2019 Sixth International Conference on Software Defined Systems (SDS)

Blockchain Based Transparent Vehicle Insurance Management

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***Abstract*—The automotive industry is re-blooming with recent enhances in technology. Electric vehicles and autonomous vehicles are already attracting attention to the industry and providing momentum for adoption of other emerging technologies. This has its impact on a diverse range of stakeholders from manufacturers to consumers.**

There is a new frontier that can lend its abilities to the experiences built around vehicles and it is the blockchain technology. Blockchain technology is an enabler. It can act as a transaction medium between interacting parties. It can also be used as a tamper-free ledger to store a history of transactions. With these two simple abilities, blockchains can enable several applications to make vehicle-related experiences better.

In this paper, we propose a tamper-free ledger of events as an insurance record of motor vehicles. This insurance record system can include all aspects of insurance transactions. It not only would improve the experience around proving insurance, but also act as evidence in the event of a dispute. This ledger can have extended services around providing a clean driving record. Individual drivers, dealers, insurance companies, lawyers, law enforcement agencies and motor vehicle agencies are all stakeholders of this blockchain based solution.

Keywords—Blockchain, Intelligent vehicles, Insurance, Security, Trust

I. INTRODUCTION

Even though there is a high volume of information content about blockchain technology, successful implementations have not caught up with the volume of publications. There are several infeasible implementations due to lack of understanding. Like most technological tools, blockchain can provide business benefits when its features are suitable to solve the business problem. In other cases, it may merely provide some advantage that may not justify its implementation costs.

In what follows, we present a literature survey of blockchain applications in the automotive industry. This survey highlights the leading use cases of the blockchain technology in this industry.

Following that, we present a novel use case and a blockchain based solution for the insurance record of motor vehicles. We then present the details of the design and the benefits of such a solution. We also list the issues that a blockchain based application needs to address. We conclude our paper with the future directions of this research.

A. Blockchain Technology

In order to understand blockchain technology, one must understand the importance of record keeping. Record keeping has been a factor to facilitate cooperation between people in large groups and eventually contributed to the formation of large-scale societies [1]. Due to its complexity and importance, keeping a history of transactions is a task for trustable authorities. These authorities keep a book of record about the activities in their subject domain. For example, a bank is a selected authority in the finance field to keep a book of record for financial transactions. A bank can keep records of activities, events, applications, and decisions. In case of a dispute, the bank's records are the truth. For motor vehicles, manufacturers, dealers, and owners all interact with the government's motor vehicle agencies. Records kept by these agencies have always been considered as the source of truth.

A ledger is a structured list of transactions that represent the state of entities, activities, and events. Since their discovery, ledgers have been proven useful for several purposes such as reconciliation, audit and issue resolution by recording a relevant history of transactions. Distributed ledger technology (DLT) is a system based on the premise of communicating ledger entries to the stakeholders. Commonly, a DLT communicates each transaction to each participant of its information network. When a member of the network records a new transaction, every other stakeholder receives the same transaction record. This level of replication turns every stakeholder to a witness of all the transactions. Denying or tampering the transactions becomes harder with the increasing number of witnesses.

Blockchain is a specific type of DLT that packages transaction entries into blocks in order to facilitate more structured communication. With the help of cryptography, each block contains the hash values of its transactions and the hash of the previous block. This pattern of each block containing the hash value of the previous block is what makes the structure called a "chain." Each new block created is appended to the chain of blocks. Participants of the network check the validity of the block with its transactions and form a consensus on

978-1-7281-0722-6/19/$31.00 ©2019 IEEE

acceptance. Blockchain networks are tolerant to participants' availability. Any member of the network can be offline without impacting the network. When a participant becomes online again, it can download the blocks that are accepted when it was offline. With the hash values included and structured as a chain, it is mathematically infeasible to tamper the blocks. Upon receiving a block or several blocks, a participant can validate the blocks, and identify any forgeries. With this ability to identify forgeries, blockchain is a tamper-resistant ledger.

There are two types of blockchain networks based on who can be a participant. A public blockchain is where participation is not restricted. Anybody can be a member, receive the transactions, issue new transactions and create a new block. Participants of public blockchains are equal and anonymous behind the public-private cryptographic key pairs. Implementations of public blockchains have different measures to guarantee the healthy operation of the blockchain and to prevent malicious activities. Meanwhile, permissioned blockchains identify the users and assign predefined roles to them. Business rules of each implementation define the restrictions to participation in the blockchain. This blockchain may also have restricted roles and responsibilities for participants. Operations such as forming new blocks play a significant role in permissioned blockchains.

