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Implementation of Hybrid Blockchain in a Pre-Owned Electric Vehicle Supply Chain

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ABSTRACT Ecumenical carbon dioxide (CO_2) emission emanates from car, bus, taxi, and motorcycle is around 45%. Electric vehicle could be the major contributor to abbreviate the pollution level in a transportation sector. According to the Forbes report the ecumenical passenger electric vehicle demand expected to reach 15% in 2025, and 23% in 2030. This research provides a blockchain predicated solution for a pre-owned electric vehicle market that could engender a trust, transparency, immutable records, and an efficient way to track the entire life cycle of a futuristic electric vehicle supply chain. At present most of the pre-owned electric conveyance purchase transpires through the third-party accommodations, websites, and mobile applications. This does not provide the authentic information on electric conveyance history, charging capabilities of the battery, history of the charging records, and performance of the driver (wear and tear affect battery life). Our solution implemented utilizing hybrid blockchain technology. Each stakeholder assigned with the Ethereum blockchain address to track the vehicle records as a distributed ledger. This design considered electric vehicle manufacturer, charging station, battery manufacturer, road convey ascendancy as major stakeholders. Astute contract designed with solidity programming. Truffle platform used to deploy keenly intellective contract in private blockchain that ascertain the privacy of electric conveyance owners and other stakeholders. Meta mask a mobile application utilized kovan network for tracking vehicle in a public blockchain. This application tested with 0.1 Ether for each transaction. Blockchain Electric Vehicle Cloud of Things (BEVCoT) concept proposed to integrate the IoT-Blockchain application in a cloud environment.

INDEX TERMS Automobile sector, blockchain, distributed ledger, cloud, mobile application, Ethereum sandbox, meta mask, transaction, vehicle, transparency, truffle, QR code.

I. INTRODUCTION

Blockchain is a distributed ledger technology. It provides transparency among all the stakeholders. The concept of the shared ledger and peer to peer transaction introduced by Santoshi Nakamoto [1]. This concept brought the attention of financial sector, logistics and supply chain industry, automobile companies, aviation, telecommunication, other industries where business needs the trust, transparency, and immutable records [2]. Initially the blockchain concept was introduced to make financial transactions. The companies like bitcoin and Ethereum came up with their own cryptocurrency as digital cash and made the genuine time application of blockchain [3]. This research fixates on bringing the transparency in an automobile sector in case of pre-owned conveyance/electric conveyance purchase. The automobile industry has grown up well in the past decennium. Innovations in automobile sector leads to the manufacturer comes with the incipient model every year [4]. People would relish to sell their car and buy the incipient model with technological updates. Currently, most of the pre-owned conveyance purchase is done through the car reseller, websites, mobile applications [5]. People may trust the few third-party accommodations or buy predicated on the details given on the website. Once they decide to buy, they need to go through the documentation process. Developing and under developing countries most of the documents are available in the form of hardcopy [6]. There are possibilities that the one who sell the conveyance could modify the data and send it to the buyer. Information technology and corruption in developing countries customs

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offices has been discussed as a case study [7]. Expeditious developments in automobile sector, technological advancements, shortage of technical expertise, poor documentation process leads to challenges in conveyance diagnostics during pre-owned conveyance purchase [8]. The electric car era commenced, according to the Forbes wheels report General Motors will eliminate the gas and diesel engine conveyance by 2035, and automakers spending 27 million on electric conveyance manufacturing between 2020 and 2025 [9]. Motor astuteness report verbalizes that 260,000 electric cars sold last in the U.S.A., out of which proximately 50% of the electric conveyance was Tesla model 3 [10]. Logistics customers like Amazon, and UPS injunctively sanctioning thousands of electric conveyances for their operation and investing heavily on research and development of long conveyances and trucks [11]. The challenges and opportunities in implementing blockchain in U.K. automobile sectors has been discussed, they have represented as review article. They amassed 35 top academic journals indited review article, proposed the technological – organizational-environmental framework (TOE) framework for the U.K. automobile sector, concluded that adoption of blockchain could bring the operational excellence in automobile sector [12]. Centralized data management system is a single point of failure, integration of IoT, blockchain and 5G mobile communication could bring the best solution, engender transparency in a conveyance purchase [13]. Like healthcare industry, present automobile industry works as centralized system where partial conveyance records are with the road convey ascendancy, some records are with owner, few records are with indemnification company, fundamentally the conveyance records are not available in a distributed ledger, anyone could mute the data of the conveyances. It is not a distributed ledger system. This leads to unauthentically spurious documents in a conveyance trade [14]. The subsisting system does not provide consummate data of the conveyances like history of the owners, maintenance records, indemnification details, contingency information, rental conveyance or single owner. In order to solve above challenges this research propose the conveyance chain designed with blockchain technology. Blockchain is a most trusted platform, and it engenders transparency among the stakeholders [15]. Review on blockchain technology in automobile sector discussed, and the authors have explored the possibilities to introduce the blockchain technology for automobile applications [16]. This research utilizes the Ethereum blockchain technology to bring the transparency in the conveyance purchase. Incipient conveyance registration, accommodation, bank loans, accidents, owner details, license information are available with the blockchain, it is shared among all the stakeholders. Each conveyance assigned with the Ethereum address to track all the transactions, each transaction has the date and time stamp. The simulation of the conveyance chain tested with Ethereum sandbox platform simulation implement [17]. Each transaction engenders the hash code that ascertain the security. The authentic-time deployment done with the truffle environment. There are three types of blockchain technology available in the market to test the applications [18]. Public blockchain: This sanction anyone to be a component of the blockchain, Bitcoin, Ethereum, NEM are the few among many public blockchains [19]. They do the cryptocurrency business, where it sanctions anyone to trade in the form of transactions. It utilizes the standard algorithm to operate their network, Ethereum utilizes the proof of work consensus mechanism to run the network, whereas private blockchain sanctions anyone to engender their own keenly intellective contract, this gives more flexibility compared with the public blockchain [20]. It has the username and password, gives restricted access to the people. Hybrid blockchain: This has the feature of integrating the private and public blockchain [21]. We utilized the Ethereum permissioned blockchain to test the electric conveyance chain application. This research work organized as follows: Section 2 represent the related work. Section 3 discuss the challenges and opportunities for the people during the electric car purchase. Section 4 represent the architecture of electric conveyance. Section 5 shows the blockchain electric conveyance cloud of things architecture that integrate the blockchain and cloud. Section 6 demonstrate the Ethereum sandbox blockchain simulations, hash code engendered for each transaction. Section 7 discuss the Ethereum blockchain implementation in a truffle platform. Section 8 discuss the implementation of meta mask, a mobile application integrated Ethereum blockchain to track the record of the conveyances. The full history of the conveyance can be tracked with the car chassis number. Fig.1 represents the magnification of the electric conveyance era. The subsisting system utilizes the centralized server approach in an electric conveyance purchase [22]. The stakeholders are not connected with distributed ledger. Developing countries most of the cases document verification transpires in the form of hardcopy, that gives opportunity to the buyer/seller to mute the pristine documents [23]. Verification of conveyance details during the pre-owned car purchase becomes a challenge, time-consuming, pay fees to third party for processing the documents, car loan, indemnification validity, contingency details become a challenge for a buyer. Blockchain connects all the stakeholder with distributed ledger that make the process simple, efficient, abbreviate delay, transparency, and engender trust.

II. RELATED WORK

Blockchain is a distributed ledger technology. The unique features of the blockchain are transparency, tracking of end-to-end transaction, and the information stored in a blockchain are immutable. Recent advancements in blockchain technology and their applications in sundry domains like automobile sector, logistics, and the consensus mechanism utilized in blockchain are discussed [24]. Cornell University research team accentuated the consequentiality of tracking of health care report, they expressed proximately a moiety of the

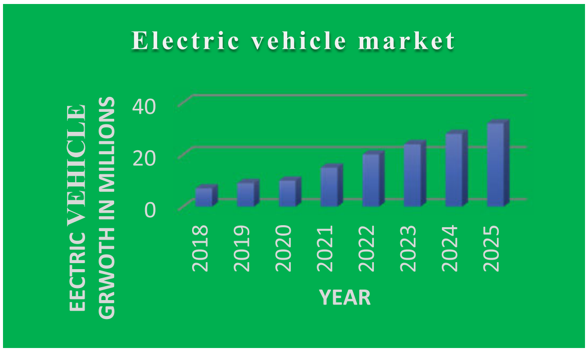


FIGURE 1. Electric vehicle market growth.

