Improving Facility Management Through Digitized Task Management

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ABSTRACT

Task management and project coordination issues are becoming more and more prevalent in organizations across a variety of industries, which can result in inefficiencies and downtime. Data shows that 17,000 elevator-related injuries and 31 maintenance-related deaths occurs in the US each year, it is reasonable to compare the annual substantial operational delays and dissatisfaction caused by task and resource mismanagement. In order to evaluate how a blockchain-based tool can change the way activities are handled, tracked, and completed, this study shifts its focuses on task management. It suggests that applying blockchain to manage jobs meticulously can greatly improve operational workflows, equating it with the potential for blockchain to improve maintenance by averting delays and minimizing losses. Task management should become more transparent, efficient, and secure with the use of smart contracts, decentralized apps furthermore by utilizing a case study methodology related to task management procedures, this research will investigate and authenticate the application's efficacy in an actual context, thereby displaying its capacity to optimize project management. This study intends to demonstrate the flexible use of blockchain technology in enhancing the execution and monitoring of jobs across several domains by extrapolating data from maintenance situations. Blockchain provides a decentralized, immutable record that guarantees the security, traceability, and transparency of data. The digital task management system offers automated and simplified supply chain management with smart contracts. Organizations can achieve enhanced maintenance practices, which improve service quality, cost savings, and customer happiness by addressing key issues and optimizing operations. The findings of this study are expected to highlight the transformative potential of blockchain in task management and open avenues for future research, particularly in evaluating economic viability and integration with emerging technologies.

Keywords: Facility Management, Blockchain, Smart Contract, Task Management

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CHAPTER 1: INTRODUCTION

1.1 Background Study:

The field and domain of facility management (FM) mainly focuses on assisting and providing ease to people. It does so by guaranteeing the efficiency, sustainability and functionality of the built environment, which involves the structures where we reside and work as well as the infrastructure around them. As per ISO, the term facility management is as an organizational deity that integrates people, place, and process within the physical environment so that it can improve both the quality of lives and efficiency of core businesses. Facilities management essentially makes sure that a building runs properly for the duration of its operating life and that tenants are satisfied. They are now routinely included in project design to help prevent upcoming maintenance issues.

The industry of construction is quite dynamic and challenging. The discipline of facility management has lately grown in popularity within the construction industry and has contributed to the improvement of productivity by making the working environment more pleasant for all parties concerned. Facility management, which takes into consideration life expectancies of several decades, is the most significant factor determining the facility's cost and energy efficiency. Facility management traditionally was done manually, but in recent years, a variety of technologies and strategies has helped the operation to streamline and automate the process.

1.2 Problem:

The current inventory management in construction industry is using manual logbooks for record keeping and it is prone to several issues ranging from mismanagement of data to poor decision making. In addition, due to high cluster of information and poorly documented data it is vulnerable to data fragmentation. Many other concerns include data privacy and security due to it being paper bound and accessible in nature which further makes it vulnerable to tampering and getting fabricated.

So due to above issues the current inventory management is resulting in ill-timed decision making and poor inventory management due to delays in corrective and reaction measures which is affecting the supply chain process on the whole.

1.3 Previous studies:

1.3.1 Civil Engineering and Facility Management

There needs to be a change in how civil engineering is carried out globally(ASCE 2008) .Engineers working in the field of civil engineering must constantly adapt to new socioeconomic, environmental, and political factors. Industry, labor, the market, and education all undergo change with each industrial revolution. We are currently in the fourth industrial revolution, sometimes known as the digital age (Azmi, Kamin et al. 2018). The facility management phase, which is the longest in the building life cycle, has a significant impact on the lifespan of buildings as a whole by producing the vast majority of costs (House, Ballesty et al. 2007). In fact, the operational phase accounts for more than 60% of the building lifespan in terms of both cost and time, whereas the design and construction phases typically account for less than 15% of the entire life cycle cost of buildings (Teicholz 2004).

A number of tasks, including data collection, storage, retrieval, and analysis, are required to improve FM decision-making processes. Traditional FM software solutions, however, such Computer Maintenance and Management System (CMMS) and Computer Aided Facility Management (CAFM), are unable to handle FM adequately (Motamedi, Soltani et al. 2016). These technologies typically take advantage of Computer Aided Design (CAD) systems, which are unable to maintain data in a centralized, one-of-a-kind repository and do not provide immediate updates of all sources when some sections are modified. Data is therefore fragmented and is kept in many digital apps (Walsh, O'Reilly et al. 2021) as well as on paper and/or in file notes, among other places (Lin, Su et al. 2014). As of now, owners and maintenance teams continue to use the traditional logbook, which is paper-bound and manually updated by general staff; as a result, in addition to having a dispersed appearance due to access challenges(Benbunan-Fich and Castellanos 2018), it is also more vulnerable to data manipulation and has less data traceability.

1.3.2 Civil Engineering and Blockchain Technologies:

Based on the literature now available, this section aims to illustrate how Digital Inventory Management has enhanced the phases of tracking and tracing furthermore how blockchain implementation can improve spare parts preventive maintenance. Blockchain is a type of transactional data structure that is decentralized, meaning that it does not rely on a central authority to manage and store information. Instead, records and other data are managed by a consensus mechanism, which ensures that all participants agree on the state of the data. The data is being secured by cryptography, making it difficult for non-authorized parties to tamper information. Distributed ledger technology (DLT) is considered the foundational framework for many blockchain-based systems, paving and providing the underlying architecture for how data is stored and managed (Masood, Faridi et al. 2018).

In a blockchain system , data recordings are referred to as blocks whereas distributed ledgers are represented by chains. The network is created by connecting many blocks and chains, and the ledger transactions are processed and validated automatically using cryptography (Zhai, Yang et al. 2019) According to (Falazi, Hahn et al. 2019), a blockchain system can be classed as either public (permissionless) or private (permissioned). The nature of blockchain membership, where participation in the network requires authorization, distinguishes the two. A public blockchain allows for unrestricted registration and participation by anybody. Additionally, the consensus mechanism offers an algorithm for protecting, verifying, and troubleshooting peer-to-peer network operations based on the established rules (Bitcoin 2008).The fact that no single entry controls the operation, which resolves the issue of accountability and disclosure between individuals and parties, is one of the main advantages of employing a distributed system. Important data in the blockchain can be updated in real time, eliminating the time-consuming and error-prone process of individual internal data reconciliation and giving each member a clear view of all network activity. Compared to conventional third-party communication, the value exchange can be confirmed and carried out in a safer, quicker, and less expensive manner. The recorded transactions cannot be changed or removed in retroactive fashion since the blockchain data is unchangeable. Also, this feature offers a data provenance that identifies the data history of time and location over the course of the lifetime, according to (Bitcoin 2008). Digital supply chain management benefits greatly from the increased trust, effectiveness, and transparency in information sharing between organizations brought about by the data security and encryption of blockchain. The application of blockchain has been considered in recent works. (Shojaei, Ketabi et al. 2021) have highlighted the importance of implementing blockchain directly to promote circular economy in the construction industry. According to their research, blockchain technology can facilitate the tracking and prediction of material values and energy consumption at various stages of the project and asset lifecycle for construction practitioners.(Aleshi, Seker et al. 2019) have also studied and suggested blockchain based system for the storage of aircraft service records in a digital distributed ledger. The system's data and transaction structures adhere to the maintenance record logbook requirements of the Federal Aviation Administration (FAA). They suggest that the stored information be validated through consensus using the Proof of Elapsed Time (PoET) algorithm of hyper ledger Saw tooth. Meanwhile, Wickboldt and Kliewer (2019) introduced a blockchain-based IT artifact that digitizes the documentation process in the ASPM using Hyperledger Fabric. The system accommodates multiple stakeholders, diverse types of certificates, and decentralized authorities. Without the implementation of more efficient methods, logistics companies may struggle to handle the increased workload. To enhance the process and increase efficiency, new technology is necessary. Blockchain technology can ensure the security of transaction records and distribute the required information to other stakeholders. Blockchain has the ability to maintain records through a central authority by improving the traceability of logistics records, and enhancing the security of data. (Helo, Hao et al. 2019).In Asset management , lack of consistency and traceability is a result of different record systems used by users in an asset's life cycle. To address this issue, de Vos (2017) recommended the use of blockchain technology in asset management. This would allow each peer to add blocks to the asset records, resulting in a trustworthy asset management system with real-time status updates and traceable records. While every peer with access permission can view the records and edit the state of assets, they cannot write new information without access to previous records. With private and secure records, along with the application of smart contracts in every transaction, blockchain technology can be effectively implemented in construction activities. This is especially useful in transactions between different parties where record traceability needs to be ensured. Thus, these implementations can enhance transaction processes and ensure the security of data, which is a significant concern in construction activities.