Blockchain technology is a trust provider. Participants who otherwise would not trust each other can use this technology to create a medium for collaboration. Having a ledger to depend on enables more business opportunities between entities that otherwise would not easily trust each other.

B. Industry, Information, and Blockchain

The automobile industry has always focused on producing better vehicles. With the recent technological advancements, this industry has found great opportunities to improve and innovate. From battery technologies to big data and AI [2], there are a lot of great tools that help this trend. This industry is committed to innovation. A European Commission report reveals an automobile manufacturer (Volkswagen) to be the top R&D investor in the world [3] in front of Microsoft, Intel and Apple. Eight of the top 23 R&D investors in the world are part of this industry [3]. This orientation suggests that auto manufacturers would embrace innovative technologies like blockchain once their benefits are proven.

The volume of collected data on vehicle-related interactions is also increasing. Previously, automotive industry defined identifying attributes such as VIN, engine number, make, model, year and color of the car. These data originate at the creation of the car, and mostly stay unchanged if the vehicle was not subject to significant reconstruction. Dynamic attributes such as ownership related data include the owner, license plate, insurance and several types of taxes. Even though it is changeable, these data do not frequently change either. In the last decade, the data we would like to retain on vehicles and their interactions increased many folds. In this decade of disruptive technologies, we need to record behaviors, interactions, and step by step history of events. It is beneficial to record who can drive the car, performance of the car, driver's driving performance, purpose of the journey (business or leisure), odometer readings at the beginning and end, signaling patterns, and much more.

II. Background Study

There are several subject areas in the automotive industry that can benefit from blockchain technology. In this section, we present current applications of blockchain technology on automotive vehicles.

Utilization of blockchains is reaching to a broad set of targets. This large set of ideas is an indication of benefits that blockchain technology is adding to the industry by convincing its major players. Mobility Open Blockchain Initiative (MOBI) [4] believes that blockchain technology is going to enable a whole range of mobility services.

A. Payments

The lightning network [5] and smart contracts are opening many opportunities for recording sensor data in major blockchains like bitcoin. Secure communication and payment can be defined between electric vehicles, charging stations and operator corporations using blockchains [6] [7] [8] [9]. Hybrid vehicles can also sell electricity to each other and record these transactions on a blockchain [10].

Currently, wireless charging of devices is considered to be a practical topic. Blockchains can be used to facilitate this transaction [11]. Even though the implementation is not widespread, there are several types of wireless charging stations under discussion. There are ideas to build vehicle charging stations at traffic lights or parking areas where charging happens while waiting or parking. Blockchain technology is very suitable for recording such a transaction to be used to facilitate payments.

B. Autonomous Vehicle Charging

Autonomous vehicles have a lot to benefit from a tamper-free ledger. They can pick the charging stations using blockchains [12]. In order to provide a reliable ledger of the events, a blockchain can record charging station and vehicle communication including the acknowledgment of the energy transfer and payment for the service.

C. Odometer Fraud Prevention

Motor vehicles are durable products that have long lifetimes. That is why second-hand sales are very common. The used car industries serving this market are large with an annual business volume of hundreds of billion dollars. Only in Europe, this volume is reported to be 180.4 billion euros [13]

One of the most common frauds related to used vehicles is odometer fraud. Lowering the mileage of a vehicle by tampering an odometer and would increase the perceived value of the vehicle and trick buyers to believe the vehicle is in better condition than it is. When cars are transported beyond state borders, tracing their history becomes even more difficult. Odometer fraud is costing Europeans as much as 9.6 billion euros as of 2014 [14]

A blockchain periodically recording odometer values can prevent this fraud. Such a blockchain can also record odometer values when a significant or witnessed event happens. Significant events can be service visits or the renewal of vehicle license stickers.

It is certain that a car odometer tracking platform running on blockchain technology is beneficial for recording the complete

lifecycle of a car, informing the interested parties with tamper-free information, and helping the community with injected trust in order to let them reach a more precise valuation of vehicles [15].

