Blockchain Technology Adoption in Malaysia's e-Government Services: Insights from Case Studies and a Framework for Implementation

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Abstract—**This paper examines the adoption of blockchain technology in Malaysia's e-government services, providing empirical insights and a comprehensive framework to guide effective implementation. The primary objectives are to investigate current adoption trends, identify barriers and enablers, and propose a structured approach for policymakers and practitioners. Materials for the research include qualitative data collected from multiple case studies of key Malaysian government agencies that are currently piloting or deploying blockchain solutions. In addition, secondary sources, such as official government reports and policy documents, are analyzed for context. The methodology combines a qualitative case study approach with thematic analysis, enabling in-depth exploration of implementation processes, stakeholder perceptions, and challenges encountered. Data triangulation ensures the validity and reliability of findings. Results highlight varying degrees of blockchain integration across the studied agencies, with primary drivers including a pursuit of process transparency, improved data integrity, and enhanced public trust. Key challenges include technical infrastructure limitations, regulatory uncertainties, and stakeholder resistance to change. The proposed framework, synthesized from case findings, emphasizes leadership commitment, capacity building, stakeholder engagement, and iterative pilot testing. The study offers actionable recommendations for government bodies considering blockchain integration and underscores the need for context-sensitive strategies. It concludes with implications for further research, suggesting longitudinal studies to track adoption over time and evaluations of citizen-centric outcomes to refine implementation models.**

Keywords—**Blockchain technology; e-government services; implementation framework; case studies.**

I. INTRODUCTION

The rapid rise of digital technologies is driving governments to seek innovative ways to improve service delivery and public trust. Blockchain, with its secure and transparent record-keeping, offers significant potential for revolutionizing governmental processes, but its integration into e-government presents both opportunities and unique challenges. Malaysia's digital government initiatives, guided by MyDigital and the National Blockchain Roadmap, have launched blockchain pilots in land registration, procurement, and digital identity. Yet, adoption faces challenges, including technological readiness, regulatory uncertainty, resource constraints, and differing stakeholder acceptance factors that must be understood to ensure effective, scalable implementation. This paper analyzes blockchain integration in Malaysia's e-government through case studies of key agencies and develops a practical framework to guide policymakers and practitioners. It offers insights into digital transformation and suggests directions for future research in blockchain-enabled governance. Although blockchain promises increased transparency and trust in e-government, there is a notable lack of metrics for measuring its adoption and effective use in the public sector, resulting in inconsistent and largely unquantified implementation.

Existing research highlights critical challenges, including limited technological readiness, varying levels of stakeholder engagement, and unclear regulatory frameworks, which hinder the widespread adoption of blockchain technology in e-government [1]. Nonetheless, there remains a lack of comprehensive frameworks to assess the multiple dimensions of adoption in a structured manner. Developing a systematic

framework encompassing the technological, organizational, and socioeconomic dimensions is vital for effectively assessing and guiding the integration of blockchain into public administration. The literature review analyzed journals, books, articles, and websites on blockchain, e-government, adoption factors, and measurement frameworks to identify key influences on the uptake of blockchain in e-government. It also examined case studies of blockchain-based e-government services, identified their limitations, and used these insights to inform a framework for evaluating successful implementation.

Today, deep learning has demonstrated its ability to recognize and learn complex patterns for object detection, both living and non-living. Deep Learning is a subset of machine learning that involves algorithms that use a deep, hierarchically structured set of non-linear transformation functions to model high-level abstractions of data [5]. Many deep learning algorithms have been used in expression detection, among which convolutional neural networks (CNNs) are particularly popular. CNN algorithms have proven successful in detecting emotions from human' expressions, with the highest validation accuracy up to 98.65% [6]. Another deep learning algorithm widely used for object detection is YOLO. The YOLO algorithm has proven to be very good in detecting multiple types of objects, such as human activities, very quickly [7]. In addition, the newest version of YOLO, YOLOv11, is also used in early Diagnoses of Acute Lymphoblastic Leukemia [8]. YOLOv11 also achieves the fastest inference time on fruit detection with only 2.4 ms, although the best performance was achieved by YOLOv9 gelan-base and YOLOv9 gelan-e with a score of 93.5% in the same research [9].

