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Article

Designing the Blockchain-Integrated Collaborative E-Payment Framework: A Philosophical Reflection

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ABSTRACT - This study is a philosophical and methodological reflection on the development of a Blockchain-Integrated Collaborative E-Payment Framework (BICEF) within the Transport License Department of Malaysia. Grounded in an interpretivist paradigm, this study employs the Design Science Research (DSR) approach. This study addresses persistent inter-organisational collaboration workflow challenges in public sector e-payment, including system fragmentation, manual reconciliation, inconsistent enforcement of service-level agreements and reliance on informal communication practices. This study is guided by the Context, Intervention, Mechanism and Outcome (CIMO) logic, which adopts a socio-technical lens and recognises the need for technological solutions. It needs to be contextually adapted to organisational realities shaped by human agency and institutional dynamics. A proof of concept (PoC) dashboard was developed using simulated data to demonstrate key blockchain features, including real-time reconciliation, smart contract-based service level agreement automation and inter-agency ledger transparency. Through qualitative case study inquiry comprising interviews, focus group discussions and expert validation, the research applied abductive reasoning and iterative design evaluation cycles to produce a contextually embedded artefact. The findings show that BICEF improves operational efficiency, strengthens inter-agency trust and supports Malaysia's broader public sector digital transformation agenda. This study contributes to the DSR discourse by combining interpretive paradigm, socio-technical insights and practice-oriented artefact development. It also offers a methodological pathway for designing digital solutions in complex institutional settings. Future studies are recommended to test BICEF's scalability across other government agencies and evaluate its long-term impact through real-world implementation.

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INTRODUCTION

The digital transformation initiatives have increasingly been sought to improve public service delivery, enhance inter-agency coordination and improve public engagement (Economic Planning Unit, 2021). The critical domain undergoing such transformation is the payment system. Government agencies in Malaysia were forced to implement electronic payment (e-payment) for public convenience, transparency and security (Unit Pemodenan Tadbiran dan Perancangan

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Pengurusan Malaysia (MAMPU), 2021). Despite the benefits of the e-payment, there are persistent challenges to inter-organisational collaboration (IOC) workflow. In 2022, the Auditor General reported discrepancies in the service delivery of acquiring banks and collection agents (Jabatan Audit Negara Malaysia, 2022). The report specifically identified failures of the acquiring bank and collection agent to remit collected funds within the stipulated time as mentioned in the service level agreement (SLA). The Transport License Department (TLD) is one of the agencies highlighted in the report. As illustrated in Table 1, between 2021 and 2022, TLD experienced delayed remittances amounting to RM38.9 million, which resulted in penalty charges totalling RM1.56 million imposed on the responsible collection agent and acquiring bank. Therefore, the TLD stands as a salient example of the challenges in IOC workflow in the e-payment process. Existing back-end e-payment processes are often fragmented, largely manual and prone to delays and operational inconsistencies, especially in the interactions between the TLD, the acquiring bank (AB) and the accounting office (AO) (Khairi et al., 2025).

Table 1: Late revenue remittance for the Transport License Department

Year	Amount (RM) in million	Delay in days	Penalty (RM) in million
2021	10.52	01 to 08	0.42
2022	28.42	06 to 12	1.14
Total	**38.94**		**1.56**

Source: Jabatan Audit Negara Malaysia (2022)

In recent years, several emerging technologies such as artificial intelligent (AI), cloud computing, robotic process automation (RPA) and blockchain technology (BCT) have been identified to improve IOC workflows (Baiod & Hussain, 2024; Ilin et al., 2017; Khairi et al., 2025; Mujahid, n.d.; Zhang et al., 2020). However, BCT has been identified as a suitable solution to improve IOC workflow. This is due to its unique features, including transparency, immutability, traceability and enhanced security (Saadan et al., 2024). Hence, in this study, the researcher proposes developing a Blockchain-Integrated Collaborative E-Payment Framework (BICEF) to address these challenges.

Nevertheless, developing BICEF is part of the socio-technical design challenge. This study articulates its research philosophy and methodological foundations of Design Science Research (DSR), that embedded with a qualitative case study as research inquiry. Socio-technical challenges in DSR arise from the inherent complexity of integrating human, organizational and technological factors in the creation of innovative artefacts (van Aken, 2013). Therefore, this reflective paper aims to demonstrate how valid design knowledge can be generated within the social world through structured inquiry and experiential learning. By integrating DSR with a qualitative case study inquiry, this study addresses the socio-technical imperative for context-sensitive and solution-oriented research within public sector organisation in Malaysia.

RESEARCHER'S ONTOLOGICAL AND EPISTEMOLOGICAL FOUNDATIONS

The researcher believes that reality is socially constructed and context-dependent (Sekaran & Bougie, 2016). In terms of ontology, this study is grounded in a non-positivist stance. This philosophical stance rejects the notion of a single, objective reality. Instead, this study embraces the existence of multiple realities that shaped by individual experiences and contexts (Creswell et al., 2007; Merriam & Grenier, 2019). This orientation is relevant to the development of the Blockchain-Integrated Collaborative E-Payment Framework (BICEF). It enables a nuanced understanding of participants on the IOC workflow challenges. A singular perspective may yield generalisable outcomes, but multiple realities facilitate insight and a more contextualised interpretation of participants' experiences.

In terms of epistemology, this study employs an interpretivist paradigm where the knowledge is constructed through interaction, dialogue and reflection between the researcher and participants (Merriam & Tisdell, 2016). This perspective is reflected in the data collection method, which includes interviews and focus group discussions. Their insights on operational issues and perspectives on BCT applicability informed the iterative process in the development of the BICEF framework. In contrast to statistical generalisation approach, this study focuses on producing specific contextual understanding that is bounded in organisational realities (Yin, 2016). This interpretive stance is essential for identifying and addressing the complex, institutionally embedded factors that shape IOC workflows and the usability of artefacts.

