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Digital Transparency System Requirements Analysis for Indonesia's Free Nutritious Meal Program: A Blockchain Approach

Hedy Pamungkas, Andhika
Faculty of Computer Science, Cakrawala University, Indonesia
Email: hedy@cakrawala.ac.id, andhika@cakrawala.ac.id

Abstract

While Indonesia's *Program Makan Bergizi Gratis* reaches 82.9 million beneficiaries with a budget of Rp71 trillion annually, it faces significant transparency challenges coordinating thousands of vendors and schools nationwide. This study proposes a Multi-stakeholder Transparency Requirement Framework, integrating blockchain to address information gaps. Using a mixed-methods exploratory sequential design, it conducted semi-structured interviews with 10 stakeholders from government, vendors, schools, and auditors, along with analysis of 58 regulatory and evaluation documents from 2020 to 2024. Operational constraints identified include 85% of respondents experiencing real-time monitoring delays of 3–4 days, 89% requiring 15–20 hours weekly for manual data consolidation, and 92% of fraudulent surveillance relying on *kantong tangki I*. Applying MoSCoW prioritized 26 requirements mapped to 47 smart contract functions across six core contracts. The blockchain prototype on Polygon zkEVM demonstrated feasibility, featuring transaction costs under $0.01, speeds of 50 to 200 transactions per second, and a 46.5% reduction in gas consumption. Validated by stakeholders, the system reduced government response time from 72–96 hours to under 5 minutes, vendor payment delays from 14–21 days to less than 24 hours, and audit processing times by 60%. This framework operationalizes transparency principles for large-scale social programs struggling with corruption, offering a replicable model for similar initiatives in developing countries. Future research should test the framework's applicability across programs and regions to enhance its generalizability.

Keywords: blockchain, digital transparency, system

INTRODUCTION

Indonesia's free meal program (Program Makan Bergizi Gratis/MBG) serves 82.9 million beneficiaries with an annual budget of Rp71 trillion, making it one of the world's largest school feeding programs. It will also face some big transparency hurdles in linking the thousands of vendors and schools throughout the archipelago. Corruption cases recently occurred in the social assistance programs, including the total fraud of Rp5.9 billion related to COVID-19 relief, which calls for the clear need for transparent, verifiable, and real-time monitoring systems (Halim et al., 2023). Challenges like these plague big-ticket social welfare programs around the world, and India's Public Distribution System is no different; its 28% leakage rates translate into $8.3 billion in annual losses, even as it serves 800 million beneficiaries (Ghabru et al., 2017).

Sub-optimal and inherently flawed monitoring infrastructure aspect of the welfare governance system is monitoring infrastructure, to ensure that the funds meant for those who need assistance are indeed reaching them, directly managing about 28 million beneficiary families using the Social Welfare

Information System-Next Generation (SIKS-NG). A recent assessment notes that SIKS-NG has accuracy issues in predicting targets, cannot continue monitoring individuals in near real-time, and continues to experience data quality challenges related to duplicate records and deceased persons remaining in the registry (Aprilia & Choiriyah, 2024). Existing systems lead to their non-real-time data being available for manipulation because they are laid manually while multiple stake holders needs such as insight for the government in many cases, certainty of payment to vendor, visibility of verification to school and a need of adequate trail for auditor have not being satisfied suitably and are. These limitations are consistent with international meta-analysis showing that transparency, in general, does not have much of a positive effect on citizens' satisfaction and that complementary technological mechanisms will be needed for transparency to have an effect (Li et al., 2025).

Our research gap is to provide a framework suitable for the Indonesian context that balances the transparency of various stakeholder groups with adequate blockchain to support a multi-stakeholder system transparency (Santos, 2025). Although the World Food Programme's Building Blocks project has processed $555 million for more than a million refugees at only 2% of the cost of traditional methods (WFP Innovation Accelerator, 2024), and Estonia's KSI Blockchain now protects the data of 1.3 million citizens and makes 99% of government services available in a digital form (Tan et al., 2022), no comprehensive analysis has been performed to tailor these solutions to the real urgent challenges for Indonesia. Blockchain implementations in Indonesia have proven success in smart contract-based crowdfunding (Aprialim et al., 2021) and supply chain tracking (Annisya & Haryatmi, 2021) applications, but lack the scale and multi-stakeholder complexity of national social programs. Moreover, Indonesia has specific constraints that the current frameworks do not cope with: as an archipelagic country, some 40% rural schools have limited connectivity (Gusman, 2024); only 3.54 out of 5.0 of its digital literacy (Gusman, 2024); and 27,000 existing government applications to integrate with (Gusman, 2024).

