Implementation of a Proof of Concept for a Blockchain-based Smart Contract for the Automotive Industry in Mauritius

Keshav Luchoomun[1], Sameerchamd Pudaruth[2], Somveer Kishnah[3]
Faculty of Information
Communication and Digital Technologies
University of Mauritius

***Abstract*—In recent years, there has been a growth of interest in the blockchain technology across a wide range of industries. Blockchain technology has the potential to transform the way businesses operate especially in the automotive industry. The distributed infrastructure and the secure nature of the blockchain technology encourages trust among businesses and consumers. In Mauritius, the automotive industry is facing challenges such as tampering of vehicle information, falsification of mileage and poor traceability which leads to a lack of trust from customers. In this work, an implementation of a proof of concept (POC) for a blockchain-based smart contract application has been proposed and implemented to mitigate these challenges. The automotives use cases: (a) vehicle importation; and (b) vehicle sale and registration have been implemented in the IBM blockchain platform which provides a secure and transparent way to invoke transactions. Finally, the performance and benefits of the Hyperledger Fabric vehicle application have been assessed based on transparency, security, traceability and efficiency.**

***Keywords*—Blockchain; smart contract; hyperledger fabric; vehicles; Mauritius**

I. Introduction

Blockchain and smart contracts are terms that have constantly been the subject of heated debates across a wide range of industries over the last few years. Blockchain has moved into the mainstream development tools and technologies, with a wide variety of organisations that are keen to explore how it can be implemented for their businesses [1][2]. Smart contract is another term which has received much industry attention. The concept of smart contract was first coined by an American computer scientist, Nick Szabo, who proposed a smart contract to embed contractual clauses based on events such as time or transactions [3]. A smart contract is similar to physical legal contracts in that it is an agreement made between two different parties to finalise the terms of one or more transactions [4].

For decades, both private individuals and businesses have been facing the same dilemma when purchasing a used vehicle. How can the buyer ensure that a vehicle is really in the exact conditions as described by the seller? How can the buyer have trust when buying a pre-owned vehicle without having to worry about its history, mileage, service history, vehicle inspection history and plenty of other factors critical when assessing a vehicle's condition?

Mileage is one of the most significant parameters when assessing the condition of a pre-owned vehicle. It is probably the most widely acknowledged indicator of how 'used' the vehicle is, and therefore has the most significant effect on the vehicle's valuation and the price the buyer pays. Low mileage equals to higher prices and high mileage equals to lower prices. When mileage is such as important indicator of how used the vehicle is, it is critical that the odometer reading is correct. Unfortunately, the vehicle mileage is sometimes tampered with in some manner to conceal this high mileage. This uncertainty has always plagued the used vehicle market. The consequences of tampered vehicles in the same category as 'straight' vehicles have led to unfair and misleading prices. According to an article published by the Défi Media Group, the car industry was shaken by scandals in which odometers were tampered with. The authorised dealer of this car model in Mauritius announced several more cases in which odometer readings were different from those received from the headquarter [5]. Moreover, the process of purchasing vehicle has always been cumbersome and time consuming where multiple parties/authorities are involved and also poses a risk of information manipulation, data duplication and additional transactional costs. One of the major problems plaguing the automotive industry is the sale of counterfeit parts.

The blockchain technology can change the way the automotive industry functions. Blockchain's application will become a part of everyday life across many industries. With the automotive landscape evolving at an exponential rate, it is only fitting that blockchain will find its way into the industry in the early stages of its development. The broad purposes of this paper are: (a) achieve transparency – transaction histories of the vehicle are becoming more transparent with blockchain technology where a distributed ledger is shared among all network participants, (b) enhanced security – blockchain provides an encryption mechanism for approving transactions, (c) improved traceability – in the automotive industry, the purchase of a vehicle needs to undergo a chain of processes and it can be very expensive and cumbersome to trace an item from its origin, (d) increased efficiency and speed – the current system involves lots of paper processes and therefore it is time-consuming, prone to human mistakes and may require mediation from third-parties, (e) reducing costs – for the

majority of businesses, cost reductions are a priority. With the implementation of the blockchain technology in the automotive industry, third parties or middleman will no longer be required. The trust is gained from the data on the blockchain, knowing that the ledger is secure, error-free, accurate and immutable.

For this paper, two use cases have been considered: (a) importation of a vehicle from the car manufacturer to the showroom (b) purchase of a vehicle. The application will be a proof of concept to allow the participants in the network to perform transactions in the blockchain platform. Only the digital asset of the blockchain technology has been considered.

The remainder of this paper is organised as follows. Section 2 introduces to literature review on blockchain technologies. The methodology adopted for this study is given in Section 3. Evaluation of the existing system is presented in Section 4. Section 5 shows the proposed system of Hyperledger Fabric vehicle. Section 6 presents the evaluation performance of the proposed system. The conclusion is given in Section 7.

II. Literature Review

The automotive industry of the future will be disruptive from that of today. Blockchain has the potential to play a major role in underpinning the industry transformation for the future. In this section, a systematic study has been carried out to help shape our understanding on the application of blockchain and smart contract to fit business particular use cases.

The first business endeavor that used a blockchain-based ledger was presented in the white-paper published in 2008 by Satoshi Nakamoto describing a system for electronic cash [6] where the Bitcoin technology started. Blockchain is divided as public and private ledgers. Public ledger is accessible to the public domain and everybody can add blocks to them. On the other hand, private ledger only includes a selected group of people [7]. To make a blockchain viable, a single chain is needed, and this is achieved by an agreement of the majority of participants in the network which is known as consensus.

For the automotive industry to implement blockchain technology, it must meet the following requirements [8]:

- Is a business network involved?
- Is consensus used to validate transactions?
- Is an audit trail, or provenance required?
- Must the record of transactions be immutable or tamper proof?

If the automotive business use case answered the first and at least another criterion positively, then it would benefit from the blockchain technology. The network can be designed across organisations or within an organisation.

Smart contract represents the second generation in blockchain technology from a financial transaction protocol to an all-purpose utility. A smart contract is a piece of code that can be executed on a blockchain. The purpose of a smart contract is to enforce the terms and conditions in the agreement. The idea of smart contracts is not new. It was first proposed by Nick Szabo in 1994 [9]. A smart contract can also be considered as an asset manager which controls the allocation of digital assets to the different parties and/or participants in a blockchain network [10]. A smart contract which is self-contained and does not require any external information to be executed is called a deterministic smart contract while one which require inputs from external sources is called a non-deterministic smart contract [11]. Writing smart contracts require both business and technical skills as any bugs can lead to highly unexpected outputs. This can lead to huge business losses or loss in business reputation, which can have negative long-term consequences [12]. There are several payment platforms which are currently in use and which use smart contract. Bitcoin and Ethereum are too such cryptocurrencies. Smart contracts for bitcoin are not Turing complete and supports only monetary transactions. On the other hand, Ethereum is build using Solidity, which is a Turing complete machine. Solidity is a new language designed especially for Ethereum. It has support for loading code from another address and this enables the creation of libraries (pieces of reusable software code) [13].