1.4 Problem Statement

As our construction industry is still using the traditional method for inventory management that is paper bound manual logbooks for record keeping. It is prone to slowed decision making and vulnerable to many issues and problems from data fragmentation to privacy and security risk. While there is a large space for improvement if facility management is effectively utilized. So, in this thesis we will study whether Digitized Blockchain Based Task Management can replace manual logbooks for effective facility and preventive maintenance.

1.5.Research Objectives

- Identify the challenges hindering the adoption of digital ledger technology and explore how blockchain can effectively address these obstacles
- Devising a digitized blockchain based task management tool tailored for elevator facility maintenance.
- Validating the tool through a case study focused on elevator maintenance procedures based on literature review and get feedback on its utility.

1.6.Significance of this research:

The facility management phase, which is the longest in the building life cycle, has a significant impact on the lifespan of buildings as a whole because it accounts for the vast majority of costs. In fact, the operating phase makes up more than 60% of the entire cost and duration of a building's existence(Marocco and Garofolo 2021) In general, elevator maintenance is significantly more important than other building amenities (such as heating, air conditioning, and water supply). While the failure of other facilities can result in significant irritation for end users, the failure of an elevator can inflict discomfort to the body, anxiety to the mind, and, in the worst situations, injuries and fatalities. It is essential to review present procedures that can be considered an underlying cause of the recurrence of these events in order to reduce such undesirable instances in the future. The applied maintenance practice is one factor that has a considerable impact on the functioning of elevators. Effective facility management, which in our instance is adoption of digitized task management supported by Blockchain technology, might considerably improve the application of effective maintenance procedures to reach the necessary performance targets. (Zhang and Zubair 2022).The demand for better methods to coordinate and sustain all of those operations for a higher standard of living for its citizens grows with each passing day as the building and maintenance sector expands. This study meets national needs and is pertinent because it provides a framework or plan for efficient facility management that consumes less resources, boosts productivity, and increases transparency and security while also making key stakeholders more accessible. This research focuses on streamlining elevator maintenance procedures to improve its functionality.

CHAPTER 2: LITERATURE REVIEW

Most nations throughout the world see a considerable economic influence from the construction industry. Building and development becomes a crucial component of the economy, especially for developing nations like Pakistan. Construction is the third-highest GDP-generating industry , behind manufacturing, according to a Board of Investment Pakistan report, which estimates that it contributes 2.53% of the nation's total GDP (Board of Investment Pakistan, 2020), or 992747 USD in 2021–2022 (Pakistan, 2022). By 2028, the construction industry is predicted by Fitch Solution to reach 2705.5 billion Pkr. This demonstrates the value of the building and housing sectors to Pakistan's total economy.

2.1.Impact of Facility Management on Construction industry:

The facility management phase, which is the longest in the building life cycle, has a significant impact on the lifespan of buildings as a whole by producing the vast majority of costs (Becerik-Gerber, Jazizadeh et al. 2012). In fact, the operational phase accounts for more than 60% of the building lifespan in terms of both cost and time, compared to the design and construction phases, which typically account for less than 15% (Teicholz 2004) of the entire life cycle cost of structures. A number of tasks, including data collection, storage, retrieval, and analysis, are required to improve FM decision-making processes. Traditional FM software solutions, however, such Computer Maintenance and Management System (CMMS) and Computer Aided Facility Management (CAFM), are unable to handle FM adequately (Motamedi, Soltani et al. 2016). These technologies typically take advantage of Computer Aided Design (CAD) systems, which are unable to maintain data in a centralized, one-of-a-kind repository and do not provide immediate updates. Of all sources when some sections are modified. As a result, there is data fragmentation that is stored in various digital apps as well as on paper and/or in file notes. The goal of facility management (FM) is to ensure that the facility functions as efficiently as possible. A key duty of a facility owner or operator is to optimize a building's performance and effectively manage its operations over the course of its existence. Building Information Modeling (BIM) solutions are gaining popularity and are expected to help achieve this goal by giving users access to the data and information required for operations and maintenance (Chen, Das et al. 2020) in order to increase efficiency, enable proactive decision-making, and cut costs(House, Ballesty et al. 2007). Deployment of innovative technologies for facility management and operations has been slower and is still in its infancy (Pishdad-Bozorgi, Gao et al. 2018).

2.2.Impact of Facility management on elevators maintenance:

In general, elevator maintenance is significantly more important than other building amenities (such as heating, air conditioning, and water supply). While the failure of other facilities can result in significant irritation for end users, the failure of an elevator can inflict discomfort to the body, anxiety to the mind, and, in the worst situations, injuries and fatalities. It is essential to review present procedures that can be considered an underlying cause of the recurrence of these events in order to reduce such undesirable instances in the future. Effective facility management, which in our instance is adoption of Digitized Task Database supported by Blockchain technology, might considerably improve the application of effective maintenance procedures to reach the necessary performance targets (Zhang and Zubair 2022).The use of a comprehensive platform with data integration capabilities is necessary to address flaws such dispersed information, constrained communication channels, and a lack of historical records (Lu, Chen et al. 2018). Whether information is gathered, stored, and used over the life of the property, potential savings for the owner are generated (Scarponcini 1996). Localizing and tracking building components, storing asset information, and better visualization and interaction with facility information are the focus of current research on disruptive technologies for information management. These requirements make it possible to create an FM-capable deliverable that gives owners the crucial operation and maintenance information they require. It further demonstrates exactly what was built, addresses operational challenges by enabling viewing and navigation of the model from a systems-centric perspective. This helped in provision of simple integrated and bi-directional data exchange between the model and the owner's FM system if linked to the facility management system, for example Computerized Maintenance. This example would cut down on the amount of time needed to find necessary data after handover, enable the maintenance cycle to begin right after project closeout, and lower expenses. This is crucial for responding to maintenance emergencies. Making quicker and more educated judgements to immediately address the emergency situation is possible when looking at connected building components that have been filtered and segregated by system and sub system.

The FM personnel can more effectively use their perceptual and cognitive reasoning to react when using a systems-oriented model set up with pre-defined viewpoints of building components connected to the same system or sub-system(Ensafi, Harode et al. 2022) Users can assess the emergency more quickly and effectively, make more precise operational judgements, and respond to it more quickly.

2.3.Inventory Database for Maintenance and Blockchains Potential :

It is a statutory requirement under the Lifts and Escalators Ordinance (LEO) that lift/escalator responsible persons (RPs), or the owners or management businesses of lifts/escalators, maintain a logbook for their lifts/escalators. Since 1987, these logbooks have been paper-bound, and those in the trade—registered contractors (RCs), registered workers and registered engineers (RWs & REs), and general workers (GWs)—are in charge of entering basic lift/escalator specifications and information about lift/escalator work in the log books.(Yeung, Stephen et al. 2022) The installation, testing, commissioning, inspection, repair, maintenance, fault and incident attendance of lifts and escalators are all included in lift and escalator logbooks. The assignment date and time, the type of work performed, and the signatures of the people are all important pieces of evidence used in criminal prosecution and disciplinary measures, emphasizing how crucial it is that these records accurately reflect the history of the job performed. Paperbound logbooks are accessible in nature and can be altered by anyone, thus making them vulnerable to tampering. The log books may occasionally be damaged or even missing.(Yeung, Stephen et al. 2022).The concept of blockchain has changed over the past ten years and continues to do so depending on its uses. (Baashar, Alkawsi et al. 2021) explored the potential benefits of blockchain technology for the construction industry. The study displayed that utilising blockchain technology can improve collaboration, enhance trust, transparency, and security in the industry. The research further highlights the significance of addressing the challenges of data privacy, scalability, and governance for successful blockchain implementation in the construction industry. The challenges to adoption and implementation of digital ledger technology includes many factors including resistance to change (Carlan, Coppens et al. 2020). Other research studies done by (Walsh, O'Reilly et al. 2021) and (Benbunan-Fich and Castellanos 2018) have further validated this issue. Further challenges includes the high cost associated with provision of training and resources (Ho, Tang et al. 2021) and (Wang, Ouyang et al. 2019). The vulnerability of data getting breached by non-authorized people is another major issue (Saberi, Kouhizadeh et al. 2019) and (Li, Jiang et al. 2020). (Block and Marcussen 2020) have also presented the barrier of data security as one of the concerns in implementation of blockchain in the supply chain industry. Legal and regulatory barriers of sticking to guidelines and policies have also been presented by (Wang, Ouyang et al. 2019) as organizations may need to maintain paper records or follow certain guidelines for electronic documents. Another barrier is the role distribution as Businesses must assume new and unexpected responsibilities, which can be discouraging, especially during the supply chain's technology adoption phase (Seebacher and Schüritz 2019)

