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BCVehis: A Blockchain-Based Service Prototype of Vehicle History Tracking for Used-Car Trades in China

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ABSTRACT The vehicle information in used-car transactions is always asymmetric and disputes always happen in China. In order to reduce such disputes caused by the lack of transparency in a transaction, Blockchain technology is adopted to construct a trust mechanism for vehicle information storage and sharing in a transparent manner. In this work, a Blockchain-based vehicle history storing and tracking service, named BCVehis, is proposed. BCVehis allows vehicle owners, vehicle authority, mechanic workshops, insurance brokers and other related individuals/organizations to upload vehicle historical records via simple manners (i.e. mobile app or application programming interfaces). The system provides trustworthy vehicle history to used-car dealers, potential buyers, and other business-related parties. The design rationale and functional implementation of the BCVehis are introduced, and the increased deal volume in a local used-car dealer X is presented, which integrated BCVehis to its online dealing system.

INDEX TERMS Blockchain, decentralized, vehicle history, smart contract, automotive industry.

I. INTRODUCTION

Up to 2019, it has been reported that the vehicle population in China is about 2.6 billion [1]. There are approximately 15 million used-car transactions and over 30 large-scale online platforms running for used-car business in 2019 [2]. However, for a potential used-car buyer without technical background, it is impossible to evaluate a vehicle's condition from the mechanic aspects. Generally in the used-car market, a used car is assessed by referring to readily accessible metrics (e.g. mileage, engine health, exterior and interior appearance). Unfortunately, the metric veracity is questionable. For example, it is difficult to distinguish the veracity of the odometer since it is easy to be manipulated to a fewer value. The similar problem also exists when attempting to find the vehicle damage just from the exterior and interior appearance. Besides, accident records are untraceable if the vehicle has been repaired in an uncertified mechanic workshop. Some opportunistic owners even tried to cover up maintenance records for a good price. It is also frustrated for a

vehicle owner if the bid price of the vehicle under meticulous maintenance is much lower than he/she expects.

However, under traditional mode, there is no appropriate mechanism for a vehicle owner to claim the vehicle condition with trustable supporting documents, whereas the new buyer has no way of easily checking and verifying the vehicle history. The vehicle-related information is completely unequal for both the owner and new buyer, which is the main barrier in the used-car transactions [3]–[9].

In USA, CarFax (<https://www.carfax.com>) starts to provide independent vehicle history reports since 1984, which collects information from thousands of data sources to build a used-car database. Another similar service available in EU is AA history check service (<https://www.theaa.com/vehicle-check>). In China, Guazi (<https://www.guazi.com>), an online platform for used-car trade, facilitates vehicle inspection service to ensure the quality of used cars available on its online platform. Although the engagement of the used-car dealers partially reduces the risk arising from the lack of transparency, such dealer-led trade mode is still not an optimal choice because the used-car dealer works as an intermediary agent. To be worse, in some cases, dealers intentionally hid

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critical information pretended such used cars in bad condition to be in “perfect condition” for a higher price. Due to their centralized mechanism for vehicle information collection, such vehicle history report services are not as trustworthy as they claimed, resulting in unavoidable frauds and disputes.

In China, vehicle historical data are kept by different private individuals and organizations (manufacturers, bureau of motor vehicle, certified dealers, insurance brokers, etc.), and each of them only keeps a small piece of vehicle historical information. For example, the certified (even uncertified) vehicle mechanic workshops reserve the repair records and maintenance data. However, only certified workshop is required to share their records to the database of the car manufacturer. The most valuable data retained by insurance companies are not open for public. Additionally, each part of the whole historical data is locally stored and logically disconnected. It is impossible for new buyers to traverse all standalone databases scattered in different sectors and to investigate the complete vehicle history. The major challenge in integration of tiny pieces is the lack of appropriate mechanisms to form an intact vehicle history.

Blockchain technology (BCT), proposed by Nakamoto in 2008 [10], is an emerging technology attracting much attention from a variety of fields [11]–[14]. In order to solve the pain point when selling/buying used cars, we propose a BCT-based vehicle history tracking service -BCVehis in this work. It collects data from different sources and appends these data to the Blockchain, which cannot be either tampered or manipulated. All participants in the BCVehis ecosystem are capable of appending and accessing data on the Blockchain equivalently. Therefore, BCVehis can provide full transparency of vehicle historical data and build trust among participants in a used-car transaction.

The key novel contributions of the solution proposed in this article are summarized as follows:

1) proposing a BCT-driven vehicle information sharing model to address issue of information asymmetry in used-car market, and enhance the transaction transparency during the used-car trade.