Nevertheless, the researcher acknowledges the axiological dimension of qualitative inquiry. It recognises that the research process and proposed artefact are inherently value laden. Maxwell (2013) asserts that a researcher's position, background and reflexivity shape data interpretation and design outcomes. This element is particularly relevant in socio-technical solutions, where technological solutions are connected with social, ethical and institutional values (Merriam, 1998). Therefore, this study acknowledges these ethical considerations throughout the design and inquiry process. This is to ensure that the BICEF framework aligns with technical requirements and meets the values and expectations of its intended users.

Interpretivist approach in Design Science Research

The application of DSR using an interpretivist approach entails a deep engagement with the social, political and contextual dimensions in the design and realisation of artefacts (Monson, 2021). This approach departs from the traditional positivist orientation typically associated with DSR. It emphasises on meaning-making, stakeholder perspectives and iterative reflection necessary to capture complex, uncertain environments (Opdenakker & Cuijpers, 2025). The development of the BICEF made the interpretivist approach suitable for navigating the fragmented IOC workflows and accommodating the diverse perspectives of participants on their daily routine operations with the acquiring bank and accounting office. According to Osah and Pade-Khene (2023), they demonstrated that integrating Soft Systems Methodology (SSM) into DSR accommodates unstructured and multi-stakeholder dynamics; hence, the BICEF study likewise recognised that improving the IOC workflow in the e-payment process at the TLD that connected to human determinism, procedural and institutional nuances rather than imposing a rigid, deterministic solution. The use of a qualitative case study and a proof-of-concept (PoC) dashboard, participants could visualise BCT's usability and co-construct their interpretations of its potential value within their specific operational context. This experiential engagement allowed the framework to emerge iteratively, reflecting local needs rather than prescriptive assumptions (Lind et al., 2010).

Similarly, Gonzalez and Sol (2012) argue that embracing epistemological diversity enriches artefact design and validation. This is in line with the case study at the TLD that deliberately sought to capture multiple interpretations of IOC workflow challenges by engaging with the participants across the research phases. In answering research question one, which aimed to identify IOC challenges in the e-payment process, the target participants consisted of operational personnel directly involved in the day-to-day e-payment processes across four TLD locations: Johor, Kedah, Perlis and the TLD Headquarters. The selection of these sites was based on differences in transaction volume and the mode of payment offered, which is relevant to the TLD in the context of the study. One-on-one interviews were conducted to gather first-hand experiential insights from the participants.

Meanwhile, to address research question two, which explored the suitability of BCT in improving IOC workflows, a focus group discussion was conducted using the Ask, Record and Confirm (ARC) technique which proposed by Zairul et al. (2023). This technique would expedite the members' checking process. Recognising the participants' limited prior exposure to BCT, the researcher has provided a proof-of-concept (PoC) dashboard that simulated key BCT

functionalities. This approach is similar with Vern et al. (2025) in providing PoC for the BCT-based traceability framework, which was developed with inputs from the use-case organisation and the technology provider. Prior to the actual focus group session, the researcher conducted individual visits with the selected TLD personnel who directly engaged in e-payment operation. This is to demonstrate the PoC and facilitate their understanding. This preparatory engagement ensured that participants could provide informed and reflective feedback on BCT's potential application.

Finally, for the third research question, the initial BICEF was presented to a panel of experts to evaluate its institutional applicability and potential for refinement. This expert validation process, consistent with the principles of DSR, was essential to assess the framework's institutional applicability and to gather informed feedback for its refinement (Hevner et al., 2004). The panel comprised representatives from financial institutions, government agencies, academia, fintech companies and blockchain developers. Their multidisciplinary perspectives were instrumental in validating the artefact's functional and socio-technical relevance in the public sector context.

By integrating iterative and interpretive cycles across the three phases of interviews, focus group reflections and expert validation, the study ensured that the BICEF framework emerged as both technically robust and socially meaningful, while remaining closely aligned with its organisational context. This multi-layered form of engagement reduced the likelihood of producing an artefact that is technologically advanced yet difficult to implement within existing institutional arrangements. This issue that can arise in DSR when interpretivist sensitivity is overlooked. Pulla and Carter (2018) contend, qualitative flexibility is crucial when addressing the complex and often ambiguous requirements of diverse stakeholders. Furthermore, the interpretivist paradigm supported grounded thematic process that revealed the actual IOC workflow challenges occur in the real e-payment operation.

Finally, although pragmatism highlights the importance of developing workable and actionable solutions, interpretivism, as noted by Goldkuhl (2012), deepens inquiry by foregrounding context-sensitive interpretations of social realities. This interplay between the two perspectives was crucial in shaping the development of BICEF. While the artefact was intended to improve operational efficiency such as through faster reconciliation and more consistent SLA enforcement, its real value depended on how well it aligned with the socio-organisational conditions of its users. The iterative development process therefore ensured that BICEF's practical functionality was continually calibrated to the complex and nuanced realities of the institutions it was meant to support.

