Enhancing Hardcopy Document Management with a Digital Tracking and Monitoring System

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ABSTRACT

The study addressed the long-standing inefficiency in the management of hardcopy documents in construction organisations, where manual and semi-digital processes lead to document loss, reduced traceability, and inadequate accountability. Although the construction industry undergoes continuous digital transformation research, there remains a research gap regarding the systematic deployment of digital technologies to manage physical documents, which cannot be neglected in light of legal and operational requirements.

The qualitative approach has been followed, including the review of current document workflows, the assessment of available tracking technologies, and the design of a conceptual digital tracking system. The work contributed by proposing a systematic model that incorporates barcode or QR code recognition and identification, a cloud-based database, and secure access controls to manage hardcopy documents.

The results showed that the suggested solution minimised errors related to manual operations, enhanced document traceability, reduced time spent during retrieval, and increased coordination and security among staff members and databases. In general, research has shown that a systematic digital tracking alternative can enhance operational efficiency and help construction organisations align hardcopy document management with their digital transformation goals.

Keywords: Construction industry, Cloud-based system, Information management, Document management, Quick response code, Construction Digital, Built Environment

INTRODUCTION

In 2020, the Malaysian government introduced the Construction 4.0 Strategic Plan to encourage digitalization across the construction project life cycle (CIDB, 2020). Information management and efficiency, along with accuracy, have been improved by the use of technology, including Computer-Aided Design (CAD), Building Information Modelling (BIM), and cloud-based documentation systems, through digitalization and computerization. Such developments facilitate automated operations and data-driven decision-making in construction organizations.

Although there is a growing trend towards digital technologies, hardcopy documents such as drawings, contracts, and official records remain popular in the construction industry due to legal, contractual, and regulatory factors.

The apparent permanence of using physical documents has led to ongoing difficulties, including document loss, exposure to forgery risks, slow access, poor traceability, and inadequate protection of confidential data. The current document management practices, based on manual filing systems and primitive spreadsheet tracking, are unproductive and likely to lead to human error, especially in large, intricate projects.

The research gap is that no systematic, technology-assisted solution has been developed to manage and track hardcopy documents in a digitally transforming construction setting. Although much work has been done on

digital document management systems, little has been done on integrating digital tracking technology into the physical document workflow.

Problems Statement

The critical problem with current construction document control practices is the lack of a standardized, automated system to track the movement, location, and accountability of hard-copy documents, including drawings, contracts, and reports. Most organizations rely on hand-controlled logbooks or ad hoc tracking methods, which are non-standard in format, incomplete, and prone to human error (Björk, 2003; Al-Dalaeen & Allahawiah, 2020). Lacking a standard mechanism, physical files are commonly misfiled, their whereabouts cannot be determined with certainty, and it is unclear who has the document.

It can be difficult to identify who is responsible for document handling when tracking is insufficient. When documents are taken without proper recording, employees are unable to determine who currently has a file or when it was last viewed. The reason for the operational delay could be that the quantity surveyors, engineers, and project managers will have to spend more time securing collaboration from their workmates or searching for documents.

In situations where the work must be done immediately, such as site allocation or changes, the lack of accountability may delay efficiency or require decisions to be made even before the documents are confirmed (Björk, 2003). The lack of clear accountability may lead to efficiency delays that will gradually increase and form bottlenecks in the flow of resources (Guo et al., 2019).

Furthermore, the absence of automatic audit trail generation also makes it difficult to monitor document use and control documents within the organization. This is because manual records do not always provide a clear record of a specific document's use, since they do not always show the document's access, the time it was taken from the record store, or the time it was returned to the record store.

This makes the control of organizational performance difficult, according to research, as a lack of quality control in the use of the document management system, especially with respect to accuracy and the value of the records produced, compromises the control and performance of the organization (Al-Dalaeen & Allahawiah, 2020; Yankah et al., 2024).