2) proposing multi-source data collection and data validation mechanism to ensure the reliability and authenticity of vehicle history.

3) incorporating smart contract to implement the workflow automation of data collection, data validation, data exchange, and data query for vehicle history.

The remainder of this article is organized as follows: Section 2 describes related work. Section 3 presents the design rationales. Section 4 introduces the system implementation. The discussion is presented in Section 5. We conclude the study in Section 6.

II. LITERATURES

A. BASIC CONCEPTS

Blockchain is defined as a data structure, which creates a shared ledger among a peer-to-peer (P2P) network [15].

Cryptography is used to guarantee the security of shared ledger management by each participant in the network, obviating the need for a central intermediary to enforce the rules. The decentralized structure is the most powerful feature of BCT. It is hard to tamper the data when they are appended into a Blockchain. Prior to formally inserting a record into the Blockchain, the submitted records must be verified by peers in the Blockchain network. A typical Blockchain network usually consists of three core components: 1) data block: a list of data added to a ledger over a given period, which usually contains the data size, timestamp, nonce, Merkle root, version, and hash value of previous block; 2) block chain: a chain structure that logically links these data blocks; and 3) P2P network [16]. As a principle mechanism of data consistency, the consensus is the process to negotiate an agreement among a group of peers in a Blockchain network, and consensus algorithm is an essential for transaction verification in a Blockchain network. Due to the different purposes (value trading, immutable data storing, and etc.), various types of consensus algorithms are developed, such as Ripple [17], PoW [18], PoS [19], DPoS [20], and PBFT [21].

Blockchains are generally divided into permissionless ones and permissioned ones [22]. Actually, permissionless Blockchains usually allow public access, whereas permissioned Blockchains usually restrict access of the consortium members. Governmental and industrial sectors prefer to utilize permissioned Blockchains, since only selected participants can involve in the consensus process. Permissioned Blockchains can be further divided into consortium Blockchains and fully private Blockchains [23], [24]. It is easier to reach the consensus in consortium Blockchains because only trusted participants account for the authority. Each data appending requires the privilege granting from a trusted participant and the underlying protocol is modifiable when the majority of trusted participants reach an agreement. To adapt specific situations and business scenarios, the permission in Blockchains can be further tailored. For example, in partially decentralized Blockchains, the public members are given permission for queries in a limited time. In contrast, the privilege to append data in fully private Blockchains is owned by a single participant whereas the privilege to read is granted to the public.

B. SMART CONTRACT

The concept of smart contract was first proposed by Szabo in 1997 [25]. It is first implemented as a core feature in Ethereum [26]. In the context of BCT, smart contract is defined as a term-based contract that can be translated into codes and built as a self-executed program. It is intelligent that the contract is capable of condition checking, monitoring, and self-enforcing inputs from external trusted parties if it meets the criteria. Users can compile the terms of a contract via programming, which is automatically replicated and self-executed across the nodes in a Blockchain network.

C. BLOCKCHAIN APPLICATIONS IN AUTOMOTIVE INDUSTRY

Nowadays, there are more automotive-related companies utilizing BCT to improve their businesses [27], [27]–[31]. In the automotive industry, three main objectives can be achieved through BCT. First, business-related data could be exchanged in a reliable way [8], [23]–[35]. Second, data produced by vehicles would be monetized by selling unused capability through ride sharing service. Finally, data held by different organizations (vehicle manufacturers, certified dealers, auto finance services, insurance brokers, etc.) across the automotive industry can be linked [36], [37].

Loyal is a BCT-driven reward ecosystem, which supports redemption of loyalty points to customers and eliminates delays and cost while exchanging information [38]. CarVertical is another BCT-based platform, which can trace and share vehicle information among original equipment manufacturers (OEMs) and external partners in an instant and reliable way [39]. The shared ledger contains basic information of a vehicle, history of ownership, maintenance and repair works, and it would be reviewed and updated by OEMs and other authorized participants. Users are able to settle the payment through smart contracts for services rendered (e.g. repairing a vehicle and purchasing/selling a vehicle). Some researchers attempted to check and verify odometer data by using a built-in-car connector to periodically send vehicle mileage data to its BCT-based logbook [40]. Through this mechanism, the displayed mileage can be verified against the actual mileage stored on a Blockchain to avoid odometer tampering. A BCT-based system by Toyota Research Institute is proposed to enable P2P car sharing (e.g. passage of vehicle and trip payments), which records and executes monetary transactions. The system connects smart vehicles, P2P-vehicle-sharing providers and the terminal customers in an efficient and secure way. Users and car-sharing providers would register on the Blockchain and securely exchange data, such as the vehicle location, rent fee, insurance term, and payment account. At the end of the trip, the system will automatically bill the user and update the travel record [41].

