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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 aims to examine the adoption of blockchain technology within Malaysia's e-government services, offering 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 involving key Malaysian government agencies currently piloting or deploying blockchain solutions. Supplementing this, 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, allowing for in-depth exploration of implementation processes, stakeholder perceptions, and encountered challenges. Data triangulation ensures the validity and reliability of findings. Results highlight varying degrees of blockchain integration across studied agencies, with primary drivers including a quest for process transparency, improved data integrity, and enhanced public trust. Key challenges are identified as 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.**

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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. However, adoption faces challenges including technological readiness, regulatory uncertainty, resource limits, and differing stakeholder acceptance-factors that must be understood for effective, scalable implementation. This paper analyzes blockchain integration in Malaysia's e-government through case studies of key agencies, developing a practical framework to guide policymakers and practitioners. It offers insights for 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 measurement regarding its adoption and effective use in the public sector, leading to 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 is still a lack of complete and extensive measuring frameworks that can assess these multiple dimensions of adoption in a structured manner. Developing a systematic framework covering technological,

organizational, and socio-economic aspects is vital for effectively assessing and guiding blockchain integration in public administration.

The literature review analyzed journals, books, articles, and websites on blockchain, e-government, adoption factors, and measurement frameworks to understand key influences on blockchain uptake in e-government. It also examined case studies of blockchain-based e-government services, identifying their limitations and using these insights to inform a framework for evaluating successful implementation.

Nowadays, deep learning has shown its ability to recognize and learn complex patterns in detecting various objects, 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 the expression detection process, among which the convolutional neural network (CNN) algorithm is quite popular. CNN algorithms have proven successful in detecting emotions from humas's expressions with the highest validation accuracy up to 98.65% [6]. Another deep learning algorithm that is widely used in the detection of various objects is YOLO. 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 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 previous related research, there is an opportunity to create a faster enthusiasm level detection model using YOLOv11 with hyperparameter optimization to achieve more accurate performance results. This research aims to develop an enthusiasm detection model that recognizes the level of enthusiasm in online learning. This will help teachers monitor and acknowledge their students' interests more quickly, enabling them to respond and adjust to students' needs more easily.

A. Blockchain Technology: Research Landscape

Blockchain technology has rapidly evolved as a foundational innovation beyond cryptocurrency, increasingly shaping applications in various sectors such as healthcare, supply chain, financial systems, and public governance. Recent systematic literature reviews highlight the broadening of blockchain research from early work concentrated on cryptocurrencies—especially Bitcoin—to emerging areas including data privacy, security, scalability, operational efficiency, and usability [2], [3]. Notably, researchers find blockchain especially valuable for its transparency, immutability, and ability 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 in 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 drive to harness blockchain for 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 in the form of fragmented technical systems, shortage of blockchain expertise, and evolving regulatory frameworks [12], [13].

II. MATERIALS AND METHOD

Empirical research on blockchain in e-government lacks comprehensive frameworks for measuring readiness and success. This case study proposes a framework to identify and

analyze key success factors for effective blockchain adoption, aiming to advance 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 analyse the implementation of blockchain technology in Malaysia's e-Government services. Each cases contributes unique insights to understanding 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 the maturity of the project, the availability of data, and the potential for generating valuable insights for other organizations considering blockchain adoption.

B. Data Collection

The study used multiple methods for data collection, including document review 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 provided 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 digital government experience and at least three years directly involved 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 different approaches to blockchain implementation, allowing for the identification of best practices and the exploration of shared challenges faced by each project. 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 involved in each project to ensure their 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 and continuously evolving nature of blockchain technology may constrain 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 blockchain's potential 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 by the authority of China as importer to ensure the quality of the product and improve transparency for importer.

The challenges identified including 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 the infrastructure and making sure a regular follow up with China's authority to fulfil their export requirement is met.

The outcomes of this project included compliance with international standards and improved confidence in nest quality. A key lesson learned during the development of the project was to start small and scale up gradually for their future project.

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 vaccine's quality, preventing 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 on handling each challenge by providing comprehensive reports and data for the budget allocation to make sure the integration costs are covered. MOH also has been sending their technical support for training which focus on blockchain technology. They also used the centralized data center infrastructure provided by the central agency which is National Digital Department to cater for the complex integration with existing system. By implementing blockchain technology, MOH has been able to prevent illegal vaccines and the issuance of false vaccination

certificates. MOH also learned that it is necessary to highlight the importance of considering data privacy and anticipating other technical challenges that occurred 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 guarantee the authenticity of halal products and enhance consumer confidence and thus will increase power of purchase.

During the development and implementation phases, JAKIM faces challenges in ensuring alignment and conformation with global halal standards. Challenges also include in addressing public trust over their concerns on the halal product status. JAKIM technical team also needs to manage the technological demands with lower budget. To overcome the challenges, JAKIM needs to provide solid reporting to the top management which will secure the budget allocation on the project. JAKIM also enhances the skills of their technical support by sending them to courses which will help in supporting the system. Since the National Digital Department has already a proper and equipped centralized data center, JAKIM also has been utilizing the infrastructure provided by NDD. By adopting blockchain, it will improve and increase transparency in halal certification and reduced fraud. JAKIM also learned that there is a need for cross-agency collaboration in their current process and should be considering data privacy measures.