There is one of the efforts to obtain optimal performance in the Convolutional Neural Network (CNN), like the YOLO model, by hyperparameter optimization involving epoch adjustment, batch size, and learning rate, as has been done in the study 3D printer error detection research using the YOLOv8 algorithm to find out the best configuration for the model to find improvements and different results from each configuration [10]. Based on prior related research, there is an opportunity to develop a faster model for detecting enthusiasm levels using YOLOv11 with hyperparameter optimization to achieve improved performance. This research aims to develop an enthusiasm detection model that recognizes the level of enthusiasm in online learning. This can help teachers monitor and acknowledge students' interests more quickly, enabling them to respond and adapt to students' needs more effectively.

A. Blockchain Technology: Research Landscape

Blockchain technology has rapidly evolved into a foundational innovation beyond cryptocurrency, increasingly shaping applications across sectors such as healthcare, supply chains, financial systems, and public governance. Recent systematic literature reviews highlight the broadening of blockchain research beyond early work focused on cryptocurrencies—especially Bitcoin—to emerging areas such as data privacy, security, scalability, operational efficiency, and usability [2], [3]. Notably, researchers find blockchain particularly valuable for its transparency, immutability, and its capacity to enhance trust in digital systems [4], [5]. Despite its potential, key challenges include technical immaturity, scalability bottlenecks, interoperability issues, and legal uncertainties, which continue to restrict widespread adoption—particularly in complex, multi-organizational environments [3], [5].

B. Digital Transformation in the Public Sector

Digital transformation in the public sector encompasses the integration of digital technologies to modernize workflows, improve citizen engagement, and increase transparency. Empirical studies reveal that successful transformation programs hinge on visionary leadership, inclusive change management, investment in technological infrastructure, staff skills enhancement, and cross-agency collaboration [6], [7], [8]. Key enabling technologies—such as artificial intelligence, the Internet of Things (IoT), big data analytics, and blockchain—have been found to elevate efficiency, service personalization, and accountability in public service delivery. Major obstacles include resistance to organizational change, legacy bureaucratic structures, data privacy concerns, and insufficient interoperability among government systems [9].

C. Global Trends in E-Government Innovation

Globally, countries at the forefront of e-government development—such as Denmark, Finland, South Korea, and Estonia—demonstrate success by combining clear digital strategies, robust infrastructures, strong cybersecurity, and a commitment to accessible, user-centric services [10], [11]. The COVID-19 pandemic prompted a surge in digital public service delivery and accelerated digital transformation agendas; however, progress remains uneven across regions, with developing countries facing pronounced digital divides and capacity gaps [11]. Innovative examples of global e-government include unified digital identity platforms, integrated e-payment systems, and comprehensive data-driven decision frameworks, with evaluation criteria focused on government-as-a-platform, user-driven design, openness, and proactive service provision [10], [11].

D. Blockchain and Digital Transformation in Malaysia

Malaysia's approach is characterized by an ambition for national leadership in the digital economy, articulated through strategic government roadmaps and inter-ministerial collaborations. The National Blockchain Roadmap 2021-2025 and the launch of the Malaysia Blockchain Infrastructure (MBI) reflect a coordinated effort to harness blockchain to enhance operational efficiency, transparency, and trust across public services, finance, the halal industry, and trade [12], [13]. Recent research analyzes how blockchain can remedy inefficiencies in government inter-organizational workflows, especially in e-payment systems, by streamlining processes, reducing delays, automating compliance, and enhancing trust among government agencies. Despite promising developments, challenges remain, including fragmented technical systems, a shortage of blockchain expertise, and evolving regulatory frameworks [12], [13].