Hyperledger Fabric is the first blockchain-based system that supports the use of conventional programming languages for building smart contracts and enable complex data queries [14]. This mechanism gives an edge to Hyperledger Fabric and provides possibilities of using smart contracts in enterprise systems [15][16]. Blockchain developer uses Fabric SDK to code the application and smart contract. A registered user interacts with the application by sending an INVOKE order or a QUERY for requesting information. All participants must be registered in the system to have access to membership services. The content of each transaction is encrypted to ensure that only the intended participants can see the content. All transactions are secured, private and confidential. Fabric can only be updated by consensus of the peers. The events are structured as transactions and shared among the different participants. Fabric provides three distinct roles: (a) a committer peer who is responsible for committing transactions, maintaining the ledger and its state, (b) an endorsing peer who receives a transaction proposal for endorsement and it responds by either giving or rejecting endorsement, (c) an ordering peer who approves the new transactions and add them to the ledger.

Many blockchain initiatives are being adopted by car manufacturers around the world. For example, Ford has implemented a blockchain-based system to control the supply chain of cobalt and to ensure that children are not working as labourers anywhere along this supply chain [17]. Volkswagen has built a tracking system to ensure that odometers are not being manipulated to produce deceptive mileage values [18]. Hyundai is working with IBM and its cloud-based AI to improve its supply chain and payment systems [19][20]. In this work, we intend to leverage on the blockchain technology to implement a new system for the automotive ecosystem in Mauritius which will facilitate all processes, reduce cost for all stakeholders and improve customer experience.

III. Methodology

The research in this paper has been conducted as a case study and data has been collected by focusing on business operations and relevant stakeholders. The purpose of this study

is to analyse the performance, efficiency and identify flaws when purchasing a vehicle. Subsequently, interviews will be conducted where customised questions will be set to different stakeholders of the automotive business such as buyers and sellers, senior officers from vehicle showroom, marketing, sales and finance, supply chain department of the automotive industry. Information will also be collected through questionnaire-based survey. The research questions identified for this paper are:

Research Question 1: To what extent the buyers/consumers and car dealers/sellers are aware of the benefits of blockchain and smart contract?

This research question is based on case studies where the employees, especially in sales department from the car showroom Ginza Motors has been interviewed to analyse the actual situation regarding the use and implementation of blockchain smart contracts in the automotive industry. The interviews will help to gain knowledge and identifies the flaws in the vehicle purchase process. Moreover, a survey has been conducted to target the buyers and this has showed that a great challenge in the implementation of the proposed framework is to gain the consumer trust and ease in adopting the proposed system. Hence, this question can be answered by analysing the data that have been collected through interviews, on-site observations and questionnaires.

Research Question 2: How can blockchain improve the vehicle purchase process to be more secure, reliable and trustworthy? Are buyers willing to purchase a vehicle that has its information stored in Blockchain with the ease of mind that the purchase they are making is accurate and error-free. How the proposed framework will improve quality (customer's trust, accuracy of vehicle's condition, etc.) in the automotive industry in Mauritius?

This research question can be answered after the proposed framework has been implemented. The collected data has been analysed and interpreted to measure the business success in adopting blockchain and a smart contract solution.

Research Question 3: Has the proposed framework mitigated the barriers or challenges that the automotive industry is facing?

This research question will help to understand the barriers and factors in adopting the blockchain framework in the real world. An in-depth study has been conducted to identify the weaknesses of the automotive industry and based on the data collected through interviews, survey and questionnaires, a framework has been devised to mitigate these weaknesses.

The results from 62 respondents for an online questionnaire survey on Buyers' Experience in purchasing vehicle are discussed as follows.

Q1: To what extent are you aware of the procedures regarding the purchase of vehicle?

We observed that 69.3% of the respondents are not knowledgeable about the procedures involved in vehicle registration and purchase. The main reasons are (a) little information are available online and further assistance/personnel is required to gain more understanding on the process, (b) various authorities are involved in the vehicle registration and purchase and information needs to be collected from different sources. Sometimes, a fraction of the information collected may not be accurate and thus the buyers take more time to verify and validate those information where most of the time the buyers remains doubtful about the process and hesitate to proceed with the purchase. Thanks to the introduction of blockchain technology, this problem can be mitigated, and a smooth and seamless way of processing vehicle registration and purchase is offered to the consumers.

Q2: Do you verify the registration book (horsepower) or other documents before purchasing a vehicle?

We observed that 96.8% of the respondents answered 'Yes' and we can easily state that most of the buyers are meticulous about the vehicle's conditions (mileage, horsepower and other documents) that they are purchasing. These factors determine the cost of the vehicle, durability and maintenance cost. Unfortunately, Mauritius has witnessed many scandals over the years in terms of falsification of horsepower as related in the Défi Media Group on 'Car Traffic. Hence, the adoption of blockchain technology will mitigate this issue as the information of the vehicle will be immutable and each authority in the network will have a clone of the information across the blockchain ecosystem.

Q3: To what extent, do you have trust on the conditions (mileage, authenticity of parts) of the vehicle as described by the sale person?

The most challenging part in purchasing a vehicle is to verify that the vehicle's conditions as described by the salesperson are accurate. A relationship of trust between the buyers and sellers is created. We observed that none of the respondents have chosen options 'Confident' or 'Very Confident'. We can easily state that 100% of the respondents have had an unpleasant experience or remain doubtful when purchasing a vehicle. Thanks to the introduction of the blockchain technology, the vehicle's conditions cannot be tampered, and the authenticity of the parts will remain accurate. Hence, buyers will be able to view a history of the vehicle and parts. As a result, the blockchain technology will create a strong bonding of trust between the buyers and the car dealers.

Q4: How long have you been through a vehicle registration process?

The vehicle registration process is very lengthy. 51.6% of the respondents have waited above 4 weeks to have vehicle ownership and 35.5% of the respondents have waited between 2-4 weeks. The main reason for this lengthy process is because the process involves a lot of paperwork. It is therefore time-consuming and error prone. These transactions can potentially be completed faster and in less cost via the blockchain technology.

Q5: In the vehicle registration process, which step(s) do you find it difficult or time consuming?

We observed that a high percentage of the respondents find it challenging to verify the authenticity of a vehicle's documents, vehicle lease process and apply for insurance. The

reason is because in each step different authorities are involved and thus the buyers need to be involved with each authority for documents verification, validation and submission. Moreover, the buyers constantly need to be in communication with each authority to determine the state of the process. As a matter of fact, the steps mentioned above are processed as a chain of responsibility, in other words, verification of authenticity of documents needs to be completed prior to application of vehicle loan. With the introduction of blockchain technology, the authorities/nodes communicate with each other to inform the network that Job A (verification of vehicle's documents) from Node A has been completed and Node B can start Job B (application of car loan) immediately.

Q6: To what extent, are you aware of the benefits of the blockchain technology?

Most of the respondents are not fully versed with the blockchain technology. Hence, workshops, training and campaigns need to be organised to create awareness to the car dealers and public on the blockchain technology. Another way is to design the website or application adhering to the following principles: user-friendly, effective, aesthetic and informative, ease of navigation. In this way, the users/buyers will gain knowledge about the blockchain technology in less time.

