Journal of IoT in Social, Mobile, Analytics, and Cloud (ISSN: 2582-1369)
www.irojournals.com/iroismac/

An IoT-Based Vending Machine Using Blockchain for Enhanced Security

Sheldon Henriques[1], Shaun Lewis[2], Gautam Kotian[3]

[1-3]St. Francis Institute of Technology (Mumbai University) Mumbai, India

E-mail: [1]sheldonhenriques2727@gmail.com, [2]shaunlewis220698@gmail.com, [3]gautam.kotian7@gmail.com

Abstract

The Internet of Things (IoT) is an established technology changing the way of our daily lives. However, as its usage increases, the threat of utilizing them wrongly also increases. Blockchain technology, which provides strong security, is used to protect IoT devices from being hacked, helping solve the drawbacks of an IoT system. The automated vending machine works by distributing a variety of vended goods and helps provide disintermediation. The vending machine's primary goal is to speed up client service while minimizing human touch. In this paper, the development of a system for cashless payment is described. This helps vending companies with problems like cash handling, fake or slug currency, encashment, and change. The infrastructure of IoT vending machines, which is based on the blockchain network, is discussed thoroughly. Finally, a model has been provided for the security of the internet of things using blockchain.

Keywords: Blockchain, IoT, vending machine

1. Introduction

A vending machine is an automated machine designed to offer customers various items ranging from beverages to other essential commodities. First, the vending machine calculates an amount based on the type and quantity of the products chosen by the consumers. Then, the vending machine dispenses the product, once money is deposited into it from any form of payment. To serve the above purpose, many vending machines have been developed. In nations like Japan, the USA, and others, these machines are employed on a large scale. The linked company must do field trips to these vending machine locations to have these machines tested, which again proves to be costly. By spotting an issue and alerting the maintenance crew, this can be prevented. IoT has made it simple for stand-alone devices that

DOI: https://doi.org/10.36548/jismac.2022.3.002
Received: 17.07.2022, received in revised form: 06.08.2022, accepted: 21.08.2022, published: 02.09.2022

previously required a human operator to operate independently, thanks to sensors that provide a seamless network of tools that can connect to make life easier for the end-user. However, there is a demand for an automated vending machine that will support disintermediation and be secure for all procedures. In the suggested system, cryptocurrency would be used in place of actual money, further strengthening and guaranteeing the validity of the data. Today's vending machines struggle with slug cash. A slug is a counterfeit coin used to make illegal purchases from a vending machine. Other similar issues are coin-rolling scams and counterfeit money. Most of the time, the machines are out of stock. Vending machines require maintenance checks from skilled technicians. The maintenance field trips to these vending machines increase costs. Manufacturers of vending machines have recently included sensors, and owners have connected the devices to local networks to broadcast real-time data. However, once a device is connected to a network, the network becomes vulnerable to dangers and online threats. Section 2 has a literature survey of related work. Section 3 describes the proposed work. Sections 4 and 5 contain results and conclusions.

2. Related Work

Blockchain technology is the broken thread to settle the Vending machine's extensibility, insulation, and reliability concerns. Blockchain technologies could conceivably be the silver bullet needed by the IoT industry. Blockchain technology is usually utilized in tracking millions of connected devices, enabling transactions and coordination between devices, leaving enormous savings to IoT industry manufacturers. A decentralized approach helps eliminate single or multiple failure points and provides a more robust atmosphere for operating and running devices. The cryptographic algorithms employed by blockchain can make customer data more confidential.

The domain of the project [1], is IoT and Security. In the study, an IoT-based smart home environment that employs a local and private blockchain for protected access control to the IoT devices and the data associated with them was discussed. Due to the scattered structure and extensive scope of Internet of Things (IoT) networks, privacy and security remain a severe concern in the IoT. Blockchain-based solutions provide decentralized privacy and security but involve essential energy, latency, and overhead computation. That is not suitable for many resource constrained IoT devices. The author described the smart home tier's innovative core components in this article and addressed the various associated transactions and procedures. They also published detailed security and private study. Their

simulation results show that the overheads incurred by their system are small for low-resource IoT devices and are manageable. Thus, given the significant security and privacy benefits on offer, these overheads are worth their weight.