II. MATERIALS AND METHODS

Empirical research on blockchain in e-government lacks comprehensive frameworks for measuring readiness and

success. This case study proposes a framework for identifying and analyzing key success factors for effective blockchain adoption, with the aim of advancing both academic knowledge and practical, citizen-centric e-government services. In this research, five (5) case studies from various government agencies have been selected to study and analyze the implementation of blockchain technology in Malaysia's e-Government services. Each case provides unique insights into the applications, challenges, and benefits of blockchain technology across diverse sectors in Malaysia. Each project also serves as a valuable example of how blockchain can address specific problems and deliver tangible results.

A. Case Selection

The case studies were selected to represent a diverse range of industries and government services currently exploring or implementing blockchain solutions in Malaysia. Selection criteria included project maturity, data availability, and the potential to generate valuable insights for other organizations considering blockchain adoption.

B. Data Collection

The study employed multiple data-collection methods, including document reviews of project plans, reports, and policy documents, to provide essential background and context for each project. Semi-structured interviews with key stakeholders—including project managers, technical experts, government officials, and industry representatives to provide insights into the challenges, successes, and overall perspectives of the blockchain projects. Participants were 10 senior IT managers and subject-matter experts from relevant government agencies, each with significant experience in digital government and at least 3 years of direct involvement in blockchain projects. All were actively engaged in blockchain adoption within their organizations.

C. Data Collection

A thematic approach was employed to identify common themes, patterns, and key insights across the various case studies. This method enabled a comprehensive understanding of the recurring elements and critical factors influencing blockchain adoption. Additionally, a comparative analysis was conducted to evaluate and contrast approaches to blockchain implementation, thereby identifying best practices and exploring shared challenges across projects. To ensure a structured and systematic assessment, existing frameworks related to blockchain adoption and success factors were applied to analyze the data. This approach facilitated a thorough evaluation of each case study within a broader conceptual context, ultimately providing valuable insights into effective strategies and potential obstacles.

D. Validation

Draft versions of the case studies were reviewed by key stakeholders for each project to ensure accuracy and completeness. Feedback received from these stakeholders was thoughtfully incorporated into the final versions, helping to ensure that the case studies accurately reflected the projects and provided reliable insights.

E. Limitation

The findings are based on a limited number of case studies and may not be applicable to all blockchain implementations across Malaysia. Furthermore, data collection depended on self-reported information from stakeholders, which could introduce biases or inaccuracies. Additionally, the fast-paced, continuously evolving nature of blockchain technology may limit the long-term validity of certain findings, as new developments could alter the context or effectiveness of the solutions studied.

F. Significance

These case studies provide valuable insights into the real-world applications of blockchain technology in Malaysia and can inform future initiatives and policy decisions related to blockchain adoption. By documenting the successes and challenges of these projects, this research aims to contribute to a better understanding of the potential of blockchain to transform government services and industries.

G. Case Description

1) Case Study 1-MyWalet: MyWalet's project, implemented by the Department of Veterinary Services (DVS), focuses on enhancing the security and traceability of swiftlet nests. The blockchain system tracks the production activities of walet's nests until exportation to China. It is also a requirement of the Chinese authorities for importers to ensure product quality and improve transparency. The challenges identified include initial compliance issues with importer requirements and the need for robust infrastructure to handle high transaction volumes. Their initial solutions involved providing sufficient reporting data for budget allocation to enhance infrastructure and ensuring regular follow-up with China's authorities to fulfil their export requirements. The outcomes of this project included compliance with international standards and improved confidence in nest quality. A key lesson learned during the project's development was to start small and scale up gradually for future projects.

2) Case Study 2-Vaccine Management System (VMS): The Ministry of Health (MOH) implemented the VMS system to improve vaccine traceability and management within the National Covid-19 Immunization Program (PICK). The system aimed to ensure the quality, prevent fraud, and increase the efficiency of the vaccination process. During the project development phase, challenges centered on the complexity of integrating with existing systems, gaining public trust, and managing the technical complexities of blockchain technology. MOH's approach to addressing each challenge is to provide comprehensive reports and data to support budget allocation and ensure that integration costs are covered. MOH has also been providing technical support for training in blockchain technology. They also used the centralized data center infrastructure provided by the National Digital Department to support the complex integration with the existing system. By implementing blockchain technology, MOH has prevented the illicit distribution of vaccines and the issuance of fraudulent vaccination certificates. MOH also learned that it is necessary to emphasize the importance of

considering data privacy and anticipating technical challenges that arose during the development phase.