BCT is also adopted for the emission management in automotive. Previously, Circular proposed a BCT-based system to track the emission sources for auto manufacture, which utilizes shared ledger as an interoperable database to lower the cost. It can be an important pull factor for those drivers who attempt to reduce their car pollution. Moreover, Daimler has issued a €100,000,000 bond to verify a BCT-driven clean driving reward solution. It is an exciting attempt to incentivize safe driving through a decentralized mechanism. Kasko2Go is designed to evaluate a driver’s habit and yoke to insurance system via Blockchains.

III. DESIGN RATIONALE

In the traditional mode, the vehicle historical information is always asymmetrical among these participants in a used-car trade, as illustrated in Fig. 1. Due to the lack of transparency,

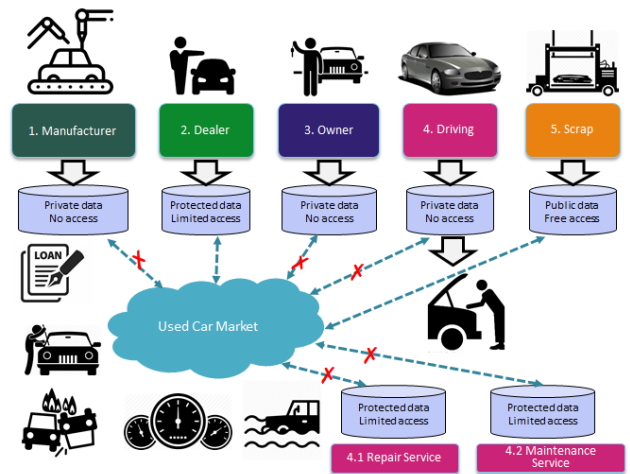


FIGURE 1. The current used-car trade goes at a high risk due to asymmetric information.

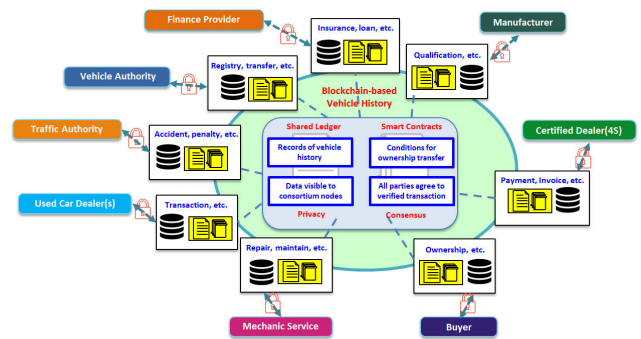


FIGURE 2. A Blockchain-based solution offers a reliable and integrated vehicle history.

frauds (e.g. mileage manipulation and flooded damage concealment) are always inevitable.

To improve the efficiency of automotive industry, many Internet technology systems are developed to support vehicle mechanic work, vehicle insurance and other vehicle-related business. Unfortunately, these systems and their underlying databases are only designed for local services without the considerations of external cooperation; in other words, such service model is disconnected. Limited by these centralized structures, information in the local databases is not allowed to access across organizations, which might easily lead to distrust among participants.

BCT-driven solution (as show in Fig. 2) is proposed to collect vehicle historical records throughout the whole life-cycle from different data sources, which establishes basic trust between the owners of used cars and new buyers. In this solution, an integrated vehicle historical ledger contains the maintenance and ownership history, which also provides the fundamental functionality of viewing and uploading vehicle data to the ledger by OEMs and other authorized partners. It is a reliable and anti-tampering way to check the history of vehicles since data are being stored to the Blockchain on an ongoing basis.

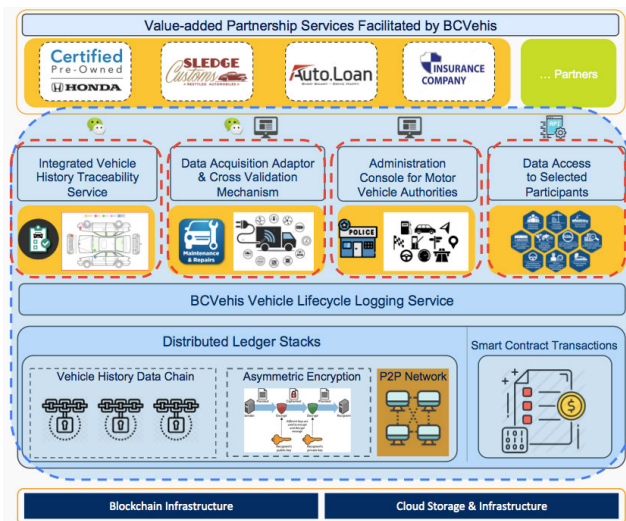


FIGURE 3. An overview of BCVehis architecture and orchestration.