clinical tribulations are not reported, medicine prices keep incrementing, blockchain technology could provide the best solution in terms of transparency and tracking of medical information [25]. Keenly intellective contract is a piece of software utilized in blockchain to make the transaction in a more secured way. Consider the situation Party A would relish to purchase some equipment's from party B, then party A always worried about quality of the product, on time distribution, advance payment, these processes can be automated with keenly intellective contract [26]. Blockchain technology could be applied for electric conveyance, perspicacious conveyance, keenly intellective city, urban developments, amend the quality of life, most of the applications are theoretical not implemented in authentic time [27]. Blockchain predicated approach for digital twins enhance the transparency from design phase, all the information available in a distributed ledger [28]. The layered architecture of the blockchain, and the protocol utilized by the intel to safeguard the blockchain application has been discussed [29]. Integration of conveyance network and blockchain will enhance the data security in a conveyance-to-conveyance communication environment [30]. Authors suggested that blockchain implementation will have the more impact on developing countries rather than developed countries, 90% of the rural lands in Africa unregistered or undocumented, more than 20 million families who reside in rural area do not have their own land where there is a sizably voluminous potential to implement the land registration with blockchain [6]. Fake export invoices have been utilized in China borders. In September 2014 10 million worth of fake transaction were identified [31]. BMW is one of the bellwethers in automobile industry would relish to integrate the raw material purchase, and other functions through blockchain [32]. China used cars market fascinated with integrating the blockchain for their business. This will enhance the buyer experience and full history of the conveyances can be tracked [33]. Few startup companies commenced working to engender a blockchain predicated solution for the automobile industry [34]–[39]. Hybrid blockchain can be utilized for tracking the counterfeit medicines in a pharma supply chain [40]. Indemnification is one of the major sectors where the multi trillion-dollar worth of business transpires every year but still not addressed, blockchain technology could expedite the transactions, and truncate the paperwork [41]. Design pattern for making the micro payments with cryptocurrency make more facile, off chain and on chain concept introduced [42]. Conveyance parking payment system utilizing the Ethereum blockchain discussed, this provides the interface with the mobile application platforms for facile payments [43]. Blockchain and edge technologies solve the subsisting challenges. This enhances the analysis with IoT integration [44]. Drones operated in an unsecured environment leads to the information security issues in data sharing, blockchain predicated encryption could enhance the security [45]. There are two types of the blockchain. First one is the public where anyone can access the blockchain network. Bitcoin, Ethereum, NEM blockchain are the few companies works as public blockchain where it sanctions the public to make the cryptocurrency transactions [46]. Ethereum public blockchain works with proof of work algorithm, recently they introduced proof of stake algorithm. Private blockchain or permissioned blockchain has the restricted access [47]. It sanctions only the registered users to be a component of the blockchain network. Ethereum and NEM blockchain support the private blockchain where the users can develop their own algorithm [48]. We introduced the proof of conveyances algorithm to design and test the perspicacious contract. Each node in a blockchain assigned with the Ethereum address for making a transaction. Each transaction associated with the block number, gas fees utilized, source address, block hash, and the transaction hash. It withal has the mining date and time. This information cannot be muted by any third party. The same process is followed to engender all the subsequent blocks. Since blockchain is a distributed ledger, each transaction verified and shared with all the stakeholder who is a component of the conveyance chain. Blockchain operates with the consensus mechanism [49]. Each transaction approved by the algorithm. The Proof of work needs astronomically immense computational power to solve the involute mathematical operation [50]. The one who solve the puzzle gets rewarded. This algorithm consumes a substantial magnitude of electricity. Proof of stake works predicated on the quantity of stake owned by the blockchain node. It does not consume sizably voluminous electricity, or the node does not require any special hardware to operate [51]. The major inhibition is the node which has the highest stake to dominate the network. In order to surmount this the mining constraint is defined in the algorithm. Incentive policies given by the regime emboldens the people to buy electric conveyance [52].

Based on the literature review we found that there is a huge potential to implement the blockchain in electric vehicle sector. Cryptocurrency payments, rewards, tracking history of electric vehicle, cross border payments for an electric vehicle charging, resale value of an electric vehicle, authentication, and battery replacements are possible with blockchain technology.

III. CHALLENGES AND OPPORTUNITIES IN ELECTRIC VEHICLE SUPPLY CHAIN MARKET

The following are the challenges faced during the conventional pre-owned electric conveyance purchase. Types of chargers used to charge the conveyances and charging time, one sizably voluminous challenge faced by the electric car users are chargers and the charging time [53].

A. TYPES OF ELECTRIC VEHICLES

Electric conveyances are relegated in to three variants. Battery Electric Conveyances (BEV), Plugin Hybrid Electric Conveyance (PHEC), Hybrid Electric Conveyances (HEV). BEV's are plenary electric conveyance with zero carbon emission. HEV has both engine and electric motor, it utilizes the regenerative braking system. Plugin hybrid electric conveyance has major inhibition in terms of battery [54]. Only few models are available in the market for the customers to purchase.

B. TYPES OF ELECTRIC CHARGERS

There are three types of chargers available in the market. Type 1 is a 120V plug utilized for charging that takes 30 to 40 hours. Type 2 chargers will take 8 to 9 hours' time to charge the conveyance. Type3 chargers which can charge 80% in 30 minutes time [55]. Since the electric cars market is emerging, finding the right charging point and the originality would be a challenge. Electric charger's compatibility is another issue. There is a coordination in making the Type 2 chargers with all the automobile except Tesla electric conveyances.

C. CHARGING INFRASTRUCTURE

Non compatibility in charging station leads to arduousness in electric conveyance adaption. Charging Infrastructure for electric conveyances are growing in the automobile sector. They require enough charging facility to power the conveyance. People reside in the flats face the quandary of charging the electric conveyance [56]. Mobile charging vehicle will be the future to avoid shortage of charging, cryptocurrency payment is possible to charge the electric vehicle.

D. DOCUMENTATION

The subsisting system manufacturer engenders the conveyance and ship it to different components of the world. Manufacturers utilize the sea cargo or air cargo to ship the conveyance. Once it is shipped, it goes to the distributors of the respective country, who took the dealers ship for selling the electric conveyances. All the information cognate to the conveyance is available with them. There are possibilities that they may transmute the designation of few conveyances, mainly the luxury conveyances. Similarly, in case of pre-owned conveyance purchase the history of the conveyance is available with reseller. Subsisting conveyances purchase the information is not shared as distributed ledger. There is no transparency in the automobile sector for the pre-owned car purchase. Blockchain and cloud integration could bring the better solution.

E. CRYPTOCURRENCY FOR ELECTRIC VEHICLE PAYMENTS

Many people would relish to charge the conveyance at home or office building, this would be possible since the average driving distance of a conveyance would be around 50-60 km per day [57]. Electric chargers installed on the ground floor of buildings consumes more energy, it is paramount to have the billing system by the building owners. People can pay predicated on the utilization. Cryptocurrency (digital currency) can be utilized for the sustainable payment [58].

F. SHORTAGE OF ELECTRIC VEHICLE TECHNICIAN

Shortage of technician would be another quandary, only 3% of people are having the erudition on electric car maintenance [59]. There is an opportunity to introduce the online electric conveyance maintenance training by electric conveyance manufacturers through the blockchain cryptocurrency platform. Their certificates can be linked to electric conveyance blockchain application. This will avail the electric conveyance buyers to ken the authenticated technicians and the conveyance accommodation details updated on blockchain. This will engender more job opportunities, and transparency in conveyance maintenance.

G. MULTIPLE PROCESSORS FOR MODERN ELECTRIC VEHICLE

Multiple processors are needed to take care of the functions. Minuscule cars need 30 processors, and the sizably voluminous conveyance may require 100 processors to handle the operation smoothly. Astute batteries are required for power management. There should be an option to integrate an extra cell if you are driving the distance more than expected. Power consumed in the electric car cabin could minimize the efficiency of the conveyance by 30%. Lightweight body material could be considered as one of the parameters to the battery power savings [60]. University of Texas estimated that Electric conveyance require more energy, the current imperilment needs to be ameliorated by the solar puissance [61].

H. BLOCKCHAIN REWARDS FOR ELECTRIC VEHICLE RECYCLING

Once the life cycle of an electric conveyance come to a cessation, that signifies the frequent maintenance of battery and motor, that would be more extravagant. Once the owner decided to demolish the conveyance, they could go to the electric conveyance recycling center. The electric conveyance is evaluated by the blockchain system predicated on the conveyance history and blockchain rewards will be given to the owner. As a manufacturer they can track the life cycle of an electric conveyance through blockchain cloud accommodations [62].

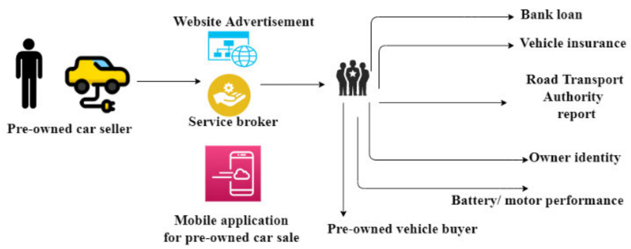


FIGURE 2. Existing pre-owned electric vehicle purchase and documents needed for validation.

I. PRE-OWNED ELECTRIC VEHICLE BUYER

As an incipient car buyer or during the pre-owned electric car purchase most of the time customers are not cognizant about inchoation of the car manufacturer, shipment, quality test, drive test by the manufacturer, battery, motor performance details are not shared with the customer. There is no transparency in the manufacturing process. People trust with the brand of the car then purchase. Seller identity becomes more critical with developing and underdeveloped countries. Most of the documents are available as hard copy. This can be facilely muted. The buyer does not have the system to cross verify the details. The car indemnification is renewed on yearly rudiments. The buyer does not ken the number of accidents transpired with the car. The records are available with indemnification companies. The buyer could not access the information cognate to conveyance accidents. Blockchain could provide the full history of the accidents with full details like date, time, location, any injuries, damage level of the conveyances. Automated or history of the car reports are not available to the buyer. They must trust the road to convey the ascendancy report. In Most of the cases people may supersede the subsisting spare components with the duplicate one. The buyer needs to pay to the consultant for inspecting the conveyances. Still there is no distributed ledger documentation where the buyer can verify the conveyance maintenance report or inspection of the conveyance transparently. People always worried on the accidents of the conveyances whenever they purchase the used cars, trucks, or two-wheelers. There is no record available to track the number of accidents reported on a conveyance. Few conveyances had gone through the major accidents. The owner might have transmuted the body of the car or the consummate painting. There are cases they might have painted with different colour compared with the pristine colour of the conveyance. Fig.2 shows the subsisting process in electric conveyance purchase. They are not connected with the shared ledger. Buyer or seller needs to submit the documents like their identity and other information to every stakeholder independently. In Some cases, they inductively sanction the hard facsimile of documents. There is a different documentation process involved in the automobile industry either people buy an incipient car or pre-owned cars. It requires a plethora of time. The Fig.3 shows the blockchain based solution involved in the electric conveyance purchase.

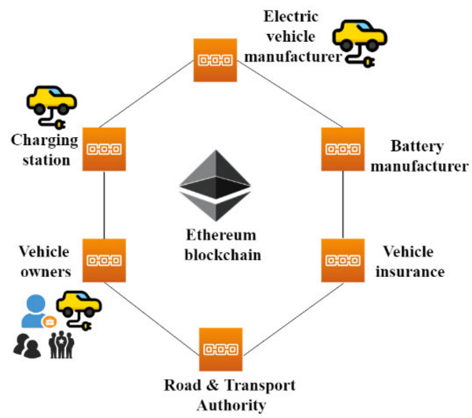


FIGURE 3. Blockchain based electric vehicle supply chain.