Q7: To what extent, are you willing to trust and purchase your vehicle through the blockchain technology?

The majority of the respondents are willing to move away from the traditional system and adopt blockchain technology to purchase their vehicle as the blockchain technology can solve the problem in the existing traditional system by (a) achieving transparency where the vehicle data is more accurate, consistent and no fraud or falsification of horsepower or mileage. Moreover, the authenticity of vehicle's parts can be traced from its origin; (b) increasing efficiency and speed of vehicle registration process to be faster, efficient and eliminate the heavy paper works; (c) reducing cost where buyers will not require paying additional costs.

IV. Evaluation of the Existing System

Registration of vehicles in Mauritius is a very cumbersome process. This is because multiple parties are involved. This creates the risk of data duplication, tampering, manipulation and mismanagement. The process for importation of vehicles in the traditional system is as follows:

1) Car dealer (showroom) needs to have the following prior to importation of vehicles.

a) Clearance from the Ministry of Commerce and Consumer Protection.

b) Importation Permit

c) Bill of Landing

2) Car dealer (showroom) orders vehicles form Manufacturer. Car Dealer can access the vehicle information such as make, model, variant, engine number, chassis number, etc.

3) Manufacturer displays the vehicles in an Auction where there are other suppliers.

4) Car dealer chooses vehicles and makes payments.

5) Vehicles are shipped to Mauritius and remain under MRA (Bond) Custody.

6) Car Dealer needs to complete the following:

a) Register vehicle chassis number (VCN)

b) Duty payment

c) Insurance payment

The following is the process of the traditional system when a customer purchases a vehicle from a car dealer.

1) Customer visits the showroom, chooses vehicle model and request for a test drive.

2) Customer requests for a quotation with vehicle specifications and informs whether purchase will be duty paid or duty free and whether by cash or through leasing.

3) Duty free confirmation letter required from Registrar general for government official or Mauritius Revenue Authority (MRA) for returning resident.

4) The quotation must consist of the showroom price as per duty payable, registration fees, road tax and horsepower fees.

5) Customer confirms purchase, effects a deposit of 15% or more and provides the following documents: photocopies of NIC recto/verso, proof of address (utility bill Central Water Authority, Central Electricity Board, Mauritius telecom), driving license, Payments above ₹ 500 000 is done through office cheque or bank transfer.

6) If purchase is through leasing, the customer has to provide a pay slip, a bank statement for the last 3 months and then waits for approval and the lease documents.

7) Vehicle is sent to workshop for verification, servicing and valeting.

8) Showroom issues sales invoice and customer effects remaining payment.

9) Sales deed document with vehicle specifications is signed by customer and authorised showroom representative.

*10)*Customer and showroom agree on delivery date.

*11)*Sales document is sent for registration with Registrar department.

*12)*Vehicle is insured.

*13)*Vehicle is sent to the National Transport Authority (NTA) for verification, registration and horsepower is issued.

*14)*If vehicle purchase is through leasing a lien is inscribed on the vehicle and horsepower updated accordingly at NTA.

*15)*Road license and insurance vignette is affixed on windscreen and number plate fitted.

*16)*Customer inspects vehicle and sign delivery note and collect documents (delivery note, sales deed, warranty certificate, horsepower, and insurance certificate).

V. Proposed System

Implementation of the vehicle importation, registration and purchase processes using the Blockchain technology can mitigate many of the challenges that were identified in the current system. The architecture diagram of Hyperledger Fabric vehicle server-side for the proposed system is shown in Fig. 4 in the appendix. The technologies used for the

development of the proposed system are Spring Boot framework for server-side application and Angular 8+ for client-side application. Hyperledger Fabric vehicle application server consists of following tiers: (a) the web tier exposes web services for client application to consume. The client application sends a JSON request to the web tier which authenticates the request via a token management mechanism using OAuth2 and maps the JSON to java stub. The web layer communicates to the business layer which consists of several services (interfaces). (b) The business tier consists of 2 modules. These are the Hyperledger Fabric Vehicle Services which contains business requirements and the Hyperledger Fabric Vehicle Provider which is responsible for the IBM blockchain endpoints integration. Once the requested service is executed, the business tier sends the data to the web tier. The latter converts the object to JSON and sends to the client application. The Model View Component (MVC) framework has been adopted for the development of the client application. Each of these components is implemented to manage specific functionalities of the Hyperledger Vehicle web application. The description of the modules is as follows:

- AccountService is responsible for account functionalities; (a) login of user (b) registration of a participant (c) logout.
- VehicleCustomerSaleService is responsible for vehicle sale and registration flow.
- VehicleImportationService contains methods responsible for vehicle importation flow.
- VehicleSmartContractService invokes and queries transactions in the IBM Blockchain network.
- IbmBlockchainProvider is responsible for the IBM Blockchain web services integration.

The description (attributes) of the Smart Contract for Vehicle asset is as follows: VIN (vehicle identification number), make, model, type, color, year, engine number, engine capacity, mileage, fuel used, seat capacity, registration number, owner ID, owner name, owner address, amount, duty, description. The description of the methods of the smart contract is as follows:

- In this, method is executed when the smart contract is created.
- Invoke method is executed when a request is received to run a smart contract.
- CreateVehicle method creates the first block for a specific asset in the blockchain network.
- QueryAllVehicle method retrieves all the assets in the blockchain network.
- ChangeVehicleOwner method creates a new chain block with the owner's details.
- ChangeVehicleDetails method creates a new chain block with the modified vehicle's details.
- QueryVehicle method retrieves a vehicle transaction by the asset's key.
- GetHistoryOfVehicle method retrieves a historical chain of blocks for a specific vehicle.

The application interacts with the IBM Blockchain network to perform registration/enrollment, queries and updates. The smart contract contains functions that allow interacting with the ledger. Fig. 1 shows a representation of the application interaction with the ledger in the IBM blockchain network.

Enrolling the admin user: when the application is launched in the IBM blockchain network, an admin user is registered with the certificate authority. An enrollment call is triggered to the CA (Certificate Authority) server to retrieve the certificate (eCert) for this user. This enrollment certificate is used subsequently to register and enroll a new user.

Register and enroll a new user**:** a new user such as a manufacturer is created using the generated admin eCert. The latter is used to communicate with the CA server. This user <manufacturer> will be referenced as the identity to be used when querying and updating the ledger. It is important to highlight that the admin user's identity is used to issue the registration and enrollment calls for the new user. In other words, the user <manufacturer> is acting in the role of a registrar.

Querying the ledger: the data is stored as a series of key-value pairs. The application queries the ledger for the value of a single key or multiple keys. The data is returned in JSON format. Fig. 2 shows a representation of how a query works in the IBM Blockchain network.

Updating the ledger: The application creates a vehicle asset by the following steps: propose, endorse and notify the application. An order transaction is sent to the orderer and written to every peer's ledger. Fig. 3 shows the flow for updating a ledger on the IBM Blockchain network.