4) Case Study 4: Ship Registry System (LESA)

Malaysia Marine Department (MMD) implemented LESA to improve the traceability and safety of the ship registration process. This blockchain system aimed to provide faster and more efficient transactions on managing the vaccine thus will enhance transparency.

During implementation, MMD faced difficulties in assessing the system since inspection is done outside Malaysia's water. Thus, LESA in need of robust application and network infrastructure to support their daily operations. MMD also has been utilising the National Digital Department centralized data centre to support their system. LESA is expected to increase transparency of the Non- Fungible Token (NFT) issuance. It will also minimize the processing cost since no third party will be involved in the application of NFT by ship's owner. Through the project life cycle, MMD also learned the need to enable real time update of ship's registries and information, allowing the enforcement division to access the latest information for quick decision making.

5) Case Study 5: Custom's 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 declaration, reduced fraudulent activities, and empowered users. Prior to blockchain implementation, RMCD are unable to verify the integrity of the permit thus it makes it impossible to combat fraud.

During the development phase, RMCD must also ensure full participation from various government agencies that also produce import and export permits for their controlled goods. Since maintaining the AEOChain is crucial, RMCD focus on maintaining the system and sending their respective technical support teams to improve their strength in blockchain technology. By implementing AEOChain the overall process of handling imports and export permit becomes easier and improved efficiency of the overall team.

III. Results and Discussion

This chapter presents the results and findings from an in-depth analysis of blockchain technology adoption across key e-Government services in Malaysia. Drawing from multiple case studies—including MyWalet, 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 encapsulates a different spectrum of service delivery and regulatory requirement, offering a rich landscape to assess the real-world impact of blockchain. Detailed examination of these initiatives highlights recurring themes in adoption strategy, 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, better traceability, increased efficiency, and stronger stakeholder trust—all contributing to resolving common service delivery challenges. The key benefits are;

- *Security:* All projects demonstrated improvement in security and data integrity, reducing fraud and unauthorized interference.
- *Traceability & Transparency:* Blockchain's immutable ledger improved traceability across supply chains and service delivery workflows.
- *Operational Efficiency:* Automated validation, reduced paperwork, and faster transaction times yielded measurable efficiency gains.
- *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 impacting blockchain adoption in Malaysia's e-Government, including technical resource shortages, integration difficulties, infrastructure needs, and regulatory issues. Recognizing these hurdles is crucial for developing strategies to support broader

and more sustainable blockchain implementation in the public sector. The common challenges are:

- *Technical Resource Constraints:* Shortages of blockchain professionals and the need for ongoing training.
- *Integration Complexities:* Difficulty aligning new blockchain solutions with legacy systems and multi-agency mandates.
- *Infrastructure Demands:* Requirement for robust, scalable national digital infrastructure to support high transaction volumes.
- *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;

- *Pilot Programs:* Starting with small-scale pilots enabled refinement and stakeholder buy-in before full- scale rollout.
- *Cross-Agency and Cross-Border Collaboration:* Successful projects engaged multiple governmental or international bodies for standardization and integration.
- *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 are:
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:

- *Integrated Explanatory Power:* Combining individual, organizational, and system perspectives to capture multi-dimensional factors driving adoption.
- *Broader Measurement:* Covering a wide range of determinants—policy, management, engagement, infrastructure—for robust, context-specific assessment.
- 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:

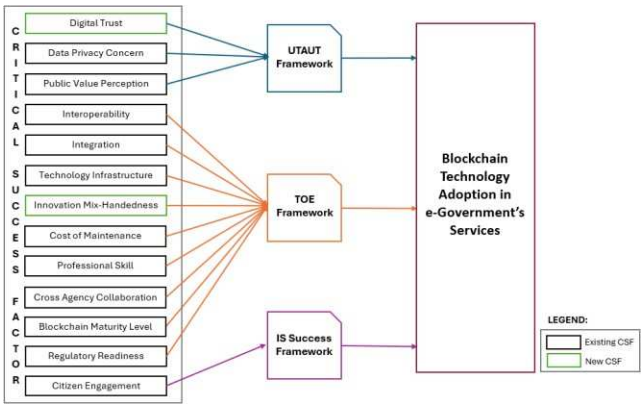

Fig. 1 Proposed Framework

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;

- *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 will maintain trust and compliance amid technological change.
- *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.
- *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.
- *Building Trust and Enhancing Value Perception:* Building public trust is key to blockchain adoption. Policymakers should clearly communicate benefits,

address security and privacy concerns, and gather citizen feedback to guide continuous improvement. Regularly tracking trust and engagement metrics will help refine policies and services.

- *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 decisions, while adaptive governance with feedback loops ensures responsive, up-to-date policy improvements.

The measurement framework developed will provides 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 blockchain adoption in e-government services.

- *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.
- *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.
- *Innovation and Integration Research:* Blockchain's full value in e-government is often realized through integration with other digital technologies. Future work should consider to examine multi-technology adoption, including blockchain with AI, quantum computing, and big data analytics.
- *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 will also provide guidance on governance models, including public-private partnerships, data stewardship, and risk management in blockchain-enabled services.
- *Addressing Practical and Technical Barriers:* Research is still needed to address persistent technical and organizational challenges, such as enhancing scalability, security, and sustainability of blockchain platforms. It will 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 groundwork for wider blockchain-enabled public service transformation.

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