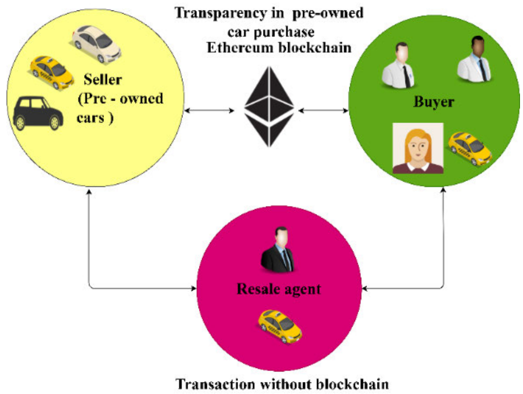


FIGURE 4. Ethereum blockchain connects electric vehicle buyer/seller.

J. OBJECTIVES

This research has the following objectives.

- Design the blockchain and cloud integration architecture for an electric vehicle to track the details.
- Design a hybrid blockchain for an electric vehicle to track all the transactions.
- Use the truffle platform/Meta mask to record all the transaction like battery performance, owner details, accident information in a public/private blockchain.
- Implement the cryptocurrency payments for electric vehicle eco system, and blockchain rewards for effective battery maintenance and zero wear and tear records.

The subsisting system manufacturer engenders the conveyance and ship it to different components of the world.

The above Fig.4 shows the peer-to-peer connectivity between the buyer and the seller. They are connected with the distributed ledger. Anyone buys the car has all the information cognate to the conveyance appended to the blockchain as a transaction. Each transaction has the date and time. This brings the transparency among all the stakeholders. The major details include in the blockchain are.

1. Electric vehicle chassis number
2. Manufacturer name
3. Shipping information

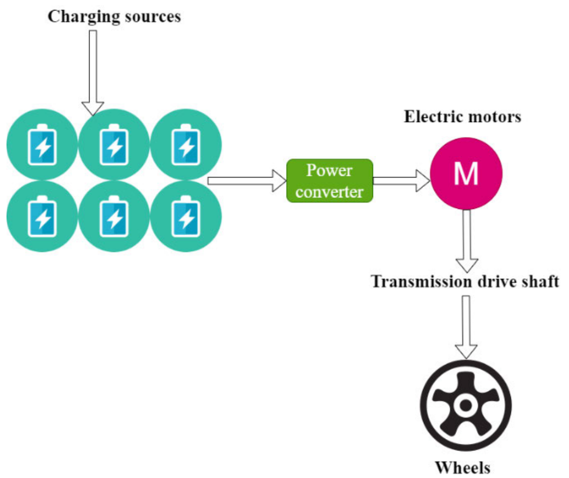


FIGURE 5. Architecture of electric vehicle.

4. Owner name and other details
5. Driver licenses details in case of rental car
6. Battery performance
7. Battery Insurance details
8. Bank loan details
9. Maintenance information, accident records
10. Police report

Electric conveyance chassis number: It is a unique number provided by the manufacturer. Vin chain platform utilized for conveyance tracking in the U.S.A. [63]. It is like a third-party accommodation, and it does not provide a cessation-to-end solution. The option is given to the conveyance owners to register with their platform. They withal take commission for their accommodation. In our proposed model the manufacturer keeps all the information in a cloud environment to bring more transparency and monitor the life cycle of their product [64]. This enhances the automobile ecosystem to be more sustainable. The battery can be recycled, once the conveyance utilized for certain miles then it could be given back to the manufacturer for recycling. The rewards and payments issued to the owners by the manufacturer in the form of cryptocurrency. This will embolden more people to move towards electric conveyance.

IV. ELECTRIC VEHICLE ARCHITECTURE

The Fig.5 shows the architecture of an electric conveyance. The major components of the electric conveyances are charging sources, power converters, electric motors, transmission drive shaft and wheels. The sources of charging are AC (alternating current) and DC (direct current). Renewable energy-predicated charging like solar or wind energy could be acclimated to charge the electric conveyance battery. Pre-owned electric conveyance purchase, the major challenge is the buyer would relish to ken the performance of a battery for the past one year, time taken to charge the electric conveyance (full battery), types of charging stations used to charge the battery during the lifecycle of the electric conveyance. The subsisting system does not provide the access to this information. It requires to be recorded with the blockchain to bring the transparency in the pre-owned electric conveyance purchase. In order to bring the transparency in a battery management and monitor the healthiness of the battery, it is linked with the conveyance chassis number. Table 1 show the process of mapping the electric conveyance manufacturer with the Ethereum address. Each electric conveyance assigned with the blockchain address to track all the transaction associated with the conveyance. The major concern on the electric conveyance cognate to the batteries. Since batteries are manufactured by different vendors like Panasonic and other companies. Electric conveyance batteries need to be integrated with the car chassis number relished to the blockchain cloud.

TABLE 1. Ethereum blockchain registration for vehicle and battery.

S:No	Manufacturer	Chassis number-Vehicle Identification	Battery number given by manufacturer	Ethereum Truffle account for Electric Vehicle
1	EV manufacturer 1(Tesla)	Vehicle Identification Number (VIN -1)	Serial number 1 (LG)	Ethereum blockchain account 1
2	EV manufacturer 2(Audi)	Vehicle Identification Number (VIN - 2)	Serial number 2 (Panasonic)	Ethereum blockchain account 2
3	EV manufacturer 3(Nissan)	Vehicle Identification Number (VIN - 3)	Serial number 3(Panasonic)	Ethereum blockchain account 3
4	EV manufacturer 4(Mahindra)	Vehicle Identification Number (VIN- 4)	Serial number 4(LG)	Ethereum blockchain account 4

V. BLOCKCHAIN ELECTIC VEHICLE CLOUD OF THINGS (BEVCoT) – DECENTRALIZED COMPUTING

There are variants of cloud accommodations available where the electric conveyance operations, maintenance, performance can be monitored through the blockchain cloud accommodations. This brings the transparency among all stakeholders. AWS (Amazon Web Services) is the most popular cloud accommodation integrated with the Ethereum and Hyperledger fabric [65]. AWS fortifies the private/public blockchain operations.

A. BACKEND-as-a-SERVICE (BaaS)

This provides all the backend activities as accommodation like storage space, authentication, push notifications, mobile

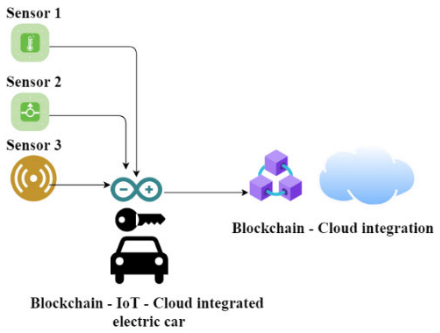


FIGURE 6. IoT- Blockchain – Cloud integration to monitor the performance of the electric vehicle.

application interface and other services [66]. It can be utilized for edge computing, accessed from remote locations. Maintenance of the servers given to third party as a service, and the organization could fixate on the front-end applications. This service enables the pre-owned electric conveyance buyers to connect with the manufacturer through cloud accommodations to verify the credentials.

B. MOBILE-BACKEND-as-a-SERVICE (MBaaS)

This enables the mobile application as a backend accommodation. This accommodation needed for IoT predicated applications where we require to push the data to the cloud. Application Programming Interface (API) connect the mobile application and the cloud accommodations. This accommodation monitors the authentic-time data then push it to the cloud [67]. In order to enhance the security in vehicle supply chain a mobile application integrated with the blockchain gives the best performance. The services needed for an electrical vehicle incorporated with the mobile application. It can be divided into cryptocurrency-based applications and non-cryptocurrency-based application. Digital wallets, Dapp, and cryptocurrency exchange app needed for cryptocurrency applications. Inventory management system like specification of an electric vehicle, and other services can be considered as non-crypto applications.

Sensors are connected with IoT (Internet of Things) devices such as Arduino IoT or Raspberry Pi to interface with the cloud services. Fig.6 represent the IoT sensors integrated with the blockchain cloud applications.

C. INFRASTRUCTURE-as-a-SERVICE (IaaS)

It is utilized as a cloud accommodation where the corporates could rent the cloud space. Computation and storage are possible for the users. An electric conveyance could utilize this accommodation to track all the information. This accommodation utilized as a pay as you go model [68], [69]. The battery performance, conveyance maintenance details, contingency information could be stored in a blockchain cloud space. Each conveyance assigned with Ethereum address as an identification number and a private key associated with it to track the details.

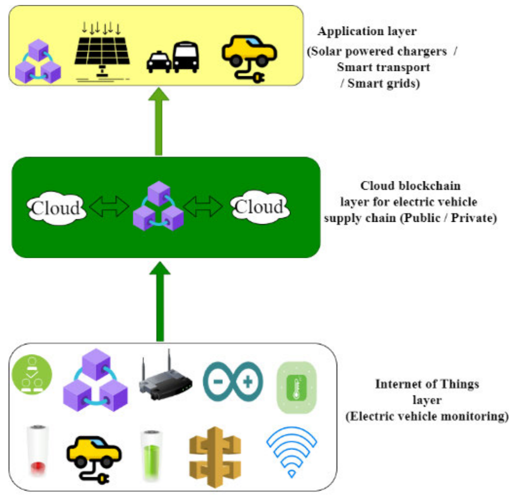


FIGURE 7. Blockchain and cloud integration for electric vehicle.

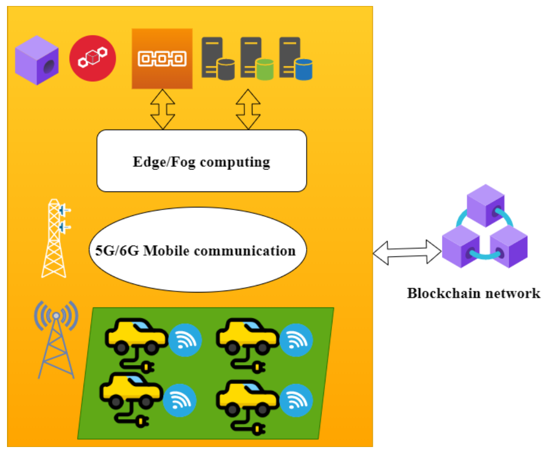


FIGURE 8. Blockchain Electric Vehicle Cloud of Things (BEVCoT).