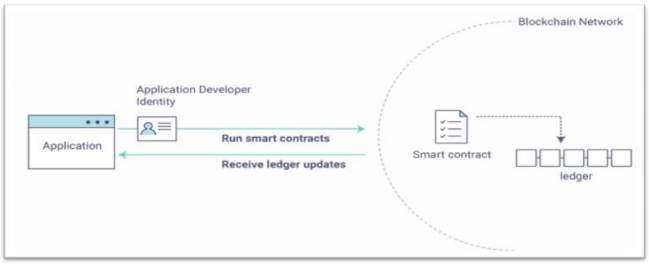

Fig. 1. Interactions in the IBM Blockchain Network.

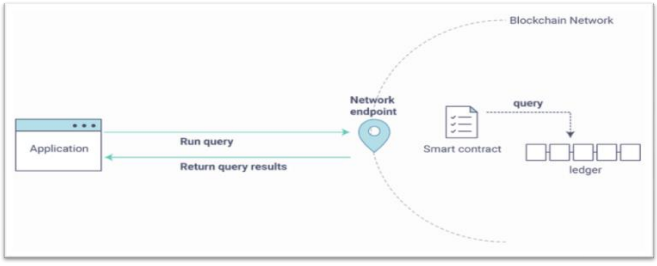

Fig. 2. Querying the Blockchain.

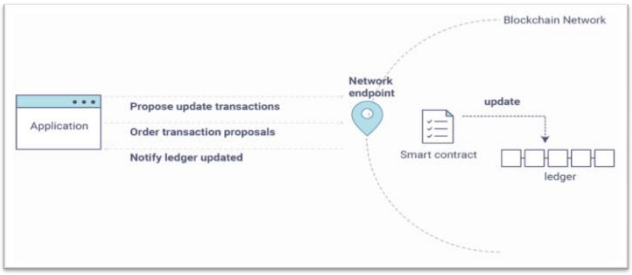

Fig. 3. Updating a Ledger on the Blockchain.

VI. Implementation of the Proposed System

The Hyperledger fabric vehicle application provides authentication mechanism for participants/peers in the IBM blockchain network. These participants are the manufacturer, auction, shipment, Mauritius Revenue Authority, car dealer, insurance, bank, registrar, National Transport Authority. Each participant has his/her own login credential to the system. Each participant has his/her assigned roles and responsibilities in the system. The access rights on the functionalities of the system are defined by the role of the participant. Upon successful authentication, the dashboard web page is loaded as shown in Fig. 5 (see appendix). It provides an overview of the system with the statistics of vehicle importations and sales and real-time information about the status and participants of the IBM Blockchain network.

A toolbox is always on display to ease the use for adding new process of vehicle importation and sale. The button <ADD VEHICLE IMPORTATION PROCESS> creates a new process flow is created in the database. The vehicle importation process provides a flow of the different stages and conditions involved when importing a vehicle and also the different participants/peers who are responsible in each stage. Moreover, the button <ADD VEHICLE SALES/REGISTATION PROCESS> creates a new process flow in the database for vehicle sales and registration after filling a form as shown in Fig. 6 (see appendix). The user (car dealer or admin) needs to provide information such as payment method and duty type. Likewise, the vehicle sales and registration process provide a flow of the different stages and conditions involved when a customer is proceeding with the deed of contract for the vehicle. Each stage is managed by different participants.

The import web page shows a list of vehicle importation processes. The different stages in the importation flow are tabulated with descriptions, rules, respective participants and status. For example, a car dealer needs to be complied with a set of rules prior to import vehicle in showroom. To create a vehicle record on the IBM Blockchain network, the user clicks on button <Go to Chain Code> and a form is loaded as shown in Fig. 7. The vehicle importation process consists of the following steps (Fig. 7 to 12 in appendix):

- The admin or manufacturer creates the genesis block in the IBM Blockchain network as shown in Fig. 7.
- Next, the admin or car dealer puts an offer and purchases the vehicle from the auction. The transaction is recorded into the blockchain as shown in Fig. 8.
- The asset needs to be shipped to the car dealer's physical address. Another block is created and linked to the chain into the IBM blockchain network as shown in Fig. 9.
- Once the asset is shipped to Mauritius, the asset is under Mauritius Revenue Authority's custody (bond). The car dealer needs to pay a duty to release the bond as shown in Fig. 10.
- Ownership of asset is transferred to the car dealer and the transaction is recorded on the IBM Blockchain network linked to the specific asset ID as shown in Fig. 11.
- Finally, the vehicle importation process is completed and is immutable as shown in Fig. 12.

The vehicle sale and registration dashboard web page provide a list of processes related to the vehicle sales as shown in Fig. 13 (see appendix). In order to sell a vehicle/asset to a customer, the user (car dealer or admin) clicks on button <Go to Chain Code> and fills the form as shown in Fig. 14 and Fig. 15 (see appendix). The vehicle sale and registration processed involve the following steps:

- The car dealer records the payment of the customer in the IBM Blockchain network as shown in Fig. 14.
- The car dealer creates a new block in the IBM blockchain network to transfer the asset's ownership to the customer as illustrated in Fig. 15.

The list of assets' transactions recorded in the IBM Blockchain network is provided on the Vehicle Asset dashboard web page as shown in Fig. 16 (see appendix). Each asset has its own historical records in the blockchain network which can be viewed when the user clicks on <VIEW HISTORY> as illustrated in Fig. 17 (see appendix).

The assessment of the POC blockchain-base smart contract application for automotive industry has been conducted as follows: (a) using the Hyperledger Fabric Vehicle application, we have demonstrated that the transaction histories of the vehicle are more transparent through the use of IBM blockchain technology where distributed ledger is shared among all network participants, (b) the Hyperledger Fabric Vehicle application provides an encryption mechanism to approve transactions. Falsification of mileage and other frauds are mitigated through the adoption of the IBM blockchain technology for the automotive industry. (c) We demonstrated that the purchase of vehicle needs to undergo a chain of processes and it can be very expensive and cumbersome to trace an item from its origin. Hence, through the application, it has become easy to audit trail the journey of an asset. Moreover, the application provides historical data that can be used to verify transactions. (d) Moreover, the Hyperledger Fabric vehicle application offers the ability for transactions or processes to be more efficiently through streamlining and automating. As demonstrated, the Hyperledger Fabric vehicle application provides a platform to make payments to different parties. The trust is gained from the data on the blockchains as the ledger is secure, error-free, accurate and immutable.

VII. Conclusion

Blockchain technology is still in a development phase and there are still discussions about its scalability. In this work, a Hyperledger Fabric Vehicle application has been developed that could solve the challenges and risks that the automotive industry is currently facing in the Republic of Mauritius. Due to the flexibility and modular consensus algorithm, the Hyperledger Fabric Vehicle can be further enhanced to implement other transactions for the automotive industry. The analysis of the application underlined that with the adoption of the IBM blockchain platform, we were able to achieve transparency, improve traceability, enhanced security, reduce costs and increase efficiency in the traditional system. Innovators have just started to scratch the surface of blockchain applications in the automotive industry of this long journey of disruptions.