The [2] project's domain is IoT and Security. The subject discussed in this paper is a high-performance blockchain platform for intelligent devices. Over time, these smart devices generate a massive amount of valuable data; however, there is still a platform shortage that will quickly transfer and use the price of the extensive IoT data. Blockchain can transfer value at a comparatively low cost, which enables the knowledge from smart devices to form value. This paper aims to design a high-performance blockchain platform using technologies such as distributed requirements, smart device node mapping, and the PBFT-DPOC consensus algorithm to understand the decentralized autonomy of smart devices.

The domain of the project [3], is IoT and Security. The subject discussed within the paper is IoT's role and applications in online transactions with blockchain technology. This work attempts to make the online transactions more open, autonomous, and safe to integrate them into the next-generation smart home systems. Blockchain is the key that is needed to incorporate IoT, make the transactions more object-centered, and have our payment system autonomous. To make interactions with the daily services monitored by an IoT-based smart device ecosystem more hassle-free and fully secured. The proposed model operates with less energy consumption, which is significant because the model's economic viability prevents it from working more effectively. The model is going to be ready to handle other sorts of digital wallet payments. The model will choose devices and their integration with the opposite devices, just like the refrigerator with the health app on the phone to see the daily calorie intake. In India, where the crypto market is gaining momentum, implementing such a model through its automated system would benefit the labor force.

The domain of the project [4] is IoT and Security. This project was about a new research project on Secure and Safe Internet of Things (SerIoT) to enhance the physical security, privacy, and knowledge of IoT applications during a comprehensive and multi-dimensional technology framework. IoT is developing because the next big thing triggers a wave of disruption that creates a massive window of opportunity for technological advancement (such as robotics, sensing, machine-to-machine connectivity, etc.), aims to enhance and automate our lifestyle, and promotes communication and cooperation between intelligent devices and smart objects.

The domain of the paper [5] is IoT. In this paper, the idea of vending and critical activities of a contemporary vending company was revealed, one of the purposes of which was to provide maximum payment methods as practicable. The system performs the relationship between the coin acceptor, which handles the transactions within the exchanging facility, and thus the vendor servicing the cards or keys. The coin acceptor interfaces with the trading system via the Executive serial interface protocol (in this situation, a coin acceptor is a mandatory unit, which can be a different controller controlling the sales transactions). The cashless payment device works via the MDB / ICP protocol with a coin changer. MDB / ICP may be an ECU Vending Association EVA-accredited serial interface protocol. Including a slot machine with a cashless payment system, which often allows payment "one-touch" with individual electronic pass support, will save time. The level of customer service usually improves with the relation of a cashless system. There is no need to fear banknotes and coins.

The domain of paper [6] is IoT, Blockchain, and Ethereum. This paper discussed the improvements and drawbacks of using smart contracts for machine-to-machine contact through the creation, implementation, and assessment of smart contracts. They created two decentralized frameworks, one for the car and the gas station. Using JavaScript, the Ethereum JavaScript API web3, to communicate with the AGasP smart contract. Every station has the AGasP smart contract address installed. The program for the gas station offers an interface for calling setGasData, checking- Deposit, and sendingFuelUsage. The software for the car provides an app to call on getGasInfo and sendDeposit. These apps are helping us to review and improve the smart contract AGasP.

The domain of the paper [7] is Blockchain and IoT. This paper discussed how Blockchain can strengthen the Internet of Things. A decentralized blockchain-based approach will address many of the issues associated with the centralized solution to the cloud. Blockchain helps you to check the properties it holds. The transactions focused on Blockchain are easy to audit. Because of this and other features, in particular, Blockchain may play a key role in monitoring the origins of vulnerability in supply chains as well as addressing and coping with emergencies such as product shortages that arise after weaknesses in safety and security. And as stated, blockchain-based identity and access management systems, such as those involved with IP spoofing, will resolve key IoT security issues. Due to Blockchain technology, they were able to overcome the problem of security.