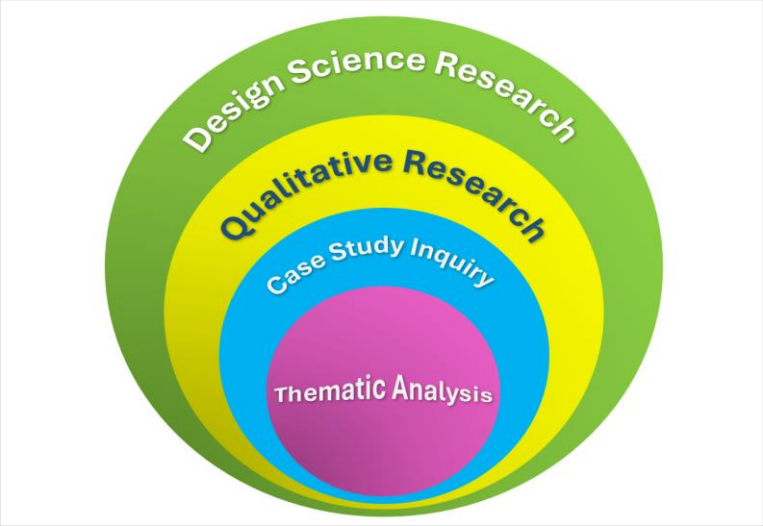

Figure 1: Design science research and qualitative methodology

Figure 1 presents a nested methodological framework that brings together DSR, qualitative inquiry, case study investigation and thematic analysis. The layered structure of the diagram reflects how these components reinforce the study's interpretivist paradigm. At its broadest level, DSR serves as the research approach, shaping the development of an artefact to address practical challenges within institutional environments. This overarching frame grounds the study in a qualitative approach that appreciates socially constructed meanings and the organisational contexts in which they arise. Moreover, this structure lies the case study inquiry, which enables a detailed and contextually rich examination of the TLD as the focal unit of analysis. At the core lies thematic analysis, which serves as the analytical strategy for interpreting participant narratives, identifying patterns and constructing insights from empirical data. This framework is conceptually informed by Zairul (2017) study on the development of the FlexZhouse business model, which similarly employed an interpretivist-informed DSR approach to address complex societal issues, such as affordable housing. The use of nested methodologies demonstrated the value of continuous stakeholder engagement, iterative artefact refinement and responsiveness to contextual dynamics. Hence, the present study adopts a similar interpretivist configuration to ensure that BCT, as instantiated through the BICEF framework, functions not merely as a technical intervention but as a socially integrated enabler of IOC workflows within the e-payment process in the Malaysian public sector context.

SOCIO-TECHNICAL IN DESIGN SCIENCE RESEARCH

Unpredictable human agency is a significant challenge in applying DSR to a socio-technical study (vom Brocke et al., 2020). Van Aken (2013) argues that design science in the scientific field benefits from invariant mechanisms (e.g., gravity, mechanics). In reality, the social world is influenced by voluntary human action, which resists determinism (Howcroft & Taylor, 2023). In addressing the challenges, Van Aken suggests that the researcher adopt the objective and systematic experiential learning strategy. He posits that this is the most appropriate approach to generating valid design knowledge in social contexts. In contrast to traditional explanatory study, which seeks to describe and predict phenomena, DSR is interventionist as it aims to produce knowledge that solves real-world problems through tangible artefacts. In his commentary, Van Aken further distinguishes the DSR and explanatory study as follows: -

Table 2 : The differences between explanatory and design science research

No	Context	Explanatory Research	Design Science Research
1	Research driven	By pure knowledge problems; observer perspective	By field problems; actor perspective
2	Mission	To understand, a quest for truth (knowledge as an end)	To improve the human condition (knowledge as a means)
3	Interest	Interested in the world that is	Interested in the world that can be
4	Justification	Justification on the basis of explanatory validity	Justification on the basis of pragmatic validity
5	Researcher trained as	Students are trained to become researchers by researchers	Students are trained to become professionals, largely by (ex) professionals
6	Outcome	Iconic research product: the causal model	Iconic research product: generic solution and the design proposition

Source: Adapted from van Aken (2013)

Following the earlier problem contextualisation phase, a PoC dashboard was designed as a technical prototype to bridge conceptual understanding between participants and the BCT artefact. The dashboard's architecture was intentionally constructed to reflect the embeddedness of technology in institutional processes as what McKay et al. (2020) describe as the "fusion of

social and technical elements" in socio-technical systems design. In this context of study, three core interface components were developed to illustrate IOC workflows integration with the BCT. First, the Login screen (see Figure 2) that served as a representation of role-based access control, reinforcing the organisation need for control role governance and secure auditability.

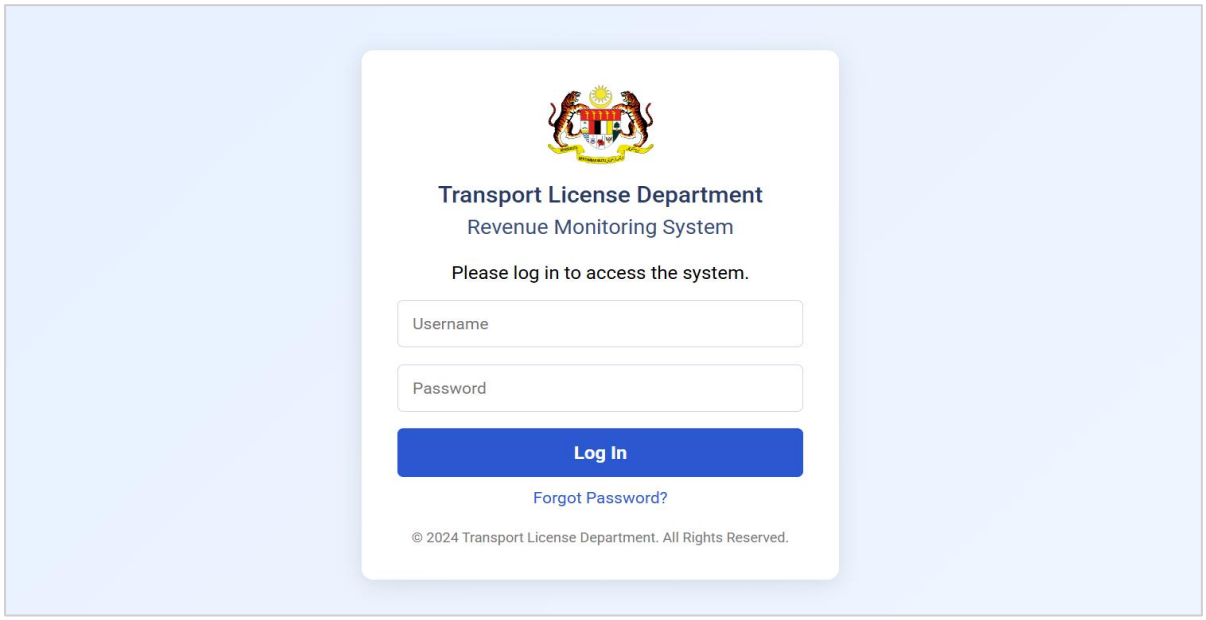

Figure 2: User login screen interface

Secondly, the Blockchain Ledger screen (see Figure 3) visually instantiated the concept of distributed transparency, enabling users to trace financial transactions across TLD branches while maintaining data integrity through cryptographic hashes.