Although technologies such as barcode-based tracking systems have been shown to improve document traceability, their use in managing hard-copy construction documents is still limited (Björk, 2003; Guo et al., 2019). Due to the high volume and significance of physical documentation in the projects being handled simultaneously, inadequate tracking systems amplify the impact of decreased productivity and decision-making. Therefore, the creation of a systematic tracking framework will not only ensure the effective functioning of the operation but also positively influence project-related decisions.

Review of the Current Approach

Construction organizations continue to depend heavily on manual document and record management practices. Common procedures include printing documents, obtaining handwritten approvals, circulating files via email, and manually recording details in logbooks or spreadsheets before storing them in filing cabinets or shared digital drives.

Prior studies in records management and construction administration indicate that such approaches are time-consuming and heavily reliant on individual discipline and memory, which often results in delays, duplication of effort, and inconsistent record quality (ISO 15489, 2016; Smallwood & Venter, 2002).

From a technological perspective, manual systems lack automated tracking and real-time visibility. Documents can be duplicated, relocated, or modified without any systematic record, leading to fragmented information and the use of outdated versions.

Research on document management systems (DMS) consistently highlights the absence of version control and audit trails as a major weakness of paper-based and spreadsheet-driven processes (Love et al., 2016; Aziz & Tezel, 2017). Without a single source of truth, construction teams face difficulties in verifying which document version is current and approved.

Organizational challenges further exacerbate these issues. Manual recording practices are often non-standardized, resulting in inconsistent formats and unclear entries that reduce the usability of records. Approval workflows relying on physical signatures introduce additional delays, particularly in multi-project environments. Studies in construction information management report that decentralized storage across filing cabinets, shared drives, and personal devices significantly increases the risk of document loss, misplacement, and unauthorized access (Whyte & Hartmann, 2017; Alaloul et al., 2020).

Human factors represent another critical limitation of manual systems. Manual data entry is inherently prone to error, especially under time pressure and high workloads. Documents may be misplaced, removed without proper logging, or inadequately tracked, making accountability difficult to establish. Behavioural studies in construction management emphasize that reliance on individual memory rather than system-based controls often leads to incomplete records and reduced data reliability (Teo & Loosemore, 2014; Goh & Abdul-Rahman, 2013).

Collectively, these technological, organizational, and human-related weaknesses reduce operational efficiency, compromise data accuracy, and hinder accountability. Existing literature broadly agrees that manual record-keeping exposes organizations to higher operational and compliance risks, as physical documents are vulnerable to loss, damage, and unauthorized access, while system performance depends excessively on human behaviour (ISO 15489, 2016; Nguyen et al., 2021).

In contrast, research on digital document management systems reports more consistent and reliable outcomes. Digital platforms provide automated tracking of document access and modifications, enabling transparent audit trails that are not achievable through manual approaches. Standardized data structures improve accuracy, while real-time updates ensure that all stakeholders access the latest approved information. Studies in construction ICT demonstrate that these features significantly enhance traceability, coordination, and decision-making (Succar & Kassem, 2015; Love et al., 2019).

Digital systems also mitigate human error, a widely recognized major limitation of manual processes. Tools such as cloud-based databases, automated workflows, and integrated document management platforms allow documents to be created, stored, updated, and monitored within a single environment.

By consolidating the document lifecycle into one interconnected system, digital solutions improve efficiency, consistency, and reliability, making them more suitable for construction organizations managing high volumes of project documentation (Whyte, 2019; Alreshidi et al., 2020).TECHNOLOGICAL SOLUTION AND AVAILABLE TOOLS

From a design science research (DSR) perspective, the selection of appropriate technologies must be grounded in both theoretical justification and practical feasibility. In the context of hardcopy document management within construction organizations, technology selection should address clearly identified problems, namely, poor traceability, high error rates, lack of real-time visibility, and weak accountability, while remaining economically and operationally viable. Prior studies on construction information systems emphasise that technology adoption in the sector is often constrained by cost constraints, fragmented workflows, and limited digital maturity, particularly among small- and medium-sized firms (Whyte & Hartmann, 2017; Alaloul et al., 2020).