The attributes of blockchain have the attributes to overcome the barriers mentioned. As blockchain provides Peer-to-peer relationship so transaction can be carried out without the intermediary of trusted third party (Aste, Tasca et al. 2017) moreover it provides Immutable record and transparency by sharing and owning of the same information by all the members(Apte, Petrovsky et al. 2016). So, it overcomes the resistance to change factor by bring in the teams together in a transparent way. As there is no need for central authority and third party so it cuts down the intermediaries and their associated costs moreover it lowers overhead expenditures by significantly reducing transaction costs (Rana, Dwivedi et al. 2022). Furthermore it has features of digital signature or private key due to which the data in blockchain is difficult to corrupt or extinguish as they are replicated across a peer to peer network moreover it used advanced encryption techniques to protect data(Koutsogiannis and Berntsen 2017). To overcome legal issues , it improves the provenance and traceability of items, enabling businesses to adhere to rules regarding product safety and authenticity (Spiekermann, Acquisti et al. 2015). As blockchain is decentralised in nature so it removes the need for a central authority or intermediary to assign and monitor roles moreover it is transparent and immutable as it records all transactions and activities within a network so all the members have the required access (Ramage 2018) . This helps in team role distribution in blockchain based platforms. Zarei and Manahouei (2021) investigated the feasibility of blockchain technology for construction project management. This research study displayed that utilizing blockchain features can improve project management by providing transparent communication, enhancing data integrity and supply chain. The study also showed that there were regulatory and technical challenges in adoption of blockchain. (Wang, Wu et al. 2020) studied and suggested that blockchain featured framework could be used for supply chain for construction material. It also states that using so could enhance accountability and transparency in the industry. The effectiveness was demonstrated through a case study implementation. Nguyen and Nguyen (2019) investigated the potential of using blockchain in construction industry aswell. Their studies showed that utilizing blockchain could enhance the coordination between different parties in the construction industry. They also discussed the challenges that could be faced while adoption of blockchain which includes technical and regulatory issues.(Shojaei, Ketabi et al. 2021) also suggested utilization of blockchain for quality control sector. The study showed that blockchain could be a vital tool in improving transparency and reliability of processes involved in quality control. The study utilized a case study and highlighted the challenges, which included security, privacy concerns. Overall, these studies have highlighted the major concerns but have also shown the potential of blockchain which could be utilized for improving transparency, security and communication in the construction sector.

2.4.Impact of Disruptive technology on elevator maintenance:

In general, elevator maintenance is significantly more important than other building amenities (such as heating, air conditioning, and water supply). As breakdown of different facilities too could cause irritation but failure of elevators could result in severe consequences including discomfort , anxiety along with possible fatalities and injuries. It is essential to review present procedures that can be considered an underlying cause of the recurrence of these events in order to reduce such undesirable instances in the future. Effective facility management, which in our instance is adoption of Task Management supported by blockchain technology, might considerably improve the application of effective maintenance procedures to reach the necessary performance targets (Zhang and Zubair 2022). Elevator malfunctions result in increased downtime, significant financial loss, a risk to the health and safety of passengers, and a significant drop in overall end-user satisfaction (Park, Yang et al. 2010).Alarmingly, despite technological advancements, stringent safety regulations, and incorporation of sophisticated safety devices, a number of unpleasant incidents linked to elevator malfunction are reported on a global scale. For example, in Ontario, Canada, more than 4,000 distress calls were made in 2015(Zubair and Zhang 2020).Such upsetting incidents have a negative impact on passengers mental health and may cause claustrophobia in people who have a dread of enclosed spaces (Lourenco, Longo et al.

2011). Between 2016 and 2020, 50 serious elevator malfunctions in Hong Kong had a direct impact on the health and safety of end users and maintenance personnel (Electrical and Mechanical Services Department 2020). For instance, each year in the US, elevator accidents result in 17,000 injuries and 31 fatalities. The applied maintenance practice is one factor that has a big impact on the functioning of elevators. The desired performance goals are attained with the use of efficient maintenance procedures (Swanson 2001). By doing so, we may switch from reactive to proactive maintenance, preventing downtime and maximizing maintenance budgets (predictive maintenance). Recent research, however, may strengthen the benefits of utilizing blockchain-based database for maintenance.

CHAPTER 3: METHODOLOGY

3.1.Background

This research deals with the implementation of digitized task management for facility management. It enhances preventive maintenance through digitization of workflows, which makes the whole process more transparent. This research aims to introduce a blockchain-based system that addresses the challenges related to manual task management along with execution of preventive maintenance routines. In the initial stage of this research which is the development phase, smart contract is written, tested and deployed using Remix IDE platform and solidity language then front end is developed using React.js and Next.js alongside Ether.js for backend compatibility with Ethereum blockchain. The blockchain-based system's traceability information set is then formulated to provide vital information for better task management, quality assurance, visibility, and authentication. The analysis of the operational process leading to the design of the blockchain-based system is also presented.

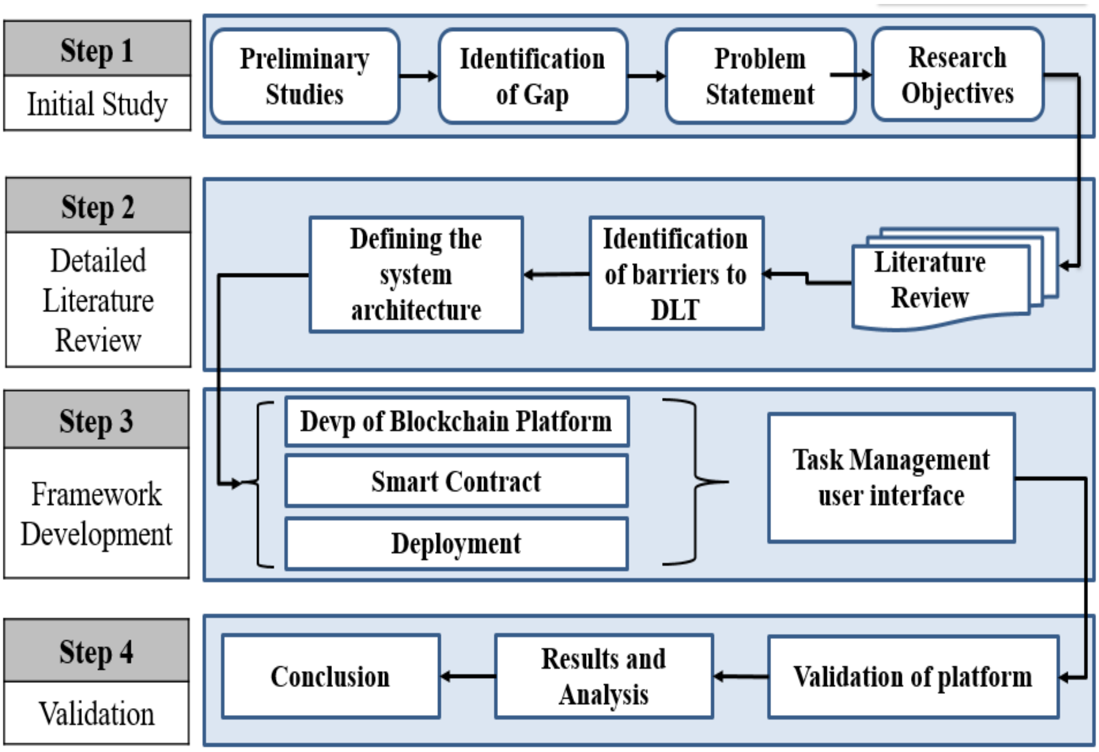

Figure 1 : Flowchart of Research Methodology

As highlighted in Figure 1, in the initial phase of the research , problem was identified along with the formulation of research objectives then through literature review and past studies, the barriers to implementation of Digital ledger technology was identified alongside how implementation of blockchain would help to overcome these issues. In the framework development phase as shown in Figure 2, smart contract was written and tested before its deployment to testnet. After which frontend development was done using NextJs and ReactJs for simple and easy user interface, Backend compatibility was done using ethers.js. Once the tool was developed it was tested on a case study based on literature review which highlighted the most common breakdown in elevators and how this tool could help in completing basic tasks for the component's preventive maintenance. In the last step, validation and feedback was done using surveys with the target audience such that they had profound experience and exposure to such emerging technologies. After compiling the results, analysis was then performed on the data to showcase its efficacy.