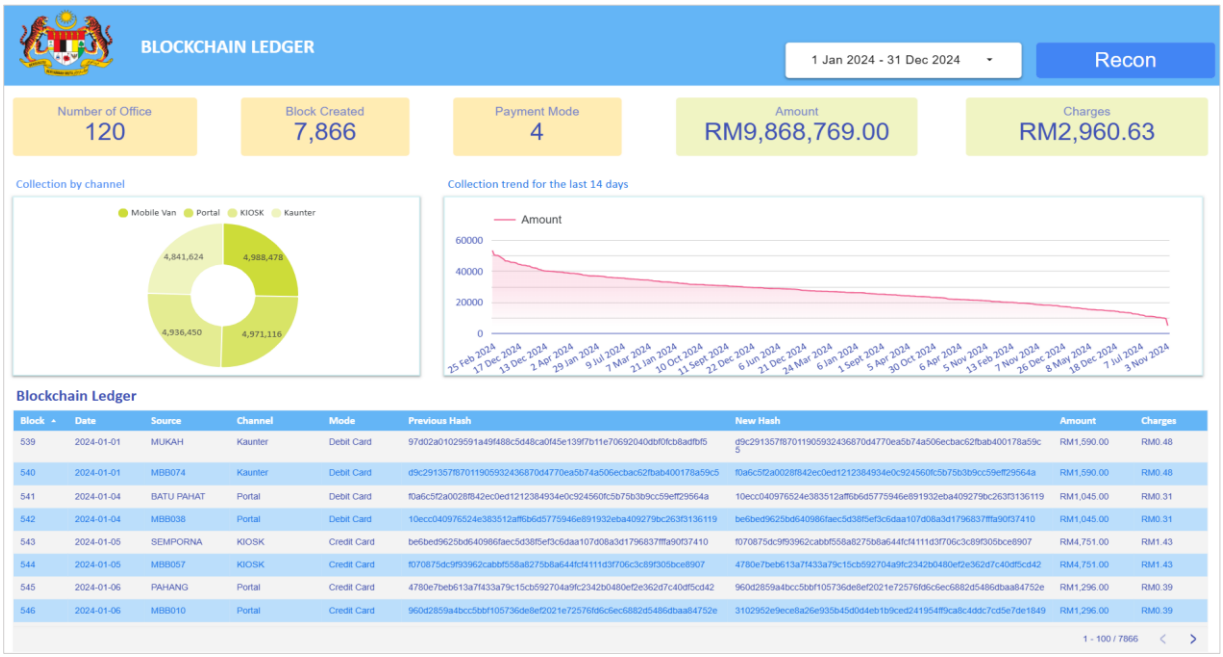

Figure 3: Blockchain ledger screen interface

Most critically, the third screen is Reconciliation Dashboard (see Figure 4) operationalised SLA compliance monitoring, automated delay tracking and penalty calculations features drawn directly from operational pain points identified during the exploratory fieldwork. These components were not only functional but also designed to mirror real-world TLD e-payment operations and to foster BCT usability through familiarity.