D. Re-Vinning or Re-build

Auto thieves change vehicle identification number (VIN)s of vehicles to re-market them as clean vehicles. A blockchain to correlate the VIN to other attributes of a vehicle can help prevent this type of fraud. An accessible history record can also reveal whether a vehicle had an accident where the insurance inspector marked it as damaged beyond repair. Mechanics repair these vehicles with low quality or unsafe methods by collecting main pieces from multiple vehicles and fusing them. This repair may not be visible to inexperienced consumers. However, it can be unsafe in high-stress conditions such as high speed or a collision [15].

E. Vehicle to Vehicle Communication in Intelligent Transportation Systems

Inter-vehicle communication is one of the emerging topics in IoT. There are several use cases of enhancing the driver experience with inter-vehicle communication. Blockchain technology can help build an inter-vehicle communication system by hosting features such as admission [16]. Announcements communicated vehicle to vehicle can improve the driver's experience. Blockchains can be used to record these communications. The credibility of the received messages can be assessed using a blockchain [17]. Blockchain technology can also be used to provide incentives to this platform [18] [19].

F. Vehicle Forensics and Insurance

Connected and Automated Vehicles (CAV) adds several new data to the potential disputes. The decision-making capacities of such vehicles are based on sensor data and in case of an incident, the sensor data is part of the evidence to be used in the decision to identify a resolution. Recent literature proposes forensic systems to be built on blockchain technology. Both B-FICA [20] and Block4Forensic [21] are proposals for a forensics blockchain. Their major challenges are IoT data volumes and timely communications. Collection of forensic data shows flood like characteristics while on the other hand, usage is very rare and generally much after the fact.

III. New Use Case

In this study, we are focusing on the following new use case that can help revolutionize the auto manufacturing and insurance industries.

A. Tracking Insurance Records and Preventing Fake Proof of Insurance (Pink Slip)

Auto insurance is mandatory in many countries. Each driver is obligated to have insurance to drive and must produce a proof of insurance ownership when requested. In Ontario, the proof of insurance form is known as a pink slip because of the color of the forms provided by the insurance companies. Drivers are the center of the insurance based communication in Ontario. Drivers provide the proof of insurance coverage when pulled over by police, buying/leasing a car, registering a car, and when renewing the license plate stickers. In all these occurrences, drivers deal with each party separately. For example, a driver buying a new car, purchase insurance from the insurance company and carry the documentation to the car dealer for the release and licencing of the car.

There are a lot of manual steps in the process of providing a proof of insurance. Manual steps and physical evidence-based systems are open to fraud such as forging vehicle insurance cards and selling them [20]. High insurance prices motivate people to accept such risks. There are several use-cases of fraudulent activities around insurance records. In official grounds, there are consequences for using a fake document, but drivers bet on the inability of the authorities accessing the correct information promptly. Since most incidents in which drivers are asked to present proof of insurance do not reach official grounds, drivers may use fraud to get out of a current trouble situation. There are several reasons for the manual process to be misused between the parties that does not trust each other. All these parties are dependent on the quality and reliability of this information. The risk of error in communication is also high where a driver is carrying and filling forms.

A blockchain for obtaining, sharing and verifying insurance records will help stakeholders as a reliable sharing platform and a ledger of events. Drivers can further share the pink slips through the blockchain. Such a blockchain can even record this sharing event in case there is value in tracking who requested to share which record and shared with whom.

The main motivations for a blockchain solution are the requirement for transparency, collective nature of contribution and participants' lack of trust to each other. A secure centralized database solution of similar purpose would have challenges in ownership, maintenance and governance. The conflict of interest between the parties would prevent a solution that would be owned by an external entity. Decentralized solutions such as blockchain are also more resilient to the attacks as there is no single point of failure.

An alternative solution could have been storing the same information in a centralized database. Even though the technology for this solution is available for long time there are several reasons that there is no such implementation. Main reason is the difficulty of governance, responsibility, management and administration of such a central system. Endless questions starting with "Who will.." ends in no party tackling above mentioned difficulties. Blockchain solution proposes liberty in joining and collective actions based on democratic behaviors to operate. Equal rights, responsibilities and cost lies to every major participant. Individuals would benefit from better service quality and automation of the system. In case of a dispute, all parties benefit from justice that better quality evidence brings. Distributed nature of the blockchain also increase its reliability and availability. Distributed management would make sure no party single handedly modifies the data especially where there is conflict of interest between the parties. Distributed systems are more resilient against denial of service attacks or service outages.

