SecVT: Securing the Vehicles of Tomorrow using Blockchain Technology

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Abstract. The Internet of Things (IoT) has developed from just an idea or concept to real-time market use-case. Automotive industry is one of the pioneers to adapt to the technology in its budding stage. They are not only focussing on the vehicle's internal features like the traditional self-driven vehicles but have developed a broader-field of view by focussing on communication with other vehicles. The exchange of large volume of data can pose a threat to the user's security. This calls for the need for implementation of multilevel cyber security countermeasures in order to prevent vulnerability to hacking. The use of blockchain has however been one the most useful and advanced technology developed to protect data, i.e., preserve user's personal information/ user's privacy (during communication). This paper mainly deals with the implementation of securing the information regarding next generation intelligent vehicles.

Keywords - Internet of Things, Automotive, Communication, Cyber security Attacks, Blockchain, Privacy and Trust Next Generation Vehicles.

I. INTRODUCTION - FUTURE VEHICLES

There has always been a constant growth in the automotive industry over the two centuries. The industry has attained new standards in the recent years due to the significant development in information and communication technologies. These include driverless autonomous vehicles, hybrid intelligent vehicles, connected vehicles etc. that are capable of operating at diverse environments. They are mainly governed by computer vision and sensor networks-based algorithms that allow them to operate according to the physical landscape [1].

a) Hybrid Intelligent Vehicles and Connected Vehicles

Intelligent vehicles equipped with Vehicle-to-vehicle or vehicle-to-internet are termed as Connected Automated Vehicles (CAV) [2]. They contain not only sensor-based networks to detect path, obstacles etc but also are interconnected with other automated vehicles through multiple communication protocols. The vehicle-vehicle communication helps in predicting traffic, detect the motion of surrounding vehicles and moving accordingly with higher accuracy than judging manually or using sensors [3,4].

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This forms the basis of a typical cyber physical and control systems where the physical parameters are controlled using communication and predictive technologies. CAV's are controlled at various junctions in a roadway like freeways, roundabouts, signalised or unsignalized intersections or merging zones etc. It helps in improving performance, pollution, delays, fuel consumption and pollution without changing the infrastructure of the road [5].

b) Autonomous Vehicles

Autonomous vehicles are a leap forward from the traditional vehicles used widely even today by most of us. It is capable of driving on its own without any human intervention. It helps in human error management by preventing accidents while driving and also saves the drivers time they spend on driving which enables them to spend it more usefully like sleeping, reading, eating, relaxing etc. Most of the users are now moving towards AV's as it helps in reducing stress during driving and also helps in saving gasoline costs. Although some of them are still hesitant to adopt to this technology as they fear losing complete control of the vehicle and wish to take back control whenever necessary [7].

Possible uses of Future Vehicles in near future in

- e-healthcare

Intelligent and connected automated vehicles can be of great help in the healthcare sector in the near future. Whenever any accident happens or in case of any medical emergency, we often find that upon calling an ambulance service, extreme delays in arrival is observed due to lack of coordination among drivers and hospital and the lack of seriousness of others' lives. This may result in delayed medical treatment and may also lead to fatality due to lack of treatment at the right time. Sometimes ambulances get caught in heavy traffic during peak hours and fail to reach the hospital at the right time. All these issues can be partially solved using a CAV network. Since intelligent vehicles are capable of detecting traffic and road scenarios, it can provide an alternate and safe route to reach for medical treatment. The high level of accuracy in these systems will also ensure that there is no delay or no medical emergency is missed out ad treats everyone equally. Miniature CAV robots can also be used inside hospitals to deliver surgical instruments and other

requirements during operations, provide food to patients and also in waste management [8].

- Supply chain

Supply chain involves a very long process starting from raw material extraction to delivery of good to consumer. It may involve transportation of bulky materials like iron, wood etc to perishable products like food material. The delivery of food supply chain is a very critical application that needs to be delivered by the right time otherwise it will result in wastage of product and ultimately in loss due to the limited life of the food material. Various sensors enabled in the CAV can ensure the quality of food and helps in monitoring the ambient temperature to prevent spoilage and adjust the speed of the vehicle accordingly to deliver the product in time [9]. This also enables consumers to order small quantities of food when required and helps in reducing the stock level in inventory which ultimately results in benefit to both the employers and consumers.

- Transportation and Other Sectors

In vehicle, blockchain technology used to improve/ preserve privacy and build trust among drivers and passenger. In the past decade, several researchers have done several serious attempts to secure the information of user/ passenger/ driver, preserve privacy of user and build among user and service provider, but none of them fulfil the expectation level of scientific community [23-32]. Still many attacks can be mitigated on Vehicular Adhoc Networks (VANET) and other types of vehicles like intelligent vehicle or autonomous vehicles or driverless vehicles. Hence, blockchain technology is used to overcome such attacks and provide a secure layer of protection against unauthorized users.