The domain of the paper [8] is IoT. During this project, a slot machine was created using RFID technology. The paper focused on building a vending machine utilizing

frequency identification technologies to improve the current cash-based payment system that involves loads of issues and threats, i.e., hacking, auditing, processing, money, and coin and notes content. The ultimate installation of different modules is completed on the Arduino device, and thus the mechanical element is combined with electrical components. The RFID reader reads the RFID card, so the current user balance is displayed. For these selling products, the shared accuracy is calculated, i.e., soda container, food family pack (Lays), powdered milk pack, candy, muffin, and beverage can be shown as a plotted graph of percentage accuracy vs. sort of sale item.

The domain of the paper [9] is Blockchain and IoT. The subject focused on the concept of Blockchain; how do bitcoins work? And, therefore, the benefits of bitcoin. It attempts to spotlight the role of Blockchain in shaping the longer term in several sectors. Bitcoin utilizes the cryptographic algorithm of the Elliptic Curve Digital Signature Method (ECDSA) to guarantee that only legal owners have access to funds once Bitcoin is created; it generates a confirmation note. It adds information on the latest public ECDSA secret. Whenever a Bitcoin is in use, it adds the public key of the new owner to sign it alongside the private key of the sender. The signature on the letter by the sender verifies that the communication is genuine. However, Bitcoin does not allow the third party to keep the transaction history because it distributes Blockchain's ledger openly. Vulnerability capital (VC) companies expect Bitcoin, and the next big thing is that Blockchain is. Bitcoin risk capital data from CoinDesk reveals that VC funds invest in Bitcoin start-up ventures. Blockchain may serve as ledgers or record-keepers for trillions of transactions created by the Things Network (IoT), like uploading, storage, and information is typically a concern.

The domain of paper [10] is Blockchain. The author created a design approach for an established trust-based self-service system at their university's cafe-place run by students. The author fixes the current issue of the punched card method, usually used for self-dispensing coffee, now using smart contracts. The commonly employed punched card system, where each coffee drinker has to clip off a bit of a pre-purchased card is used. Represented as a trust-based system under specific transaction rules ten clips consisting of punched cards could be used while having a cup of coffee.

Essentially, coffee robbery was typical, or people could fail to cut a bit of their punched card off. To obtain the required features, a reasonable arrangement must be put in place to determine the framework values. Supporting the values and specifications of a Digital punch card-based coffee drinking scheme, all features are required to issue punch cards for users to

get them. This smart property is distributed through a feature called buy Clipcard, which enables users to buy a punch card at a predetermined cost. The value is often changed to whatever sum by the issuer of the smart contract via a function called fixed price. The smart contract must ensure while buying a punched card that one features a proper balance of ether before being able to commit the transaction. A list of user addresses in the network and their punched card properties, called clip cards, is introduced to keep track of users and their balances. First, a digital lock on the coffee dispensers is necessary for this to be fully automated. You build a transaction with the smart contract logic to send such smart contracts to the network. Conversely, the importance of running such a contract calculation is calculated by the number of activities it contains. If the wallet has sufficient ether to power the smart contract, then the transaction will be sent to the Blockchain and available via an address.

3. Proposed Work

3.1 Design

The below figure provides a thorough explanation of how various system components interact with one another:

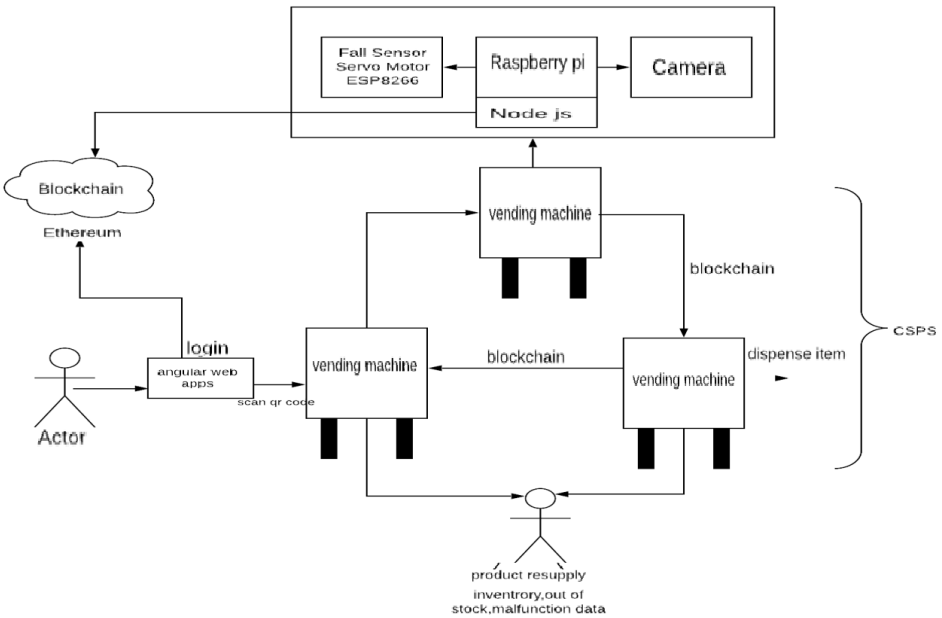

Figure 1. System Architecture

The System Architecture previously only had the individual vending machines, which had no interaction. The user could go access any vending machine and get a product. The

new design creates a network between these machines and using a unified interface and robust transaction system has its advantages. The above system diagram gives an idea of how the different components interface with each other, the steps that are followed in the process are:

3.1.1 Generate Order QR

Select a product on the application and pay for it using a cryptocurrency and generate a QR code for your order.

3.1.2 Scan it on Vending Machine

Place the QR code in front of the camera and let it scan the QR code to get the order details.

3.1.3 Check Ledger

Check the ledger for the transaction, and any changes are made to the transactions, or any tampering is done with the QR code.

3.1.4 Check Inventory

Check the inventory of the vending machine to see if the demand can be fulfilled.

3.1.5 Dispense the Product

Send the instruction to the servo motors to drop the ordered product.

3.1.6 Check if the Product is Dispensed

Using the fall Sensor, check if the product is dispensed if not, then send an instruction to rotate again.

3.2 Methodology

3.2.1 Smart Contract Algorithm

A Smart Contract (crypto contract, or digital contract) is a program that has automatic control of the transfer of digital assets between the parties confined within specific parameters. Smart Contracts execute as they are created (coded, programmed) by their programmers. Smart contracts can be thought of as events triggered easily by buying/selling/or reaching the desired condition. Each vending machine acts like a node on

this blockchain. Each node or vending machine will have its record of the inventory supply on the blockchain. The use of smart contracts helps transfer data of products like their brand, model, quantity, and price between the vending machines and the user device, forming a blockchain network. Purchasing a product or refilling the node will trigger events that update the blockcahin. Change in the values in the table in any machine will update the inventory information in all the machines. This algorithm has four steps:

a) Pre-Programmed Contract

The seller establishes and specifies the agreement's terms, regulations, and conditions.

b) Chain of Events

When the events specified in the code occur, i.e., when a consumer buys a product, the code automatically executes.

c) Execution and Value Transfer

Once the code is executed, the terms in the contract will automatically transfer the value from the consumer’s wallet to the seller’s wallet.

d) Settlement

The transfer of value to the seller will be recorded on the Blockchain.

4. Results and Discussion

Fig.2 shows the UI for creating a transaction by a seller. Adding this product will make a purchasable item on the market.