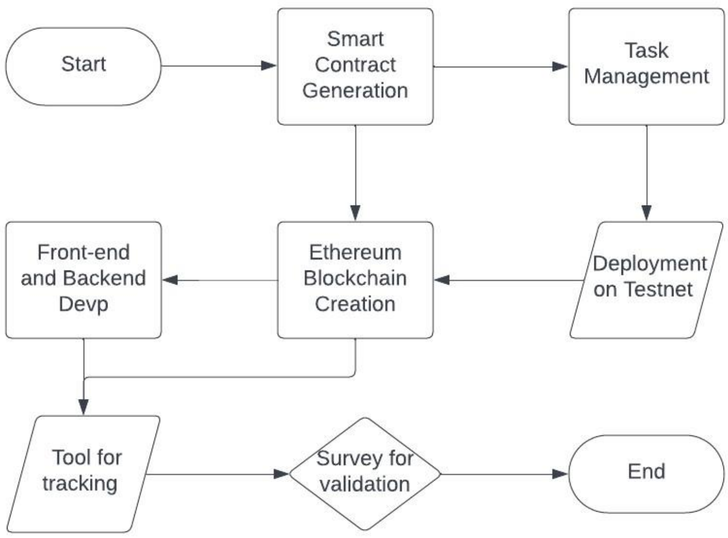

Figure 2 : Framework of Research

3.2.Barriers to Implementation of DLT and how Blockchain overcomes it

Identification of the most common barriers to implementation of emerging technologies such as Digital ledger technology was found through extensive literature review. Problems identified included organizations resistance to change from traditional method (Aste, Tasca et al. 2017). Other barriers include the high cost factor which includes introduction of infrastructure, difficulty in understanding the technology, and the experts needed for its utility and maintenance. Studies have highlighted that one of the challenge of adoption of emerging technology is high cost of implementing it with other issues like difficulty , interoperability. (Yadlapalli, Rahman et al. 2022). Other issues of implementation includes the policies and regulations which shows lack of support to adoption of such technologies (Boutkhoum, Hanine et al. 2021). The study done by (Boutkhoum, Hanine et al. 2021) have also highlighted barriers like intra-organizational resistance alongside environmental costs of such emerging technologies.

On the other side, attributes of blockchain makes the pros overweight the cons. Despite being costly initially, it can bring long term benefits in cost saving by enhancing efficiency, reducing chances of being tampered or getting misplaced, streamlining the processes. By bringing such additions it has a potential to bring large return on investment for future gains (Cocco, Pinna et al. 2017) . Other attributes include ability of blockchain to improve supply chain management transparency by contributing to sustainability of environment. It does so by streamlining processes and improving efficiency in the organization processes which helps to overcome the resistance by bringing tangible advantages(Paliwal, Chandra et al. 2020) & (Njualem 2022). The overall barriers and attributes of blockchain that would overcome the barriers can be seen in figure 3.

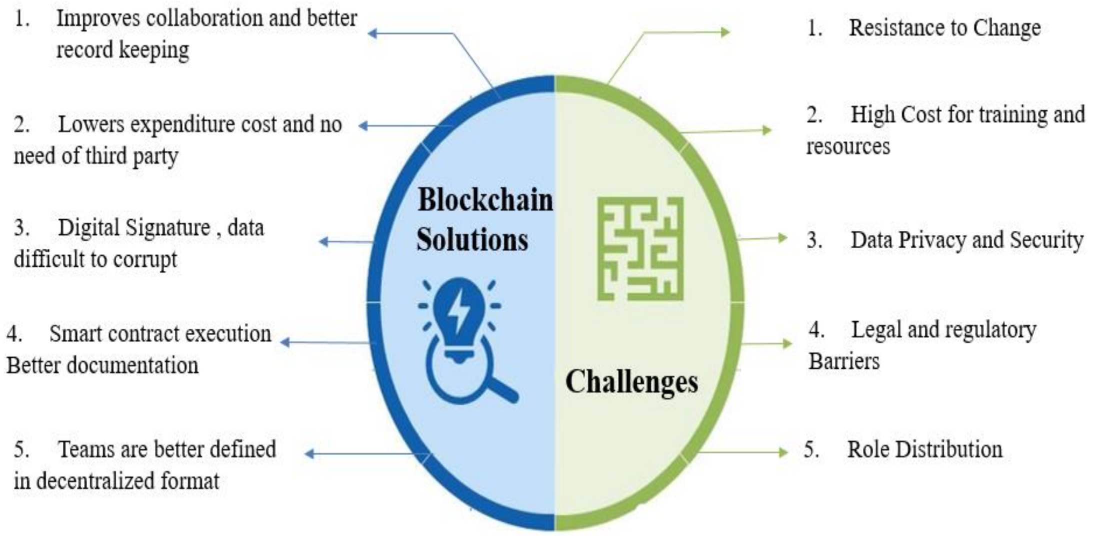

Figure 3 : Barriers to blockchain and solutions provided by its adoption

3.3.Defining the Smart Contract and the System Architecture

Before the creation of smart contract which would act as the brain of the architecture. We had to perform some pre-requisites, which first included the creation of Metamask wallet. Metamask acts as the entry point such that the users can access the network and secure their transactions by creating Ethereum wallet. It helps them to conduct communications, transactions and launch networks and application on the blockchain by linking metamask to either Testnet or Ethereum Mainnet.Metamask wallet acts as gateway to Ethereum network by allowing users to gain access and perform transactions (Pramulia and Anggorojati 2020).Subsequently, using Sepolia network, which was setup using Alchemy platform we created a testnet account. The use of alchemy was beneficial as it provided seamless integration and API features (Khvan, Kizilirmak et al. 2023). Next phase was to create smart contract for task management involved in maintenance of elevators along with how it enhances the workflow and operation using Remix IDE(Integrated development environment)(Amir Latif, Hussain et al. 2020). Remix IDE is an open source tool, which makes development of smart contracts for Ethereum Blockchain much simpler (Jain 2022). The features of Remix IDE, which involved support for solidity and integration with Ethereum network helped in developing the smart contract facilitating task creation, task modification and updates. It has an intuitive user interface so it can easily accommodate novice and experienced developers alike. Remix IDE offers all the tools required to write, compile, debug and deploy the smart contracts furthermore it supports both the Solidity and Vyper languages. Solidity was used while writing smart contract for task management. Its features allow contracts to be directly deployed to Ethereum networks. All these extensive features and ease to use makes it an important tool for Smart Contract development. Key features include addition of tasks which automatically designates that particular task the status of ‘’Pending’’. The user can then interact with the contract once the task is finished, as a result the status would then be changed to ‘’Completed’’. This shift is a blockchain transaction rather than just a modification to the database, the tools operation relies heavily on this smart contract, which provides a reliable and open way to handle maintenance duties.

From start to end, it automates the task lifecycle management process by ensuring that each task is recorded and stored permanently on the blockchain. Pseudocode for smart contract is shown in table 1. The result provides an unchangeable log of maintenance operations.

Table 1 : *Pseudocode for Smart Contract*

PSEUDOCODE FOR SMART CONTRACT		
1	Create a **new** Contract Todolist	
2	Define the Task **structure** :	
		• Description of task (a **string**) • Status of the task (**Pending** or **Finished**)
3	Initiate an array to store tasks once the contract is created:	
		• The owner should be set as the creator
4	Define a rule (**onlyOwner**):	
		• The owner will be allowed to perform actions
5	Function to **add a task**:	
		• Input should be the description of task • Addition of new tasks with assigned description and set the status as Pending
6	Function to **mark a task** as finished:	
		• Input to be the task ID • Check if the task/s still exists • Status of the task changed to finished
7	Function to **get all tasks**:	
		• List of all tasks would be returned
8	Function to **get a specific task**:	
		• Input would be task ID • Check if the task/s still exists • The task details would be returned

After writing the contract in Remix IDE, using the same tool deployment was done by choosing "Injected Provider Metamask" as the environment to connect Remix IDE with Metamask. Then after selection of the created contract and clicking "Deploy". Metamask will ask showing a message prompting to confirm the transaction as shown in figure 4. Once after the confirmation, Remix IDE deploys the contract using Metamask wallet and Testnet (Sepolia Network).

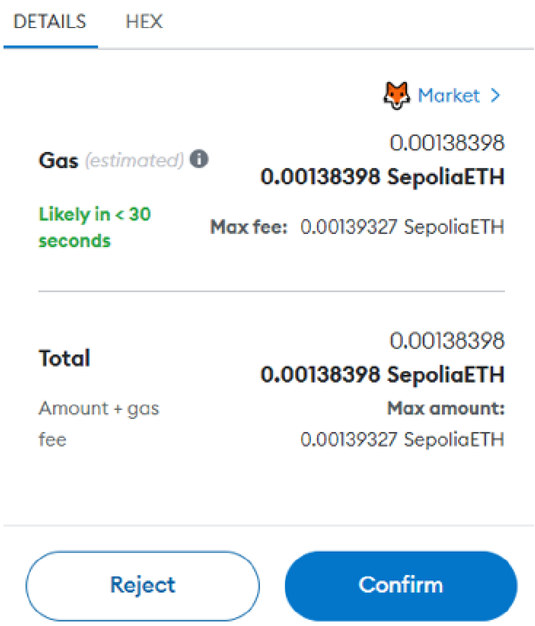

Figure 4 : *Confirmation of transaction (Contract Deployment)*

After the deployment, Remix IDE further provides the address of where the contract is stored. Furthermore, one can use this address to interact with the deployed contract like