In the last, there are many uses of Vehicles in near future are: Data Protection and Management, Data and Resource Trading, Resource sharing, ride sharing, Content Broadcasting, traffic management, etc

II. BLOCKCHAIN TECHNOLOGY – AN INTRODUCTION

Blockchain Technology, is a Decentralized Ledger Technology (DLT) [36], which is immutable build trust via storing information in form of Blocks (encrypted data stored in blocks). A complete procedure of creating chain of many blocks can be found in figure 1. We can see several possible uses of Blockchain in current smart era in figure 2.

Blockchain Characteristics

There are multiple factors that characterize Blockchain systems. Here, we include few important characteristics in the aspects of deployments, implementation, and properties.

- Private, Public, and Permission Blockchain.
- Centralization and Decentralization
- Persistency
- Validity
- Anonymity and Identity
- Auditability
- Closeness and Openness

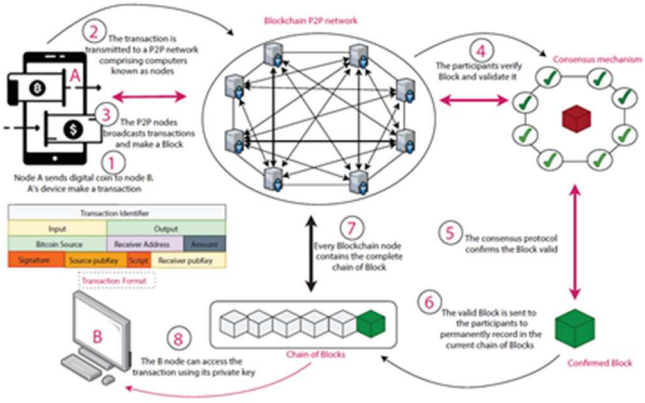

Figure 1: Procedure of creating Blocks and a chain of Blocks

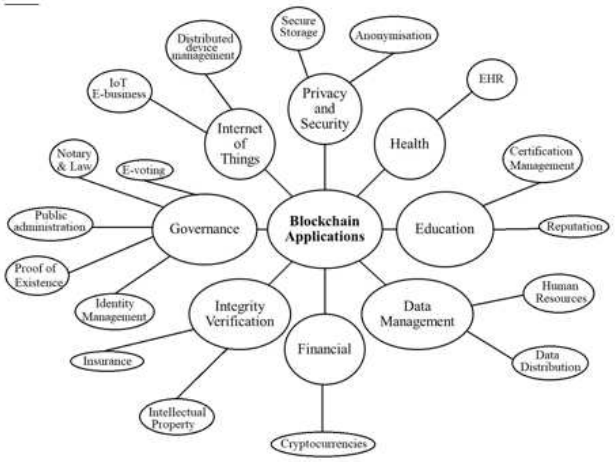

Figure 2: Blockchain Applications in the Smart Era

Role of Internet of Things (IoTs) in Future Vehicles

Internet of Things involves the connection of things (hardware devices) to the internet and deals with the transportation of data over a cloud platform and analyse it in a smart way.

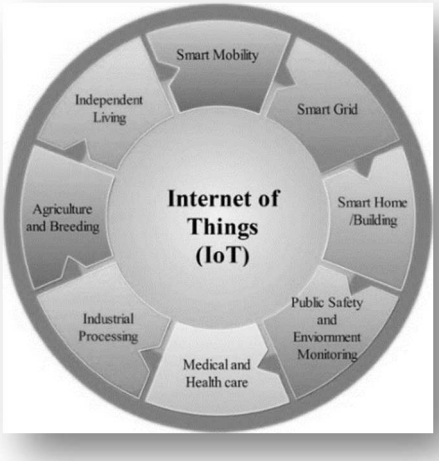

Figure 3: Internet of Things Applications in the Smart Era

Intelligent transportation system involves a smarter way of managing transportation services like traffic management, highway accident management, road safety etc. With the increase in the growth rate of vehicles day by day, people and government are confronted with challenges in terms of increased fuel consumption, pollution and traffic congestions. Hence, we can find several possible applications of IoT devices in Figure 3.