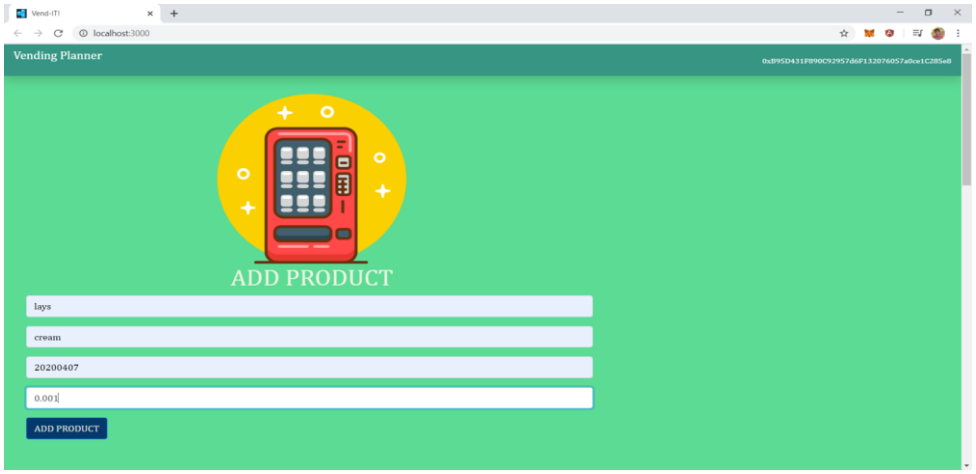

Figure 2. UI for Seller to add products

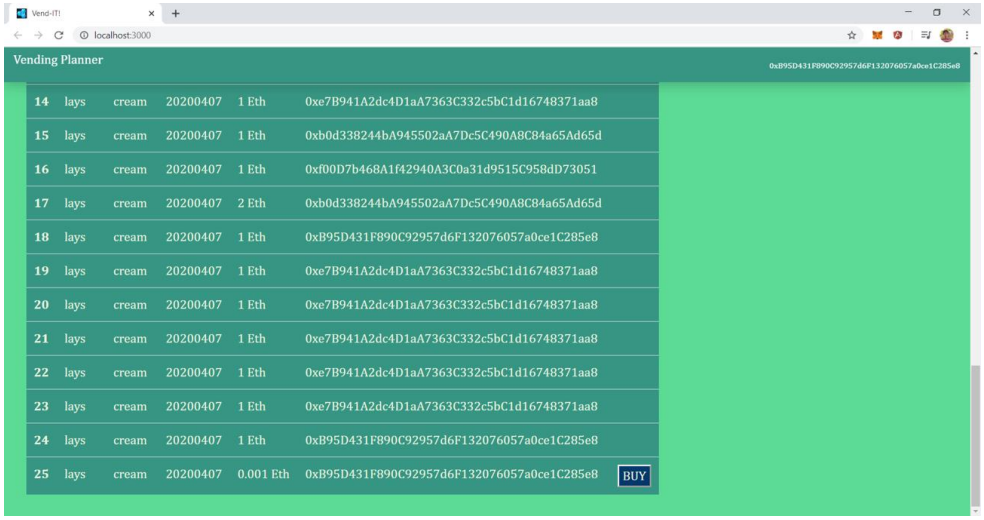

Figure 3. Market Listing

Figure 4. QR code

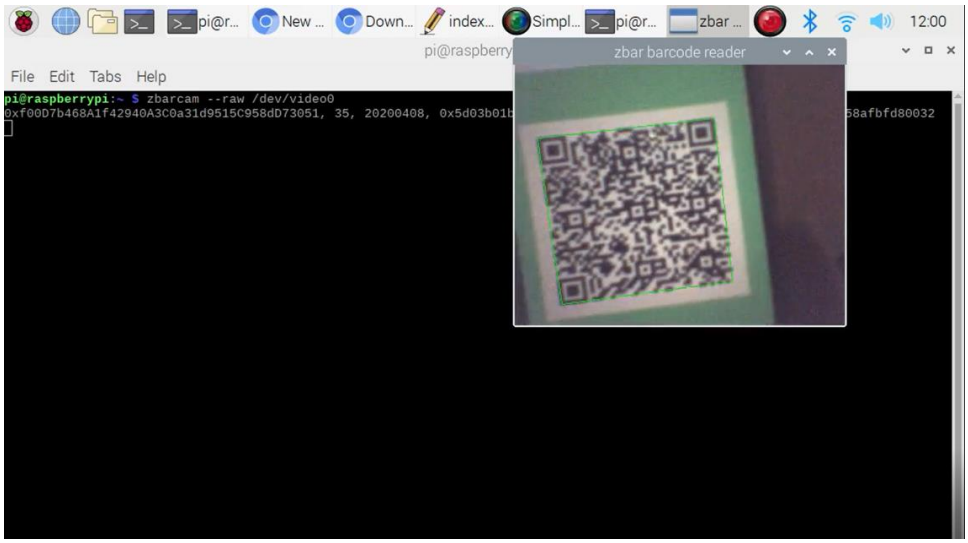

Figure 5. Scanning the QR on a vending machine (Camera view)

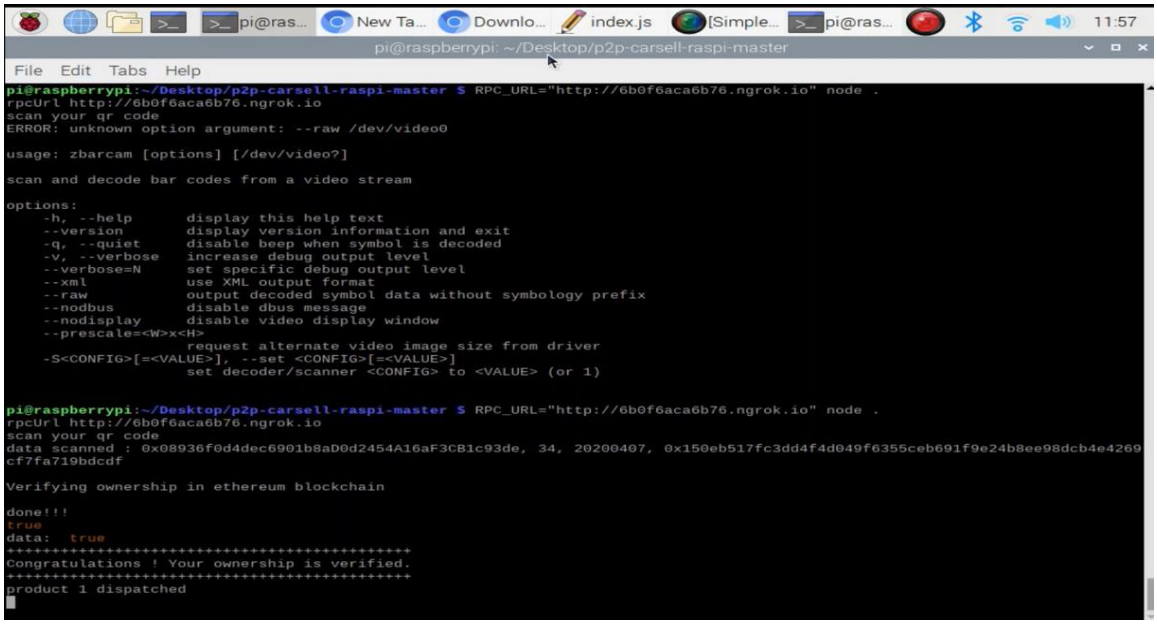

Figure 6. Verifying the ownership of the QR Code

Fig. 3 shows the market listing of all available products, a description of the product and its cost using which a customer can buy products. Fig. 4 shows the QR that is generated once the product is purchased by a consumer. By scanning this QR a vending machine will dispatch the item. Fig. 5 shows the QR being scanned by the vending machine. Fig. 6 shows the Vending machine confirming the transaction on the blockchain network. Once the validation of the QR code is complete, the product is dispatched.

The suggested vending machine offers a user interface for the vendor and the customer instead of the current vending machine's lack of a user interface. Once the seller adds a product, the market listing reflects that addition. The consumer may view the product's code and the address of the block in the blockchain network in addition to the price and name of the product, which is not possible with the older system design. The new system is also more robust compared to the previous design.