IV. Design

The solution to the difficulties in tracking insurance records is creating a blockchain platform to enable all participants to

communicate, share and record information. We have a phased approach to the production roll out. The first phase will be the insurance records as described in this paper. The following phase will include an extended set of capabilities targeting vehicle-based information including telematics.

A. Participants

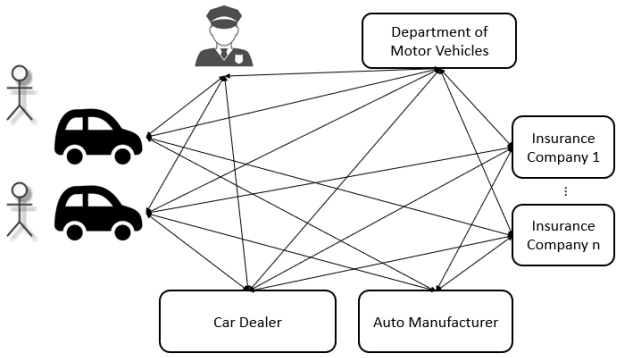

Fig. 1. Participants of the blockchain based solution

The participation in the proposed blockchain network is as depicted in the Fig. 1. Participants include individual drivers, business organizations such as insurance companies, and governments agencies.

Individual drivers are key participants in this ecosystem. Like in most systems, benefits provided to the individuals and their adaptation to the new platform will define the success of this project. Even though individuals who do not own a vehicle can access this system, we expect most individuals to be drivers with vehicles, purchasing insurance, and using the interfaces provided by the system. Depending on the privacy rules and concerns, individuals can be a full node in this system involved in all communication, or they can be allowed to access only limited information via their insurance agency. We discuss this matter further in the privacy section. At this time, we assume they are a direct participant in the system.

Businesses will uncover great opportunities with the blockchain to improve their data collection and precision. Businesses such as manufacturers and dealers are significant contributors to this system. Manufacturers can improve their brand image by contributing to this project. Currently, dealers are under obligation to check whether customers have insurance for the vehicles they are buying or leasing. This check is highly dependent on manual steps and paper-based communication. Adoption of the new blockchain solution will eliminate the need for unnecessary risk of information gathering through manual channels. Moreover, in the future, businesses can significantly benefit from product-based telematics. Service reminders and performance monitoring of the vehicles are some of the possible use cases for this information.

Insurance companies have several benefits to their business due to the quality of data collected with the blockchain. First of all, preventing insurance fraud translates to more business for the insurance companies.. Removal of pink slips and all other manual forms of communicating the insurance information not only will save from paper mailing services, but also collect reliable information in case of incidents. Insurance customers will get better service by using the electronic communication and sharing of information. The blockchain will record all relevant events. Stakeholders can use some of this information in the future for determining promotions and pricing.

Government agencies are another set of contributors to the system as they can collect reliable information quickly by using the technology. Governments mostly depend on voluntary data delivered to them. For example, during the license sticker renewal, drivers voluntarily provide their insurance details such as the insurance company and policy number. The blockchain can significantly improve the quality of such data where governments receive the same information directly from the blockchain without the risk of mistyping. Lawyers can also be participants of this blockchain. They can use the ledger information in case of a dispute.

V. Platform

Since we need separate roles for participants of the blockchain network, a permissioned blockchain is a good fit for our problem. Therefore, we started designing a blockchain solution based on Hyperledger. Hyperledger is a product set of open source tools and libraries needed to form a blockchain. A blockchain project in Hyperledger consists of the following entities: “Insurance Record” and “Insurance Sharing Record” TABLE I. presents these entities with a representative set of attributes. In future projects, adding more attributes relevant to future use cases will improve the overall solution.

A. Assets

The main assets in this system will be the record of insurance and the sharing record of insurance. The insurance record will be the primary record in the blockchain representing the proof of insurance. Dealers will create this record at the time of car sales. VIN and vehicle specific details will be added to the record. Dealer will set the status as "Initialized" for this original record. Following this initial record, the driver will share this record with insurance companies by sharing the driver public key. Since the insurance company accesses blockchain records, they can locate and access all the insurance records that belong to this specific driver. Assuming the next step will be completing the sale of the insurance, the insurance company would enter fields related to the insurance business such as the “Insurance Company”, “Policy Number”, “Start Date” and “Expiry Date”. When any company issues new data into the system, related records have to have their signature to validate that an authorized participant issued this update. The sharing record of insurance is the record for the event of a driver sharing her insurance information with another party. This typically happens when there is an accident and proof of insurance is to be shared.