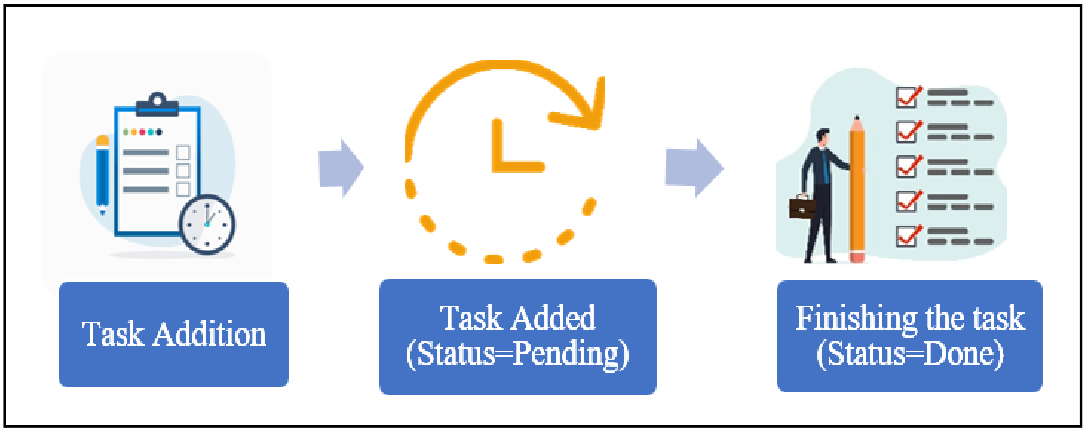

Figure 5 : *Basic Functionality of the tool*

testing the features and transaction. The basic functionality of the tool can also be seen in figure 5 where tasks could be added and once completed their status would change from ''Pending'' to ''Done''.

The application of this tool adopted validation through a case study methodology, which focused on preventive maintenance for elevator systems. Through literature review, we identified the most common breakdowns in elevators (Zhang and Zubair 2022) & (Park, Yang et al. 2010), which helped us is shortlisting the preventive maintenance tasks for the tools test use. The study by (Zhang and Zubair 2022) highlighted and carried out a vast and thorough investigation of 25,548 breakdowns resulting from 5,400 elevators in Hong Kong. The study's main aim was studying the useful life of elevators and how preventive maintenance can delay the onset of elevator breakdown. The paper challenged the belief that useful life of elevator is 20-25 years and concluded that the useful life of elevator is infact 30 years. Approaches adopted in this research included statistical analysis and Pareto Analysis with main focus on breakdown rates for different groups categorized by age and the identification of crucial elements that lead to failures. The findings showed that the major breakdowns included malfunctions in the controller, landing door mechanism, car door mechanism, and other components housed within the elevator cage. It was found out that the failure of controller is the main reason behind the wear-out phase in elevators. Total eighteen reasons of elevator failures were analyzed using Pareto analysis 80/20 rule. The results showed that an astonishing 76% of the problems were attributed to the top four most common reasons of elevator breakdown. (Park, Yang et al. 2010) further validated the selected reasons of elevator breakdowns and how these parts maintenance must be ensured.

3.4. Survey questionnaire design for validation

The designed survey had the aim to gain insights into various aspects ranging from the tool's effectiveness, usability compared to conventional practices in facility management. The survey was designed using Likert scale questionnaire, which focused on comparative analysis of functional attributes. While designing the survey, validated scales were being used from the established research methodologies (Jesionkowska, Wild et al. 2020) , (Kazemiroodsari and Folajimi 2022) & (Sekaran and Bougie 2016). Respondents were provided with a scale from 1 to 5 and were asked how much did they agree with the following aspects of this tool. Questions included asked respondents the level of ease with which new tasks could be entered in the tool compared to traditional method which was based on the study done by (Alsemari, Ramegowda et al. 2024) that implemented the tool of BIM compared to conventional 2D measures for project management. The study aimed to improve project management and efficiency in oil and gas sector of Iraq. Whereas study done by (Marzouk, Labib et al. 2024) which investigated the integration of Blockchain features to improve the management of heritage building and showed how this inclusion brought secure , reliable and improved platform for data communication. Based on this study we prepared questions regarding security, transparency and data integrity. The study done by (Ghosh and Chakraborty

2024) which developed a trusted decentralized tool CollabCloud which provided a secure cloud environment and eliminated the need for central authority showed that it will reduce time taken overall. So, our questions in survey regarding effectiveness based on time taken and tools efficiency were inspired by this study.

CHAPTER 4: Results and Analysis

4.1.General

This chapter explores the analysis of a new tool that uses blockchain technology to automate elevator maintenance task operations. We wanted to see how well it works to make field engineers' jobs easier. After the development and use of this instrument, we collected input from 106 field engineers. We obtained their opinions and ideas regarding the impact and usefulness of the blockchain-based task management tool through a thoughtfully designed survey. Through the process of scrutinizing their answers, we acquired a thorough comprehension of the effectiveness of the instrument and pinpointed possible directions for enhancement. The minimum target audience experience selected for survey was kept four years as it meant that they had exposure and learnings regarding emerging tools like Blockchain and other digital application in addition to having a vast experience in traditional methods so they had deep understanding of both traditional and modern technological innovations. Since they witnessed all these transformations first hand so they are better equipped to verify and validate the efficiency this tool has in actual use.

4.2. User-Interface of the tool

The interface of the tool is shown in figure 6 with the preventive maintenance tasks, selected after finding the most common breakdowns in elevators. In depth, explanation is elaborated thereafter.

Figure 6 : *Digitized Tool User Interface*

Step 01- Gaining Access of the tool

In figure 7, the first step, which is gaining access through the metamask wallet, is shown. By entering a unique password known to the authorized person, the user gains access. The password should remain confidential for security purposes. By gaining access to the tool, the list of tasks already stored would become visible in the dashboard.

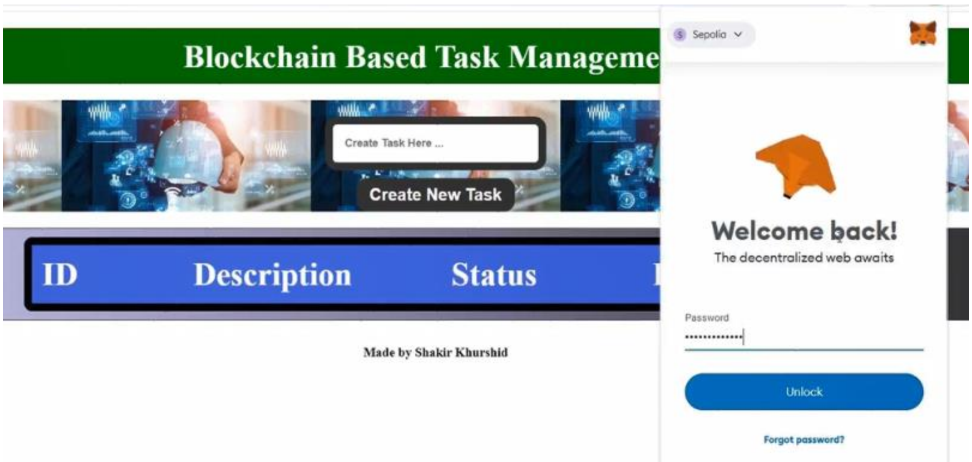

Figure 7 : *Gaining access of the tool*

Stage 02- Adding Tasks and Changing Status

For the process of adding task, the user has to simply click on create new task tab. The added task is displayed on the dashboard. Once the task is added, its status would automatically be saved as ‘’Pending’’ along with its ID. Likewise, in order to change the status of the task after completing it, the user has to click on the done button under the event tab. This will change the status of that specific task from ‘’Pending’’ to ‘’Finished’’. Figure 8 below shows how task status is changed.

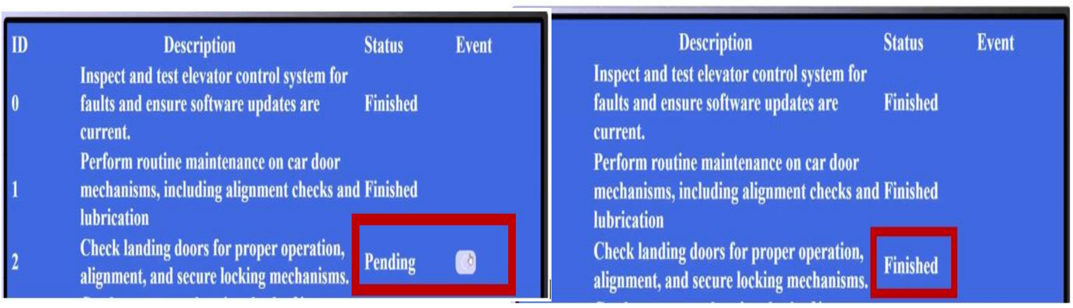

Figure 8 : *Changing status of the tasks*

Stage 03- Viewing the details of transactions

For the process of viewing the details of stored tasks. We have to click on the ‘’view on explorer’’ button under the metamask tab which will display details of the Ethereum address on this Sepolia testnet. This will open a page containing all the stored tasks including the specified transactions as shown in figure 9, which includes the timestamp of task creation including the IDs of each tasks. Further information includes the remaining balance of the testnet along with information on the most recent transactions sent from the specified address. Other details shown includes transaction hashes, age of block and the number of accounts involved in the transaction.