5. Conclusion

Thus, by implementing Blockchain in a vending machine, one of the many possibilities to change the trade sector has been explored. Blockchain's distributed ledger and security make it an effective technology for resolving issues in the financial and non-financial industries. Blockchain technology has been used in a vending machine. Various advantages

like distributed ID storage, increased accuracy, faster ID checks, lower costs, and a wider variety of goods have been introduced. With the rapid pace of development, it only makes sense to upgrade the older convenient machines with the most recent technology available today, enabling them to vend more products to people around the world. In conclusion, it is believed that an effective model to set up trustworthy provenance for vending machines, will significantly achieve an end-to-end demonstrable system. The work to accomplish this is ongoing in the form of an additional provenance layer to assist the existing blockchain infrastructure.

6. Future Work

The number of devices in the Blockchain can be increased, forming a bigger network with additional functions. The machine can be designed to collect data on the products in the inventory and use this information for data analysis.

References

[1] Ali Dorri , Salil S. Kanhere , Raja Jurdak , Praveen Gauravaram" Blockchain for IoT security and privacy:The case study of a smart home", Consumer Communications & Networking Conference (CCNC) 2017 15thIEEE Annual, pp. 1-5, 2017.

[2] Shitang Yu, Kun Lv, Zhou Shao," A High-Performance Blockchain Platform for Intelligent Devices",20181st IEEE International Conference on Hot Information-Centric Networking (HotICN), pp. 15- 17 Aug. 2018.

[3] S. Singh and N. Singh," Blockchain: Future of financialand cyber security", .2016 2nd International Conference on Contemporary Computing and Informatics (IC3I), Noida, 2016, pp. 463-467.

[4] E. Gelenbe, J. Domanska, T. Czachorski, A. Drosou andD. Tzovaras" Security for the Internet of Things: The SerIoTProject", 2018 International Symposium on Networks, Computers and Communications (ISNCC), Rome, 2018, pp. 1-5.

[5] Semenov, Viktor P., Vladimir V. Chernokulsky, and Natalya V. Razmochaeva. "The cashless payment device for vending machines—Import substitution in the sphere of vending." In *2017 International Conference" Quality Management, Transport and Information Security, Information Technologies"(IT&QM&IS)*, pp. 798-801. IEEE, 2017.

[6] Yuichi Hanada, Luke Hsiao, Philip Levis" Smart Contracts for Machine-to-Machine Communication: Possibilities and Limitations",2018 IEEE International Conference on Internet of Things and Intelligence System(IOTAIS), pp. 1-3 Nov. 2018.

[7] Nir Kshetri," Can Blockchain Strengthen the Internet of things?.", Journal of IT Professional Volume 19, Issue4, 2017, pp. 68-72.

[8] A. Ramzan, S. Rehman and A. Perwaiz," RFID technology: Beyond cash-based methods in vending machine",2017 2nd International Conference on Control and Robotics Engineering (ICCRE), Bangkok, 2017, pp. 189-193.

[9] Beck, Roman, Jacob Stenum Czepluch, Nikolaj Lollike, and Simon Malone. "Blockchain–the gateway to trust-free cryptographic transactions." In Twenty-Fourth European Conference on Information Systems (ECIS), İstanbul, Turkey, 2016, pp. 1-14. Springer Publishing Company, 2016.

[10] Zhu Qing, Yang Pu" Research and application on vending machine data integration based on EPC system", Computing Networking and Communications (ICNC)2011 International Conference on, pp. 1-5, 2011.

Author's biography

Sheldon Henriques is a graduate student. Captivated by technology, he obtained a bachelor's degree in Information Technology. He is currently working as a Software Engineer, using his knowledge from projects during his curriculum and his passion for software development to add value to society.

Shaun Lewis is a graduate student. He works at India's leading tech company as a software developer. He likes to keep up with the upcoming trends in the technology field and is always looking for new opportunities to explore those.

Gautam Kotian is a graduate student. He is always looking for challenging opportunities and currently works at India's leading Tech Company as a software developer. He never shies away from even the most challenging problems, which the most skilled might be hesitant to pick.