IV. SOLUTION

BCVehis is implemented based on a commercial Blockchain infrastructure - Xuper (<https://xuper.baidu.com>). To avoid overload by massive data produced in BCVehis ecosystem, a hierarchical schema is proposed for the data storage in BCVehis. Baidu Object Storage (<https://cloud.baidu.com/product/bos.html>) is used as an “auxiliary storage”. BCVehis employs a vast array of technique stacks (e.g. Python and HTML5), and runs on the basis of Software as a Service (SaaS). All users are required to verify their identities by submitting authenticate certificates. The services are delivered via mobile app, webpages and application programming interfaces (APIs). By merging a series of vehicle historical information flows to a shared ledger, BCVehis provides a transparent vehicle history throughout the whole lifecycle. It offers vehicle owners opportunities to present the trustworthy vehicle history to the new buyers, used-car dealers or other interested parties in the ecosystem. At the same time, the potential buyers or other interested parties can check and validate the claimed vehicle history with the help of BCVehis in a convenient way.

A. ARCHITECTURE

As illustrated in Fig. 3, the architecture of BCVehis consists of 1) infrastructure layer, 2) service layer, and 3) application layer. In the infrastructure layer, mass of vehicle data will be uploaded and stored in the auxiliary storage, which releases more storage capability. These less frequently-used data are kept in the auxiliary storage instead of the Blockchain network. For example, photos uploaded by the mechanic workshops remain in the auxiliary storage; while, the driving, accident and repair data are copied to the Blockchain, which provide meaningful information for purchases. In this layer, all the data are encrypted and serving the requests from service layer. The service layer provides three types of interfaces (i.e. app, webpage and application programming interfaces) for users, and it also supports programming

operation for specific users to securely interact (i.e. data acquisition and data querying) with vehicle history ledger under accurate access management. Thus, many decentralized applications can be implemented based on the vehicle history ledger. The application layer is the place, where BCVehis service can be incorporated by external partners to build vast types of Decentralized app (Dapp) services (car loan service, car insurance, certified used cars, car modification service, etc.).The data produced by Dapp services in the application layer continuously contributes to the vehicle history and enriches the vehicle ecosystem. Such complete vehicle histories could help vehicle rental agencies effectively associate customers’ driving habits with customized rates. It is also a good way to encourage safe driving for those car rental users, and consequently boosts overall customer satisfaction.

B. CONCEPTS

BCVehis aims to log the details of every event to form a chain of accurate vehicle history. In the phase of vehicle delivery, the participants include the insurance agencies, car dealers and the vehicle owner. The data regarding the new vehicle and its first owner are added into the vehicle ledger and granted the access to related participants. The driving data are uploaded to BCVehis periodically, and these data can be referred by insurance agencies while renewing the vehicle insurance. During the non-driving phase, the insurance agencies, mechanic service department, traffic police, and the owners or the drivers of the vehicle will produce vehicle-related data. Also, the vehicle authority, car owner and vehicle-scrapping agencies will get involved while scrapping a vehicle.

C. SERVICES

1) REGISTRATION

Owner registration refers to the procedure that BCVehis generates a pair of public key and private key for vehicle owner. Two addresses are generated with regards to the vehicle identification number (VIN), and a citizen ID (which represents the identity of a private individual or an organization), respectively. The vehicle owner keeps the private key locally, and publishes its public key to the Blockchain network for information communication and data exchange with other peers. Similarly, brand-certified dealer, used-car dealer, regulators, insurance brokers and other users need to register in BCVehis and be assigned the public/private key pairs. It’s emphasized that the registration processes are monitored and executed by smart contracts.