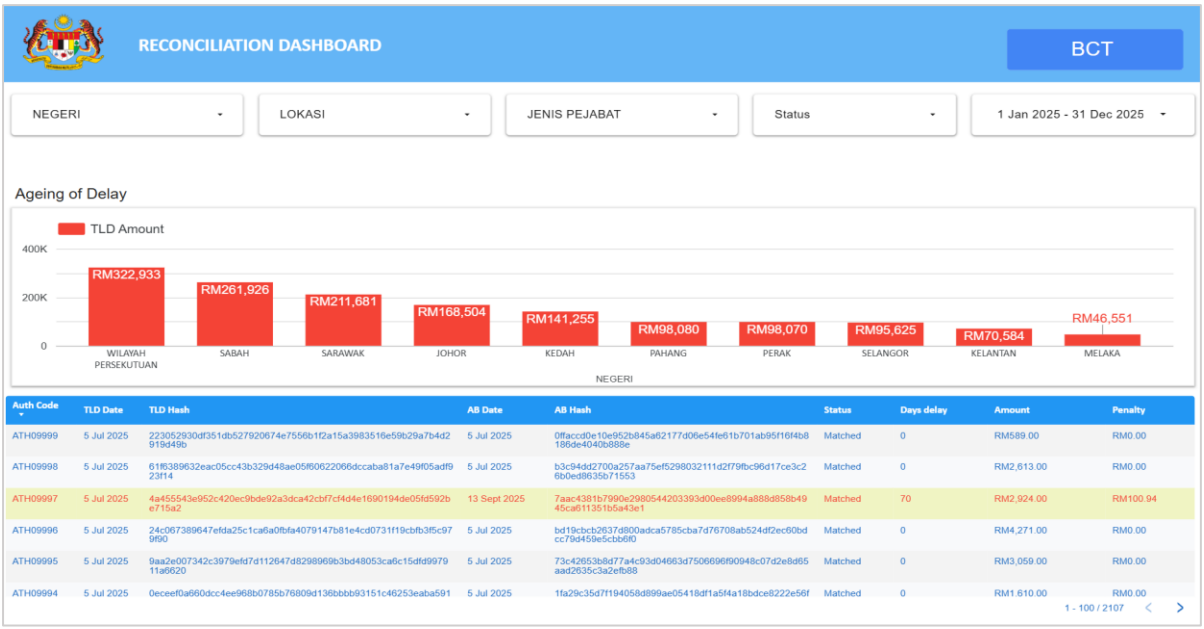

Figure 4: Reconciliation dashboard interface

What distinguishes this implementation of a socio-technical artefact from a pure technical solution is its intentional integration of institutional context, existing data structures and procedural practices already embedded in the TLD's operational environment. Although only the mock data was used due to confidentiality constraints, the data structures, fields and transaction categories remained consistent with the actual operational documentation. This fidelity aligns with Orlikowski and Iacono's (2006) study, which describes the "organisational embeddedness" of an artefact, enabling users to perceive the framework not as an abstract technological construct but as a natural extension of their everyday work practices. In line with the DSR's emphasis on iterative refinement, the POC did not represent a final product but served as a system usability test to inform the development of the BICEF as the final artefact. Its deployment in the lead-up to the focus group discussions allowed participants to reflect on system behaviour, identify alignment gaps and propose refinements to the framework. This participatory feedback process exemplifies what vom Brocke et al. (2020) define as pragmatic validity in DSR: the artefact's worth is measured not only by internal coherence but by its relevance and usability in the target context. Ultimately, the BICEF demonstrates how socio-technical artefacts can be developed within the DSR approach by linking interpretivist inquiry, stakeholder engagement and context-aware design. It underscores the importance of designing not only for functionality but for institutional resonance where artefacts become meaningful, acceptable and actionable within the context they aim to improve.

Socio-technical challenges in Design Science Research

Socio-technical challenges in DSR are derived from the inherent complexity of integrating human, organisational and technological elements in the development of innovative artefacts (Papachristos, 2011). One of the challenges in DSR is the difficulty in resolving conflicts between disciplinary perspectives. For instance, Maathuis and Chockalingam (2023) argue for a multidisciplinary DSR approach that embeds societal values and meaning into artefact

development, arguing that models must not only resolve technical issues but also account for broader human and social dimensions. Moreover, Nouws et al. (2022) in their study on public-sector algorithmic systems require design methodologies that explicitly incorporate technical specifications and sociopolitical concerns. Similarly, John and Rutherford (2022) emphasise that the foundation of DSR in information systems education must lie in building socio-technical artefacts that address complex, real-world problems, highlighting the dual imperatives of technical innovation and social relevance. Hence, in the context of this study, the development of the BICEF at the TLD highlights the socio-technical challenges inherent in the design process. While the BICEF framework was created to address technical issues such as SLA enforcement, it was equally influenced by stakeholder perspectives, inter-agency dynamics and existing organisational practices. The design process required close collaboration with operational personnel to ensure the artefact is functional and meaningful in their day-to-day context. This approach helped align the technical features of BCT with the organisational realities of IOC workflows in the e-payment process, thus ensuring the solution was not only innovative but also practically viable (Khairi et al., 2025).

Secondly, DSR challenges also lie in ensuring the rigorous integration between the technical solution and stakeholder engagement throughout the design cycle. For instance, , Gade and Svidt (2021) describe how a Building Model Checking (BMC) prototype evolved through iterative practitioner feedback, leading to improved transparency and flexibility on two critical dimensions of socio-technical systems. In parallel, Abbas and Munoz (2021) discuss the concept of antifragile information systems, which not only withstand but also adapt to uncertainty, suggesting that socio-technical artefacts should incorporate adaptive mechanisms rather than relying solely on deterministic technical logic. Furthermore, Hoda (2022) introduces the Socio-Technical Grounded Theory framework to bridge traditional social science methodologies with emergent technological design needs, thereby helping researchers close the persistent gap between artefact development and the social contexts in which those artefacts are deployed. Therefore, in this study, stakeholder engagement played a critical role in ensuring that the BICEF framework was both technically viable and operationally relevant to the context of TLD. Therefore, the iterative feedback gathered during these sessions allowed the framework to be refined based on real-world input, ensuring that it remained adaptable, transparent and aligned with the needs of those directly involved in the e-payment process.

Beyond operational integration, a methodological impediment arises in aligning the theoretical underpinnings of socio-technical systems with the practical realities of design execution. McKay et al. (2020) caution that conventional systems engineering approaches often fail to capture the nuanced interdependencies between human agency and technological infrastructure. This disconnect contributes to the discussion by Pikas et al. (2022), who use the term "disintegrated and mutually inconsistent design theories," in which social and technical dimensions are treated separately rather than as a cohesive whole. Schulman (2020) further asserts that when ambiguous social science constructs are combined with deterministic engineering paradigms, both theoretical coherence and practical application may suffer. In the context of this study, the methodological tension between theory and practice was addressed through a hybrid approach that combined interpretivist inquiry with iterative artefact design. These insights acknowledge the importance of hybrid, interdisciplinary methodologies that promote ongoing dialogue and iterative evaluation, ensuring that artefacts are not only technically feasible but also socially inclusive (Guerra, 2025).

CIMO logic framework

In designing the DSR study, Denyer et al. (2008) have simplified the DSR process into the CIMO logic framework. The CIMO logic consists of Context, Intervention, Mechanism and Outcome, providing a structured process to assist researchers in delineating the specific problem under study, identifying the mechanisms that drive its efficacy and articulating the associated outcomes (Enam et al., 2022). This approach is beneficial in socio-technical systems, where the dynamic interplay

between technical artefacts and social elements is intricate and complex. For instance, a study by Bagni and Filho (2024) integrated DSR with CIMO logic to develop a model for understanding servitisation trajectories. In their study, the initial list of contextual factors was derived from the literature and was refined through engagement with employees in the organisation. Similarly, Caiado et al. (2025) employed a configurational framework based on CIMO logic to integrate Industry 4.0 enablers with sustainability practices in operations and supply chain management. In this research, CIMO was utilised to capture how dynamic capabilities and social exchange elements interact to produce strategic benefits. The context (i.e., the operating environment, particularly in developing countries) informs the design intervention and shapes the mechanism through which strategic benefits are expected to be realised. This application of CIMO logic facilitates the translation of multifaceted socio-technical problems into design propositions that are context-sensitive and outcome-oriented.