Justification of Core Technological Components

The proposed solution integrates three core technological components: a cloud-based database, a QR code or barcode identification mechanism, and a security and access control system. This combination is justified by its ability to directly address the identified problem classes while maintaining alignment with existing organisational capabilities.

Cloud-Based Database System

A cloud-based database is justified as the foundational component due to its ability to provide centralised, real-time, and standardised data management. Construction organisations increasingly use cloud platforms for digital file storage; however, the literature shows that these platforms are rarely extended to manage physical document workflows in a structured manner (Rezgui et al., 2013; Alreshidi et al., 2020). From a DSR standpoint, leveraging existing cloud infrastructure reduces implementation complexity and enhances organizational fit.

Empirical studies demonstrate that cloud-based systems improve data consistency, accessibility, and traceability, all of which are critical design requirements for effective document lifecycle management in construction projects (Marston et al., 2011; Whyte, 2019).

QR Code or Barcode Identification System

QR code and barcode technologies are selected as the primary identification mechanism due to their proven reliability, low implementation cost, and widespread adoption across asset-tracking domains. In contrast to manual search-based retrieval, code-based identification enables direct linkage between physical artefacts and digital records, significantly reducing retrieval time and ambiguity (Ashford & Hall, 2011; Chong et al., 2019). Compared to more advanced tracking technologies such as RFID, QR code, and barcode systems, these require minimal hardware investment and do not necessitate specialised tags or readers.

Although these systems rely on user compliance for scanning, prior studies indicate that their simplicity and compatibility with smartphones contribute to higher adoption rates in resource-constrained environments (Zhou et al., 2018; Whyte & Lobo, 2010).

Security and Access Control System

Security and access control mechanisms are justified as essential design elements due to the confidential nature of construction documents, which often include contractual, financial, and technical information. Research on construction information governance indicates that inadequate access controls increase the risk of data misuse, loss, and accountability gaps (Rezgui & Miles, 2010; Succar & Kassem, 2015).

Incorporating authentication mechanisms such as user logins or staff-based QR identification supports traceability by ensuring that all document interactions are attributable to authorised individuals. Within a DSR framework, this component satisfies the design requirements of accountability, auditability, and compliance

Comparative Evaluation of Alternative Technologies

A comparative evaluation of alternative technologies further supports the selection of the proposed solution. Spreadsheet-based tracking systems remain prevalent due to their low cost and familiarity; however, extensive literature confirms that such systems are highly susceptible to human error, lack real-time updating capabilities, and fail to support systematic audit trails (Pärn et al., 2017; Love et al., 2016). Consequently, they do not adequately address the core problem classes identified in this study.

RFID-based tracking systems offer automated, wireless identification capabilities and have demonstrated effectiveness in material and asset-tracking applications.

Nevertheless, their applicability to document management is limited by high initial costs, tag installation requirements, and susceptibility to signal interference in office environments (Lu et al., 2011; Wang et al., 2014). These constraints reduce their feasibility for widespread adoption in construction firms with limited digital investment capacity.

AI-based image recognition and edge detection systems represent a highly automated alternative, capable of identifying documents without predefined placement.

While technically advanced, studies indicate that such systems require substantial computational resources, controlled environments, and significant financial investment, making them impractical for routine document management in most construction organizations (Turk & Klinc, 2017; Bock & Linner, 2016).

In contrast, QR code and barcode-based systems provide a balanced solution that satisfies key DSR evaluation criteria, including utility, feasibility, and cost-effectiveness. Although they do not offer fully automated detection, their integration with cloud-based databases and access control mechanisms delivers substantial improvements in traceability, efficiency, and accountability at a comparatively low cost.

Consequently, this technological configuration is the most appropriate design choice for enhancing hardcopy document management in the construction industry.