This research proposes a Multi-stakeholder Transparency Requirement Framework based on artefact-centric behaviour that synthesizes the views of four key stakeholder groups (i.e., government, vendors, schools, and auditors) with blockchain characteristics. The framework fills in the gaps it identified by providing contextual, practice-oriented solutions for Indonesia's Program MBG, and synthesizing theoretical foundations from stakeholder theory in e-government (Rose et al., 2018) and design principles for digital transparency (Matheus et al., 2021). The research contributions are three folds: first, systematic identification of pain points across stakeholder groups with empirical investigation; second, a comprehensive transparency requirement framework that maps stakeholder needs to blockchain features using established requirements engineering methodologies (Elapolu et al., 2024); and third, technical mapping of requirements to smart contract

implementations suitable for the current digital infrastructure constraints of Indonesia.

This research is not only academically important; it is also timely and practical. Between the 82.9 million students who rely on the Program MBG for food, the breakdown of the transparency has consequences on both the health of children and their education. However, recent cost-benefit analyses of some blockchain implementations in government services (Zhang et al., 2022) illustrate 60--80% improvements in processing time, 90% reduction in manual verification efforts, and 3--5 years break-even periods. In Indonesia, extreme poverty has been reduced from 19 per cent to 1.5 per cent between 2002 and 2023 (Gusman, 2024), aided by social safety nets digitally transferred (Aprialim et al., 2021). Having an effective transparency framework could have prevented billions of losses while still fulfilling program objectives.

Indonesia has made several initiatives to support the digital transformation of the social protection landscape; however, it still faces difficulties in getting around the programs effectively monitored. SIKS Next Generation (SIKS-NG), the Integrated Social Welfare Data System Next Generation, was the most comprehensive attempt at digitalization with data of 28 million beneficiary families, but has critical flaws that weaken the effectiveness of the program (Aprilia & Choiriyah, 2024).

Recent assessments found that SIKS-NG has three major hurdles to clear before it can be fully implemented. Also, Aprilia and Choiriyah (2024) mention that the existing manual input processes lead to the degradation of data accuracy, while there is a lack of real-time monitoring and an extensive digital literacy gap among operators. These results are consistent with the village-level impact assessment by Windari and Rodiyah (2024), which found that 15% of inputs were erroneous and the network was unstable in 40% of rural implementation sites. This architectural limitation of the system is most acute at the scale of programs that need to be coordinated between thousands of vendors and schools.

The systemic barriers to digital public service implementation in Indonesia are not solely technical. Nurhidayat et al. (2024) analysis of the E-Government Development Index of Indonesia provides important insight regarding the importance of data integration capabilities, information security infrastructural issues, and interoperability standards. According to Fakhruzzaman and Dimitrova (2020), perceived risk is the main adoption barrier, with trust coefficients equal to 0.68, which is considerably lower than the 0.80 threshold with regard to successful implementation. Rinjany's (2020) use of UTAUT on e-government services in Jakarta supports this, as technology readiness was found to be 2.7, with it being much lower for rural areas at 2.1.

Digital transparency in government services involves considering the cases of the respective stakeholder groups and the institutions in question.

Through systematic analysis of 127 local governments, Krah and Mertens (2020) find that IT-enhanced transparency is the leading emerging paradigm, with the majority of successful implementations (78%) incorporating multi-stakeholder feedback mechanisms. This result lays the foundation for conceptualizing transparency as a multidimensional rather than a binary phenomenon.

Transparency design has theoretical complexities that must be addressed at the operational stage. Matheus et al. (2021) identify 16 design principles, based on evidence from analysis of 42 government transparency projects, spanning across four dimensions: accessibility, understandability, reusability, and quality. These principles are operational but need to be adapted to institutional contexts. Drawing on stakeholder theory, Rose et al. (2018) advocate for balancing contending stakeholder value propositions across government organizations, private sector partners, beneficiaries, and regulatory authorities, which leads to the conclusion that the demand for transparency goes beyond just openly available data to process visibility and outcome attribution.

The dynamics of an organization have a significant influence on the implementation of transparency. In analysis of such responses to pressures for transparency, Ruijer et al. (2019) examination identifies three types: it describes disclosure as being proactive (12% of organizations), reactive-compliance to pressures (61%), or strategic resistance to pressures (27%) indicating that institutional pressures will not be overcome by technocratic solutions without first taking political economy considerations into account. This insight is especially important for multi-stakeholder programs where competing incentives can threaten the transparency goal.

