i.e. 100k) to use the GreenRide application, the average daily commuted distance of 30 km only, and since the application is dedicated for university students/ private sector and government employees; the application is estimated to be used for five days per week. In the meantime, the majority of private vehicles in Jordan are midsize, thus we estimate that each car emits 250g CO2 per Km in our calculations [CO2 emission per trip= Trip distance (KM) X Emission factor (CO2/KM)]. By reflecting the above assumptions on the three possible ridesharing scenarios (2 commuters, 3 commuters and 4 commuters), it can be noticed that at least 195 Million kg of CO2 can be saved annually if only two people shared a car to the same destination. This figure could reach up to 585 million kg CO2 can be saved if four people shared the ride, which is equivalent to planting 26.5 million new trees. Each GRT is equivalent to 1 kg CO2 saved, and total GRT for a ride of 2 commuters for instance will be divided on 2 (1 driver and 1 rider) so that to be added to each user’s GRT wallet.

The transport sector (land, air and marine) in Jordan produced 7905 Million kg CO2 in 2014, with Greenride this amount can be reduced by 5% on average annually. While the direct cost saving that is due to reduce the fuel cost from the shared trips for three possible rideshare scenarios (2 commuters, 3 commuters and 4 commuters) are ranged from US$ 86 million annually for two commuters scenario up to US$ 257 million annually for four commuters shared a ride to the same destination. Whereas the indirect cost could reach up to US$ 100-150 Million annually that could be saved from other costs associated with health care, travel of time delay, excess fuel consumption and others.[2]

# of Rideshared Vehicles	Annual Commuted Distance (Million Km)	# of Commuters/ Vehicle	Annual Saved Co2 (Million kg)	Annual money saved (million $)
100000	780	2	195	85.8
100000	780	3	390	171.6
100000	780	4	585	257.4

Fig. 4. Estimated annual CO2 and money saved via Greenride [2].

VI. APPLICATIONS OF BLOCKCHAIN CONCEPTS IN RIDE-SHARING

- Blockchain based firmware update scheme: Autonomous vehicles manufacturers form a consortium blockchain ensuring high availability and quick delivery of products and updates with low computational cost which is resistant to a DoS attack. Attribute-Based En-cryption (ABE) generates an access policy that ensures that only approved autonomous vehicles may download and install new updates while also utilizing a smart contract to assure the validity and integrity of firmware updates. Due to the limited time required for crypto-graphic computations and the transfer time, the scheme can be implemented during the contact time of two moving autonomous vehicles.
- Use of Zero Knowledge Proof Module:

  In a volatile environment a zero-knowledge proof pro-tocol is utilized. In exchange for proofs of distribution from receiver AVs, each distributor can trade an encrypted version of the update. The smart contract guarantees the delivery of the decryption key, which will be revealed after the proofs are collected. Based on the received proof, the smart contract also increases the distributor's reputation.
- Use of Incentives and Rewards:

  A reward mechanism is designed to incentivize au-tonomous vehicles to distribute Firmware updates for consortium blockchain by maintaining a credit reputation for each distributor account in the blockchain.
- Use of Smart Contract:

  Consider a Blockchain-based service that provides smart contract templates for drivers and passengers. The two parties will choose a "basic" smart contract template initially (for example, the transfer of goods or people; rewarding the driver in fiat currency or cryptocurrency; payment in cash, or through reward points;) The par-ties will then agree on the transaction's specifics (For instance, the precise fee to be paid; the choice to carry more people or not;) Individuals will no longer require a third party to complete the transaction since the Smart Contract template will ensure that either both sides of the transaction are fulfilled, or none at all.
- Use of Pseudonymity:

  Pseudonymity is defined as the usage of aliases (pseudonyms) for confidentiality for the purpose of either shielding one's identity, achieving self-sovereignty, or for privacy and security concerns. Privacy in Blockchain refers to the preservation of anonymity and the unravel-ling of transactions. Transaction anonymity entails that it is impossible to connect each transaction to a unique user. Consequently, the user makes use of a unique address for every single new transaction. Unravelling makes the assumption that Blockchain addresses and transactions are not linked to the real user identities.[4]

VII. CONCLUSION

In this research paper, we have demonstrated a practical use case of the blockchain technology in fields beyond finance and cryptocurrencies. This innovation can be customized to meet the business needs and requirements. We proposed deploying a hybrid blockchain based application – GreenRide- to offer real-time and prompt ridesharing services in cities that suffer from traffic jams and poor public transport infrastructure. The architecture of GreenRide utilizes the decentralization and distribution nature of blockchain to create the GRT to reward users for their carbon emissions reduction. Users information along with application transactions (find ride, book ride, etc) are all conducted via Cloud to spare users time while locating their suitable rides. GreenRide is one promising solution that has a tremendous environmental and economic impacts on communities while incentivizing users to share their rides. It has other advantages compared to regular ridesharing services where it offers corporate and governmental bodies a mean to fulfil their environmental obligations through tracking the carbon footprint.

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