References

[1] G. Ciatto, S. Mariani, A.Maffi and A. Omicini, “Blockchain-based Coordination: Assessing the Expressive Power of Smart Contracts”, Information, vol. 11, no. 52, pp. 1-20, January 2020. doi:10.3390/info11010052.

[2] S. Underwood, “Blockchain beyond Bitcoin”, Communications of the ACM, vol. 59, no. 11, pp. 15–17, October 2016. https://doi.org/10.1145/2994581.

[3] N. Szabo, “The idea of smart contracts. Nick Szabo’s Papers and Concise Tutorials”, 1997. Accessed on: Jan. 10, 2020. [Online]. Available: http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech

[4] QuillHash Team, “Looking Ahead: The Future of Automotive Industry and Blockchain Technology”, 2019. Accessed on: November 21, 2019. [Online]. Available: https://medium.com/quillhash.

[5] Défi Media Group, “Car Traffic: The Falsified Odometers for New Cars”, 2012. Accessed on: October 14, 2019. [Online]. Available: https://motors.mega.mu/news/car-traffic-falsified-odometers-new-cars-20120417.html.

[6] S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System", 2008. Accessed on: October 28, 2019. [Online]. Available: https://bitcoin.org/bitcoin.pdf.

[7] Z. Zheng, S. Xie, H. Dai, X. Chen and H. Wang, “An Overview of Blockchain Technology: Architecture, Consensus and Future Trends”, in Proceedings of the 6th IEEE International Congress on Big Data, 25-30 June 2017, Honolulu, USA. doi: 10.1109/BigDataCongress.2017.85.

[8] S. Brakeville and B. Perepa, “Blockchain Basics: Introduction to Distributed Ledgers”, June 2019. Accessed on: Aug. 30, 2019. [Online]. Available: https://developer.ibm.com/technologies/blockchain/tutorials.

[9] X. Xu, C. Pautasso, L. Zhu, V. Gramoli, A. Ponomarev, A. B. Tran and S. Chen, "The Blockchain as a Software Connector", in Proceedings of the 13th IEEE/IFIP Conference on Software Architecture, 5-8 April 2016, pp. 182-191, Venice, Italy. doi: 10.1109/WICSA.2016.21.

[10] J. Stark, “Making sense of blockchain smart contracts”, June 4, 2016. Accessed on: September 30, 2019. [Online]. Available: http://www.coindesk.com/making-sense-smart-contracts/.

[11] K. Delmolino, M. Arnett, A. Kosba, A. Miller, and E. Shi, “Step by step towards creating a safe smart contract: Lessons and insights from a cryptocurrency lab," in Proceedings of the International Conference on Financial Cryptography and Data Security, 22-26 February 2016, pp. 79-94, Christ Church, Barbados.

[12] V. Morabito, “Business Innovation Through Blockchain: The B^3 Perspective”, 1st ed., Springer, 2017.

[13] D. Vujicic, d. Jagodic and S. Randic, “Blockchain technology, bitcoin, and Ethereum: A brief overview”, in Proceedings of the 17th IEEE International Symposium INFOTEH, 21-23 March 2018, East Sarajevo, Bosnia-Herzegovina. doi: 10.1109/INFOTEH.2018.8345547.

[14] N. Atzei, M. Bartoletti and T. Cimoli, "A survey of attacks on Ethereum smart contracts", in Proceedings of the 6th International Conference on Principles of Security and Trust, vol. 10204, pp. 164-186, 22-29 April 2017, Uppsala, Sweden.

[15] SecureLyte, “Introduction to Hyperlogic Fabric”, 2020. Accessed on: January 10, 2020. [Online]. Available: https://www.securelyte.com/introduction-to-hyperlogic-fabric/.

[16] SVR Technologies, “Blockchain Interview Questions and Answers”, 2020. Accessed on: January 10, 2020. [Online]. Available: https://svrtechnologies.com/blockchain-interview-questions-and-answers-pdf.

[17] R. Wolfson, “Ford Motor Company Launches Blockchain Pilot On IBM Platform to Ensure Ethical Sourcing of Cobalt”, January 16, 2019. Accessed on October 17, 2019. [Online]. Available: https://www.forbes.com/sites/rachelwolfson/2019/01/16/ford-motor-company-launches-blockchain-pilot-on-ibm-platform-to-ensure-ethical-sourcing-of-cobalt/#520837e75a1d.

[18] Business Blockchain HQ, “Automotive Blockchain News”, 2019. Accessed on October 17, 2019. [Online]. Available: https://businessblockchainhq.com/automotive-blockchain-news/.

[19] C. Torres, “Hyundai Subsidiaries Partner IBM to Accelerate AI and Blockchain Development”, February 20, 2019. Accessed on October 17, 2019. [Online]. Available: https://thecryptosight.com/hyundai-subsidiaries-partner-ibm-to-accelerate-ai-and-blockchain-development/.

[20] L. Mullan, “Hyundai Card and Hyundai Commercial partner with IBM to drive digital transformation”, February 21, 2019. Accessed on October 17, 2019. [Online]. Available: https://www.gigabitmagazine.com/ai/hyundai-card-and-hyundai-commercial-partner-ibm-drive-digital-transformation.