D. PLATFORM-as-a-SERVICE (PaaS)

This platform engenders a space for the developers to develop the application utilizing different implements, conventionally. This model is extravagant compared to other accommodations [68], [69]. Hardware/Software implements needed to test the application or proof of concept available with PaaS as remote authenticate. Example: Intel dev cloud provide access to the developers to run their model with their platform, users need not own or buy the hardware to test their application.

E. BLOCKCHAIN CLOUD

Most of the customers select Amazon Web Services (AWS) as a trusted platform to host their blockchain. The 25% of Ethereum workload runs with AWS. Hyperledger fabric enterprise customers like BMW, Nestle, Sage, Legal & General are the few companies as part of the AWS blockchain cloud. Electric vehicle enterprises like TESLA, BENZ, General Motors, and Audi could use the AWS blockchain platform to bring the transparency of vehicle in a supply chain [70].

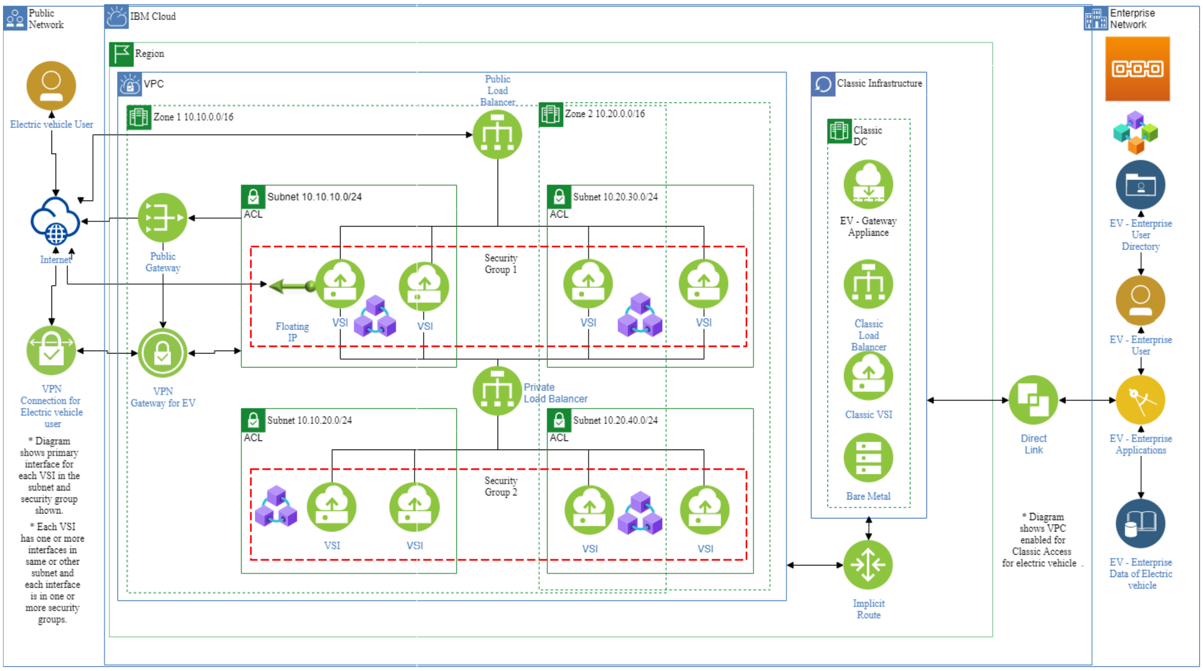


FIGURE 9. Blockchain – Cloud integration architecture.

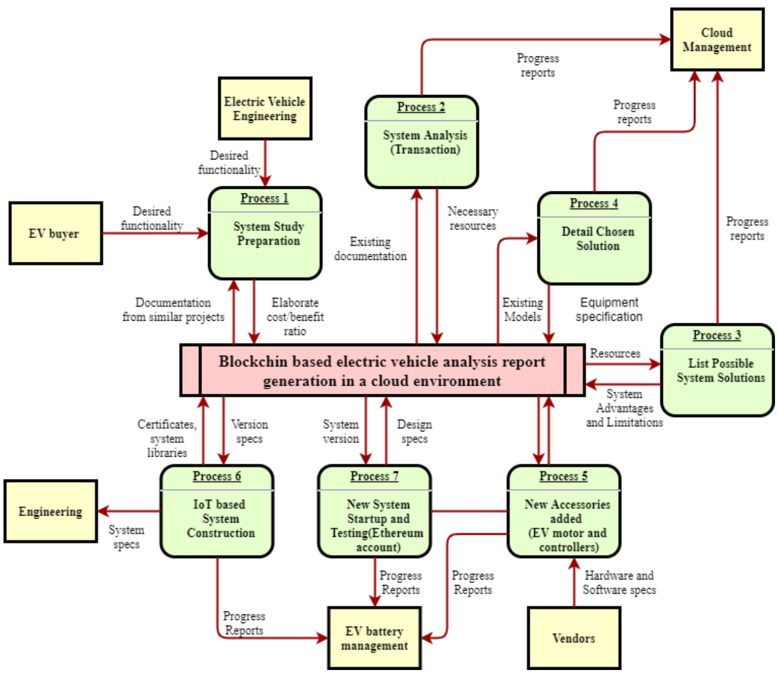


FIGURE 10. Blockchain based electric vehicle analysis in a cloud environment.

F. BLOCKCHAIN CLOUD OF THINGS

Blockchain cloud of things can be habituated to monitor the performance of the electric conveyance. Fig.7 shows the blockchain cloud of things architecture where it has three-layer architecture. Layer 1 connected with the IoT contrivances, it accumulates the data from sensors like pressure of tyre, acceleration of vehicle, battery heat, charging time of battery. These real time data captured then push it to the next layer. Layer 2 is cloud architecture this sanctions private/public cloud to be a component of this design. Private cloud give access only to the registered people. Public cloud sanctions anyone to be a component of this service. Hybrid cloud gives access to private/public [71]. Fig.8 represents the blockchain conveyance cloud of things where

TABLE 2. Comparision of blockchain platforms.

S: No	Programming language	Support & documentation	Development	Number of transactions per sec (TPS)	Limitation & Flexibility	Consensus mechanism	Incentives
Ethereum blockchain	Solidity	Ethereum website has technical documentation and few case studies also available.	Ethereum was introduced in 2014. Developer community have significant contribution, and applicable for real-time applications.	1000 – 4000 TPS Ethereum 2.0, 10,000 TPS.	More flexible, many applications are running with Ethereum. More than 60% of Ethereum nodes are already running with cloud.	PoW – This has the major limitation, recently PoS introduced to overcome the issues.	Block is rewarded/ Financial reward. Accommodate private/public blockchain.
IBM blockchain	Chain code, Java and JavaScript	GitHub repository, Technical support, FAQ.	IBM in collaboration with Linux foundation started Hyperledger platform.	Goal to achieve 100,000 transactions per second.	There are no limitations they also provide blockchain cloud service	It allows users to create their own consensus algorithm.	There is no financial reward.
Oracle blockchain	Golang, Python, C++	Oracle blockchain as cloud service/enterprise edition	It uses fabric as a platform.	Enterprise X4 – 4000 transaction per hour.	Enterprise cloud blockchain	RAFT consensus algorithm used.	No financial reward, own token can be created.
NEM blockchain	C++, Java, Python	GitHub, and NEM technical documentation	NEM can be used as private/public blockchain	4000 TPS	It can be integrated with mobile application using API.	Proof of Importance protocol is used	Financial reward given as XYM, cryptocurrency of NEM.
Intel blockchain	API, JavaScript, Python, Go, C++ and Rust.	GitHub repository, website developer page.	Sawtooth is part of the Hyperledger platform support the private blockchain	1300 TPS	It has the option to integrate with IoT based applications (Sea food supply chain).	PoET	There is no financial reward.
Bit coin	C++	Bitcoin developer document available with their website	It is used as public blockchain	9000 TPS	Mainly used as public blockchain for financial transactions.	PoW	Financial rewards are given.

electrical conveyances are connected to 5G/6G mobile communication accommodations. It has the highest data transfer rate where the genuine-time data from sensors can be transmitted to the cloud. The edge computing/fog computing avails to take efficacious management of electric conveyance [72].

Blockchain could play major role in getting trusted data from sensors. Edge computing integrated with blockchain could achieve valid transaction with date and time stamps [73]. The scalability quandary in a blockchain could be solved if we Integrate the data to the cloud accommodations.

G. EDGE COMPUTING

Predictive maintenance on battery maintenance could avail to preserve the battery life. Once the electric conveyance sold to the owner then blockchain conveyance cloud of things plays a major role in capturing the genuine time data of the electric conveyance. This would be possible with the IoT-Blockchain- Cloud integration. Blockchain plays major role in edge computing of electric vehicles. The critical parameters are captured by the sensors, validated by the blockchain then push it to the cloud [74].

H. VIRTUAL PRIVATE NETWORK (VPN)

VPN network used to make the transaction in a more secured way. TESLA utilizes the VPN accommodation for making the software updates over the air [75]. Each conveyance assigned with the utilizer id and password to access the VPN accommodation.

I. VIRTUAL PRIVATE CLOUD (VPC)

VPC could manage many machines. Some popular VPC accommodations are Amazon, Google cloud, RAK space [76]. This engenders the more secured private space in a public cloud environment. Each user assigned with the private key to access this place. No one can enter without the private key. These features could be utilized by a pre-owned conveyance in a cloud space.

J. VIRTUAL SERVER INSTANCES (VSI)

IBM clouds virtual are scalable, these accommodations could be integrated in a minute to the blockchain conveyance supply chain [77]. Life cycle of an electric conveyance is monitored through the VPC. IBM blockchain platform is interoperable, connected with IoT devices to collect the real time data from vehicles. Blockchain adds trust to the Artificial Intelligence (AI) and IoT [78]. Blockchain -IoT can be used in electric vehicle which has many sensors to monitor the vehicle performance, also as verification tool to validate the parameters of electrical vehicle. Few critical parameters like battery heat, tyre pressure, deportments of the driver that can engender the wear and tear quandary lead to truncate the performance of the battery, battery charging time, expedition, charging cycles needs to be monitored and the data pushed to the cloud to make genuine time analysis. VSI and VPC could solve these issues. Electric conveyance battery is the most sumptuous one, the cost of a battery ranges from $10,000 to $20,000 [79].