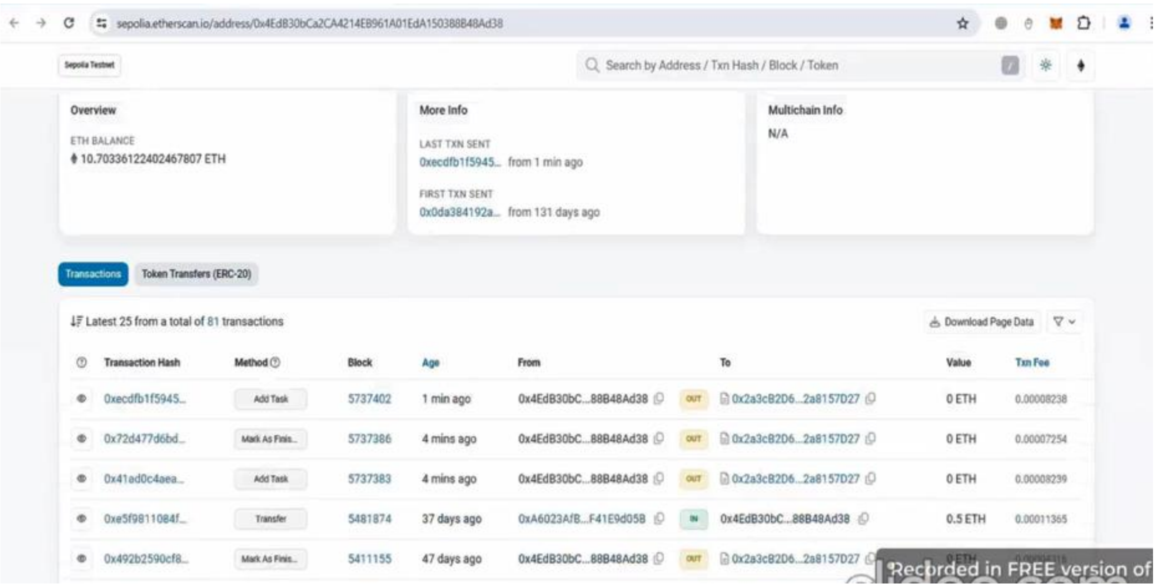

Figure 9 : *List of performed transactions*

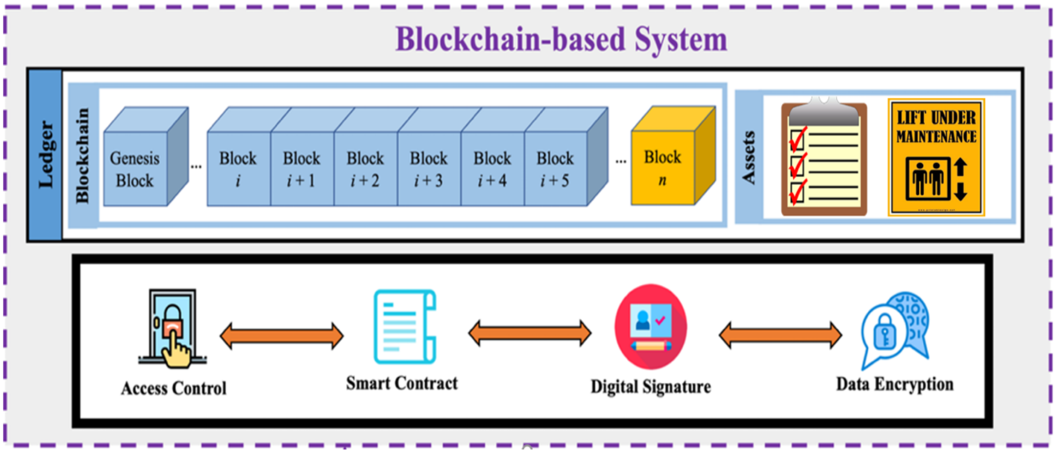

Figure 10 : *Task Management Tool Operational Process*

The operational process of the tool in figure 10 displays how blockchain adds and stores data. Blockchain here represents the data container, which stores transactions. The blocks are linked to each other forming a chain in chronological order and contains hash of the last block making it difficult to tamper as any tampering attempt to one block would require doing the same for all the blocks(Agbo, Mahmoud et al. 2019). This also ensures transparency and security for the whole system. On the other hand several features makes the developed tool more reliant which includes its access control using cryptographic techniques for accessing permissions making sure that only authorized user has the access of the data(Shi, He et al. 2020). Furthermore usage of smart contracts automates the whole process without the need for third party(Khan, Loukil et al. 2021). Digital signature ensures data integrity along with providing proof of origin of the data ensuring security and trust(Fang, Chen et al. 2020). Data encryption uses encrypted algorithms to make data more safe and secure while maintaining the confidentiality(Baygin, Baygin et al. 2019)

4.3. Survey for validation

After the development of Digitized Task Management tool, the following went through a validation phase with field engineers having optimum experience (minimum four-year experience) so the proposed tool could not just be validated for its use but will also highlight areas of improvement so it could be effective for use. Following the development, a thorough survey was carried out. Respondents were shown the features of the tools and were asked for their opinion regarding it compared to the conventional manual techniques in the field of facility management. This would help in direct comparison between traditional approaches and the new innovative blockchain based solution. Main highlight of this survey were the opinions and assessment of how useful the tool is furthermore it gave responses regarding tools features, effectiveness and user feedback.

4.4.SPSS Analysis

A survey with target audience of field engineers having four years of experience were used to assess the tool. Total 106 responses were recorded which did made up the sample for the analysis in this study. After recording the responses, the following were analyzed statistically in Statistical Package for the social sciences (SPSS) to evaluate the tools usefulness and opinions regarding it. The following tests were applied

4.4.1.Data Normality Test:

After recording the responses through questionnaire survey based on Likert scale, the next step was its analysis. The first phase was to check to see if the data followed a normal distribution, which is a common pattern in statistical analysis. The check was to show whether data fits within the normal range.

Skewness and Kurtosis Check:

The first step was to calculate the kurtosis and skewness value for each factor. Kurtosis is a statistical measure that shows us how data is distributed. Upon determination of the kurtosis value for survey data it was found that they were in the acceptable range for normal distribution as shown in Table 2. Whereas Skewness indicates the symmetry or asymmetry of data ((Tabachnick, Fidell et al. 2013). Kurtosis and skewness (Table 2 & 3) checks further endorsed the conclusion that the data from survey is normally distributed.

Table 2 : *Skewness Ranges*

Data Type	Skewness Range	Acceptable Range
Field Engineers Survey Data	-1.166 To -0.310	-2.58 To +2.58

Table 3 : *Kurtosis Ranges*

Data Type	Kurtosis Range	Acceptable Range
Field Engineers Survey Data	-0.821 To +3.289	-3 To +3

Our research study had a total of 106 responses which was above the acceptable threshold suggested by the Central Limit Theorem to ensure datas mean distribution reaching normality. Despite one factor had skewness score of 3.28 which was above the acceptable range of 3. this slight deviation is considered acceptable within the context of our sample size as highlighted by the study of (Pek, Wong et al. 2018) which states that slight deviation in skewness won't affect the distributions normality. So therefore, we proceeded with further analysis with the assumption that our research data does not diverge from normality.

4.4.2.Factor Analysis:

For analysis, we used Exploratory Factor Analysis (EFA), which is considered ideal for discovering the structure for a large data set with no clear hypothesis about factors. It is ideal for finding components based on factor loadings, Eigenvalues and scree plots. EFA helps to reduce the data into a more manageable form by shortlisting the factors and thus can investigate interconnections between them (Thompson 2004). I utilized IBMs Statistical Package for Social Sciences (SPSS), a popular tool in field for data analysis to conduct a comprehensive component analysis for my research survey. The steps I followed includes firstly importing the dataset from the forms which was in CSV format into SPSS tool. Next step was to categorize the data into their specific data types, which deems fit for each like ordinal or scale depending on the type of data. After which the ''Analyze'' tab was selected, from where we were able to choose the factor reduction option to perform component analysis. The output elements, which I wanted, were selected 'marked tick' from the analysis. Output selected included KMO and Bartlett's test of Sphericity, Scree Plots, component matrix and Rotated Component matrix using the Varimax Rotation. All these would help to evaluate and interpret the survey results more efficiently. Scree plot was created for analysis using SPSS, which depicts a graph showing each component and their respective Eigenvalue. The tool finds the key components by selecting those components with Eigenvalue greater than 1. The next step was applying a Varimax Rotation, which resulted in a rotated component matrix. The matrix was able to show how greatly each variable relates to the components (based on factor loading). The values below 0.50 was ignored due to their negligible contribution in displaying the relation between variables and the components.

In table 4, the data from the survey are checked for Exploratory Factor Analysis, which shows the strength of relationship (which is called Factor Loadings) between each factor and the component. Factor loadings are denoted by the symbol **λ**. The factors are grouped as per their loading on their respective components.