APPENDIX

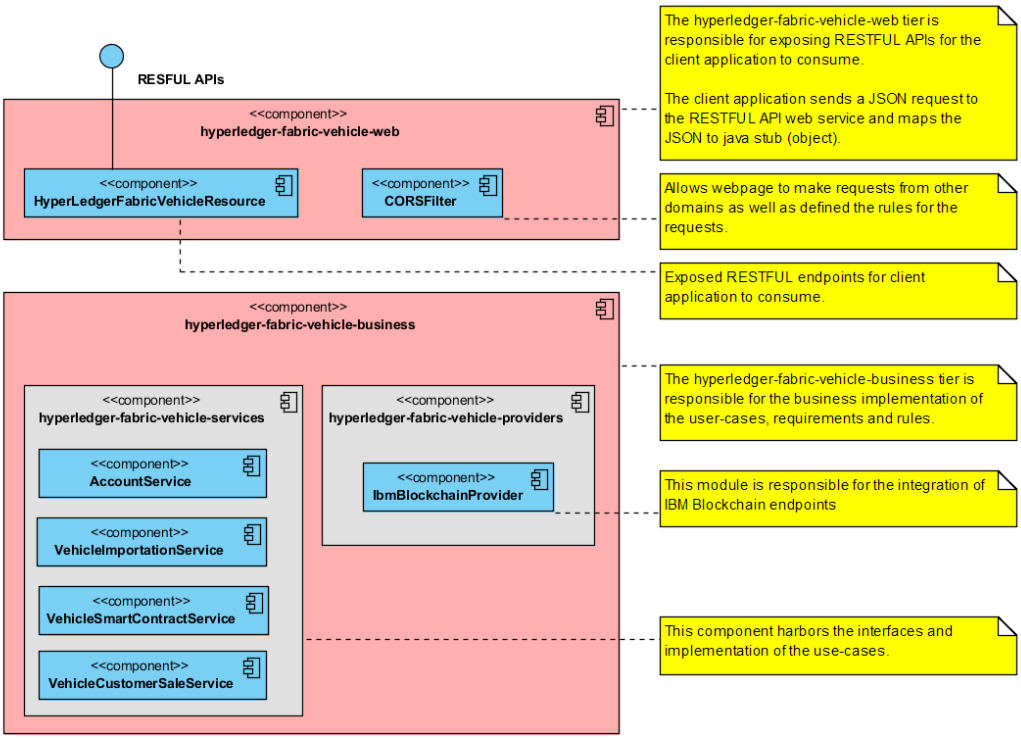

Fig. 4. Architecture Diagram for Server-Side Application for the Proposed System

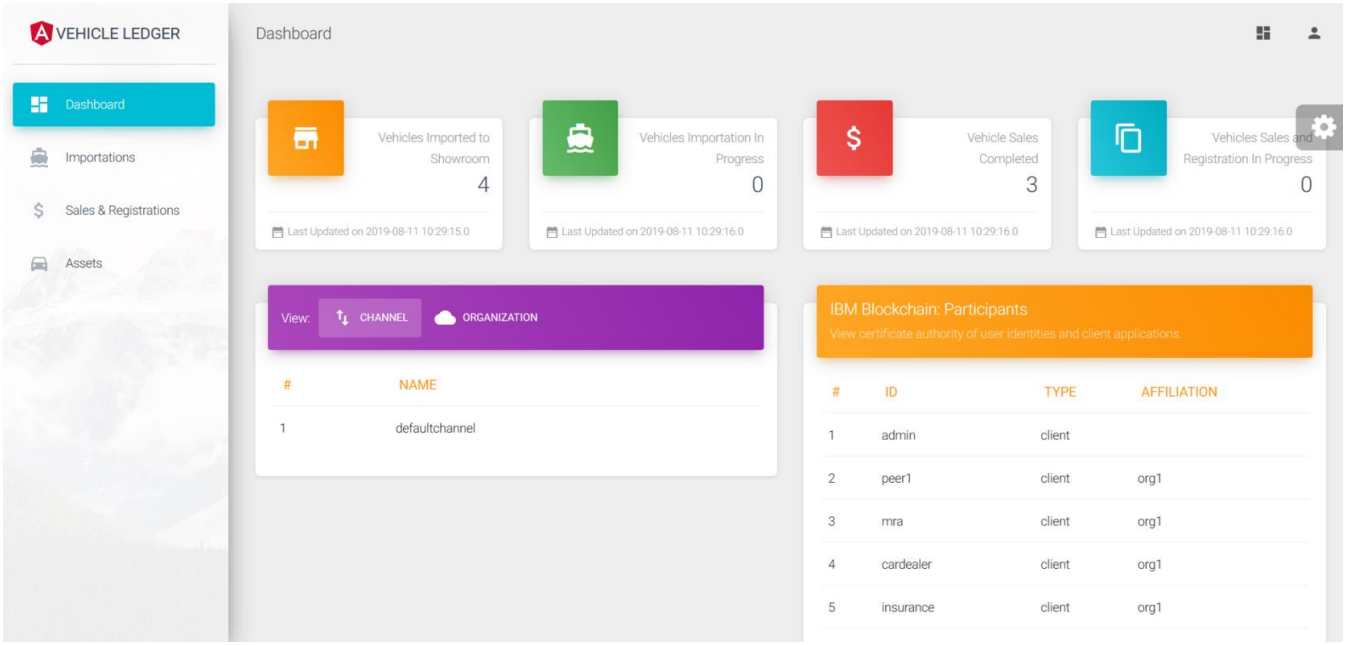

Fig. 5. Overview and Statistics of System.

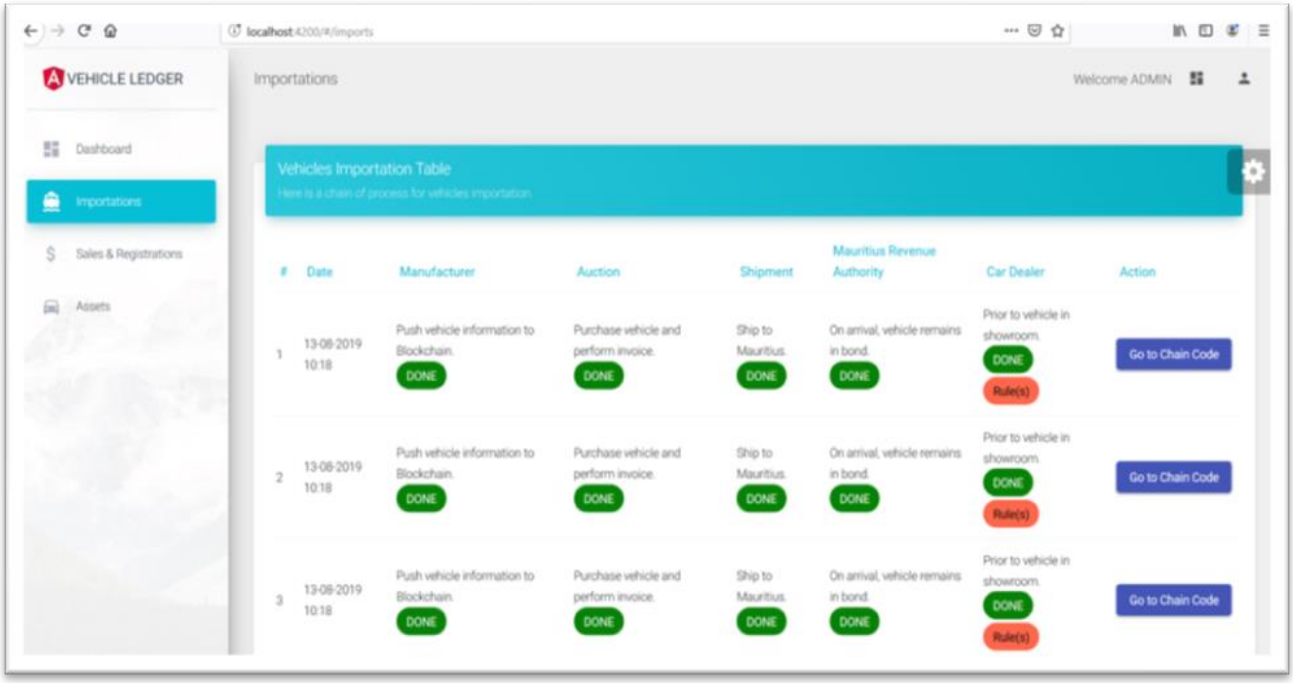

Fig. 6. Vehicle Import Page.