Table 1: Comparative Analysis of Similar Tools

No.	Tools	Function	Advantages	Limitation
1.	Manually Excel Tracking System	Tracking files and documents using manually recording status.	• Very low cost • Familiar to staff • Flexible	• Not standardize • Highly error-prone • No real-time updating
2.	RFID Tracking System	Using radio frequency identification (RFID) to track the files and documents wirelessly.	• Wireless • Read multiple tags at the same time • Real-time updating	• High initial cost • Signal interference • Required tags
3.	Edge Detection of Images with an AI-based Algorithm	Using vision-based scanning with the calculation of AI to identify the location of files and documents.	• Automation detection • Files or documents can be placed randomly • Real-time tracking	• Very high initial cost • Sensitive to image quality • Possible to detect error
4.	QR code/ Barcode Scanning System	A file and document management system using a device to scan a QR code or barcode.	• Low in cost • More universal • Less human error	• No auto detection • Requires QR/barcode • Possible to forget to scan

System Process Flow and Functional Integration

The process flow illustrates the operational logic of the proposed QR/barcode-supported hardcopy document management system, which is structured around three integrated components: a cloud-based database, a QR/barcode identification mechanism, and a security and access control system.

The process diagram represents the intended functional scope of the system, specifically the recording and review of document status throughout the document lifecycle.

Before accessing any system functionality, users must pass through the security and access control layer. This authentication step is designed to protect the integrity and confidentiality of stored records by ensuring that only authorised personnel can interact with the database.

User access is linked to the organisation's staff identification system, thereby establishing accountability and ensuring that all actions performed within the system are traceable to verified company personnel.
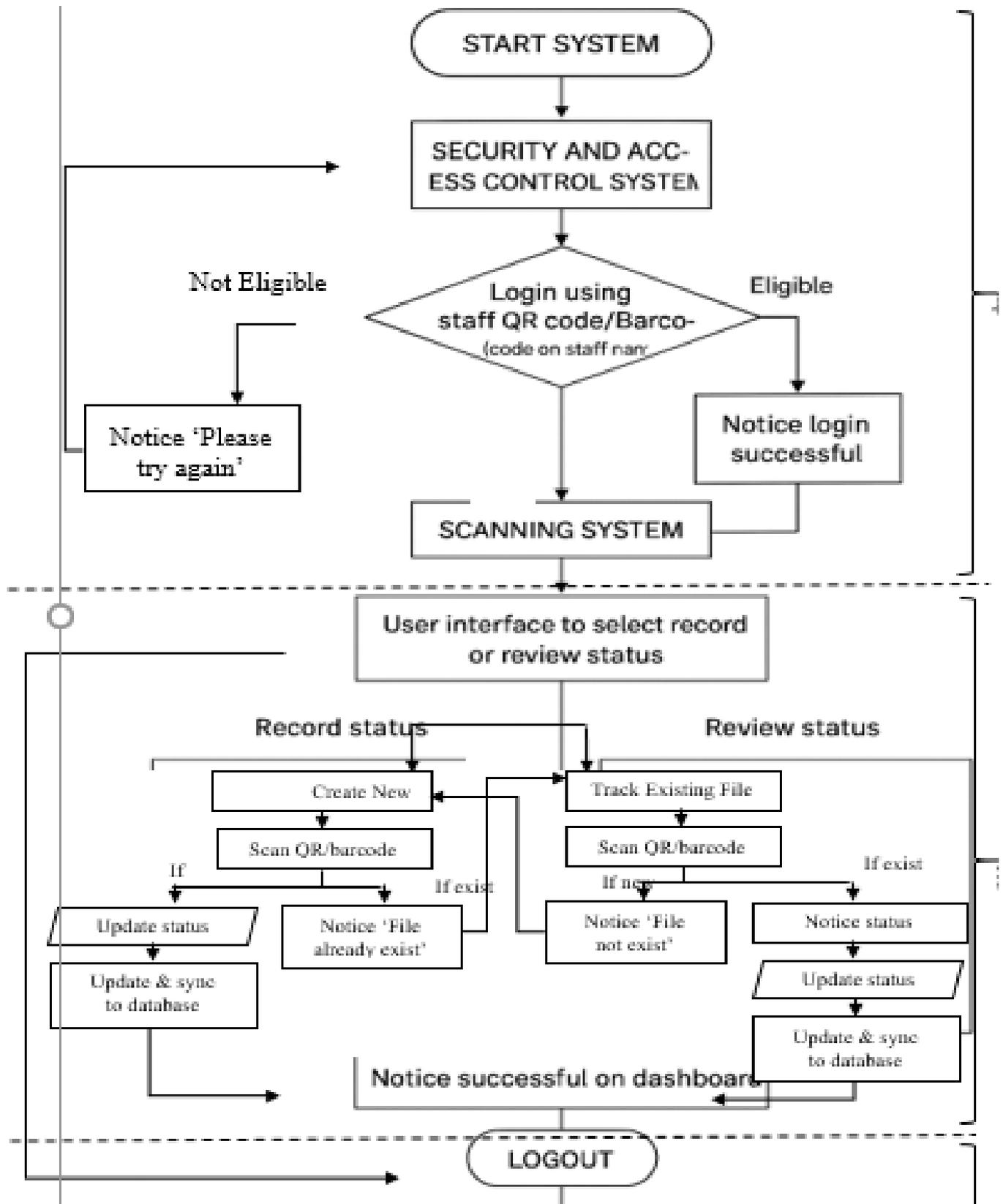