Table 4 : *Factor Loading for Technical Competencies*

Rotated Component Matrix	**Factor Loadings (λ)**		
	Component 1	**Component 2**	**Component 3**
Likelihood of use in maintenance operations	0.70686549		
Reduction in time for assigning maintenance tasks	0.69050998		
Easier navigation and use	0.68914375		
Addition of maintenance tasks	0.6794678		
Less task misplacement with the Smart Contract	0.65727884		
Effectiveness in improving elevator maintenance processes	0.53641143		
Less likelihood of data being tempered/misused		0.69511223	
Enhanced data integrity		0.72399711	
More reliable and immutable recordkeeping		0.72271151	
Reliability for managing maintenance tasks		0.70254227	
Improved transparency			0.72062682
Improved security for task data			0.79277887

Table 4 showed the rotated component matrix where the factor loading values of factors of survey to the competencies are defined by SPSS. All the factor variables are loaded onto a single latent construct, showcasing that all the factors are grouped under their respective components. All factors loadings that were below 0.5 were ignored due to their negligible loading on the components.

In my case, there were three components where component 1 represented **‘’Maintenance Task Management’’** and focuses on domain like task addition, ease of use, navigation and effectiveness in carrying maintenance processes. Component 2 represents **‘’Data Integrity’’** and focuses on domain of data security, maintaining immutable recordkeeping along with prevention of it from tampering. Component 3 represents **‘’Transparency’’** and focuses on domain of enhancing overall transparency and how secure is data in the maintenance system.

Then **convergent validity** which helps in understanding the validity of the data was checked by using the **average variance** (calculated by equation 1) and **construct reliability** (composite reliability) was then extracted using Microsoft Excel using formulae (equation 2). It checks how well different variables are representing the same construct. It further checks if the factors that are under a specified component rightly belongs there or not. Study conducted by (Hair, Anderson et al. 2010) suggested that Average Variance Extracted (AVE) could also be used to check the measure for validity and how much variance is there in the constructs. Study by (Fornell and Larcker 1981) outlined that value of AVE should be above 0.50 for acceptance , however it also notifies that lower AVE values are also acceptable if composite reliability is above 0.60.

Average variance was calculated using equation 1

$$AVE = \sum \lambda 2/N \quad \textbf{(1)}$$

- Whereas λ = Factor loading of variables on a construct

Composite reliability was calculated using equation 2

$$CR= (\sum\lambda)\ 2\ /\ ((\sum\lambda)\ 2 + \sum\ (1- \lambda 2) \quad \textbf{(2)}$$

- Whereas λ = Factor loading of variables on a construct

For Composite reliability , an alpha value of greater than 0.80 is acceptable (Ringle, Sarstedt et al. 2020)

The next step was to find **Discriminant validity**, which is important when there are latent variables in tool development. It further verifies that constructs are different from each other so that variables which are not expected to correlate actually remain so in the results as well.(Fornell and Larcker 1981) suggested that square root of average variance should be above the correlation it has with constructs.

$\sqrt{AVE}$ Construct Reliability: >Correlation Between the Construct **(3)**

The SPSS tool was further used to determine the **Cronbach's alpha** which shows the level of internal consistency of the scale. SPSS and Excel were crucial in this multi-step process for comprehensive statistical analysis.

Using SPSS, I checked the **KMO (Kaiser Meyer Olkin)** measure of sample adequacy, which denotes whether the sample data was sufficient for factor analysis, or not. The value of KMO (provided in Table 5) was above the acceptable threshold of 0.5 (Tabachnick, Fidell et al. 2013) showcasing that the survey data was sufficient for the analysis. Next step was to calculate the AVE (average variance extracted) which is important for checking construct validity. This was useful in showing that its indicators respectively represented all the constructs in this research. After which the computation of composite reliability was done using Excel and Cronbach's Alpha using IBM SPSS, which showed the reliability, internal consistency of the constructs

For my research analysis, I checked construct reliability by using two measure techniques: composite reliability and Cronbach's Alpha. After which Cronbach's Alpha was checked using IBM SPSS, which is also displayed in table 5 along with its criteria. For construct validity, I used two measure techniques: convergent and discriminant validity. Discriminant validity was checked using Heterotrait Monotrait ratios by making sure that the square root of constructs average variance was above its heterotrait correlations with other constructs. Details of this are shown in table 5

Table 5 : *Data Adequacy, Reliability and Validation*

Metrics	**Criteria**	**Component**		
		1	**2**	**3**
Composite Reliability	> 0.6	0.82321	0.837969	0.728823
Average Variance Extracted (AVE)	> 0.5	0.43880	0.50580	0.57390
√AVE	> 0.46	0.66242	0.71120	0.75756
Cronbach's Alpha	> 0.7	0.808	0.773	0.476
KMO Measure of Sampling Adequacy	> 0.5	0.831	0.773	0.5

In our case, all the factors did pass their checks except for component 3, which had 0.476 Cronbach Alpha value and was below the criteria (0.7). But according to a study done by (DeVellis and Thorpe 2021) , a lower value for Cronbach alpha is still acceptable for further analysis in cases involving complex constructs or where the research analysis is in early phase. So, we would continue with next steps in our subsequent research analysis while noting the result of component 3 with due consideration. The next step was to calculate the **HTMT (Heterotrait-monotrait ratio) correlations** for the dataset by making use of correlation matrices, which was generated using SPSS. The variables of the same construct were referred by Monotrait correlations whereas those of different constructs were denoted by heterotrait correlations. HTMT (Heterotrait-monotrait ratio) which shows the distinctiveness of constructs should be below the value of 0.90. According to our results (shown in Table 6), the data passed these criteria successfully.

Table 6 : *HTMT Ratio Calculations*

HTMT Ratio Calculations	
Monotrait Correlations	
1st Component	0.4130197
2nd Component	0.4615056
3rd Component	0.3154267
Hetrotrait Correlations	
1st Component & 2nd Component	0.3398364
1st Component & 3rd Component	0.2136468
2nd Component & 3rd Component	0.2382435
HTMT Ratio	
1st Component & 2nd Component	0.7783878
1st Component & 3rd Component	0.5919183
2nd Component & 3rd Component	0.6244294

4.4.3.Relative Importance Index (RI):

The Relative Importance Index (RI index) is a significant measure to rank data by their level of importance upon collection of data collection. By utilizing Excel, RI indexes for survey questions were determined by following the steps below:

1.Survey responses were collected where participants had to rate the significance of each question based on Likert scale i.e. on a scale from 1 to 5 (1 showing strong disagreement or least significance while 5 shows high significance)

2.Counts of each rating for all the questions were noted.

3.Following the counts, RI Index was then determined for each question by using the below formulae

$$RI = \left(\frac{\sum_{i=1}^{n} (w_i \times f_i)}{N \times W} \right)$$

Where:

- wi depicts the weightage assigned to each score
- fi = frequency of responses for each question
- N = total responses (106 in our case)
- W = Maximum Weight (5 in Likert Scale)

4.The above formulae was used to find Relative Importance Index (RI Index) which depicted a weighted average for each research question. Higher rating would have more weighted average.

5.Last step was to rank the maximum RI index, which was then shown on a range from 0 to 1.

The Relative Importance (RI index) showed which of the research factors and questions were carrying the most significance by the survey respondents is shown in Table 7. A relatively high score would mean greater significance. This is beneficial in prioritizing factors and to note areas where further study could be carried out to bring in improvements based on respondent's feedback.

Table 7 : RI Index Score

Competencies	RI Index
1. Addition of maintenance tasks	0.84
2. Improved transparency	0.88
3. Improved security for task data	0.87428571
4. Less task misplacement with the Smart Contract	0.85142857
5. Less likelihood of data being tempered/misused	0.83047619
6. Streamlines task organization and prioritization	0.85714285
7. Enhanced data integrity	0.87047619
8. More reliable and immutable recordkeeping	0.86095238
9. Reduction in time for assigning maintenance tasks	0.85523809
10. Effectiveness in improving elevator maintenance processes	0.85714285
11. Reliability for managing maintenance tasks	0.83238095
12. Likelihood of use in maintenance operations	0.82095238
13. Easier navigation and use	0.84952381
14. Blockchain features can address the challenges	0.834285714

In our context, the RI Index scores shows which aspects of the digitized blockchain based tool the respondents find most useful and beneficial. A relatively higher score indicates more agreement that the tool meets the specified need. In our case, the factor ‘’Improved transparency’’ got the highest RI Index score of 0.88 which depicts its significance in meeting the desired need. The results show the importance of factors into the context of our research and displays its significant role as per the perception of the respondents. This shows a wider consensus among the respondents regarding the critical benefits offered by this tool.

Other factors were also denoted their RI Index score on the same basis which signifies stronger agreement by the respondents. All the factors along with their scores are shown in table 7. The table is also represented in graphical form in figure 11, which contains RI Index score on X-axis whereas the factors are enlisted on the Y-axis.