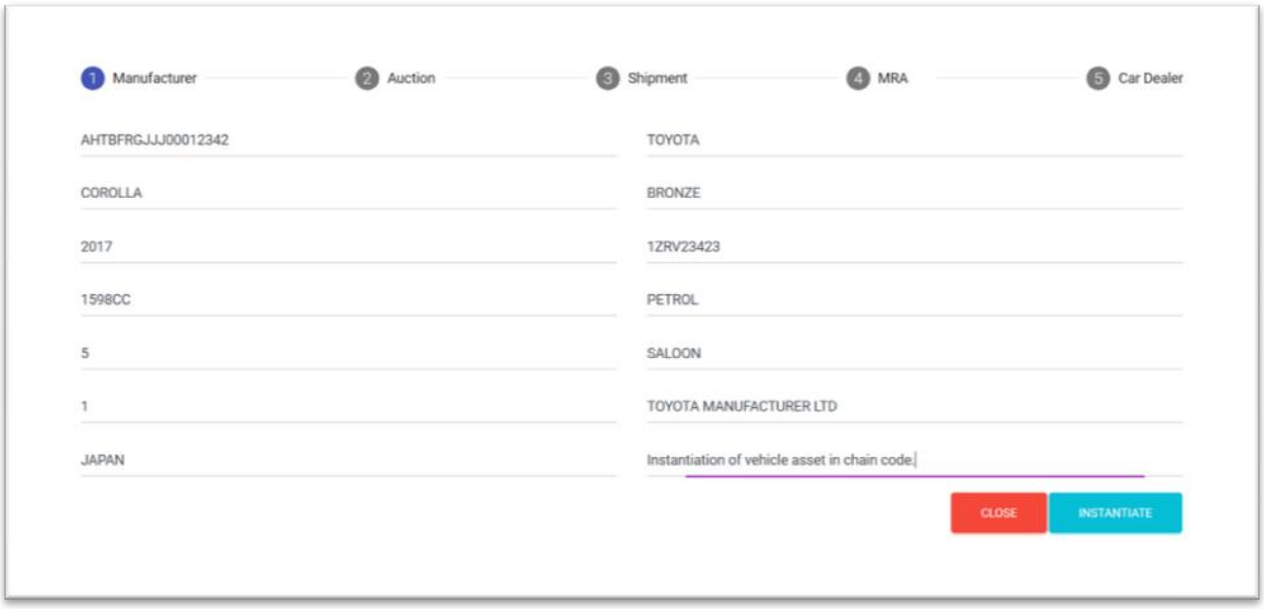

Fig. 7. Vehicle Importation - Manufacturer Creates Genesis Block in Blockchain.

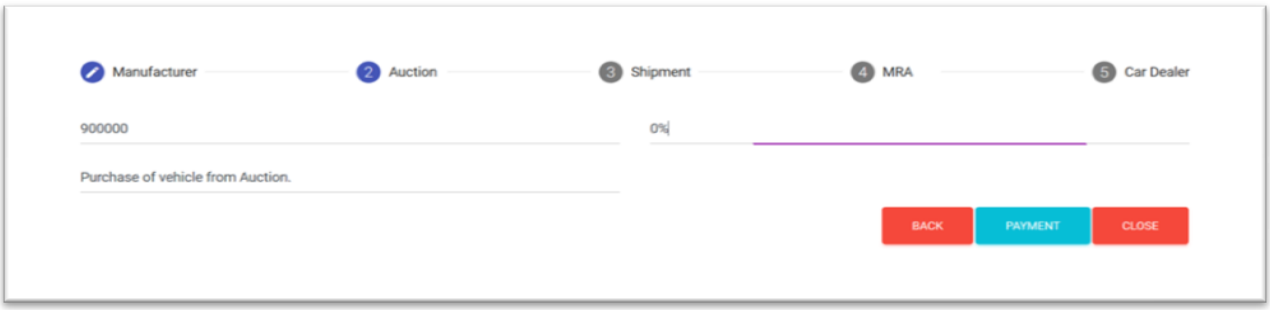

Fig. 8. Vehicle Importation – Purchase Asset from Auction.

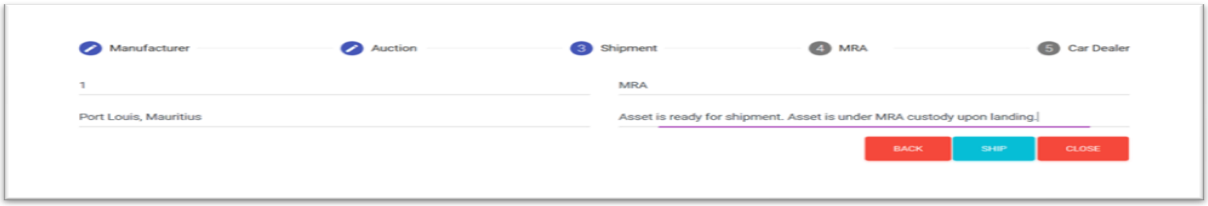

Fig. 9. Vehicle Importation – Asset Ready for Shipment.

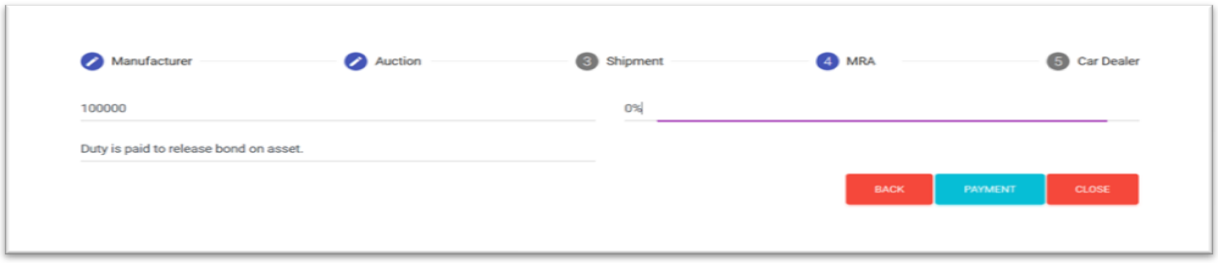

Fig. 10. Vehicle Importation – Payment to Release Custody from MRA.

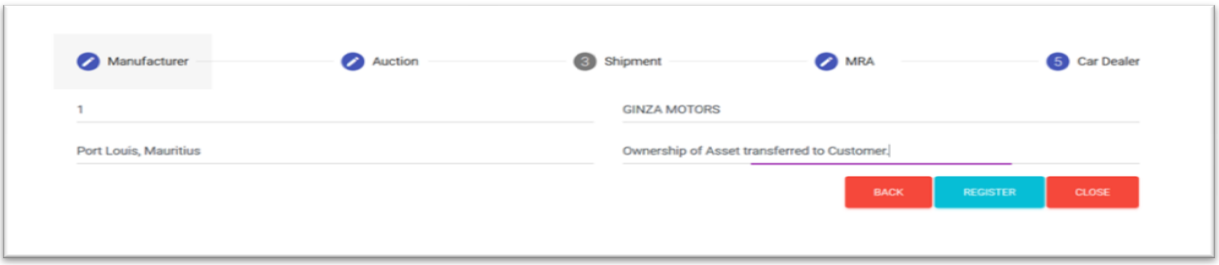

Fig. 11. Vehicle Importation – Transfer Ownership of Asset to Car Dealer.