Figure 1: System Process Flow

Once authentication is successfully completed, users are granted access to the tracking functions supported by the cloud-based database. The system provides two primary operational capabilities: recording document status and reviewing existing document records.

New documents can be registered into the system through QR or barcode scanning, while existing documents can be retrieved and tracked using the same mechanism. Each scanning action updates the database in real time, and the system provides immediate feedback indicating whether the operation succeeded or failed.

Overall, the process flow demonstrates how the integration of security and access control, cloud-based data management, and QR/barcode identification collectively supports the reliable recording, tracking, and monitoring of hardcopy documents, as shown in Figure 1.

This integrated approach enhances traceability, reduces manual handling errors, and improves overall efficiency and accountability in hardcopy document management across construction organisations.

Proposed System Development

Digital Document Management and Tracking System is a conceptual proposal which employs the Systems Development Life Cycle (SDLC) methodology.

By this systematic approach, it is guaranteed that the suggested solution is technically feasible and in harmony with the organisation's operations.

The research is focused on the initial stages of SDLC i.e. System Investigation, Analysis, and Design, aimed at transforming the present manual document management process into a full digital workflow model.

The suggested design utilises cloud storage, automated routing, and barcode identification to enhance accuracy, transparency, and operational efficiency across departments.

Comparison Between the Current Process and the New Process

The organisation's document management is mostly manual or uses semi-digital workflows right now, as shown in the current process flowchart. Employees usually fill out forms, send emails, or use simple spreadsheets to make documents.

They then submit them either in person or as email attachments. Tracking relies on staff manually entering data into Excel sheets or physical logbooks.

They are stored in filing cabinets, shared drives, and personal folders, which are all separate from each other. Because these systems are not connected, they cause significant operational issues, such as slow information retrieval and duplicate records.