Furthermore, Halminen et al. (2020) adapted the CIMO logic to digital health interventions by taking into account the maturity stage of companies and their corresponding business environments. The study employed CIMO to systematically gather contextual evidence needed to assess and guide digital health initiatives. The intervention is tailored based on the organisation's stage of technological development, while the mechanisms and outcomes are framed according to the socio-technical characteristics of the specific organisational context. This application of CIMO logic illustrates its potential to offer nuanced insights into the relationship between digital health interventions and their socio-technical environment. This iterative contextual evaluation led to the formulation of specific design propositions that encapsulate the relationship between the context in which the artefacts are implemented (the "C") and the subsequent intervention strategies (the "I"), the underlying mechanisms (the "M") and the outcomes (the "O") achieved. Therefore, the researcher emphasises that CIMO logic facilitates the mapping of complex socio-technical interactions in IOC workflows, as well as challenges related to the e-payment process at the TLD. Then, by explicitly linking contextual elements to design outcomes, thereby validating the efficacy of the proposed artefacts. Figure 5 illustrate the CIMO logic application in BICEF construction

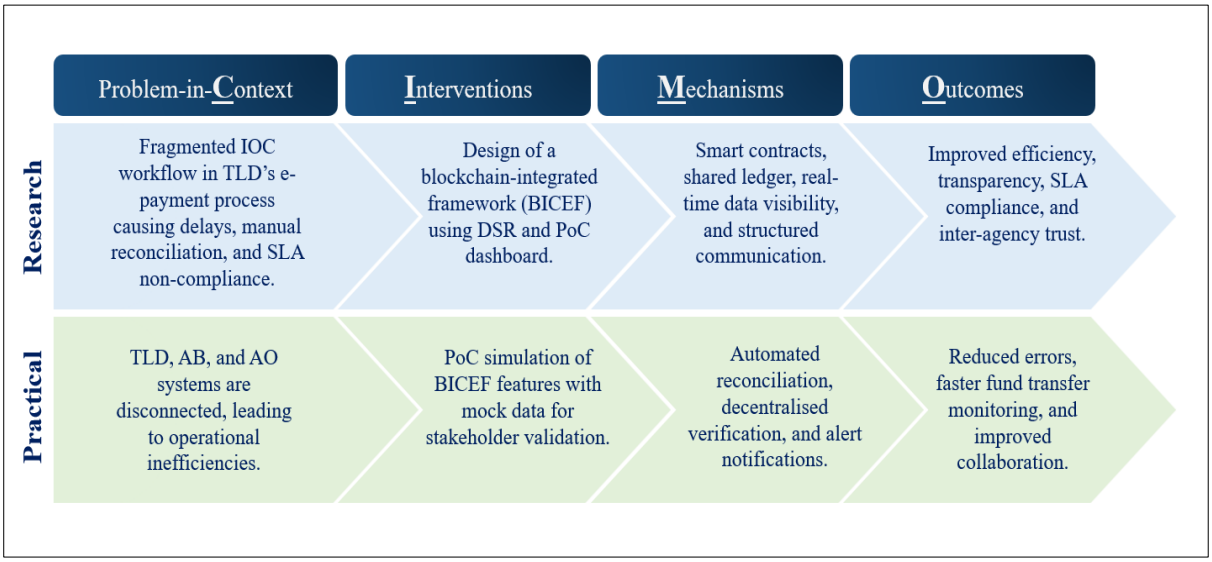

Figure 5: CIMO logic application in BICEF development

RESULT

The findings reveal that the TLD faces challenges in IOC workflows derived from fragmented and non-integrated operational systems. Participants of the study described the need for repeated manual cross-verification due to siloed processes, manual operation, lack of a monitoring platform and communication challenges, which impede efficient collaboration between TLD, acquiring banks and the accounting office. Despite partial automation, manual reconciliation remains necessary, highlighting the lack of shared data access. The IOC workflows' challenges illustrate inefficiencies and align with existing scholarship, noting how fragmented platforms obstruct collaborative governance (Adomako & Nguyen, 2023; Reindersma et al., 2022). Trust among parties is also compromised by operational inconsistencies, which do not comply with the SLA mentioned in the agreement. The reliability of outputs relies on individual efforts rather than institutionalised mechanisms. These concerns were raised by Kowalski et al. (2021) and Shivaraj, 2024), regarding the fragility of trust in manual-governed systems. Furthermore, the absence of enforceable SLA; although contractual terms exist, enforcement is weak due to inadequate monitoring tools and procedural ambiguity (Nguyen et al., 2023). Communication challenges further exacerbate these issues, with over-reliance on informal channels such as WhatsApp leading to coordination delays and reduced accountability. Participants expressed concern over the absence of structured, traceable communication protocols, underscoring the need for a centralised and auditable communication platform to facilitate timely and standardised information exchange (Centobelli et al., 2022).

In response to the issues, BCT emerges from this study as a suitable digital intervention to address the IOC workflows challenges in the e-payment process at TLD. Participants acknowledge BCTs or decentralised ledger systems as a suitable solution to rectify challenges in IOC workflows. Immutability was cited as a key feature for ensuring data integrity and reducing manual verification burdens. BCT's ability to generate tamper-proof records fosters transparency and supports auditability, critical attributes for public sector accountability (Cagigas et al., 2021). Participants also acknowledged that BCT's smart contract functionality could transform SLA enforcement by automating penalty triggers and compliance verification, reducing reliance on discretionary oversight. These findings are corroborated by prior studies, which demonstrated BCT's efficacy in enhancing coordination, trust and compliance in analogous domains such as logistics and financial services (Tan & Sundarakani, 2021; Vedapradha & Ravi, 2023). Moreover, participants expressed confidence in BCT's potential to institutionalise structured communication practices through immutable notifications and audit trails. These perspectives align with the Malaysian National Blockchain Roadmap (Ministry of Science Innovation and Technology, 2021), which prioritises BCT as a strategic tool for enhancing public sector governance, improving data security and enabling interoperable service delivery. Hence, BCT not only meets the technical requirements for overcoming the observed IOC workflow challenges but also resonates with national policy directives for digital transformation in public administration (Alafnan & Mohdzuki, 2024).