2) DATA ACQUISITION

In order to collect dynamic data while driving, vehicle owners are required to install a mobile app (as shown in Fig. 4). With the consent from the vehicle owner, the vehicle’s driving information will be gathered through global positioning system (GPS) and mobile phone build-in sensors. It contains:

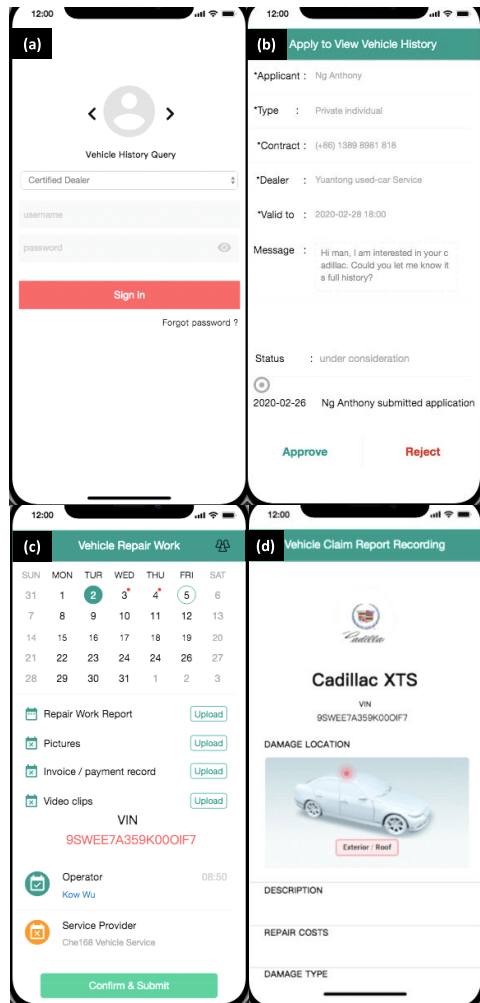


FIGURE 4. Mobile app interfaces: a) user registration; b) the owner grants the access of vehicle history to applicant; c) mechanic workshop uploads repair work report; d) insurance broker submits accident claim report.

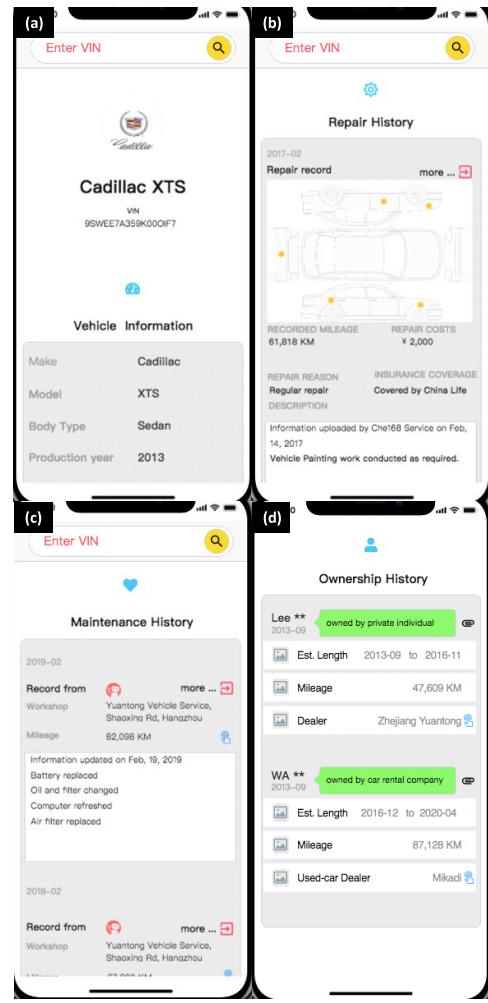


FIGURE 5. A query result of a vehicle history showing on mobile app: a) vehicle information; b) repair history; c) maintenance history; d) ownership history.

1) the starting and ending points of each journey; 2) vehicle identity; 3) speed rate and GPS data; and 4) data produced by On-board Diagnostics (OBD) and Controller Area Network (CAN) (if available). Since more than one data contributors (i.e. devices) operate simultaneously, it is necessary to perform cross-validation on these collected data.

BCVehis attempts to collect data automatically. First, participants (certified car dealer, regulators, insurance brokers, mechanic services, etc.) are invited to register in BCVehis. Some promotional information will be pushed to potential users, encouraging them to join the BCVehis ecosystem. Regular data acquisition starts from a new vehicle delivery. The vehicle-related information (e.g. VIN, owner citizen ID, and vehicle insurance) is gathered when the car owner registers in BCVehis. During driving, data will be carefully processed subject to privacy protection policies, and submitted to BCVehis. Supporting documents and materials during the non-driving period are required when submitting a vehicle event record, which is crucial for vehicle value evaluation. If other participants are related to these events, data will be linked to their account automatically.

In order to ensure transparency and reliability of vehicle historical information, a mutual verification mechanism is developed to validate the user-submitted driving records and repairing records. For example, data produced by nearby vehicles can be used to check the collected-GPS-data. Only verified data will be added to the vehicle history ledger. When a mechanic workshop submits repair records, other mechanic workshop are invited to review and check these reported records.