Also, accountability is often unclear because it takes a long time to identify the last handler, and if a paper form is thrown away before it is submitted, it leaves no trace, making it impossible to determine who created the document.
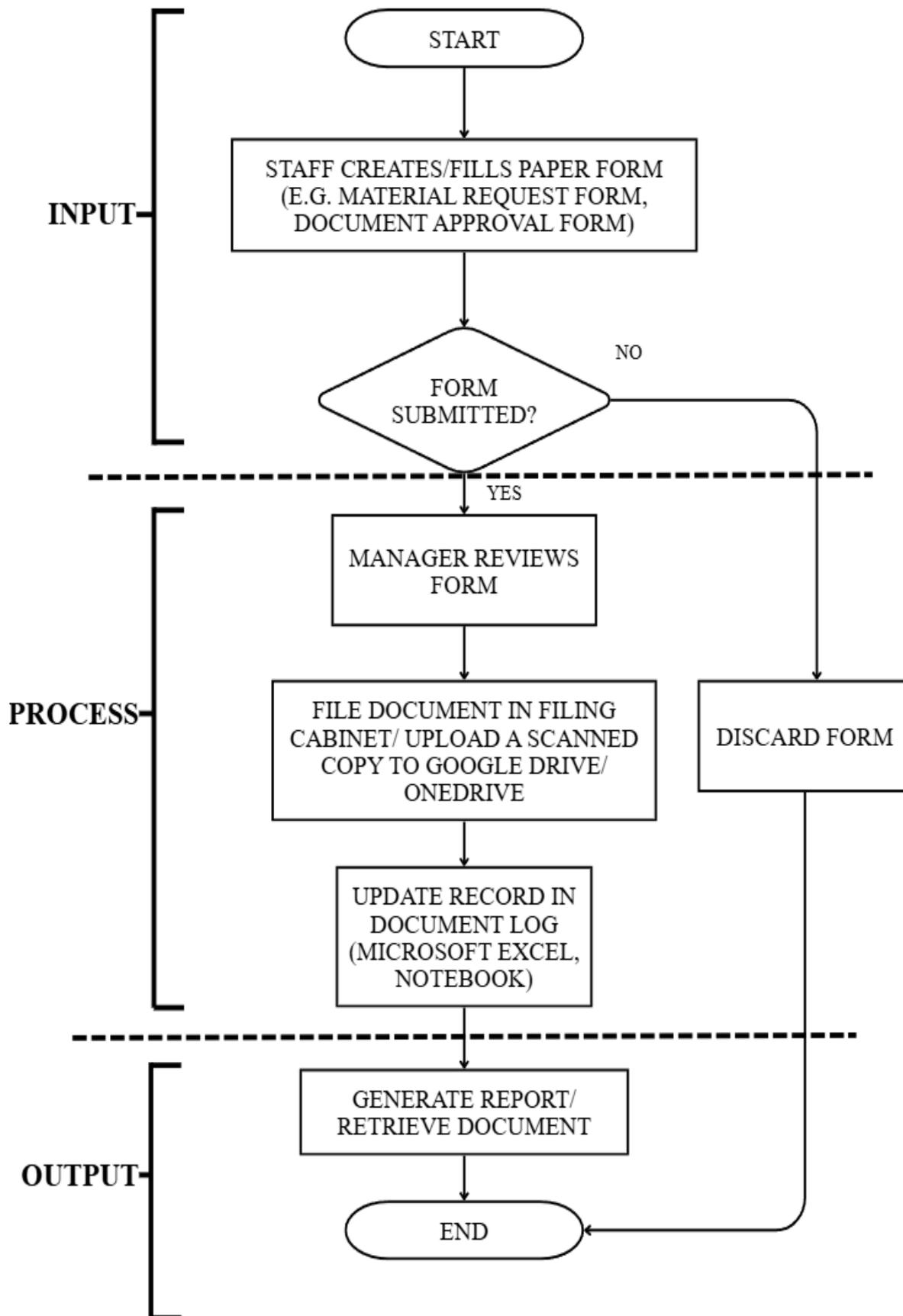
Figure 2: Flowchart of the Current Manual Document Tracking Process.

On the other hand, the suggested system adds a single workflow that can be accessed through a mobile app. The new system automates data entry and routing, directly resolving the mistakes and delays that come with manual processing. Users can scan unique barcodes to track documents immediately, preventing errors when manual