K. CLOUD INTEGRATION FOR ELECTRIC VEHICLE (VSI)

This research uses Ethereum blockchain implementation for the pre-owned electric conveyance in a cloud environment. The Fig.9 represents the amalgamation of private and public cloud integration with blockchain to bring the transparency in a pre-owned electric conveyance purchase. Table 2 represent the comparison of all the blockchain platform [80]. Ethereum blockchain could process approximately

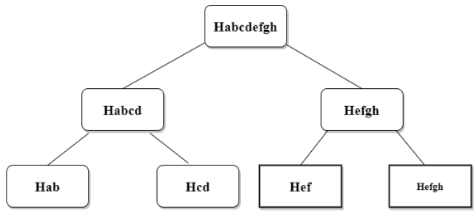


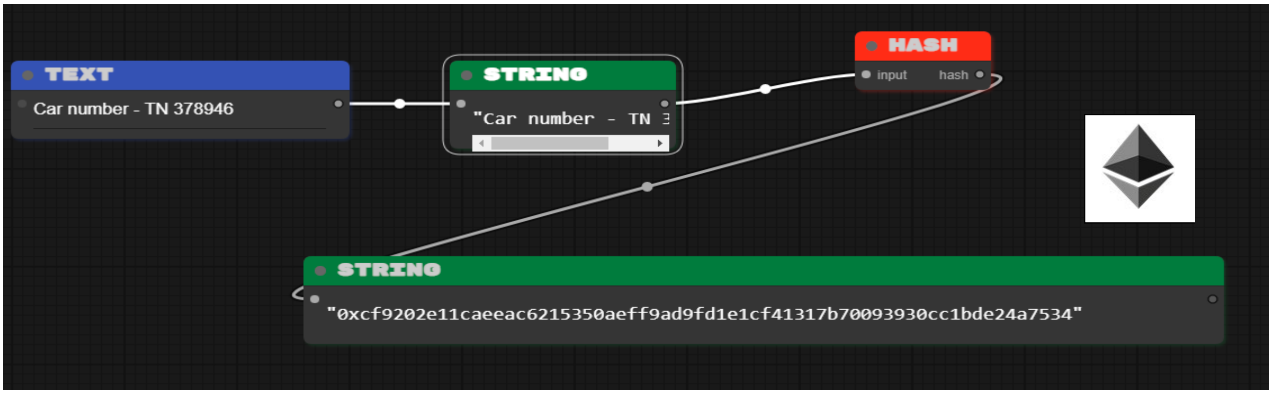
FIGURE 11. Merkle tree design for electric vehicle.

4000 transaction/second. It is an open-source platform. Ethereum sanctions the developers to engender their own application [81]. Blockchain rewards are possible with the Ethereum. It withal fortifies the cloud integration (AWS and Microsoft Azure). The following attributes like programming language, development, number of transactions, circumscriptions & flexibility, consensus protocol utilized in blockchain development, incentives have been considered. Comparison results shows that Ethereum blockchain chain has the feature of utilizing public and private blockchain.

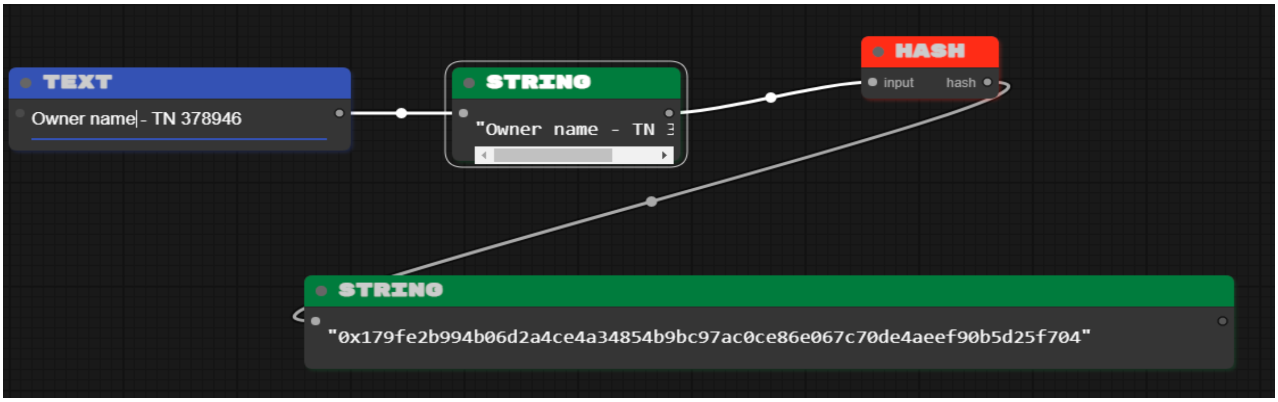
Cryptocurrency payment ETH(Ether) could be habituated to make the transaction in a public and private blockchain. This could create the tokens, and number of transactions. The Fig.10 represents the sundry process involved pre-owned electric conveyance purchase. Process1indicates the system study preparation where the authenticated documents are available in a blockchain. Buyer can check the price, model, year of manufacturing, owner, bank loan, and other information directly from blockchain cloud services. The depreciation of the conveyance price withal available transparently. Process 2 shows the system analysis, the performance of the electric motor, and the battery performance is analyzed in a fine-tuned interval through cloud computing. Process 3 betokens the list of possible solutions for pre-owned electric conveyance in case of poor performance of the motor or battery. Process 4 denotes the detail solution for the issues, availability of battery, certified technicians to do electric conveyance maintenance, electric motors, and controllers. Since blockchain is most trustable platform all the solution cognate to electric conveyance irrespective of the manufacturer linked to the Blockchain electric conveyance cloud of things. Process 5 shows the incipient appurtenant integrated to electric conveyance model, and their performance captured with cloud. Process 6 represent the IoT predicated system utilized in electric conveyance and their performance captured then linked to the cloud. This avails to monitor the authentic-time performance of the battery, driver performance, battery loss due to wear and tear, types of charges used to charge the electric conveyance. It withal validated the contrivances before we connect to the conveyance. Table 3 shows the Ethereum address assigned for each process.

Each contrivance could be certified then integrated to the blockchain to engender trust among the stakeholders. Process 7 designates the incipient system startup and testing. Each process needs an Ethereum account number to capture the information, then linked to the cloud. EV buyer could

STEP 1 – VEHICLE ON BLOCKCHAIN WITH REGISTRATION NUMBER.



STEP 2 – OWNER NAME ON BLOCKCHAIN WITH REGISTRATION NUMBER.



STEP 3 – VEHICLE ACCIDENT DETAILS CAPTURED

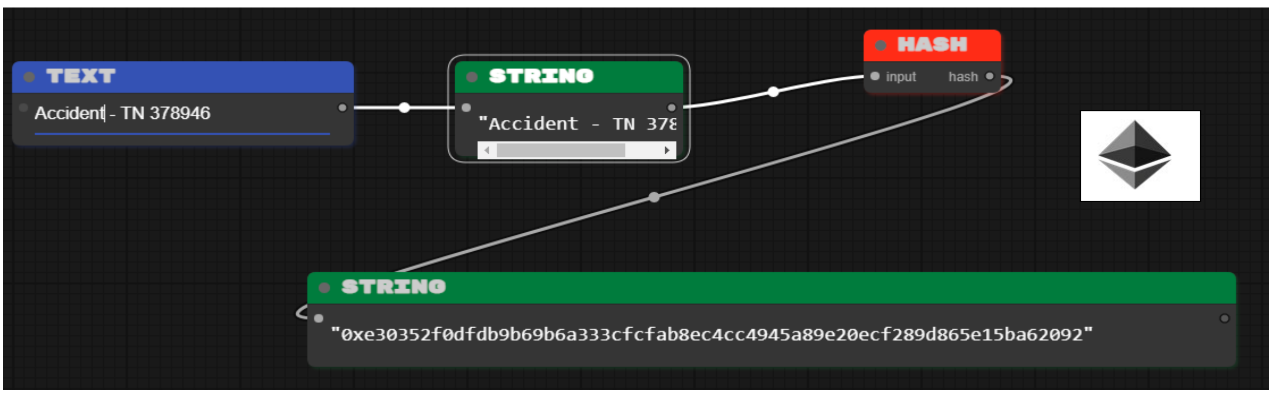


FIGURE 12. Ethereum blockchain sandbox simulations to track the vehicle.

have access to all the information in a single mobile application/desktop application that can be integrated with the blockchain.

VI. ETHEREUM SANDBOX SIMULATIONS TO TRACK THE ELECTRIC VEHICLE SUPPLY CHAIN

Ethereum sandbox is an open-source platform that provides an opportunity for the researchers to simulate their conceptions and develop the applications. The following steps represent the proposed blockchain model for the pre-owned car purchase utilizing Ethereum sandbox simulations. Step 1 - Transaction 1 represents car registration details (car number registered with blockchain for tracking) Sandbox platform has the input, output, hash function, key generation, and the digital signatures. Transaction 1 represents the pristinely incipient car details pushed to the blockchain. First

TABLE 3. Ethereum address assigned for each process.