3) Case Study 3-Halal Blockchain Network (HBN): The Department of Islamic Development Malaysia (JAKIM) utilized HBN to increase transparency and security in the halal food supply chain. They aimed to ensure the authenticity of halal products and enhance consumer confidence, thereby increasing purchase intention. During the development and implementation phases, JAKIM faces challenges in ensuring alignment and conformity with global halal standards. Challenges also include addressing public concerns about the product's halal status. JAKIM's technical team also needs to manage technological demands within a constrained budget. To overcome these challenges, JAKIM needs to provide robust reporting to top management to secure the project's budget allocation. JAKIM also enhances the skills of its technical support staff by sending them to system-specific training courses. Since the National Digital Department already has a well-equipped, centralized data center, JAKIM has also been utilizing the infrastructure provided by NDD. Adopting blockchain could enhance transparency in halal certification and reduce fraud. JAKIM also recognized the need for cross-agency collaboration in its current process and should consider data privacy measures.

4) Case Study 4-Ship Registry System (LESA): The Malaysia Marine Department (MMD) implemented LESA to enhance traceability and safety in the ship registration process. This blockchain system was designed to enable faster, more efficient transactions in vaccine management, thereby enhancing transparency. During implementation, MMD faced difficulties in assessing the system because the inspection was conducted outside Malaysia's water sector. Thus, LESA requires a robust application and network infrastructure to support its daily operations. MMD has also been utilizing the National Digital Department's centralized data center to support its system. LESA is expected to increase transparency in the Non-Fungible Token (NFT) issuance process. It could minimize processing costs, as no third party could be involved in the NFT application by the ship's owner. Throughout the project life cycle, MMD also recognized the need to enable real-time updates to the ship's registries and related information, allowing the enforcement division to access the latest information for rapid decision-making.

5) Case Study 5-Customs Authorized Economic Operator Chain (AEOChain): AEOChain, implemented by the Royal Malaysian Customs Department (RMCD), aimed to improve the security and traceability of permit issuance for authorized economic operators. The blockchain-based system improved the efficiency of import/export declarations, reduced fraudulent activities, and empowered users. Prior to blockchain implementation, RMCD is unable to verify the integrity of the permit, thereby making it impossible to combat fraud.

During the development phase, RMCD must ensure full participation by various government agencies that issue import and export permits for their controlled goods. Given the importance of maintaining the AEOChain, RMCD focuses on system upkeep and dispatching its technical support teams

to strengthen its expertise in blockchain technology. By implementing AEOChain, the process of handling imports and export permits becomes easier and improves the team's overall efficiency.

III. RESULTS AND DISCUSSION

This chapter presents the results of an in-depth analysis of the adoption of blockchain technology across key e-Government services in Malaysia. Drawing from multiple case studies—including MyWallet, the Vaccine Management System (VMS), Halal Blockchain Network (HBN), Ship Registry System (LESA), and Authorized Economic Operator Chain (AEOChain)—we synthesize the practical impacts, benefits, and challenges associated with blockchain integration in the Malaysian public sector. Each project encompasses a distinct spectrum of service delivery and regulatory requirements, providing a rich landscape for assessing the real-world impact of blockchain. A detailed examination of these initiatives highlights recurring themes in adoption strategies, critical enablers, and persistent barriers.

A. Cross-Case Thematic Analysis

The Cross-Case Thematic Analysis compares multiple Malaysian e-Government blockchain projects to identify common patterns, challenges, and enabling factors. By synthesizing insights from diverse case studies, it highlights shared benefits, obstacles, and strategic lessons to inform best practices and guide broader, scalable blockchain adoption in the public sector.

B. Key Benefits Observed

By reviewing multiple case studies, we identify key benefits of blockchain in the public sector: improved security, greater transparency, enhanced traceability, increased efficiency, and stronger stakeholder trust—all of which contribute to resolving common service-delivery challenges. The key benefits are as follows.