logging. As the flowchart shows, logical control points automatically handle exceptions. For instance, if a document cannot be found, they put it into "Search" mode, thus preventing the whole process from getting stuck. Furthermore, by storing all data in a cloud database, the system ensures there are no delays in updates and consequently reduces the time required to retrieve physical documents.
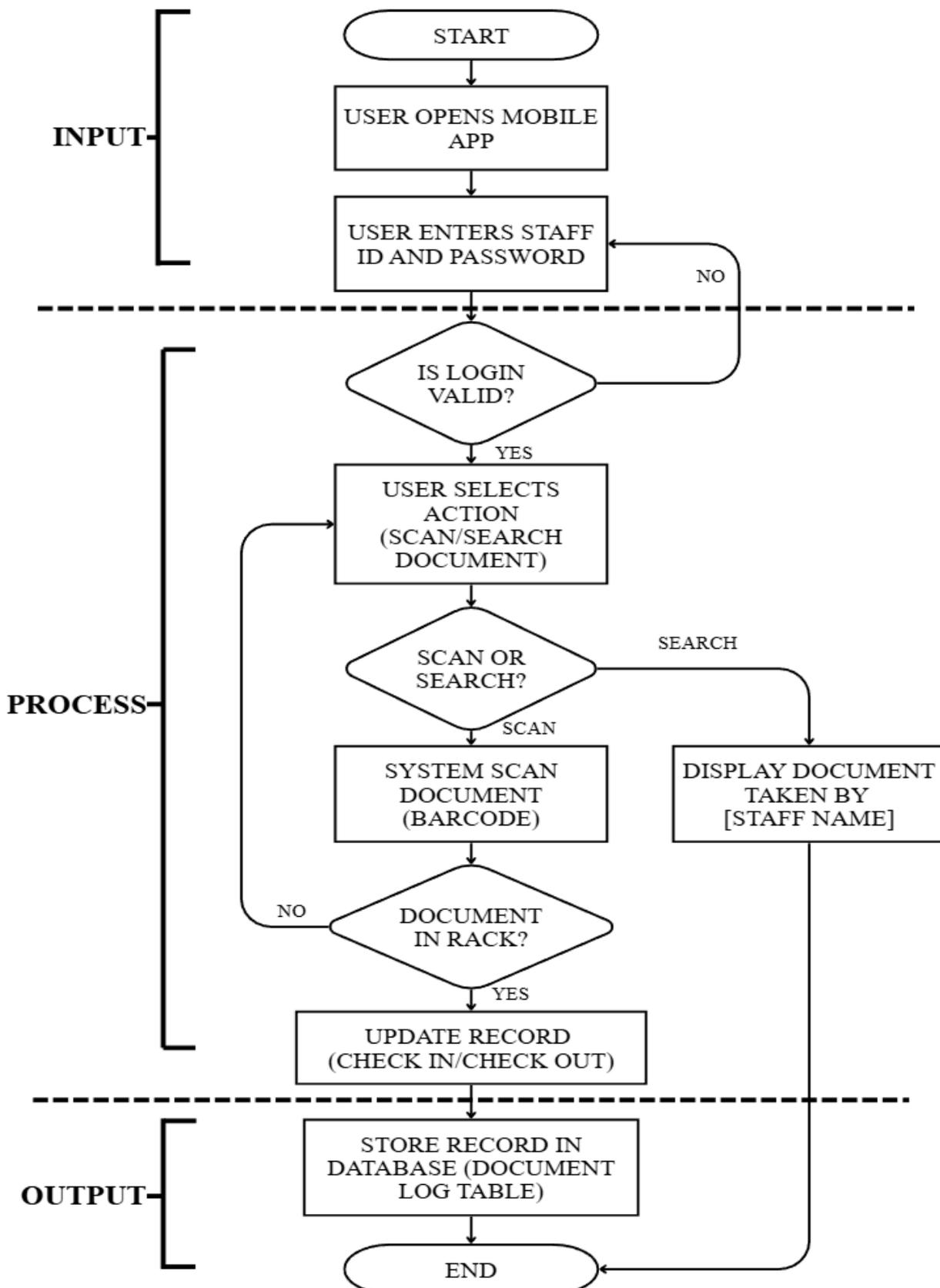

Figure 3: Flowchart of the Proposed Digital Management System.

Benefits of the Proposed System

The proposed system is designed to eliminate the difficulties and inconveniences posed by the current workflow. One of the main objectives of this project is to reduce operational time by eliminating manual data entry through automated routing and document status updates. The introduction of digital information workflows in the construction supply chain reduces throughput time and the number of human-factor errors. (Eadie et al., 2013) The addition of a "Search" feature essentially allow staff to retrieve documents more quickly than manually searching through physical files—the result is smoother daily operations.