S: No	Ethereum account – Address represents each process associated with Ethereum blockchain (Truffle platform)	Description
1	0x6581F0dDCC81fBDA91 b0813f99c8372739b3FCf6	Process1(Know the EV system study)
2	0x8E3B62A4725F5832CF4 4627a2f7Ea83CB021CF2F	Process2(Analyze the performance of motor & battery)
3	0xf599d84dA5487B81D1D c5F0E9557Bd4ff36c456A	Process 3(List of possible solution)
4	0x34f85C0e08654948c06A e79438D8aabB4265d05b	Process 4(Details of possible solution)
5	0xf97FCF7a835B299f8D5 22a72012091495B184eFa	Process 5(New accessories added to EV)
6	0xAd015E45B833792aA14 5C92F21870573d68F3dE4	Process 6(IoT based system analysis integrated with cloud)
7	0x5e6F43763096fD77D90 1808A3f4Cf0c33EC895FA	Process7(Electric vehicle battery management)

step the conveyance is registered with the road convey ascendancy. The car number TN 378946 encrypted by the hash function, and the transaction is approved by the blockchain network, the block 0 is engendered to track the conveyance blockchain. The output of the hash function is engendered this transaction with the hash code, engendered by hash algorithm. This is an immutable transaction not tampered by anyone. Step 2 - Transaction 2 represents car owner details (car number registered with blockchain used for tracking). The first owner designation is entered with the blockchain and approved by the blockchain network. The operation of the keenly intellective contract and the algorithm used to execute the contract discussed in the next chapter. Blockchain is a distributed ledger, and it provides the immutable transactions. This provides the transparency among the first owner and the one who is looking to purchase the conveyance. This plenary eschews the middleman in the conveyance purchase and provide to confide in a conveyance purchase. The car number in a blockchain is considered as unique. It is linked to the Ethereum address, all the transactions are tracked by the address associated with the transaction hash function. Each block is encrypted with the fine-tuned length hash code. Ethereum utilizes the Keccak 256 algorithm to derive the hash function. This algorithm utilizes the SHA-3 (Secure Hash Algorithm -3) for the hash function [82]. Since Ethereum utilizes the SHA-3 version they denominated as Keccak 256. The hash function has the 256 bits, represented by hex decimal numbers. The information processed by the hash function are highly secured. Step 3 - Transaction 3 represents

TABLE 4. Hash code generation for vehicle number.

Vehicle identification	Hash code	Description
TN 378946 (Vehicle identification – Chassis number)	Oxcf9202e11caeeac 62153509aeff9adgfd 1e1cf41317b700939 30cc1bde2497534	Hash code of vehicle identification

contingency. There is a possibility that the contingency may transpire due to rain, or it can transpire because of the driver carelessness. Once the contingency transpires it is reported to the police and recorded to the Ethereum blockchain as a transaction. Whenever they sell this car all the information available with the blockchain. Step 4 - Transaction 4 represents maintenance. Once the contingency occurs the conveyance needs to go for the maintenance. Fig.11 shows the Merkle tree route for a blockchain. The detail information regarding change of spare components. The Fig.12 shows the Ethereum sandbox simulations. This simulation shows how the transaction transpires in a genuine time environment. There will be a hash code for each transaction, these codes are immutable. Transaction could transpire once the peer node approves the authentication of a node, otherwise the transaction will be declined. In case of proof of work algorithm, the node which solves the intricate mathematical equation gets rewarded and the next block is engendered. Table 4 shows the hash code generation for a transaction.

Merkele tree used to track all the transactions facilely. Since electric conveyance information or analysis is done through cloud. Merkele tree analysis could retrieve the information in a more expeditious way. Fig.11 shows the merkle tree creation for vehicle supply chain.

The above Table 5 shows the comparison between the Ethereum and the Hyperledger platform. Ethereum will be the most felicitous one for electric conveyance since it fortifies the private/public blockchain.

Fig.13 represent the blockchain formation for a vehicle supply chain.

VII. ETHEREUM PERMISSIONED BLOCKCHAIN IMPLEMENTATION IN A TRUFFLE ENVIRONMENT TO TRACK THE PRE-OWNED ELECTRIC VEHICLES

The following Fig. 14 shows the blockchain design for the pre-owned vehicle supply chain using Ethereum blockchain.

Pre-owned vehicle chain application developed using meta mask, ganache, and truffle platform. The above Fig.15 represents the astute contract development with Ethereum blockchain for the conveyance supply chain. Truffle suit is an open-source platform. It enables the developer to come up with their own conception and develop the blockchain application [82]. Ethereum permissioned blockchain address

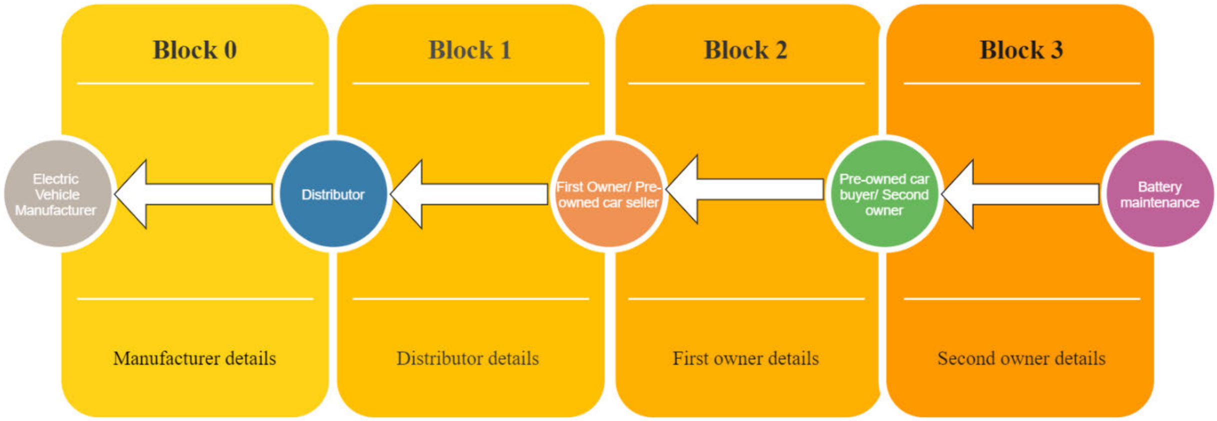


FIGURE 13. Block creation for electric vehicle.

TABLE 5. Ethereum vs Hyperledger.

Characteristics	Ethereum	Hyperledger
Restricted access	Public or private	Private
Programming	Solidity	Chain code
Currency	Ether	No currency
Scalability	Higher number of nodes can be added	Number of nodes are minimum
Governance	Ethereum developers	Linux foundation
Applications	Wide range	Wide range
Platform	Generic	Modular blockchain
Smart contract	Smart contract code	Smart contract code (e.g., Java, Go)
Platform for Business	B2C (Business to customers)	B2B (Business to Business)

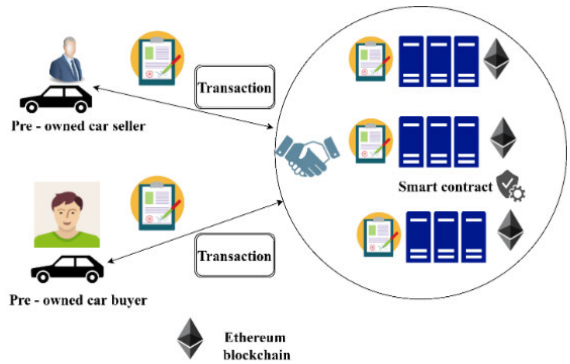


FIGURE 14. Pre-owned electric vehicle purchase with Ethereum blockchain.

FIGURE 15. Pre-owned vehicle chain created with metamask, ganache and truffle.

engendered with truffle platform to track conveyance information. Our proposed conveyance supply chain tracking application developed in a truffle environment. It utilizes the JavaScript to develop the keenly intellective contract to test this application. Smart Contract: Algorithm for vehicle supply chain shown below.

The seller needs to have the Ethereum account that enable them to do all the transactions with blockchain. The owner denomination, conveyance number, maintenance records, contingency records are linked to the seller account and verified by the conveyance chain. This information shared as distributed ledger with all the stakeholders. Perspicacious contract has a set of rules designed for the blockchain. All the blockchain machines operate predicated on the keenly intellective contract or the consensus algorithm. They are relegated as private, public, and hybrid blockchain. The public blockchain with sanctions anyone to be a component of the chain whereas the private blockchain gives access to only sanctioned people. Hybrid blockchain has the feature of integrating both. This proposed research utilizes the permissioned blockchain or the private blockchain to design the conveyance chain application. This method each stakeholder assigned with a blockchain node for the communication. Each node has the Ethereum address. Buyers need to have the Ethereum account for making a transaction. They can verify all the information with conveyance chain. All the information cognate to the conveyance can be tracked by the conveyance chain. Once the perspicacious contract is engendered between the seller/buyer. They can view all the information cognate to the conveyance. Since this application engendered on permissioned blockchain. It sanctions only the registered users to get all the information. Ethereum blockchain implemented using truffle environment. The following are steps involved in establishing the authentic-time

Pre-Owned Vehicles Chain: Module 1 – Pre-Owned Electric Vehicle Purchase

Input: *Vehicle manufacturer, Distributor, Reseller, Buyer, Bank, Maintenance technician, Battery manufacturer*

1 Manufacturer create the Ethereum address for an electric vehicle in a private *blockchain.*
2 Status of the application is ***requested with distributor.***
3 Applications are selected based on distributor information, payment terms mentioned in the smart contract.
4 **Road transport department** validate the electric vehicle records with blockchain, and the buyer/seller details.
5 **if vehicle** records = zero accidents, lower battery maintenance, and no bank loans **then**
6 Smart Contract state changes to *Approve the vehicle or recommendation to the buyer with excellent rating with blockchain rewards.*
7 Change State of application to *Approved* by smart contract with five start rating.
8 | **Blockchain vehicle analysis report is given to the buyer.**
9 | **Vehicle** details are added to the smart contract.
10 The updated smart contracts are finally sent to the road and transport authority department.
11 **end**
12 **else**
13 if the vehicle had accidents, then the price is depreciated, maintenance records, battery performance are updated with smart contract.
14 Revert application and smart contract if the vehicle is not recommended for the buyer.

ADDRESS	BALANCE
0×D5Bbe6921aa672cE56A4523aDD574aA95BA4D21c	100.00 ETH
0×CDBa91768E7d8F87e0726655abD7B0D1Ddd584FD	100.00 ETH
0×0d25352Ba02aa71E60b6EB17ED51c4b0C5dFED31	100.00 ETH
0×75dbabcA433f79bd2Af31318F8415Eff49fDaEB9	100.00 ETH

FIGURE 16. Sample Ethereum address generation in a truffle environment.

environment for deploying the astute contract. Remote procedure call (RPC) server is utilized for testing this application. Ethereum's address are assigned with 100 ETH. Ether (ETH) is the currency utilized in Ethereum blockchain for the transaction. Fig.16 shows the sample Ethereum address generation in truffle environment. The following comments are used for the configuration.