3) VEHICLE HISTORY QUERY

Due to the lack of verification of the owner’s claim, used-car dealers are eager to seeking solutions on the transparency and credibility of the vehicle history. BCVehis is the right one that they seek for. By inputting a VIN code, users can query the vehicle history via app or webpage. Access to vehicle history record requires privileges, and the requester must be a register user with the privilege to access specific records. Further, the query operation itself is treated as a record in the history ledger.

The query result including the ownership history, accident history and repair history is shown in Fig. 5. The transaction

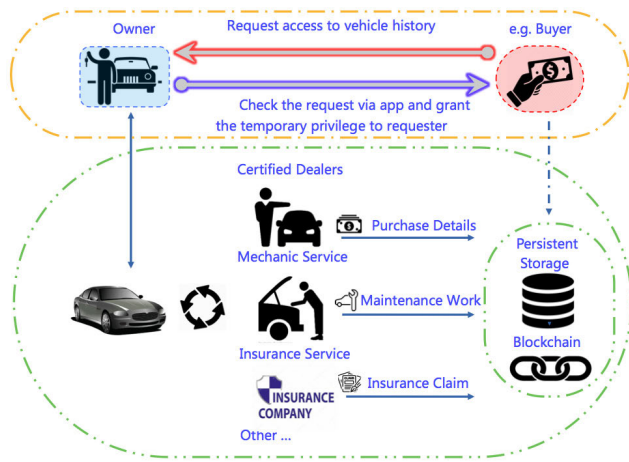


FIGURE 6. The process of requesting full vehicle history and granting access to requesters.

information is also synchronized to vehicle history ledger. Only the vehicle owners have full access to these records, and they can grant other users to access full or part of vehicle history at any time.

Repair history or the owner information can be accessed only during a trade with the consent of the owner. With the consideration of privacy protection, the owner is allowed to restrict some vehicle historical records to display, and further privilege granting is required to view such restricted records. In a vehicle trade, the owner will instantly receive a request via mobile app to provide the full vehicle history to a buyer. As illustrated in Fig. 6, the buyer is temporarily authorized access to all the data through a private key.

There are three smart contracts enabling the query service of vehicle history on an ongoing basis. The first one is “update vehicle ownership”, in which, a new user requests a transfer of a vehicle ownership. When the former owner granted the request, the new public key is recorded with the VIN and a new pair of keys is generated. Subsequently, the former owner no longer possesses the vehicle history. The second one is the design for “events relating to the vehicle insurance”, in which, a new transaction of an insurance claim will be submitted to the vehicle history ledger in an automatic manner. The third contract is the designed for “privilege control”, which is used to approve the request to view a full vehicle history report.

4) DATA SCHEMA

Vehicle-related data varies in types and volumes. Therefore, an appropriate data schema is required, and it could increase the efficiency of data storage. It is important to classify core data that are crucial to vehicle history. In this solution as shown in Table 1, core data are stored in the Blockchain network, whereas other data are stored in the auxiliary storage platform.

A vehicle is identified by VIN, which is globally unique serial number printed on the engine of each vehicle by its manufacturer. All vehicle data and owner information are

TABLE 1. Data schema for vehicle-related data.

Location	Data Entity	Definition
Blockchain	VIN	Vehicle unique identification number.
	Status	It describes the current driving status of a vehicle.
	Ownership	The ownership of a private individual or an organization to a vehicle.
	Odometer	A vehicle carried meter recording how many miles it has driven.
	Repair Work	The summary of a repair work on a vehicle.
	Accident	The summary of an accident involving one or more vehicles.
	Traffic Violation	The summary of the traffic violation.
	Maintain Work	The summary of a maintain work on a vehicle.
	Vehicle Trade	The summary of a used-car trade involving many participants.
	External auxiliary Storage	Transaction
User		The user information stored in the BCVehis.
Organization		The organization information stored in the BCVehis.
Log		The log information for every event in the system, whether it’s a system-level or a user-level.
Driving Detail		It plots the starting and ending points of each journey, and it also contains speed rate, GPS trace and steering data collected by navigation function.
Repair Detail		The full record (e.g. supporting documents, videos and photos) of a repair work, which is summarized in the Blockchain.
Accident Detail		The full record (e.g. documents, videos, and photos) of an accident, which is summarized in the Blockchain.
Violation Detail		The full record of a traffic detail, which is summarized in the Blockchain.
Trade Detail		The full record of a used-car trade, which is summarized in the Blockchain.

associated to its VIN. Also, a piece of data for a repair work includes many supporting documents, videos and photos taking up massive storage space. The files are stored on the external auxiliary storage, and only the hash values of these files are saved in the Blockchain.