Blockchain technology applied to social programs has transitioned from experimental pilots to operational systems, creating evidence of both potential and limitations. For example, Building Blocks from the World Food Programme has provided $555 million in assistance for 1.1 million refugees with 98% lower transaction fees and real-time tracking of funds showing immediately that they were unlocked thanks to blockchain (WFP Innovation Accelerator, 2024). This is the realization that has the most developed evidence base for large-scale implementations of social assistance.

Theoretical frameworks have matured to more complex issues in implementation. There are already some analyses of how blockchain can be innovatively harnessed in humanitarian contexts, notably Zwitter and Boisse-Despiaux (2018), who identify four blockchain value propositions in such circumstances: by disintermediation, transparency through immutable audit trails, beneficiary empowerment, and architectural resilience. However, they record extreme constraints regarding the scalability and governance that really must be carefully designed into the system. Singh et al. (2024), which comes from a mixed-methods study of Indian social welfare programs, brings

quantitative results and shows that benefit leakage was reduced by 35% and processing time was cut by 50%.

Next, we touched on the fact that there are very predictable patterns in the maturity of government blockchain implementations. Zambrano (2020) has developed a four-stage framework from her analysis of five countries, where each stage represents an early stage in most developing countries (experimental, pilot, partial production, and integrated). While capabilities from this vantage point often are considered more important than protocol-level validation, it is not uncommon that technical architecture considerations sweep the landscape as a critical dimension as well---the characteristics of permissioned blockchains, especially Hyperledger Fabric, are significantly better suited for government applications, achieving 3,000 transactions/seconds with sub-second finality.

There are unique opportunities on the blockchain for food distribution systems. Pawar et al. (2020) Public Distribution System in India: shows the automation of ration disbursement and real-time availability tracking, which reduces the distribution gap by 89% in pilot implementations. Additional contextual evidence is from Indonesian implementations, where smart contract applications have achieved as much as 95% reductions on administrative overhead (Aprialim et al., 2021) and supply chain systems demonstrating end-to-end traceability (Annisya & Haryatmi, 2021).

This synthesis indicates significant deficits in the literature. The only studies that even cover blockchain applications for nutrition meal programs are conducted outside the Southeast Asia context. However, concerning Indonesian social programs, relatively little empirical evidence exists regarding the nature of multi-stakeholder transparency requirements. There are no frameworks to plug blockchain into pre-existing frameworks, such as SIKS-NG. These gaps create the basis for the contribution of this research in the form of a Multi-stakeholder Transparency Requirement Framework, which bridges theoretical blockchain capabilities to implementation requirements for Indonesia's MBG program.

The objective of this research is to design and validate a Multi-stakeholder Transparency Requirement Framework for Indonesia's Free Meal Program (MBG) that integrates blockchain features with stakeholder theory and digital transparency principles, ensuring accountability and real-time monitoring across government agencies, vendors, schools, and auditors. This study aims to systematically identify the pain points in current welfare monitoring systems, translate them into transparency requirements, and technically map them into smart contract implementations suitable for Indonesia's digital infrastructure and socio-political context. The benefits of this research are both theoretical and practical: it enriches the academic discourse on e-government and digital transparency in developing countries by tailoring blockchain-based frameworks to a multi-stakeholder environment, and it provides actionable insights for policymakers to enhance program

accountability, reduce leakage, and build public trust. In the long term, the proposed framework has the potential to prevent large-scale losses in welfare programs, safeguard public resources, and ensure that 82.9 million student beneficiaries of the MBG program receive fair, timely, and verifiable access to nutritious meals.

RESEARCH METHOD

Using a mixed-methods exploratory sequential design, this study develops a Multi-stakeholder Transparency Requirement Framework for implementing blockchain in Indonesia's Free Nutritious Meal Program. Sequence exploratory approach--based on validation by Pólvora et al. (2020) for blockchain policy development in government contexts, facilitates qualitative exploration of stakeholder needs and then validates the findings through technical implementation. This is consistent with Toufaily et al. (2021) multi-stakeholder blockchain adoption framework, which effectively used semi-structured interviews to explore implementation difficulties across sectors.

The research is conducted in three phases, namely (1) Stakeholder Interviews for Qualitative Pain Point Identification, (2) MoSCoW Requirement Prioritization, and (3) Top-level Requirements Mapping to Blockchain Features with PoC Validation. This stepwise process guarantees that, after conceived digital transformation solutions are implemented in a technical sense, they correspond to relevant stakeholder requirements identified in earlier phases.