TABLE I. Assets and Attributes

Asset Name	Attributes
Insurance Record	Insurance Company, Policy Number, Driver Public Key, Status, Start Date, Expiry Date, VIN, Make, Model, Year, Dealer Signature, Insurance Company Signature
Insurance Sharing Record	Driver Public Key, Shared-With Key, Incident Code, Expiry Date

B. Smart Contracts and Automation

One of the most significant features of the blockchain networks is automated processing through smart contracts. As much as the blockchains are used to store transactions, they can be used to create contracts to produce transactions in the network.

There can be several use cases for smart contracts. Smart contracts can help execute manufacturer recalls for each vehicle. A user interface can display this information to the vehicle. The vehicle owner/driver may respond to this with decisions. All actions would be recorded on the blockchain to be tamper-free. There can be no denial of the interaction and responses.

Thanks to cryptocurrencies and other financial advancements in the blockchain technology, even insurance payments can be managed on the blockchain. There can be smart contracts that create a payment depending on the vehicle's usage statistics and driver's performance that month. The driver should be able to accept and execute such contracts from the user interface provided by the car.

TABLE II. lists the transactions. From this list of transactions, the insurance expiry event is the only one that can be automated with smart contracts by our blockchain solution.

TABLE II. TRANSACTIONS

Transaction Name	Description
Insurance Creation Event	A new insurance record is requested. Identification information for the car would be recorded. Status will be "Initialized"
Insurance Creation Event	Insurance company completes the preparation of insurance. New information such as policy number, start and end date are added. Status will be "Active"
Insurance Expiry Event	Expiry date specified for an insurance record has passed. A record will be created with Status = "Expired"
Insurance Information Shared	Owner of an insurance record provided permission to share this record with another participant.

C. Interactions

1) Purchase of a Vehicle

Purchasing a new vehicle is a use case that includes several manual interactions. After a driver decides to buy a vehicle, she needs to collect the information and communicate with an insurance company to purchase insurance for the vehicle. With the insurance information, the driver contacts the dealer in order to complete the purchase. All these steps and possible errors on the phone calls can be replaced with the following flow in Fig. 2.

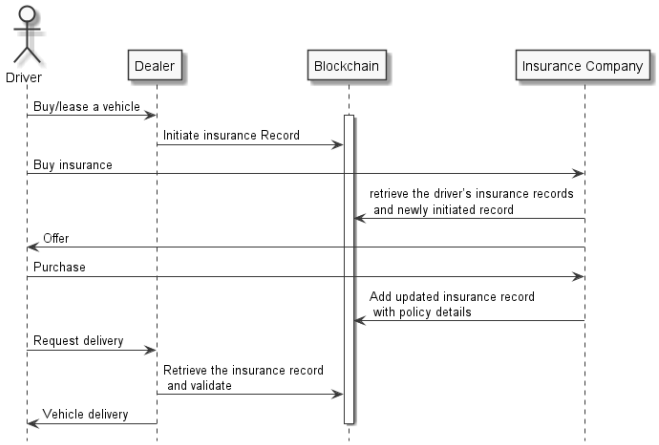

Fig. 2. Sequence of steps while purchasing/leasing a new vehicle

2) After an Accident

One of the main use cases regarding multiple untrusting parties is the motor vehicle accident use case. When a small accident happens, drivers are supposed to exchange proof of insurance documents (pink slips), and contact their insurance with information they collected. They typically need to spell several coded information on the phone with their insurance company. The following flow in Fig. 3 replaces this manual data transfer and related errors with a blockchain based flow.

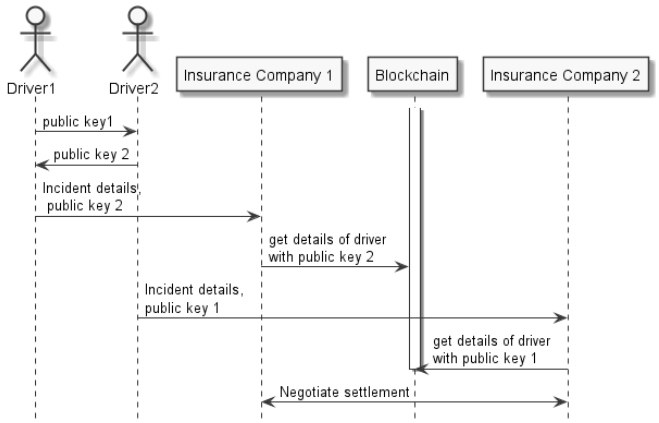

Fig. 3. Sequence of steps happening after an accident

3) Police Control

A convenience feature of the new blockchain system will be sharing documents with all interested parties such as the police. When a vehicle is pulled over and the proof of insurance is requested, the driver can let the police officer access the document with a key as depicted in Fig. 4.