1) Security: All projects demonstrated improvement in security and data integrity, reducing fraud and unauthorized interference.

2) Traceability & Transparency: Blockchain's immutable ledger improved traceability across supply chains and service delivery workflows.

3) Operational Efficiency: Automated validation, reduced paperwork, and faster transaction times yielded measurable efficiency gains.

4) Stakeholder Empowerment: Digital identities and transparent processes fostered greater confidence among users, customers, and international partners.

C. Common Challenges

This subsection identifies the main challenges affecting blockchain adoption in Malaysia's e-Government, including technical resource shortages, integration difficulties, infrastructure requirements, and regulatory constraints. Recognizing these hurdles is crucial for developing strategies to support broader and more sustainable blockchain implementation in the public sector. The common challenges are:

1) Technical Resource Constraints: Shortages of blockchain professionals and the need for ongoing training.

2) Integration Complexities: Difficulty aligning new blockchain solutions with legacy systems and multi-agency mandates.

3) Infrastructure Demands: Requirement for robust, scalable national digital infrastructure to support high transaction volumes.

4) Privacy & Regulation: Ensuring data privacy, regulatory compliance, and stakeholder alignment across sectors.

D. Key Enablers and Solutions

This subsection highlights the main factors enabling successful blockchain adoption in Malaysia's e-Government, including practical solutions for common obstacles. The enablers are as follows:

1) Pilot Programs: Starting with small-scale pilots enabled refinement and stakeholder buy-in before full-scale rollout.

2) Cross-Agency and Cross-Border Collaboration: Successful projects engaged multiple governmental or international bodies for standardization and integration.

3) Centralized Support: Utilizing centralized digital platforms provided by national authorities streamlined infrastructure management and resource sharing.

Below is the comparative summary table of the case studies:

TABLE I
COMPARATIVE SUMMARY TABLE

Case Study	Critical Success Factors							
	CSF 1	CSF 2	CSF 3	CSF 4	CSF 5	CSF 6	CSF 7	CSF 8
1	✓	✓	✓	✓	✓	✓	✓	
2	✓			✓	✓	✓	✓	
3	✓	✓		✓	✓	✓	✓	
4	✓			✓		✓	✓	✓
5	✓			✓		✓	✓	✓

where the relevant CSF is CSF 1: Security. CSF 2: Regulation/Standard CSF 3: Integration. CSF 4: Cost CSF 5: Trust. CSF 6: Blockchain Skills. CSF 7: Technology Infrastructure, and CSF 8: Cross Agency Collaborations.

E. Proposed Framework for Implementation

To support effective blockchain adoption in Malaysia's e-Government, this chapter presents a tailored hybrid framework based on case studies and leading technology adoption models. The framework integrates UTAUT, TOE, and IS Success models, bridging theory with practical strategy and addressing three key rationales:

1) Integrated Explanatory Power: Combining individual, organizational, and system perspectives to capture multi-dimensional factors driving adoption.

2) Broader Measurement: Covering a wide range of determinants—policy, management, engagement, infrastructure—for robust, context-specific assessment.

3) Contextual Flexibility: Adapting to Malaysia's dynamic e-government environment, supporting customized and strategic blockchain implementation. The hybrid framework offers a practical, research-informed foundation for Malaysia's ongoing modernization agenda, enabling effective blockchain adoption and higher-quality e-government services for citizens. Figure 1 is the proposed framework for this paper:
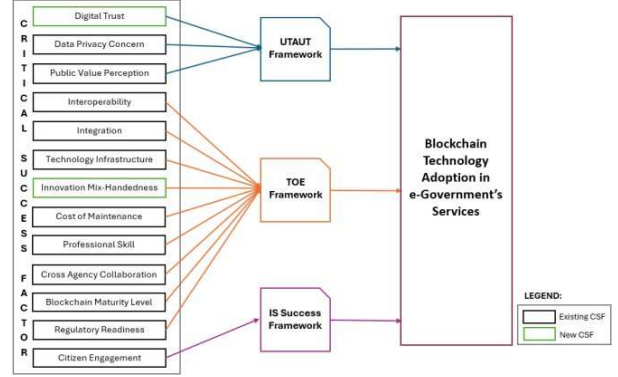