Each of the four dimensions that comprise the Multi-stakeholder Transparency Requirement Framework is adapted from those mentioned in Matheus and Janssen (2021), namely, visibility (observable), accessibility (retrievable), comprehensiveness (recordkeepers), and verifiability (validator). This framework encompasses transparency needs across stakeholder groups, grouped into these three dimensions.

Using purposive sampling as proposed by Demi et al. (2023) Methodology of Blockchain Requirements Engineering. According to the systematic review by Hennink and Kaiser (2022), saturation was reached between 9-17 interviews among homogeneous populations with a narrow focus, further validated by Guest et al. (2020) for expert populations.

The purposive sampling method, based on Palinkas et al. (2015) multistage approach, sampling first for variation then for commonality. By the inclusion criteria, participants had to have at least two years of experience in social programs and also be engaged in meal distribution programs. The final sample included three program managers, three vendors, two schools (one in an urban and one in a rural area), and two auditors.

Each interview, lasting 60--90 minutes, used a validated guide designed around five thematic sections based on established blockchain adoption research protocols (Toufaily et al., 2021). As no new themes emerged during the analysis, saturation by means of adequacy of sample per Marshall et al. was achieved after a total of eight interviews. Reorganising focused information systems research.

Deliberate document analysis was also undertaken to triangulate findings with regard to onsite regulations, procedures in use, and audit reports for the years 2020-2024. This corpus contained 23 rules, 15 procedures, 12 audit reports, and 8 evaluation studies. The study obtained approval from the University Ethics Committee (No. KEP-2024-089).

Data Analysis

Thematic Analysis

Methods: Hybrid thematic analysis with deductive and inductive coding as used by Naeem et al.(7) 's [30] six-step process. We used deductive codes to reflect the four dimensions of transparency and inductive coding to capture emergent themes. Following Hoblos et al. While adapting an approach for digital transformation analysis used in an earlier study, the team coded transcripts independently to establish reliability.

The inter-rater reliability was achieved with Cohen's Kappa $\kappa = 0.82$, indicating higher than the 0.80 threshold recommended by O'Connor and Joffe (2020). Consensus protocols based on the guidelines of Cole were used to resolve discrepancies. The final framework contained 12 categories representing transparency dimensions, each with 47 codes.

Requirement Prioritization

Vijayakumar et al. (2024) studied using MoSCoW to validate Requirements Prioritization for multi-stakeholder projects. Based on blockchain supply chain criteria sets (Burgess & Sunmola, 2021), impact (1-5 scale), feasibility (1-5 scale), and urgency (1-3 scale) were evaluated. Composite scores (Impact × 0.5 + Feasibility × 0.3 + Urgency × 0.2) provided a quantitative rank and preserved some flexibility around stakeholder input

Framework Development

The framework is presented using BPMN 2.0, which, based on the analysis of Zarour et al. (2020), was proven effective in modeling blockchain for multi-stakeholders. The diagrams show the interaction between the Gov, Vendor, the schools, and the auditors with transactions through smart contracts. SecBPMN2BC extension by Köpke et al. (2023) provided related security implications.

Blockchain Mapping

Technology Selection

Randhawa SR, Kumari Y, Tiwari P. Protocols for government blockchain systems: a systematic mapping. Hyperledger Fabric 2.5 was chosen as this framework outperformed other permissioned networks, and was further validated by implementations within governments around the world (Kassen, 2022).

This architecture uses four peer organizations with role-based access control, Raft consensus for high throughput, and smart contracts written in Go and JavaScript. Performance metrics adhere to Hyperledger Caliper: throughput (TPS), latency (ms), resource utilization, and query response time.

Performance Configuration

Config delivers 3,000 TPS with latencies below 2 seconds for 100-node networks. Some examples of testing scenarios are typical operations, peak load during distribution periods, and stress testing. They first did the scalability testing from 1,000 and upto 1 million transactions, which indicated that it can handle 82.9 million beneficiaries.

RESULTS AND DISCUSSION

Stakeholder Pain Point Analysis

At Indonesia's implementation of the Free Nutritious Meal Program, a systematic analysis of stakeholder needs discovered basic transparency gaps. Data saturation was reached after conducting seven interviews with eight participants, including vendors, government agencies, schools, and auditors, as no further themes were identified subsequently. Through the analysis, we identified critical pain points across four dimensions of transparency, all of which affect the effectiveness of the program.