V. EXPERIMENT & DISCUSSION

Incorporating with Enterprise Resource Planning (ERP) system of a used-car dealer X, we performed an analysis on the sales data during 2019 and attempted to understand how BCVehis service impacts the users’ decisions during the used-car trade. The dealer X is a Hangzhou located used-car dealer, and X integrated BCVehis service to its system to provide vehicle history report services to its customers.

As illustrated in Fig. 7, the trend of BCVehis queries in each month is synchronous with the trend of used-car transactions. It’s clear that the vehicle history reports provided by BCVehis were widely accepted by used-car buyers as reliable information, which can directly impact the final decision in a used-car trade. As reported by the dealer X, the user

TABLE 2. The distribution of users’ concerns on various sections in the vehicle inspection report by BCVehis.

Vehicle History Report	Average Time (second)	Information Page	Average Time (second)	Percentage	Remark
Part 1: vehicle delivery	356	Ownership Certificate	33	4%	
		Delivery Details	6	1%	
		Specification	40	4%	
		Photos (Interior)	124	14%	Much concerned
		Photos (External)	141	15%	Much concerned
		Vehicle License Information	12	1%	
Part 2: vehicle driving	170	Insurance Records	51	6%	
		Driver Information	12	8%	Much concerned
		Mileage Information	78	9%	Much concerned
		Traffic Violation	29	3%	
Part 3: non-driving	280	Maintenance Records	65	18%	Much concerned
		Declaration Records	31	3%	
		Damage Records	64	7%	Much concerned
		Compulsory Inspection Records	20	2%	
Part 4: used-car trading	111	Used-car Trade Invoice	45	5%	Much concerned
		Ownership Transfer Records	27	3%	
		Transaction Records	39	4%	

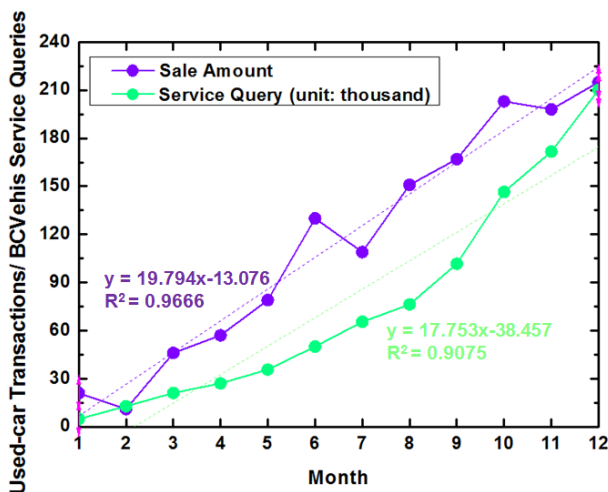


FIGURE 7. The co-relationship of the number of BCVehis query by users from X, and the number of successful transactions from X in the 2019.

satisfaction also gradually improved with accordance to the adoption of BCVehis.

The system log provided us the details to understand how these users access the BCVehis service. Furthermore, by analyzing the time a user spent on each information page, it reveals some interesting facts, such as the page that these users concerned most when reading a vehicle history report. As listed in Table 2, on average, users spent 917 seconds to read through the details of a report. In the part of vehicle delivery, 356 seconds is spent on average, and the information pages “Photos (Interior)” and “Photos (External)” are most

Average Time Stayed on This Page

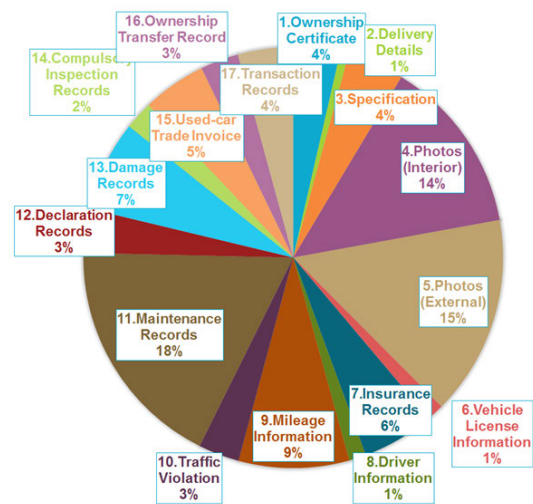


FIGURE 8. The analysis on the average time of users stayed on these pages displaying the full vehicle history.

concerned. In the vehicle driving part, 170 seconds are spent on average, and the information pages “Driver Information” and “Mileage Information” are more concerned than others. In the part of non-driving, 280 seconds are spent on average, and the information pages “Maintenance Records” and “Damage Records” are much more concerned. In the part of used-car trading, 111 seconds are spent on average, and the information page “Used-car Trade Invoice” is the most concerned. As shown in Fig. 8, the time distribution on vehicle history report indicates that “Photos”, “Mileage

TABLE 3. The comparison of BCVehis and used-car inspection services provided by dealers.