C: \Users\ganesans>npm install -g truffle.
+ truffle@5.1.62, updated 4 packages in 38.747s

Pre-Owned Vehicles Chain: Module 2 – Electric Vehicle Battery Performance Monitoring

Input: *EA address (EA) of Electric vehicle chassis number*
EA address (EA) of smart contract
EA address (EA) of Road Authority
EA address (EA) of insurance company
EA address (EA) of bank
EA address (EA) of seller
EA address (EA) of buyer

1 Smart contract is *Created between buyer and Battery service provider.*
2 Status of the application is *requested* with vehicle blockchain cloud.
3 Applications are selected for a vehicle based on the age of vehicle, battery discharging time.
4 Road transport department validate the vehicle records with blockchain.
5 *Consider the charging time T1 = 5hours for the typical EV model*.
Once the vehicle charged (actual time taken- T2) recorded with EV blockchain cloud.
If T2 == T1 then
Smart Contract state changes to
Battery performance is good.
else
Recorded with blockchain cloud.
If T2 = 7 hours to 10 hours, then battery needs to be replaced and should be recorded with blockchain cloud.
Smart contract status changes to
Battery performance is poor needs service/replacement.
6 Change State of application to new battery fixed.
Approved by smart contract.
7 | Blockchain vehicle analysis report is sent to the cloud.
8 | Vehicle details are updated to the smart contract.
9 The updated smart contracts are finally sent to the road and transport authority department.
10 **end**
12 **else**
13 Revert application and smart contract if the vehicle is not recommended for the buyer due to poor battery performance.

Commands: Compile contracts: truffle compile, Migrate contracts: truffle migrate, Test contracts: truffle test,
C: \Users\ganesans\MetaCoin> truffle migrate
Compiling your contracts...
===========================
C: \Users\ganesans\MetaCoin\build\contracts
> Compiled successfully using:
- solc: 0.5.16+commit. 9c3226ce.Emscripten.clang

Ethereum blockchain address created for making transaction in a truffle environment for a vehicle chain. (10 address

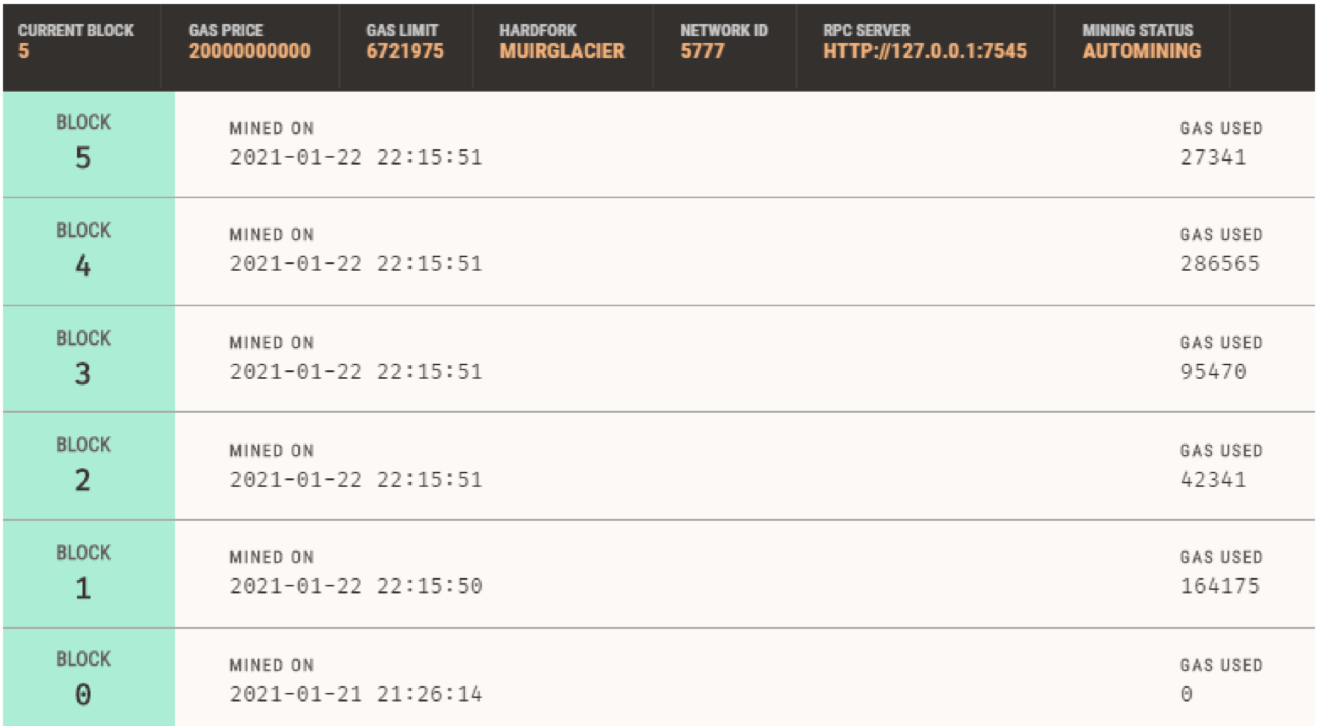


FIGURE 17. **Vehicle chain generation in a truffle environment.**

Pre-Owned Vehicle Chain: Module 3 – Blockchain Insurance Scheme For Electric Vehicle Battery

Input: '*Et' is the list of plants in the farm.*
EAaddress(EA) of Electric vehicle owner
EAaddress(EA) of Insurance company
EAaddress(EA) of Manufacturer

1 Smart contract is *created between insurance company, vehicle owner, manufacturer.*
2 Ethereum blockchain battery recorded with blockchain during the electric vehicle purchase.
3 Arduino IoT devices push battery performance to the Ethereum blockchain cloud service.
4. If the performance of the battery goes down it pushes the notification to vehicle manufacturer, they approve the insurance where the service or replacement could be done at free of cost.
5. Smart contract report the information to the distributors, and battery manufacturer.
6. else
7. Continue monitoring the battery performance and push the data to the blockchain cloud.
8. Smart contract update
9. end.

created with 100 ETH for each node to make transaction). Smart contract execution, gas price used for generating block, block generation in a truffle environment is shown in Fig.17. The truffle design deployment network details are shown below.

> Network name: 'ganache'
> Network id: 5777
> Block gas limit: 6721975 (0 × 6691.7)

Gas price: Any transaction performed in the Ethereum network associated with the cost. Transaction cost referred by gas price. Gwei: The Gwei is defined as nano ether. This is the smaller version of the ETH. 1 Gwei is 0.000000001ether. This application uses 20Gwei as gas fees for making each transaction. Solidity is the programming language used to develop the application and design the smart contract in Ethereum. Smart contract runs with Ethereum virtual machines (EVM). Vehicle blockchain design can be extended to run with the mobile application by interfacing with android or iOS. Node.js: Node.js is an open-source environment, it runs with Linux, and windows. Smart contract code written using JavaScript programming language. Gananche -cli: RPC client for developing and testing Ethereum. Truffle: Truffle is kind of framework used for testing the smart contracts. Truffle has the inbuilt compiler for solidity. It gives ten Ethereum address for developing the blockchain based applications. It has the HPC server with the address 127.0.0.0, and the port number 7545. VS code compiler used for editing the smart contract. Meta mask: It provides the secure connectivity between the client and the Ethereum network. The generated QR code is attached with the vehicle's verification process. It has the private key. Every transaction executed in a blockchain with the private key. This key kept confidential with the individuals or organizations. In case of the single node, the vehicle manufacturer could assign a Ethereum generated QR code

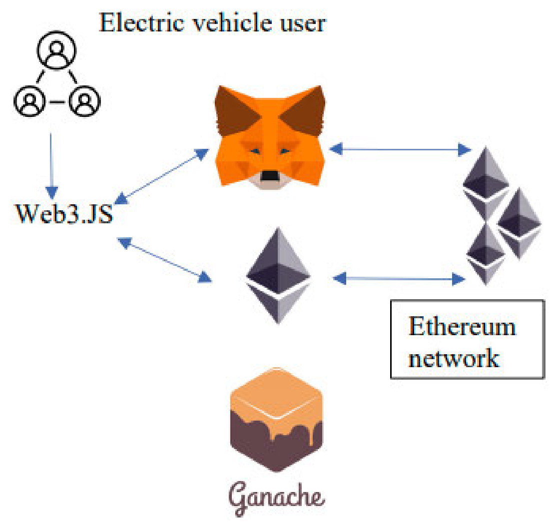


FIGURE 18. Blockchain mobile application implementation with Ethereum.

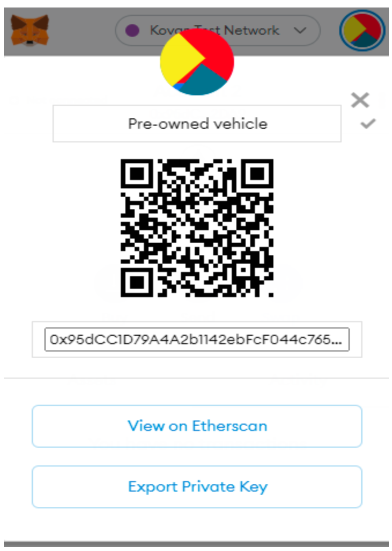


FIGURE 19. Meta mask mobile application design for tracking electric vehicles. QR code of account 1 represent a vehicle.

to each vehicle. This creates the trust among stakeholders since there is no human intervention or third-party involvement in assigning the QR code [83]–[87]. It is generated by the Ethereum blockchain node itself, no one can tamper the code. Ether scan: Ether scan is used for tracking all the assets. Everyone joins with the blockchain network assigned with user id/password. This research utilizes the proof of conveyance algorithm to validate all the transactions. Once the conveyance is registered with the blockchain, it associated with the address.   Purchase of the conveyance, maintenance of the conveyance, contingency details, owner information. Since it is a permissioned blockchain, it sanctions only the registered users to be a component of the blockchain. The utilizer id and password are required to access the permissioned blockchain. Each transaction signed with the blockchain node, date and time of the transaction withal recorded into the blockchain. Secured hash algorithm (SHA) is utilized for

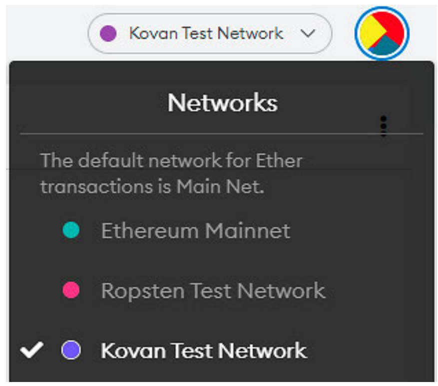


FIGURE 20. Kovan test network selected to make the crypto currency transactions.