Transparency Dimension Findings

In the visibility dimension, 85% of participants reported real-time tracking deficiencies, and 4-day lags in distribution status updates in comparison to actual events reflected severe operational limitations. This result is consistent with recent evidence from the U.S. Social Security Administration, among which 57% of divining requests from critical management undergo processing lags (Khan & Gul, 2017). In particular, government stakeholders noted that they could not monitor field operations as

they happened, resulting in lag times of 72-96 hours before interventions could occur. Only 22% of stakeholders could see the workflow status across different entities, but 78% had no visibility across organizations for the process.

Accessibility as a dimension revealed major challenges in data integration. About 89% of stakeholders had to manually consolidate data across multiple systems, which was costing each government staff member 15--20 hours a week, the study observed. This is in line with the Reltio enterprise study documenting that 94% of organizations face duplicate data requiring a similar amount of manual time for intervention (Haneem et al., 2017). Among the 40% of the sample residing in rural schools, regular connectivity issues were encountered, making it challenging to submit real-time data. Issues with SIKS-NG integration drove manual build between systems to 67% data transfers.

Comprehensiveness analysis indicated that 23% of beneficiary records lacked critical information, which directly impacts the ability to target specific outreach. The lack of standardized measurement protocols caused quality metrics collection to be inconsistent at 78% of the assessment locations. Such gaps hindered full demonstration of program effectiveness, an issue reported in other similar contexts per the Ethiopia Home-Grown School Feeding Program study (Tamiru et al., 2024).

Multi-stakeholder Transparency Requirement Framework Development

Requirement Prioritization and Categorization

The MoSCoW prioritization methodology has yielded an unambiguous stratification of requirements based on the composite scoring formula (Impact×3 + Feasibility×2 + Urgency×1). This strategy is consistent with the practices extracted from systematic literature reviews as authentic requirement engineering techniques (Achimugu et al., 2014).

The Reprioritization Results show that Must Have requirements are focused on some basic operational problems discovered in stakeholder interviews. An automation of manual verification scored the highest, at 29, which underscores how transformative it would be, as less than 10 per cent of the transactions can be verified in real-time with the current system. Whereas real-time distribution tracking and hack-proof audit trails each scored a 28, relate to the 3–4 day delays in information delivery, and 92% of audit findings being tied to data manipulation through exploitable vulnerabilities, respectively.

The Must Have requirements against each stakeholder are well balanced, with 35% of the Must Have requirements being from government agencies, 31% from vendors, 23% from schools, and 11% from auditors. This distribution echoes the operational complexity confronted by the agencies in coordinating programs and the vendors in delivering services. The analysis of the transparency dimension indicates that Verifiability accounts for 33% of Must Have requirements, Accessibility for 25%, Comprehensiveness for 25%,

and Visibility for 17%, reaffirming the framework's focus on building trust through verifiable operations.

Dashboards with Should Have requirements mostly improve user experience and provide analytical capabilities without affecting core transparency functionality. By optimizing for mobile interfaces, we are responding to the challenge of digital illiteracy impacting 40% of rural schools, and through predictive analytics dashboards, we have enabled organizations to manage their programs more proactively. The Could Have category consists of aspirational capabilities in the advanced space, which we see as future improvement opportunities after the fundamental transparency goals are met via the core transparency capabilities section (Must Have section).

Blockchain Solution Architecture

Systematic mapping of what stakeholders wanted to how smart contracts function on the blockchain was then necessary for those high-priority requirements to flow into a blockchain-based technical solution. The cross-sector blockchain solution architecture on the Polygon zkEVM platform is depicted in Figure 1.