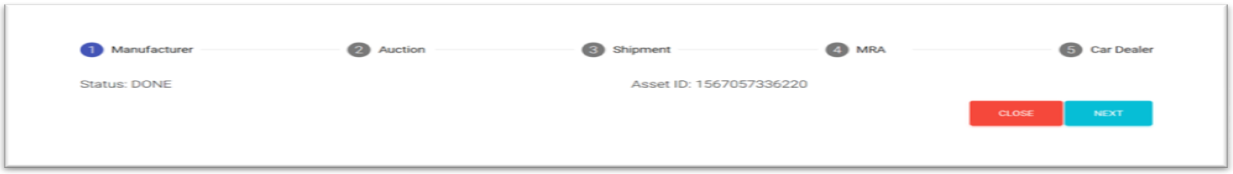

Fig. 12. Vehicle Importation Completed and Immutable.

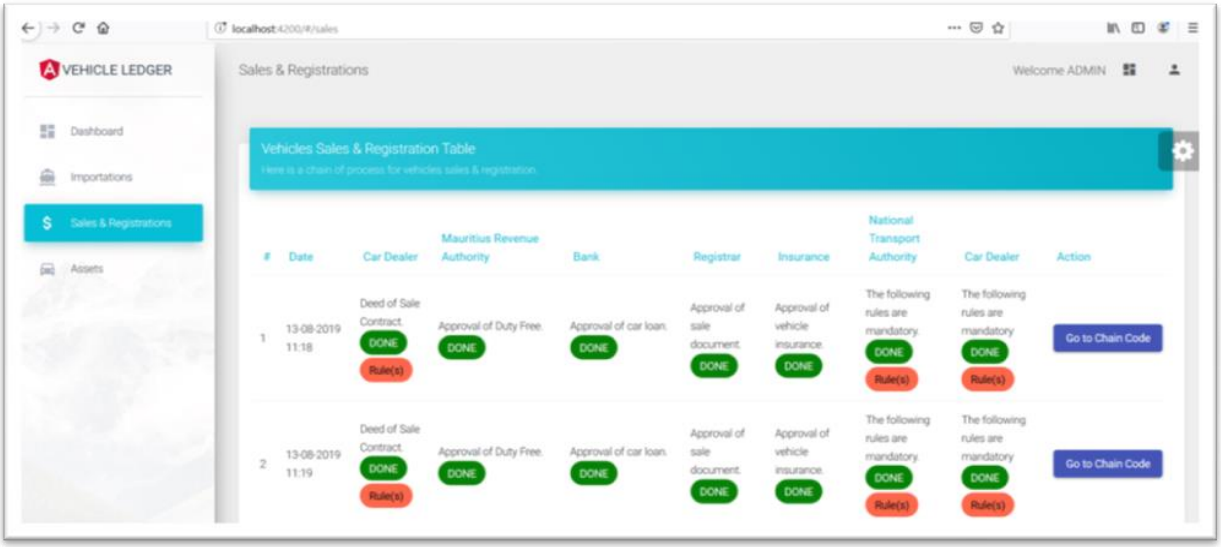

Fig. 13. Vehicle Sale and Registration Dashboard Page.

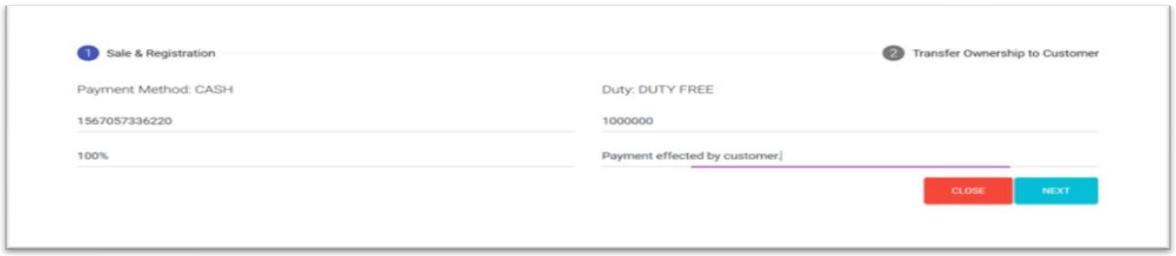

Fig. 14. Vehicle Sale – Payment by Customer.

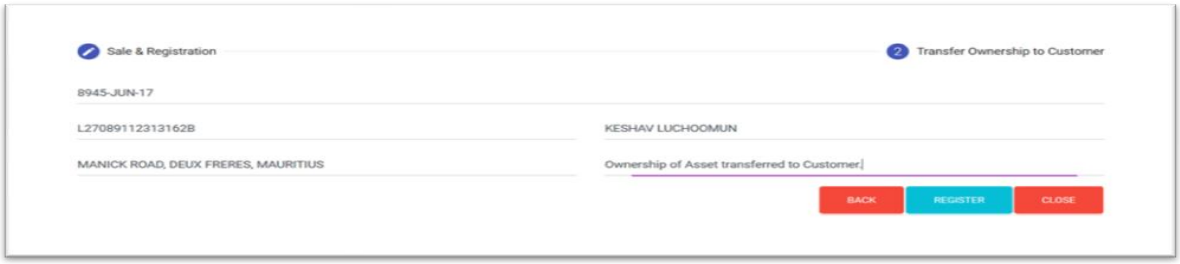

Fig. 15. Vehicle Sale – Transfer of Vehicle's Ownership to Customer.

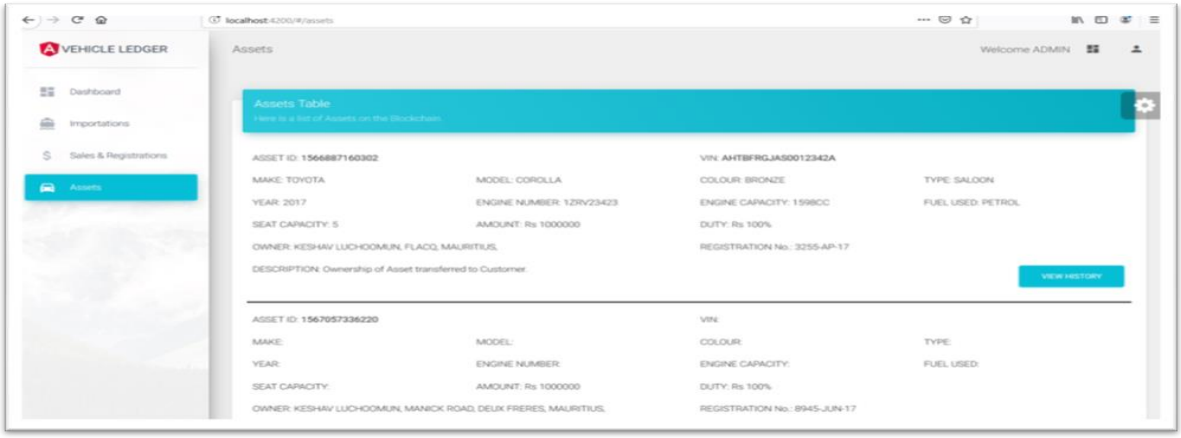

Fig. 16. Vehicle Asset – List of Assets in the IBM Blockchain Network.

Fig. 17. Vehicle Asset – view Historical Records of a Specific Asset.