Finally, this study proposes the Blockchain Integrated Collaborative E-Payment Framework (BICEF) as a business view architecture to institutionalise collaboration, trust, control and structured communication within TLD's e-payment ecosystem. The framework comprises three interconnected parties or nodes, including the TLD, the acquiring bank and the accounting office. The BICEF operates on a permissioned blockchain infrastructure that ensures controlled access and regulatory compliance. The smart contracts embedded in the system automate key operational functions, including monitoring of fund transfers to meet the T+1 requirement on the fund transfer period, real-time reconciliation, penalty enforcement for delays and bank service charge management. Communication between agencies is facilitated through a shared, immutable digital platform that enables real-time alerts, structured reporting and traceable interactions. A consensus mechanism is employed to validate each transaction, generating verifiable hashes that ensure data authenticity and cross-agency synchronisation. The system is complemented by a user-facing dashboard that presents live metrics, status updates and audit trails, enhancing operational

decision-making and institutional accountability. The design of BICEF was validated by a multidisciplinary panel comprising a Senior Accountant from the Accountant General's Department, a certified blockchain developer and an academic in digital governance. Their evaluation affirmed that the framework aligns with Surat Pekeliling Akauntan Negara Tatacara Pengurusan Terimaan Bilangan 3 Tahun 2025 (Jabatan akauntan Negara Malaysia, 2025) and adheres to best practices in blockchain deployment. As such, BICEF provides a scalable, policy-compliant solution for strengthening IOC workflows and enabling robust, transparent public sector financial governance.

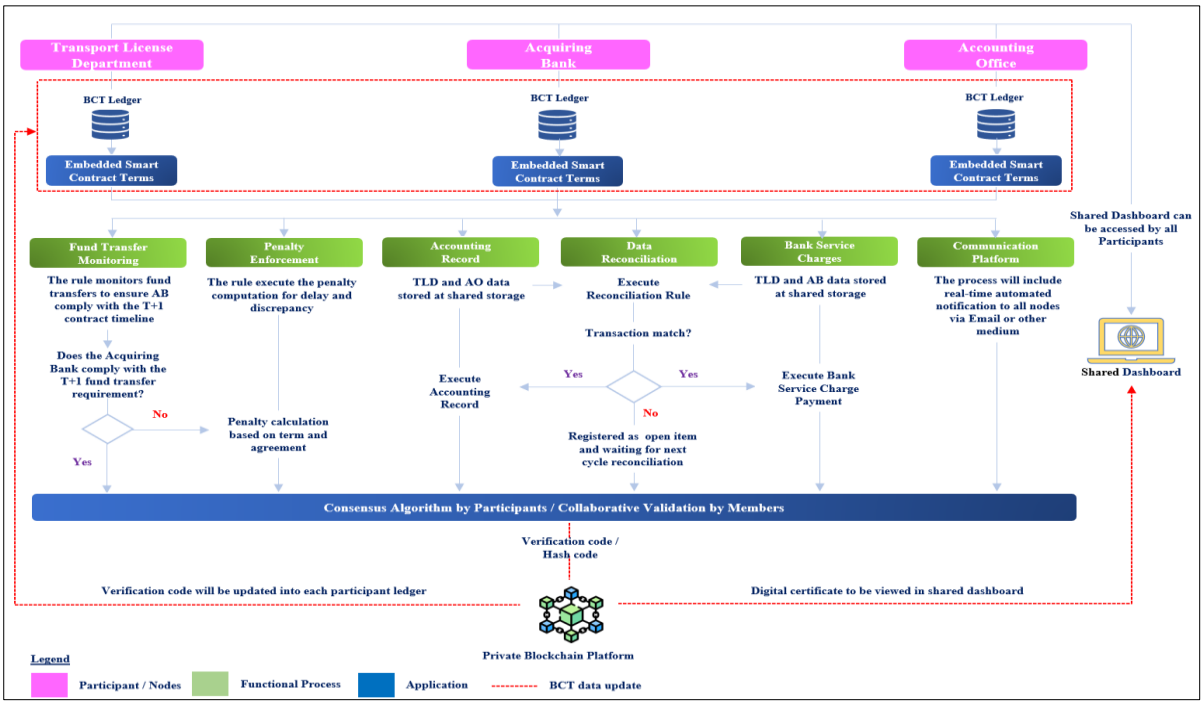

Figure 6: The blockchain integrated collaborative e-payment framework

Figure 6 depicts the BICEF framework. The BICEF is designed to address inter-organisational workflow (IOC) challenges within the TLD by leveraging blockchain technology for secure, transparent and automated transaction management. The framework connects three key entities: TLD, the Acquiring Bank (AB) and the Accounting Office (AO), each maintaining a blockchain ledger embedded with smart contract terms. BICEF operates through six main functional processes:

- Fund Transfer Monitoring ensures that the Acquiring Bank complies with the T+1 fund transfer timeline, automatically detecting delays.
- Penalty Enforcement automatically calculates penalties for late transfers based on predefined smart contract rules.
- Accounting Record Management securely records transaction data in a shared blockchain ledger accessible to TLD and AO.
- Data Reconciliation matches transaction records across institutions; unmatched transactions are flagged for the next cycle.
- Bank Service Charges manage payment settlements for bank service fees through smart contract execution.
- Communication Platform issues real-time notifications to all stakeholders, enhancing transparency and responsiveness.