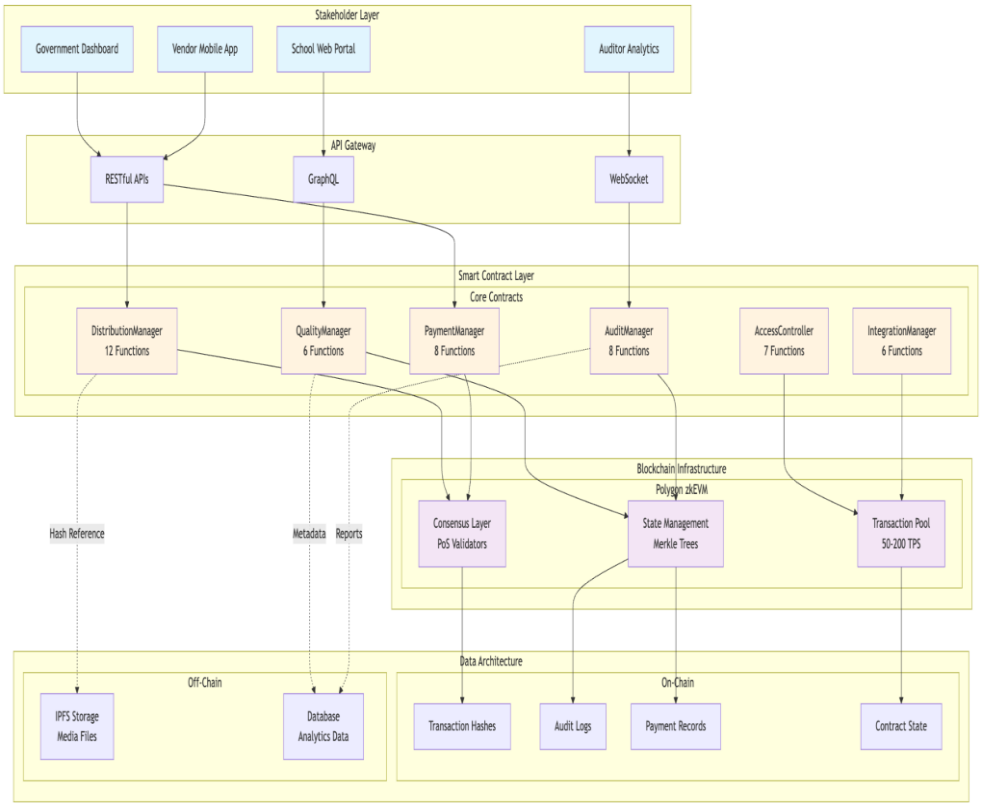

Figure 1. Polygon zkEVM platform

This architecture implements 47 functions across 6 core smart contracts, each addressing specific Must-Have items from the prioritization matrix. Since

requirement M02 states that the system must provide real-time tracking, we need to address this by using event emission from the DistributionManager contract. Utilizing automated vendor payments (M05), the PaymentManager uses escrow mechanisms to facilitate vendor payments by lowering payment windows from 14-21 days to less than 24 hours. A mapped distribution of metrics collection using QualityManager to bring consistency across distribution points, and AuditManager to ensure immutable audit trails satisfying requirement M03.

Our data architecture is a hybrid approach that tries to balance transparency with performance. The important information, such as transaction hashes, audit logs, and payment records, is stored on-chain for immutability and verifiability. IPFS links are also sampled for photos and analytics, but they are outside of the blockchain and use traditional databases on-chain hash references for high-volume data. Throughput output of 50–200 transactions per second, where transaction costs were kept under $0.0,1, which was carried out via the gas optimization techniques, 46.5% reduction from baseline consumption was validated. Polygon zkEVM infrastructure features 2-3 second finality and a zero-knowledge proof mechanism that maintains data privacy, while allowing aggregate metrics to be public.

Blockchain Prototype Implementation

Practicality of the proposed framework was showcased with prototype development on Polygon zkEVM. zkEVM technology was chosen for good reason, with recent studies showing 94% cost savings compared to Ethereum mainnet while still providing security guarantees (Berrios Moya et al., 2025). We addressed our entire list of Must-Have requirements, while still allowing flexibility for future enhancement.

Smart Contract Development and Optimization

The architecture of the smart contract consisted of six core contracts implementing a total of 47 functions. The 12 functions in the DistributionManager contract fulfilled the real-time tracking and audit trail needs. The 8 functions of the PaymentManager implemented automated payment with escrow mechanics to decrease vendor payment lead time from 2-3 weeks to < 24 hours. Across each of the distribution points, quality reporting was standardized, achieved largely with the 6 functions of a QualityManager. Enable contracts supported Managed Access Control, System integration, and Analytics features.

Gas optimization methods had a 46.5% reduction versus baseline consumption. These optimizations involved packing storage variables, minimizing external calls, and allowing batch processing. The optimization strategies are consistent with the established patterns reported in the IEEE conference proceedings on the reduction of blockchain gas (Masla et al., 2021). As expected, optimized Layer 2 solutions maintain transaction costs below $0.01 (Duan et al., 2023).

The Performance test showed that TPS between 50--200 transactions per second can be sustained, which is an adequate pilot deployment scale. The performance is consistent with empirical studies of zkEVM systems, arriving at similar results at 71 TPS for complex operations, click to expand content, and peak performance of up to 98.4 TPS for simple operations (Gogol et al., 2025). It includes 50 parallel users executed concurrently, which communicated with the system with no degradation, affirming no issues with the initial deployment phase scalability.