Similar to the restructuring done in other industries through IoT, automotive Industry also would see a major advancement with the introduction if IoT in vehicles. With integration of IoT connectivity, mobile applications, cloud services and smart sensors, the automotive industry will result in a new design for vehicles with better performance and quality control and reduced cost of vehicles that follow this technology. This is termed as Internet of Vehicles (IoV) which means convergence of vehicles and IoT. With the integration of IoT and ITS, automobiles & people and then roads and vehicles can be connected together easily which can provide a good solution to traffic congestions, air pollution and fuel shortage [10]. Use of IoT in transportation tends to give priority to minimize road accidents as it aims to support location tracking, monitoring and management identification through quick and accurate identification techniques.

III. MOTIVATION

Internet of Things (IoTs) enables a faster, safer and richer experience for drivers and provides them with access to road conditions, traffic information, vehicles performance and fuel consumption. With the increasing usage of IoT in modern automotive the vulnerability of exposure to various malicious attacks is also increasing. Internet of Vehicles (IoV) is enabled with technologies such as Vehicle-To Vehicle Infrastructures (V2I) and uses multiple sensors to collect various data. The failure of any one component may lead to the complete failure of the system and the user may become a victim to accidents etc. [11]. in addition to this the feature to share a vehicles detail with others using various communication protocols may be hazardous and might provide an opportunity to attack the user by knowing his location or by taking control of the vehicle. These vulnerabilities and lack of privacy of data can be protected using blockchain technology. Blockchain technology is a secure trust-based network that is decentralized and immutable. It can be applied to a wide area including protection of databases to IoT and embedded system-based applications [12]. We discuss the method and uses of secure decentralised blockchain environment in order to protect data in intelligent vehicles and other automotive industries. We also discuss the challenges in current vehicles and how smart and secure hybrid vehicles can help to solve these issues.

IV. POPULAR ISSUES, CONSTRAINTS, CHALLENGES WITH CURRENT VEHICLES

The majority of today's automobiles are fuelled by fossil fuels, which generate large amounts of pollutants that contribute to climate change. All of these vehicles have a wide range of engine problems and require a lot of maintenance. Oil consumption and Direct-Injection valve muck build-up are two more concerns that have been mentioned in a variety of contemporary automobiles. When automobiles sit for long periods of time, whether on a dealer lot or in your driveway, flat tyres, brake rotor corrosion, and other difficulties can occur. Electronic difficulties, such as infotainment, driving assistance, and other amenities, account for a large percentage of complaints reported by early car owners these days. Even while electric vehicles are environmentally benign, they are not without their own set of problems.

Potential Electrical Vehicles (EV) buyers are concerned about the range provided by electric vehicles. They want to make sure the automobile takes them where they need to go before the battery runs out. This is due to a lack of charging stations around the country. As a result, there is a greater need for charging infrastructure and alternate solutions such as battery swapping stations. Lack of charging infrastructure: To accommodate the rapid usage of electric vehicles in India, a comprehensive charging infrastructure is required. Aside from more charging stations, users need a place to charge their electric vehicles, and space is a challenge. In addition, the shortage of inexpensive renewable energy is placing strain on the coal-fired power infrastructure. The expense and complexity of collecting data and managing subscriptions will rise as the number of linked automobiles — and the massive volumes of data they create – increases. This will push carmakers to pay special attention to a variety of criteria, including the partners they choose. Security is a critical concern for any firm that uses software, and sadly, the car sector has not prioritised cyber security. According to research, just 10% of manufacturers have a dedicated cyber security team. Manufacturers will need to prioritise investing in more sophisticated security testing and procedures as a car's functioning becomes much more software-based.

V. PROPOSED SYSTEM MODEL FOR SECURING FUTURE VEHICLE

Problem Definition: Leaking a user's personal information or habits are serious concerns [33, 34, and 35]. Also, protecting user's privacy, user's information (including building trust in users and service provider) is a difficult in current smart era due to high mobility of vehicles.

Solution: We used following flow diagrams (in figure 4) to secure our vehicles over the road network.