Fig. 1 Proposed Framework

F. Implications for Policy and Practice

Blockchain adoption in Malaysia's e-government brings both opportunities and challenges. Drawing on case studies and a measurement framework, this chapter provides practical recommendations and guidance to help policymakers and practitioners address regulatory, organizational, and technological barriers for effective public service transformation. The implications are as follows:

1) Strengthening Regulatory and Legal Readiness: Blockchain adoption in e-government exposes regulatory gaps around data privacy, interoperability, and inter-agency collaboration. Updating legal frameworks, aligning with international standards, and ensuring regulatory clarity are essential. Ongoing audits and agile legislative updates could maintain trust and compliance amid technological change.

2) Investment in Technology Infrastructure and Skills Development: Effective blockchain implementation requires strong IT infrastructure and skilled personnel. Policymakers should invest in resilient, scalable systems for key services and provide ongoing training to upskill staff and attract blockchain talent to the public sector.

3) Fostering Cross-Agency and Stakeholder Collaboration: Successful blockchain projects in e-government depend on cross-agency integration and collaboration with external partners. Policies should promote shared governance and data ecosystems, while pilot projects and sandboxes encourage teamwork, innovation, and engagement with industry and civil society.

4) Building Trust and Enhancing Value Perception: Building public trust is key to blockchain adoption. Policymakers should clearly communicate the benefits, address security and privacy concerns, and solicit citizen feedback to inform continuous improvement. Regularly tracking trust and engagement metrics could help refine policies and services.

5) Continuous Monitoring, Evaluation, and Adaptive Governance: The framework enables continuous measurement and benchmarking of blockchain adoption. Policymakers should require regular KPI-based evaluations to support evidence-based decision-making, while adaptive governance with feedback loops ensures responsive, up-to-date policy improvements. The measurement framework developed could provide a practical tool for tracking progress, diagnosing challenges, and guiding adaptive, high-impact digital transformation.

G. Future Research and Directions

This chapter outlines promising avenues and priorities for future research, designed to build on current findings and further inform effective adoption of blockchain in e-government services.

1) Longitudinal and Cross-Agency Studies: Current research is often limited to pilot projects or short-term evaluations. Future studies should also conduct longitudinal research to monitor project sustainability, user adoption, and outcomes over time.

2) Expanding Stakeholder Perspectives: While existing case studies prioritize government officers and technical experts, future research should also integrate diverse stakeholder voices, including citizens, civil society, business users, technology vendors, and regulatory agencies.

3) Innovation and Integration Research: Blockchain's full value in e-government is often realized through integration with other digital technologies. Future work should consider examining multi-technology adoption, including blockchain with AI, quantum computing, and big data analytics.

4) Policy, Regulation, and Governance: As regulatory clarity lags behind technological innovation, research is needed to analyze evolving policy and legal frameworks and their impact on blockchain adoption and innovation. It could also provide guidance on governance models, including public-private partnerships, data stewardship, and risk management in blockchain-enabled services.

5) Addressing Practical and Technical Barriers: Research is still needed to address persistent technical and organizational challenges, such as enhancing the scalability, security, and sustainability of blockchain platforms. It could also build sustainable professional skills pipelines and organizational change readiness across the public sector.

Future research should remain adaptive and multidisciplinary to capture the changing digital landscape, support strategic decision-making, and foster regional digital leadership.

IV. CONCLUSION

This study analyzes blockchain adoption in Malaysia's e-government through five major case studies, identifying key technological, organizational, and environmental factors for successful integration. The research proposes a robust, empirically validated measurement framework tailored to Malaysia's public sector, guiding policy and practice with context-sensitive indicators. While blockchain offers benefits like transparency and efficiency, challenges remain in regulation, privacy, skills, and integration. The framework supports ongoing evaluation, adaptive policymaking, and stakeholder engagement, positioning Malaysia as a regional leader and laying the groundwork for wider blockchain-enabled public service transformation.

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