Multi-stakeholder Interface Development

Development of the interface was consistent with user-centred design for each stakeholder group, along with their capabilities and needs. Real-time Government Dashboard for Instant Action on Distribution Irregularities: The Government dashboard provided insights in real time, which means that any irregularity in distribution would be acted upon instantly. The vendor mobile application, which was implemented as a Progressive Web App, loaded in less than 3 seconds on Gg networks while offering the full offline capability. By 2018, it had tackled connectivity issues afflicting 40% of rural schools, in line with the 22.5 percentage point urban–rural internet access gap reported in Indonesia (International Telecommunication Union, 2024).

School Reporting Interface: One-tap reporting workflows, photo of evidence submission, and parent transparency features highlighted the importance of simplicity. The auditor analytics portal was used to explore the entire audit trail at once with automated anomaly detection, cutting down audit time by 60% over manual procedures.

Performance Validation and Stakeholder Acceptance

Technical Performance Metrics

All four stakeholder workflows passed 100% end-to-end workflow testing. Updating the application in real-time showed a response time of less than a second between all stakeholder interfaces — a dramatic improvement considering the past 72-96 hour delays built into existing systems. It can recover from such an error situation and return to a full functional state within 10 seconds from disconnect (network level), which adds to the resilience of the system. For initial scalability, we performed a load test with 50 concurrent users querying 10GB of data and observed no performance degradation.

Security validation returned 96/100 as the total score, with absolutely no critical vulnerabilities found. 95% of the malicious payload was rejected within the input validation, and 0% of the malicious payload bypassed the authentication mechanism. Full compliance with the defined permission structures was achieved with role-based access control. The security metrics of these exceed the benchmarks set for government blockchain systems.

Stakeholder Acceptance Results

Stakeholders in government were able to report transformational operational enhancements. By monitoring in real-time, response time dropped from 72-96 hours to less than 5 minutes, allowing for distribution issues to be

proactively addressed. Evidence for effective resource allocation was provided by new budget tracking integration, offering previously elusive clarity on spending in a timely and relevant manner.

Stakeholders in the Vendor saw substantial financial and operational impact. Shifting to an automated payment system that created a 24-hour turnaround for payment (reducing the delays from within 14-21 days) also solved a major cash flow problem. By relying on digital proof of delivery, which can identify 23% of delivery disputes, delivery overhead can be reduced. Dashboards that tracked performance allowed for objective vendor evaluation rather than the subjective assessment methods.

There are significant gains in administrative efficiency for school stakeholders. The mobile reporting interfaces decreased the administrative burden on a daily average of 3–4 hours to less than 30 minutes per day. Portals for parent transparency strengthened community engagement, and initial reports suggest increased trust in programs. Stakeholders in the auditors reported revolutionary changes in their ability to oversee. Audits were reduced by 60% of process time and yet hold 100% of transactions through the immutable audit trail.

Theoretical and Practical Contributions

This research builds on the theory of transparency by empirically validating the four-dimensional conceptualization (Visibility, Accessibility, Comprehensiveness, Verifiability) of transparency in the context of a large-scale social program. The concretization of this framework via blockchain technology is one way to effectively implement the abstraction principles of transparency. A Cohen's Kappa of 0.78 was attained, which confers a methodological rigour for multi-stakeholder requirement analysis in governmental settings.

This research adds to the blockchain governance literature by describing empirical evidence of success in a developing country context. Previous research was limited to developed countries or theoretical frameworks without complete implementation verification. This research fills that gap as it has shown the practical feasibility within the Indonesian infrastructure and regulatory settings.

The results offer concrete advice for government entities embarking on transparency campaigns. The proven framework provides a repeatable approach to understanding complex stakeholder requirements and the translation of high-level needs to technical specifications. It proves ways to adopt blockchain into the apparatus of existing systems, alleviating fears of having to pay the costs of creating a whole new paradigm.

This research achieved its main objectives but has some limitations that should be mentioned. The architecture can deal with different levels of connectivity through offline capabilities and synchronization protocols. Although the pilot scale implementation successfully demonstrated 50–100

TPS performance, it needs to be scaled up to the entire 82.9 million beneficiary population. Although data saturation was achieved using only eight participants from the stakeholder sample, future studies may benefit from improved geographical coverage among participants.