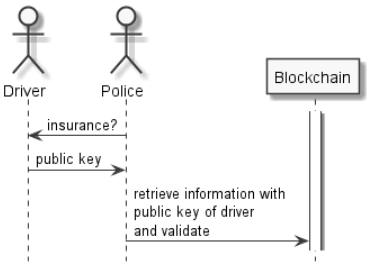

Fig. 4. Sequence of steps during a police control

VI. CHALLENGES

Blockchain systems are enablers, but they are not the solution to all problems. There can be more than one blockchain-based solution to solve a single problem. Once the blockchain application satisfies the business requirements, we should investigate if the blockchain solution is a fit for non-functional requirements as well. We can decide on the suitability of the solution after the analysis of the issues. Below are some of the significant issues.

A. Collaboration

Blockchain systems can only provide benefits to participants who are collaborating. Even for a simple data collection and communication application, parties need to agree on the fundamentals of the blockchain. The structure of records, roles and responsibilities are some common fundamentals that are worth focusing on at the beginning.

Each party would assess the benefits of the platform and decide what the value for themselves and their customers is. There may not be enough motivation for collaboration due to unproven benefits in a simple use case. However, blockchains provide mutual benefits and long-term potential. Most players who only comply with the standards enforced by the governments may now be tempted to join the collaboration. Most participants will find the incentives around increased information flow. Transparency would enable them to create cost savings, prevent forgery, increase reliability and reduce inefficiencies. Such benefits will convince participants to maintain the decentralized system. At the times of conflict, blockchain will provide evidence for the resolution. Parties of the conflict will benefit from reduced timelines and increased accuracy of justice.

This blockchain solution is probably the most secure data sharing solution that this industry has experienced before. Cryptography enables secure recording of all communication. Non-repudiation features may improve trust. Blockchains enable groundbreaking levels of sharing data. Participants that are realizing potential benefits would increasingly utilize this solution. Proper execution and better communication can solve collaboration issues.

Creating a new blockchain or utilizing an existing blockchain for a new solution requires participants to be knowledgeable about the potential benefits of a blockchain network. If the participation ratios cannot reach representative percentages, then the benefit of the blockchain may not be realized. If enough individuals and corporations would not adopt the technology, it is not possible to see the advantages of sharing. If government agencies are not involved, it would be relatively hard to achieve collective advantages such as producing statistics to improve services.

We believe there are enough reasons for all these participants to adopt this solution. However, the cost of governance may discourage the creators. In the case of high costs being an obstacle, implementing a minimum viable product will prove the initial value of the solution.

Blockchain networks need governance. A consortium must define the rules of the blockchain operations. This consortium's primary task should be the safety of the blockchain operations. In case forming such a consortium is difficult, an incentive structure may help to pay developers and contributors for their service.

B. Data Privacy and Security

Our proposed network is a data sharing network, and the biggest concern of such a network is privacy. There will be several different categories of data that will be stored in the blockchain and can be accessed by participants.

Using a permissioned blockchain, participants can have access rights according to their roles in this network. Only vehicle dealerships can issue new vehicles. Only insurance companies can create insurance transactions and related smart contracts. There are several other roles and matching activities in this solution.

For personal data, there are several concerns. Most of these concerns are to be addressed by lawmakers. The transparency of blockchain networks can be established to the extent of the permissions from governments about the privacy of citizens. There would be concerns about whether the blockchain is sharing too much to create vulnerabilities for a malicious person to exploit. The participants can access any information on the blockchain. This level of sharing means one corrupted participant means all the information in the chain is available to a malicious third party. With this risk, we kept the amount of information on the chain to be at a minimum. We excluded all personal information about the drivers including their addresses although the address is a piece of information on the Ontario pink slips which would be exchanged with other drivers in case of accidents. In case this implementation can include more information without privacy concerns, some of the driver's personally identifiable information would be useful to store in the chain.