All processes are validated collaboratively through a consensus algorithm, ensuring that only verified records are updated across all participant ledgers. A shared dashboard aggregates verified data, offering real-time visibility and auditability for all participants. This integrated approach improves fund monitoring, ensures SLA compliance, enhances data integrity and strengthens inter-agency collaboration within the Malaysian public sector e-payment ecosystem.

REFLECTIONS ON DESIGN SCIENCE RESEARCH IN THE BICEF DEVELOPMENT

The development of the BICEF in this study reflects the principles of DSR approach, particularly its application in socio-technical environments in the public sector context. Venable et al. (2017) argue that the DSR is rooted in constructing information technology (IT) artefacts to resolve contextual and practical problems. This research extends the paradigm by demonstrating how DSR can be employed to address IOC workflow challenges that is beyond traditional IT technical boundaries. Therefore, the BICEF artefact is not only a technological intervention but function as a conceptual and institutional framework that embodies design principles derived from empirical inquiry. This approach aligns with vom Brocke et al. (2020) proposition that DSR artefacts may manifest as models, frameworks, or guidelines regardless of IT or social-technical domain.

In the meantime, Denyer et al. (2008) simplify the DSR process with the CIMO logic framework, which comprises Context, Intervention, Mechanism and Outcome. In this study, the context comprised fragmented operations within TLD's e-payment system. The intervention was the BICEF artefact, instantiated through a PoC that integrated BCT features, including smart contracts, shared ledgers and automated compliance monitoring. The mechanisms activated by this intervention included real-time visibility, decentralised verification and immutable communication channels. These, in turn, generated outcomes such as improved data reconciliation, enhanced SLA enforcement and strengthened inter-agency trust and control, which demonstrate the causal logic that underpins practical DSR applications in socio-technical domains.

Operationalising the DSR process required abductive reasoning and iterative learning cycles as advocated by van Aken (2013), due to the presence of human agency and institutional complexity. Qualitative case study methods, including interviews, FGDs and document reviews, served as the empirical substrate for identifying pain points and informing the artefact's features. This dual-stream learning process unfolded along what van Aken describes as the "practice stream", where the artefact was co-developed and contextualised with the participants of the study and the "knowledge stream," where abstracted insights were transformed into mid-range design propositions. These included, for instance, embedding compliance logic through smart contracts to address SLA enforcement issues and formalising communication channels via immutable ledgers to counter the risks posed by informal messaging practices.

Ultimately, the evaluation of BICEF was interpretive and context driven. Its validity was not measured through statistical generalisation, but through analytical generalisation, where the artefact's ability to deliver desirable outcomes within its intended operational environment (Mdletshe et al., 2023). Through member checking, expert validation and iterative refinement, the framework was tested against real-world expectations, enhancing both its technical robustness and institutional fit. This approach underscores DSR's suitability for addressing IOC workflows challenges in the e-payment process, where solutions must reconcile with technological feasibility and governance legitimacy. In this way, the study contributes to the evolving DSR discourse by exemplifying how artefact design in socio-technical settings can be rigorously theorised, contextually embedded and practically validated.

LIMITATIONS AND FUTURE RESEARCH

This study provides insights into the application of DSR in a socio-technical public-sector context; however, several limitations warrant acknowledgement. First, the development of BICEF was confined to a single public organisation in Malaysia. Although rich qualitative data were gathered from interviews, focus group discussions and expert validation, the single organisational setting may limit the transferability of the findings to other public organisations with different structural, operational, or regulatory contexts. Second, the PoC was developed and tested using mock operational data due to confidentiality constraints. In contrast, this approach is valuable for participants who have limited knowledge of BCT. Nevertheless, it may not fully capture the complexities of actual system integration. Third, the interpretivist orientation, while providing deep contextual understanding, inherently limits the study's capacity for statistical generalisation.

Future research could address these limitations by extending BICEF's application across multiple government agencies to assess its adaptability and scalability in diverse organisational ecosystems. Longitudinal studies examining the actual deployment of BICEF would be valuable in evaluating its sustained impact on inter-organisational trust, data governance and service delivery outcomes over time. Furthermore, comparative studies between BCT-based and traditional e-payment reconciliation systems could provide empirical evidence on the relative efficacy, cost-benefit trade-offs and stakeholder acceptance of BCT interventions in the public sector. Finally, accelerating the PoC into a fully operational prototype and integrating it with live transaction data could provide a more comprehensive evaluation of technical robustness, compliance performance and institutional integration dynamics.

CONCLUSION

This study has demonstrated the application of the DSR approach to address IOC workflow challenges in the e-payment process at the TLD, through the development of the BICEF framework. This study employed a qualitative case study and revealed IOC workflow challenges stemming from fragmented operational systems, manual reconciliation processes, weak SLA enforcement and informal communication. The findings show that IOC workflow challenges undermine the effectiveness, accountability and coordination of the e-payment process, underscoring the need for a socio-technical intervention that integrates technological capabilities and institutional realities. BICEF was developed as a context-solution artefact, leveraging BCT's unique features, immutable, transparent and decentralised, to improve the IOC workflow via automated SLA enforcement, enhance trust and support real-time communication. The use of CIMO logic enabled the research to map context-specific problems to targeted mechanisms and outcomes. Then, the iterative process of synthesis, stakeholder co-creation and expert validation ensured that the BICEF framework is both practically relevant and institutionally fit.

Furthermore, the integration of the interpretivist paradigm in the DSR approach has facilitated an insight into socio-organisational dynamics, contributing to both practice and mid-range design theory. Ultimately, the BICEF framework illustrates how BCT can be effectively embedded in governance and operational architecture within public-sector agencies to improve collaboration, accountability and service delivery. While the study's scope is institutionally bounded, it offers a replicable model for developing BCT-enabled solutions in other contexts. Future research is encouraged to operationalise BICEF across multiple agencies, integrate it with live transactional environments and assess its long-term institutional impact. This study contributes to the evolving discourse on DSR in the socio-technical domain. It demonstrates the value of abductive design logic, experiential learning and context-aware artefact development within complex public sector ecosystems.

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