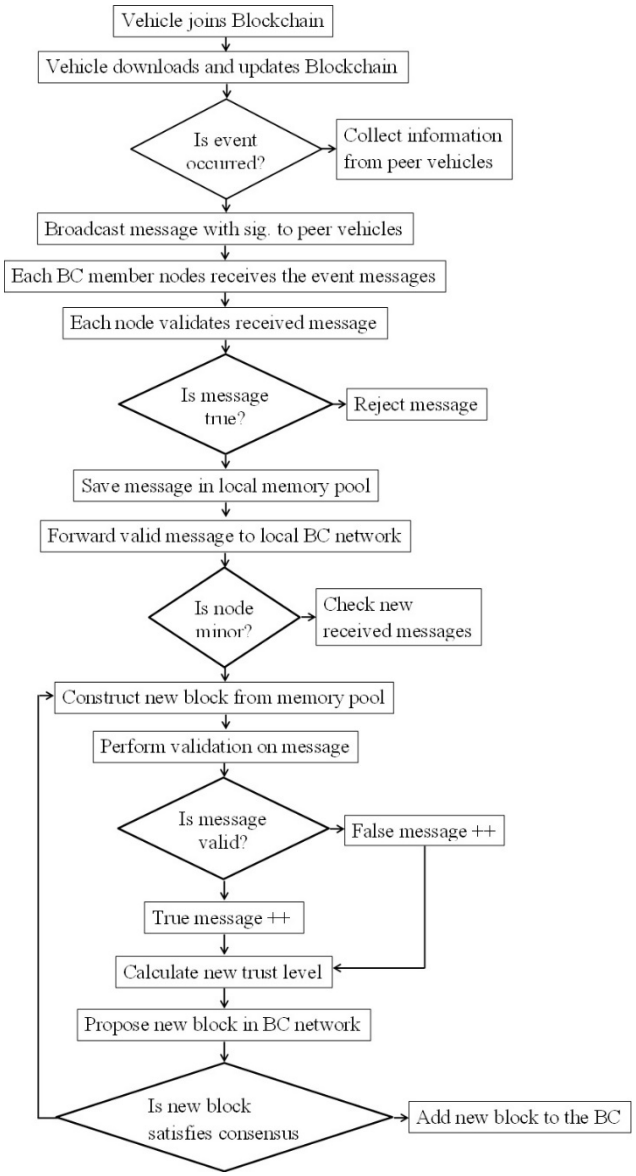

Figure 4: Securing Future Vehicles with Blockchain

VI. SYSTEM IMPLEMENTATION

Due to the financial costs, it is not viable to test the Blockchain (for a larger group of vehicle user) on the distributed ledger network. Instead, the Blockchain is implement on a local private test blockchain, Ganache. It provides a TestRPC client for Blockchain and lets us rapidly test and develop the implement blockchain network for vehicle user. Since the project is developed on the truffle suite, the compiling and deployment of the smart contract is managed by the truffle suite and we just have to run the truffle migrate command to generate the contract ABI and deploy it to the network. This allowed for testing the blockchain network performance for free in an environment. The goals of the project were accomplished as the users can create and manage their identities on the blockchain concept using the secure package; retrieve identities and verify their signatures; the system is decentralized as it used blockchain and decentralized storage of IPFS; and eventually, build a chain of blocks (i.e., chain of trust) as all vehicles user can sign attributes and build their own trust stores (based on privacy preservation).

VII. AN OPEN DISCUSSION

However, the proposed model has been successfully tested partially and, in that security, and privacy has been proven than existing. But the following are the limitations of our work, include as:

- Adoption: The proposed system relies on large number of peers being on the network for the network to be useful. And, having lower adoption initially can prove to be a barrier to entry for new entrants into the Blockchain network.
- Memory Management: The project currently provides the user options to store data locally not globally, but once all information published, it needs to shared publicly to avoid any attacks over public network.
- Cost Considerations: All transactions on the blockchain require an amount of energy to run or verify genuine blocks to add in blockchain network. Thus, this is too costly to run if the transaction triggers a huge computation. In this work, only few transactions require computation to create a new attribute/ block; adding a new signature and adding revocations are frequent tasks on such a network and thus, scaling to an internet-scale network would not be financially viable.

In next subsection, we will discuss (with difference) some important terms likeAutonomous Intelligent Vehicle (AIV), Intelligent Vehicle (IV), Internet of Vehicle (IoVs), ITS, Electric Vehicles, Autonomous Vehicle (AV) and Connected Vehicles, etc.

a) Current Vehicles vs Future Vehicles

While the appearance and sense of our motorcars have evolved over the last century, the way we drive them has not. Still, substantial change is on the way. The way they are powered and system have changed over time, but it is still driven by human. This wide robotization, combined with the electrification and increased connectivity of both the auto and society, is set to fully transfigure the machine assiduity, affecting everything from how it looks and how we spend our time inside a car to get to our destination They'll most probably have a fully distinct appearance. Large air inputs and frontal nettings, which cool our combustion machines, will be obsolete, while sect glasses will be replaced with cameras and detectors. Windows might be bigger to allow passengers to enjoy the view more freely, or nearly missing to give insulation. Innards of buses will be far more adaptable, with some allowing for one- touch customization of colour, light, sequestration, and layout. Automobile will create a multi-purpose area that can be used as a rest place or a bedroom. Technological advancements have the eventuality to alter the future of machine energy. For illustration, scientists are working hard to overcome the manufacturing and

storehouse challenges that are now limiting the possibility of hydrogen-powered buses that are clean, presto-fuelling, and long- range [13].