Finally, our system is operating with the public keys of the drivers in order to protect their identity. Another way to add more anonymity is for the driver to use a different key-pairs to record each type of data. This way it would not be clear whether one driver or many drivers have all these blockchain transactions. When the driver decides to share the data and want the recipient to link the identities, she will share the set of certificates or public keys. Where public keys are not enough for maintaining privacy, advanced cryptographic techniques such as zero knowledge proofs and bilinear pairings must be used to safeguard privacy.

C. Transaction Fees

Creating the blockchain and maintaining the operations have costs. Pricing is an essential factor in the promotion of the proposed solutions. Currently, Bitcoin network transaction fees are so high that an ecosystem that depends on the Bitcoin network would pay high prices for executing a high volume of transactions. Altcoins are focusing on lower transaction fees, but the capabilities and reliability of these altcoin networks may not be as high as Bitcoin or Ethereum.

An alternative solution to the issues at the typical public networks is to create a custom network. For the systemic requirements around a custom network, there must be some incentives for the participants to get involved. In public blockchain implementations, participants need to handle blockchain operational tasks such as creating a new block.

In case the new block creation duty is given to a specific set of participants, there should be measures to prevent any misuse of this power.

D. Scalability Issues

The blockchain technology has a well-known scalability problem. Several sources [5] [21] [22] are indicating this as the most significant risk facing the widely accepted blockchain implementations. There are several research projects and advancements in this area.

The solution to the performance requirements can be enhancements like the "lightning network." The lightning network typically records the transaction off the chain until the termination of the channel. The lightning network concept is a proposed solution for the bitcoin blockchain in order to keep the volume down, filter the unnecessary recordings, and therefore increase the capacity through increasing throughput. The lightning network suggests to use the main blockchain not for every transaction but for the summary. It is similar to recording the transactions at the local repository of the "Segregated Witness" and having period-end reconciliation with the main blockchain [23].

Vehicle-related transactions can utilize this approach for vehicle-related transactions in order to decrease the volume and cost of transactions. Bitcoin can process about five transactions per second; the lightning network can process more than thousand transactions per second and as a comparison, the transaction giant Visa network can process 56K/sec [23].

For permissioned networks, the scalability issues are less significant. As the network has roles and not all roles are available to each participant, consensus operations do not take a long time. Especially when selected participants are assigned to the block creation task, the performance of the network increases. As decentralization increases, performance decreases. Blockchain solutions cannot be compared with any centralized solution as centralized solutions do not operate under trust-seeking environments, but rather use the authority of the centralized system to decide without delay. Permissioned networks are the closest to this model by providing the trust to defined roles. By assigning roles, the solution will have a minimum burden of consensus-seeking.

VII. Conclusion

There are several use cases of blockchain technology in the vehicle industry. We have presented the variety, benefits, and issues of these solutions in a survey format in order to understand the industry as well as the blockchain adoption. Blockchain technology facilitates better service where all participants need a transparent and accessible environment to share information.

Our contribution is the new use case for creating a vehicle insurance ledger using blockchain to share the vehicle insurance records. We also contribute the digital asset design, smart contract automation design and interaction design. We propose using blockchain technology to capture the details of the insurance where several actors are collaborating, and several stakeholders are depending on. We provide details on how participants can benefit from transparency with this scenario as well as how a blockchain can facilitate transparency. Through this solution, we show that blockchain technology can be used as a communication medium between otherwise untrusting parties.

A future direction for our research would be the connected cars and telematics aspects of the auto industry. Connected cars will bring numerous opportunities to auto industry. The data collected will be beneficial for manufacturers, insurance, owners and governments. Insurance companies can take advantage of this technological front and start giving discounts to voluntarily provided reliable information. When a blockchain has the record, its tamper-free feature protects all parties. Insurance companies, individuals or any other third party cannot change the records once recorded. Since the records in a blockchain are persistent indefinitely, this system can be a perfect driving history to be used for years to come. Individuals can present their public keys or signature to a new insurance company to get better discounts. Young driver programs may consider the ledger to prove the maturity of the driver. Driver's license renewal can consider this history. It can be transferable between states to aid license exchange in case the owner moves to another state. In further cases, the records can assist the court in cases related to the behavior pattern of the drivers. The same blockchain can be used to record alcohol levels of the driver with proper accessories provided. A further use-case would be recording full event logs including details like breaking and signaling behavior for further analysis. We believe all these new features can be developed on top of our current implementation of the insurance record blockchain.

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