Dealer	Business Mode	Data Contributors	Description of Service	Vehicle information Reveal
BCVehis	A decentralized service for any user interested in vehicle history, and it is capable of partnering with any external system.	Multiple sources with full coverage of a vehicle lifecycle	A BCT-based service, which could securely gather and provide trustworthy vehicle history throughout the whole lifecycle for all participants in a reliable way.	All the records covering the whole lifecycle of a vehicle.
Guazi	An online used-car dealer on a C2C basis.	The platform itself.	Guazi (http://www.guazi.com) is a popular used-car trade platform in China. It claims 259 inspection items for evaluating vehicle including six categories: accident history, engine parameters, main function, on-road driving, brake and chassis inspection, exterior and interior. Also, extra 67 items will be inspected for double check before trading. The supporting documents include vehicle images. It reveals vehicle information (e.g. registration history, ownership transfer record, mileage, insurance status, etc.), and guarantees that no cars with serious accidents; no cars with fire accidents; no cars with flood damage.	Current situation of a vehicle, summarized description of past history (no details included).
Youxin	An online /offline used-car platform on a mixed basis including B2B/B2C/C2B.	The platform itself.	Youxin (http://www.youxinpai.com) is a used-car auction platform in China. It claims 315 inspection items, and patented its paint detection technique. It claims accessing records of vehicle maintain, repair and insurance.	Current situation of a vehicle, summarized description of past history (no details included).
Renrenche	An online used-car dealer on a C2C basis.	The platform itself.	Renrenche (http://www.renrenche.com) is a used-car trade platform in China. It claims 249 inspection items for evaluating vehicle including following categories: accident history, main function, chassis inspection, exterior and interior. It reveals vehicle information, such as basic information, payment invoice, ownership transfer record, and mileage.	Current situation of a vehicle, summarized description of past history (no details included)
Taoche	An online new car/ used-car dealer on a B2C/ C2C basis.	The platform itself.	Taoche (http://www.taoche.com) is a used-car trade platform in China. It claims 378 inspection items for evaluating vehicle including following categories: accident history, driving test, main function, paint inspection, exterior and interior. It reveals vehicle information, such as basic information, payment invoice, ownership transfer record, and mileage.	Current situation of a vehicle, summarized description of past history (no details included)

Information” and “Maintenance Records” are the major concerns for used-car buyers.

Table 3 compares these existing used-car inspection services in China and the BCVehis. It is claimed that a vehicle inspection report includes an array of inspection items, which can be generally grouped to: 1) fundamentals; 2) engine performance; 3) vehicle functionality; 4) exterior and interior check; 5) brief accident history (no details included); and 6) paint detection. Unfortunately, such reports only reveal the current status of a vehicle and limited history in the past due to its individual data source. It is worse that the quality of the vehicle inspection reports is neither stable nor reliable because they failed to obtain adequate documentations. In contrast, BCVehis gathers vehicle-related data from multi-sources and applies cross-validation measures to offer trustworthy vehicle history covering the whole lifecycle.

Therefore, a sound BCVehis will lay solid foundation for the development of used-car market.

VI. CONCLUSION

In a used-car trade, the asymmetric information environment (i.e. lack of the transparency of vehicle history) usually results in disputes (and even frauds) between the vehicle owner and the new buyer. In this study, we investigated the main problems in such trading mode and explored a BCT-based solution (named BCVehis) to tackle this challenge. BCVehis is designed to securely log all vehicle historical data: 1) involved individuals and organizations, 2) events and 3) transactions (e.g. delivery, repairing, maintaining, and vehicle ownership update) throughout the whole lifecycle in a transparent and trustworthy manner. A comparison between BCVehis and current vehicle inspection services by

mainstream used-car platforms highlights the decentralized design of BCVehis. However, BCVehis is still in its initial stage, and it faces some challenges. One constraint is the limited storage capacity in mobile devices since these devices are designed for portable purposes than massive storage. The edge computing will be taken into consideration to attempt to tackle both the computational and local storage issues. In the future, we will continue to work towards attracting and benefiting more participants and expanding the BCVehis ecosystem.

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