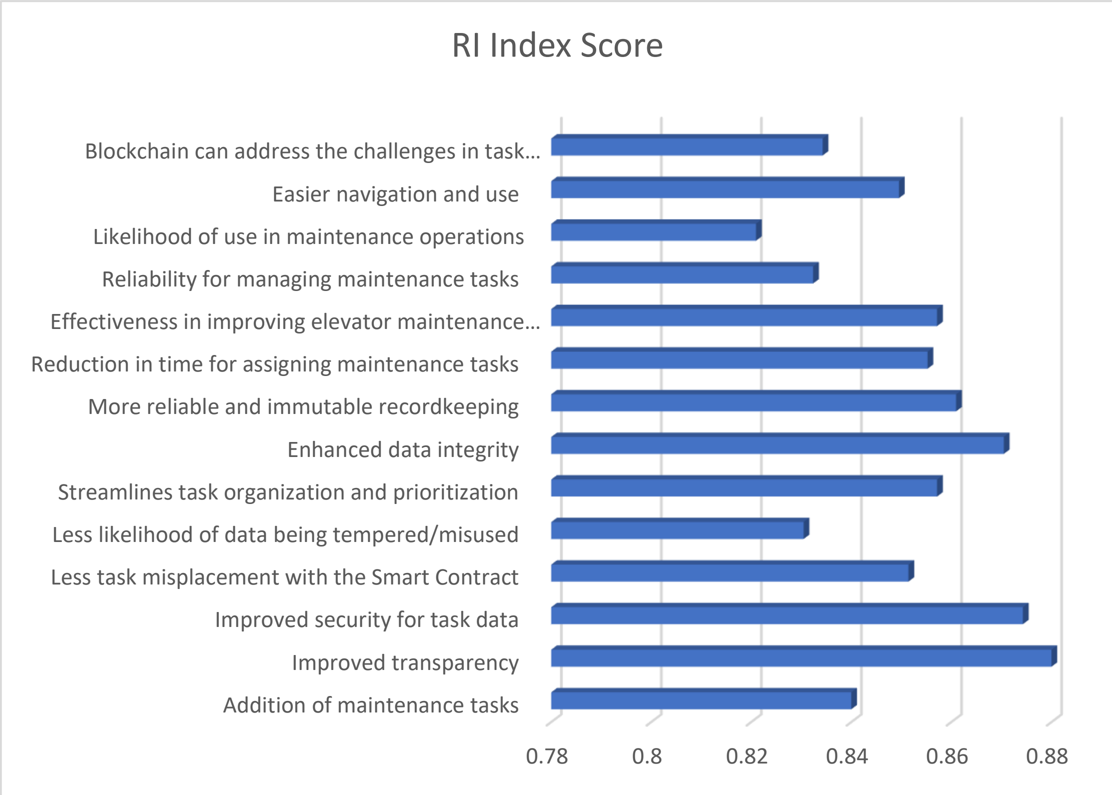

Figure 11 : *RI Index Score*

4.5.Discussion

The results and analysis of the research study highlights the usefulness of digitized blockchain based task management in enhancing elevator maintenance in the field of field facility management. Total 106 responses from field engineers were obtained. The research was aimed to highlight the benefits of blockchain based tool compared to traditional methods. Survey questionnaire based on Likert scale were prepared to get complete assessment of different dimension of the tool. The questions ranged from evaluating its ease to use to effectiveness in improving maintenance practices. The findings showed that the respondents strongly agreed with the tool's benefits and efficiency. The survey further helped to show the strong agreement of respondents regarding the tool's usefulness in domain of security, immutable record keeping, data integrity and reducing chances of data tampering. The analysis conducted by using SPSS also highlighted the validity and reliability of the data. Despite few deviations, the overall analysis was in the acceptable level which demonstrated the credibility of the survey conducted. The critical aspects which were prioritized by the respondents were also highlighted in the Relative Importance Index (RI scores). The most highly scored aspects of the tool were factors relating to improved transparency, enhanced data integrity and more reliable record keeping, highlighting their significance in domain of elevator maintenance. Despite of the encouraging results, there were few limitations which included survey sample size not representing the diversities of perceptions in the field. Future studies could incorporate these by including a more diverse range of users for a broader scope of research.

CHAPTER 5: Conclusion

5.1.Research Conclusion

The aim of this research was to transform the way maintenance tasks are being managed by utilizing cutting edge technology of blockchain, which has achieved its primary objective. The first objective was to study and identify the challenges hindering the adoption of digital ledger and how blockchain technology could address all these issues. Through detailed studies, the research identified various critical inefficiencies in existing task management practices. The second objective was to devise and develop a digitized tool, which would by backed by blockchain based smart contract and help in task management. Smart contract was designed, tested and deployed using Remix IDE to handle tasks such as adding, retrieving and updating task management entries. User interface was developed by using ReactJs and NextJs for frontend, which provides users with intuitive experience for performing their respective tasks. The frontend was integrated with backend using ethers.js for seamless integration and interaction with smart contract. The third and last objective was to ascertain the tools efficacy in managing tasks. This was accomplished by validating the tool through a case study based on literature review and getting feedback on its utility. The case study chosen was enhancing elevators maintenance procedures. Through literature review, the most common elevators breakdowns were found out which were then integrated into the tool by assigning tasks that caters its preventive maintenance. User feedback was then gathered through survey which was overwhelmingly positive. The respondents noted and provided valuable insights for the tool's user interface and its validation.

The final conclusion shows compared to traditional methods, the digitized blockchain based task management tool stands out due to its ability to enhance data integrity, keep record keeping safe, improved transparency and security while automating the tasks due to its smart contract integration, further benefits over conventional techniques includes:

- Empowering users to manage tasks proactively with an easy and user-friendly interface tool.
- Encouraging meticulous attention to maintenance tasks, due to tools structured and user-friendly approach.

- Retention of tasks while keeping it immutable and securable shows its dominance over conventional methods.

5.2.Limitations

While performing this research study, there were various challenges which came to light and could have an impact on the efficiency and implementation of this tool in facility management industry. To begin with, scalability within the network has not been defined for ideal performance which for now act as an obstacle but could be catered for scalability issues in future research. Secondly, another limitation is the user adoption which could present a hurdle. Field engineers and other users might face difficulty at first to embrace and integrate this technology in their respective yet conventional workflows. So, to address these limitations, comprehensive and occasional workshops followed by training is required to enhance organisations acceptance for these new technologies. Furthermore, the survey which was conducted might include the limitations relating to sample size and job designations which might affect the generalization of the finding.

5.3.Practical Applications

Practical application of this research ranges from utilization of blockchain based task management tool for real life scenarios in field of facility management. By adopting this tool into maintenance activities, users can make the tasks more streamlined by improving transparency and ensuring security and improved record keeping due to its immutability. It could optimize maintenance operations in industries. Industries other than construction like aviation could also make use of it to store data related to aircraft operations and maintenance. It could automate the tasks involved in field of facility management reducing the time and efforts hence improving the service quality for the end users by modernizing the domain of maintenance. Further uses includes it to track, assign and complete tasks related to maintenance which results in better efficiency by reducing downtime for facility assets. This tool could further facilitate decision making by delving into processes of maintenance and resource allocation. The practical applications can help facility management sector to adopt digitized solutions and provide improved service quality to residents.

5.4.Future Recommendations

This research study successfully devised and developed digitized blockchain based task management tool, showcasing a robust framework for digitizing and enhancing task management. However, there are other avenues, which could be incorporated into studies for future enhancement of this research study:

- Adoption to other fields: The tool could be further tested in other spheres of maintenance intensive domains for example Aviation for aircraft maintenance, Manufacturing sector and utilities for carrying out checks on infrastructures. Each sector having unique challenges could showcase how this tool could enhance transparency , streamline processes while ensuring immutable record keeping.
- Real Time Updates: integration of this tool with Building Information Modelling (BIM) could achieve a significant milestone. Integration with BIM could ensure dynamic 3D modelling which along with blockchains secure and transparent interface could pave way for an unparalleled real time update of tasks, project progress and how resource is allocated. This would result in more informed decision-making and be valuable for high complex and complicated tasks.
- Utilization of cloud computing: This would ensure and pave way for backend data storage which could be able to store larger datasets along with providing analytics for predictive maintenance which could help in forecasting maintenance needs. It could further enhance the scalability so that the tool can grow upon more users and hence more data volume.
- Advance Customizations: Future research and study could expand by inclusion of Artificial Intelligence (AI) and machine-learning algorithms that would help to anticipate what maintenance actions should be taken based on historical datas. Furthermore, IoT integration could make way for reaching out latest information from elevators directly which would enhance maintenance operations proactively and improve decision making for the relevant authority.

By adhering to these recommendations and opportunities, future research could be built upon the foundation of this study paving way for exploring the full potential of digitization in field of facility management.

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