b) Autonomous Vehicles Vs Autonomous Intelligent Vehicles

Autonomous car will completely revolutionize the industry, but with addition of intelligent features it will change how we perceive driving. Many automobiles will be equipped with augmented-reality systems that superimpose computer-generated visualisations onto the windscreen or other suitable display surfaces to calm passengers' worries about handing up the steering wheel by demonstrating what the car is going to accomplish. Audio and hand and gesture will allow drivers to communicate with their vehicles. Some early forms of brain-computer interfaces, which would correlate patterns of brain activity with orders to run the automobile or entertain occupants, might be seen in high-end cars. Prosthetic limbs and wheelchairs have already been controlled using similar technology. Cars will be able to synchronise their movements thanks to sensors that recognise and interact with improved road signs, markings, camera networks, pedestrians, and other vehicles. This will save fuel use and improve traffic flow. Cars will also be able to assist authorities in the maintenance of road infrastructure, such as by providing tyre sensors that alert authorities to deteriorating road conditions. When people choose to drive, technology will warn them of potential collisions with other road users and try to avert them. With advancements in thermal sensor technology, automobiles will be able to see well beyond the spectrum of illumination provided by headlights. These technologies, if adequately standardised and legislated upon, should significantly reduce the frequency of traffic accidents.

VIII. RELATED WORK

For the vehicular ad-hoc network, Yuan et al. [14] and Benjamin et al. [15] developed a seven-layered secure, decentralised blockchain system for Vehicular Adhoc Network (VANET). For applications like as vehicle information, vehicle tax, and so on, it was developed using a mix of Ethereum blockchain-based smart contracts and the VANET. They also expanded the use of their technology to include peer-to-peer communication and vehicle-to-vehicle communication without compromising users' personal information. Further, Dorri et al. [16] proposed a blockchain technology mechanism that updates the details of the vehicle over wireless software without exposing the details of the vehicle as well as the user. Rowen et al. [17] described blockchain technology using acoustic side channels and visible light to protect data in IV communication. It was implemented using public key infrastructure for blockchain, new session cryptographic key, and leveraging side-channels on both sides. Then, Sharma [18] suggested a concept that uses distributed clustering to manage an IoV's energy demands, which is enabled via blockchain and monitored using optimum control. In comparison to standard methods, simulation results show that the suggested system saves 40.16 percent of energy and 82.06 percent of the number of transactions required to share blockchain data.

Pustisek et al. [19] explained the blockchain technique in detail by focussing on the outlined architecture of the selection of a gas filling station for an automatic vehicle. He emphasized the various security issues and concerns that exist due to the exposure of the data that flow from vehicles to other vehicles as well as other intersections.

Buzachis et al. [20] proposed a blockchain framework for verifying, negotiating, and facilitating among the consent entities. In this paper, the authors proposed a multi-agent vehicle to intersection and vice versa communication to secure the vehicles through intersections. Further, Kuzmin et al. [21] implemented the concept of blockchain technology in unnamed aerial vehicles (UAV's) where every vehicle is considered to be a node, and the mechanism controlling the reading and creation of transactions is controlled using blockchain. Then, Yang et al. [22] employed the concept of blockchain to transfer data regarding traffic scenarios to vehicles by providing tamper-resistant and more accurate data in the agreement mechanism. The data regarding vehicles is collected using a proof-of-event agreement. warnings were accessed using a two-phase transaction mechanism through blockchain.

IX. CONCLUSION

The goals of the project were accomplished as the users can create and manage their identities on the blockchain concept using the secure package; retrieve identities and verify their signatures; the system is decentralized as it used blockchain and decentralized storage of IPFS; and eventually, build a chain of blocks (i.e., chain of trust) as all vehicles user can sign attributes and build their own trust stores (based on privacy preservation). To develop an Efficient Anonymous Authentication, we have used blockchain concept in this work. With providing sufficient level of security, we preserve privacy of users (over the road network). About future for Autonomous Vehicles, or Vehicles of Tomorrow it can be in the way of Autonomous Driving, i.e., Autonomous Healthcare? Also, blockchain-based applications can be like: Financial Applications, Integrity verification (i.e., (i) Provenance and Counterfeit, ii) Insurance; and (iii) Intellectual Property (IP) management.), (iv) Education, Data management, governance, IoT devices, Healthcare management, privacy and security in the respective applications.

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