Working in a centralised manner using cloud storage also promotes teamwork by ensuring data is easily accessible and systematically organised. The managers can monitor the progress of documents in real time via dashboards, which improves the quality of decisions made, as they are based on facts. Cloud platforms are essential for facilitating the flow of information and ensuring that all project participants have instant access to real-time data.(Redmond et al., 2012) The inclusion of automatically timestamped logs is also expected to enhance accountability, as it allows tracing every transaction back to its origin.

In conclusion, the transition from a paper-based to a digital system is not only environmentally friendly but also enhances the company's image as a modern corporate entity. The modernisation of the company's image, in turn, could lead to a reduction in operational costs associated with printing and physical storage, while helping the company fit into the current digital world. The use of such digital tools increases transparency and reduces unnecessary administrative burden, both of which are critical to the evolution of construction management.(Ibem & Laryea, 2014)

Limitations of the Proposed System

This study's main drawback is that the suggested solution remains a conceptual model and has not been applied or verified in a real-world construction project context. As a result, no empirical data on user satisfaction or system performance metrics was gathered. The advantages mentioned are speculative forecasts based on the system design, and the actual effect on the workflow would need to be confirmed through pilot testing and validation in an operational system.

Another point is that user acceptance and training for the implementation are still practical challenges the system must address. The whole process of transitioning to a digital workflow requires staff to learn new tools, which may cause some resistance or difficulty. The changeover may be very slow and, thus, lead to a loss of the system's initial effectiveness unless there are effective training programs and change management strategies.

Additionally, the financial and technical resources required for the initial setup might be a significant barrier. Software development, hardware acquisition, and ongoing cloud subscription fees can be quite high, especially for small companies. Furthermore, the digital system introduces the risk of technical instability; server downtime or network outages may affect operations, hence the need for robust technical support and strong data security measures to guarantee business continuity.

CONCLUSION

This paper has discussed the ongoing issues with the handling of hardcopy documents within the construction context and the necessity of a more structured and responsible solution that would be in line with the goals of Construction 4.0. Even though digitalisation has greatly changed the approach to information management in construction sectors, hard copies cannot be ignored as a result of legal, contractual, and regulatory acts. This generates the urgent disconnect between the digital transformation efforts and the continued use of physical documentation. The contribution of the study to the literature is that it conceptualises a planned structure of how digital tracking technologies can be integrated into the procedure of hardcopy documents and addresses an under-investigated field of digitally enabled construction environments. The results indicate that the implementation of digital monitoring systems in the physical document processes can make accountability, traceability, and decision-making easier, yet paper-based records will not be abandoned.

In addition to operational efficiency, there are wider implications of governance for the proposed framework. Following ISO 15489-1 (2016), high-quality records management involves ensuring these attributes are upheld throughout the document life cycle. Traceability is poor, and manual record-keeping processes increase governance vulnerability and compliance risks in construction projects that have high compliance burdens in terms of legal and regulatory implications. The lack of good monitoring over hardcopy documents can put organisations at risk of audit deficiencies, contractual losses, regulatory fines, and image damage. Hence, the suggested Digital Tracking and Monitoring System must not be considered as a technological improvement mechanism but rather as a risk mitigation mechanism that is driven by the government to operationalise a structured control, audit trail, and responsibility of the lifecycle.

In practice, the study provides construction organisations with a viable course of action for enhancing document management without the need to fully shift to digital documentation systems. The proposed approach is relatively cheaper and adjustable to the needs of organisations that might have different digital maturity than full digital transformation. However, the research suffers constraints due to its conceptualism and lack of empirical execution and stakeholder confirmation. Future studies ought to be conducted in terms of pilot deployment, user acceptance tests, and quantitative performance assessment to ensure the effectiveness of the system in the operational setting. More features, such as analytics, automation functionality, and smart document recognition, can also be further advanced to increase the scalability and long-term sustainability of hardcopy document management systems in the construction industry.

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