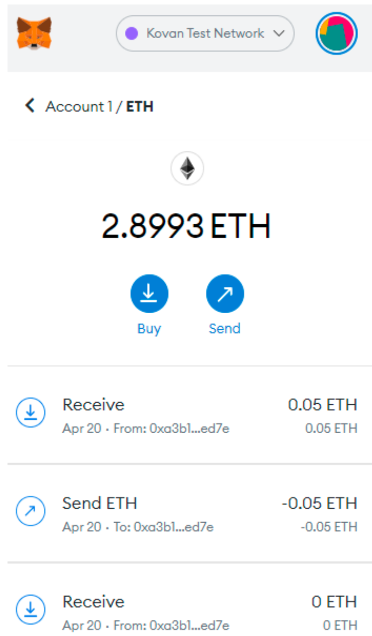


FIGURE 21. Account 1 created for Electric vehicle.

encryption. A Keenly Intellective contract is engendered for the pre-owned conveyance purchase between the Ethereum clients. All the conveyances integrated with the Ethereum virtual machine (EVM). Proof of vehicle provides validation of vehicle at each stage.

VIII. ETHEREUM METAMASK MOBILE APPLICATION IMPLEMENTATION FOR PRE – OWNED ELECTRIC VEHICLES

To test the pre-owned conveyance application in an authentic time environment meta mask can be habituated to integrate with Ethereum blockchain. QR code is engendered for the desired application by the meta mask. Each QR code interfaced with the Ethereum blockchain address. This research work used kovan test network to get the test cryptocurrency (KETH) [88]. This is not the main Ethereum network. It is used to test the developer application in a public blockchain environment. In order to test our applications, we have engendered the two accounts with

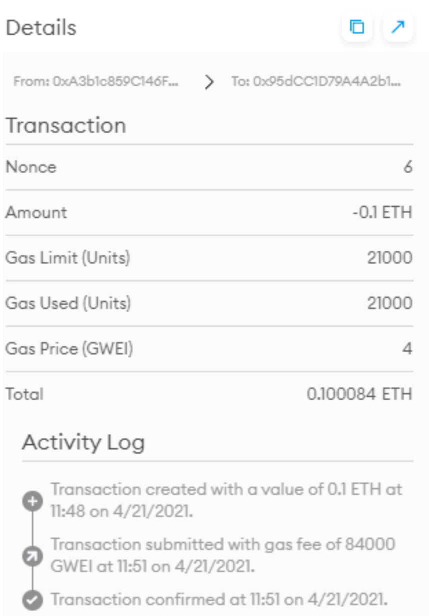


FIGURE 22. Transaction details.

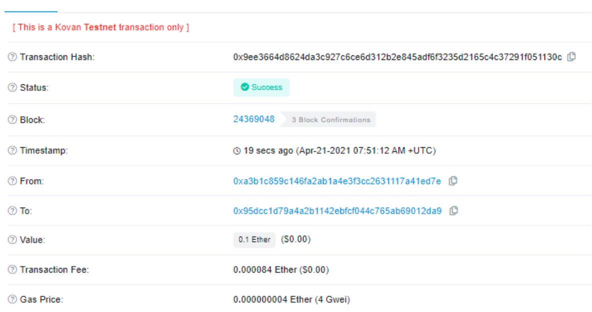


FIGURE 23. Electric vehicle battery charging payment.

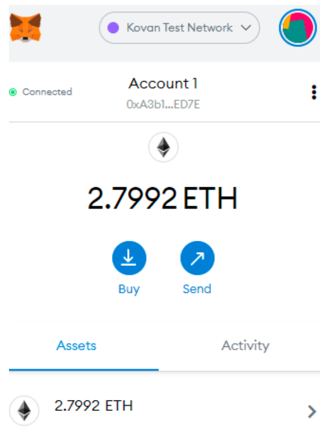


FIGURE 24. Account 1 summary after the first transaction.

TABLE 6. Ethereum block details.

S: No	Transaction details of the vegetable farm	Description
1	Block 23345787	This represents the height of the block.
2	Time stamp	Creation of the block with date & time (April 21, 2021, 07.51.12 a.m.+ UTC)
3	Number of transactions	3
4	Miner details	Name and address are displayed.
5	Size of the block	1,174 bytes.
6	Block reward	5.00710709 Ether (5 + 0.00710709)
7	Gas used	749,967 (6.01%)

the meta mask Ethereum blockchain mobile application. The test currency received using GitHub login with kovan test network. (https://github.com/kovan-testnet/faucet), could make: $1e18/(100000 * 20e9) = 500$ transactions with just 1 KEth account. Vehicle chain account number 1 0xa3b1c8 59c146fa2ab1a4e3f3cc2631117a41ed7e received 1 KEther from kovan network. Meta mask mobile/desktop application successfully created for the pre-owned vehicle tracking. All the transactions can be viewed through the Etherscan. Fig.18 represent the blockchain mobile application implementation architecture with Ethereum. Fig.19 shows Meta mask creation with account numbers in a Ethereum blockchain. Kovan network allows to transfer test currency (1KETH) for every 24 hours, transactions were made with test currency. Fig.20–Fig.24 shows the mobile application implementation with meta mask. China officially released the cryptocurrency of their own on 1st May 2021 [89].

Step 1: Meta mask mobile/desktop application created for pre-owned vehicle transaction using Ethereum blockchain.

Step 2: Kovan test network selected to transfer the test currency to the meta mask account to test the vehicle chain.

The QR code based blockchain applications like food supply chain, medicine supply chain and other application are mentioned [83] – [87].

Step 3: Electric vehicle account creation to track the transaction. It starts with vehicle chassis number registered with blockchain (Transaction 1)

Step 4: Transaction – Gas price/Gas limit

Step 5: Transaction - battery charging (Payment with cryptocurrency)

Table 6 represent the detail of a block 24369048.

The Fig.25-Fig.27 represent the steps involved in design and implementation of a mobile application to track the conveyances in a Ethereum blockchain platform. The QR code engendered by the meta mask assigned to each conveyance. Any activity initiated with reference to the conveyance is considered as a transaction. Manufacturers keep the QR code engendered by Meta mask for a conveyance. This would be the genesis block for that conveyance considered as Block 0.

Once the conveyance is manufactured then shipped to the destination, this transaction appended to the blockchain with the hash code. The Next step would be the conveyance

24369053	7 mins ago	2	0	Lab10Collective	183,959 (1.47%)	12,500,000	16,311.98 Gwei	5.00073 Ether
24369052	7 mins ago	1	0	poa.network	65,240 (0.52%)	12,499,988	46,014.06 Gwei	5.00195 Ether
24369051	7 mins ago	2	0	Shivam_Agrawal	68,659 (0.55%)	12,487,794	43,696.78 Gwei	5.00017 Ether
24369050	7 mins ago	2	0	Lab10Collective	69,257 (0.55%)	12,500,000	43,319.51 Gwei	5.00017 Ether
24369049	7 mins ago	3	0	poa.network	559,568 (4.48%)	12,499,988	5,505.35 Gwei	5.08061 Ether
24369048	7 mins ago	3	0	Shivam_Agrawal	749,967 (6.01%)	12,487,794	4,009.65 Gwei	5.0071 Ether

FIGURE 25. Ethereum blocks creation summary.

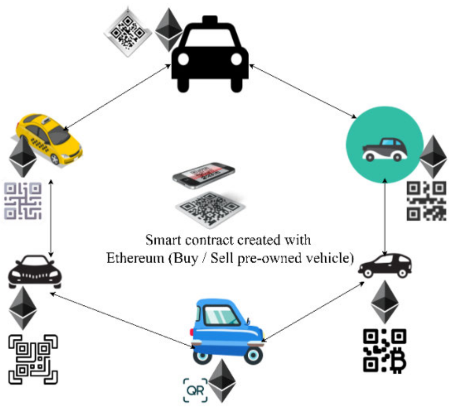


FIGURE 26. Vehicle connected in a blockchain environment.

FIGURE 27. Ethereum generated QR code to track the vehicles.

peregrinate to the defined showroom, first customer for a conveyance, his personal details, car indemnification, bank loan, all these details are considered as transactions, and appended to the blockchain. Once the first owner decides to sell the conveyance, it gives a consummate history of the conveyance by scanning a QR code of the conveyance. The one who want to buy the conveyance can get plenary information that engenders the transparency among the people in the automobile sector.

The QR code generated with Ethereum to track the vehicles shown in Fig.27.

IX. CONCLUSION

This research fixated on engendering the transparency in an automobile sector. The terminus-to-end process is monitored through the Ethereum blockchain. First, simulation of blockchain transaction of conveyance tested with the Ethereum sandbox platform. Second, the design of the conveyance chain is done with the Ethereum truffle platform. All the transactions can be monitored in an authentic time environment. Each conveyance assigned with the Ethereum address to track all the transaction; the full history of the conveyances can be accessed by the truffle platform. Third, we have engendered the meta mask interface for the conveyance chain. This is a mobile/desktop application where all the tracking is done with the avail of the QR code. Each conveyance can be assigned with the meta mask engendered QR code. All the transaction referred to that conveyance can be tracked with the QR code. This sanctions the users to test the records of conveyances afore they make purchase. Blockchain consortium approach brings all the automobile sector manufactures in a single platform. This sanctions anyone to track the conveyances records utilizing blockchain technology. Ecumenically all the manufacturers can join and engender a cumulated solution for the customers, this will enhance the utilizer experience and bring the transparency to an ecumenical level. Blockchain Electric Conveyance Cloud of Things (BEVCoT) proposed to integrate the IoT – Blockchain- Cloud accommodations to enhance the utilizer experience, accommodate sizably voluminous volume of customers.

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