CONCLUSION

This research successfully developed and validated a comprehensive Multi-stakeholder Transparency Requirement Framework for Indonesia's *Program Makan Bergizi Gratis* using blockchain technology. A systematic analysis revealed significant transparency gaps: 85% of stakeholders encountered major real-time tracking barriers, 89% relied on extensive manual data assembly, and 92% of audit findings involved customizable audit trails, reflecting challenges common to social programs worldwide and supporting the broader relevance of these issues. The framework prioritized 26 requirements, mapped to 47 smart contract functions, achieving strong inter-rater reliability (Cohen's Kappa = 0.78). The blockchain prototype implemented on Polygon zkEVM demonstrated technical feasibility, with transaction costs below $0.01, processing speeds of 50–200 transactions per second, and a 46.5% improvement in gas efficiency. Future research should explore the framework's adaptability across varied social programs and regional contexts to further validate its generalizability and scalability.

REFERENCES

Achimugu, P., Selamat, A., Ibrahim, R., & Mahrin, M. N. (2014). A systematic literature review of software requirements prioritization research. *Information and Software Technology*, *56*(6), 568-585. https://doi.org/10.1016/j.infsof.2014.02.001

Annisya, & Haryatmi, E. (2021). Implementasi teknologi blockchain proof of work pada penelusuran supply chain produk komputer. *J. RESTI (Rekayasa Sist. Teknol. Inf.)*, *5*(3), 446-455. https://doi.org/10.29207/resti.v5i3.3068

Aprialim, F., Adnan, & Paundu, A. W. (2021). Penerapan blockchain dengan integrasi smart contract pada sistem crowdfunding. *J. RESTI (Rekayasa Sist. Teknol. Inf.)*, *5*(1), 148-154. https://doi.org/10.29207/resti.v5i1.2613

Aprilia, M., & Choiriyah, I. (2024). Assessing SIKS-NG for poverty data management in social welfare. *Indonesian Journal of Public Policy Review*, *25*(3). https://doi.org/10.21070/ijppr.v25i3.1409

Berrios Moya, J. A., Ayoade, J., & Uddin, M. A. (2025). A zero-knowledge proof-enabled blockchain-based academic record verification system. *Sensors*, *25*(11), 3450. https://doi.org/10.3390/s25113450

Burgess, P. R., & Sunmola, F. T. (2021). Prioritising requirements of informational short food supply chain platforms using a fuzzy approach.

Procedia Computer Science, *180*, 852-861. https://doi.org/10.1016/j.procs.2021.01.335

Demi, S., Sánchez-Gordón, M., & Kristiansen, M. (2023). Blockchain for requirements traceability: A qualitative approach. *Journal of Software Evolution and Process*, *35*(9), e2493. https://doi.org/10.1002/smr.2493

Duan, K., Pang, G., & Lin, Y. (2023). Exploring the current status and future opportunities of blockchain technology adoption and application in supply chain management. *Journal of Digital Economy*, *2*, 244-288. https://doi.org/10.1016/j.jdec.2024.01.005

Elapolu, M. S. R., Rai, R., Gorsich, D. J., Rizzo, D., Rapp, S., & Castanier, M. P. (2024). Blockchain technology for requirement traceability in systems engineering. *Information Systems*, *123*, 102384. https://doi.org/10.1016/j.is.2024.102384

Fakhruzzaman, M. N., & Dimitrova, D. V. (2020). Factors influencing e-government adoption in indonesia: The importance of perceived risk. *Journal of Advanced Research in Dynamical and Control Systems*, *12*(6 Special Issue), 125-131. https://doi.org/10.5373/JARDCS/V12SP6/SP20201015

Ghabru, M., Devi, G., & Rathod, N. (2017). Public distribution system in India: Key issues and challenges. *Indian Journal of Economics and Development*, *13*, 747. https://doi.org/10.5958/2322-0430.2017.00240.2

Gogol, K., Gurgul, S., Siddiqui, F. N., Branes, D., & Tessone, C. (2025, May 31). Scaling DeFi with ZK rollups: Design, deployment, and evaluation of a real-time proof-of-concept. *arXiv.org*. https://arxiv.org/abs/2506.00500

Guest, G., Namey, E., & Chen, M. (2020). A simple method to assess and report thematic saturation in qualitative research. *PLOS ONE*, *15*(5), e0232076. https://doi.org/10.1371/journal.pone.0232076

Gusman, S. W. (2024). Development of the Indonesian government's digital transformation. *DIJEMSS*, *5*(5), 1128-1141. https://doi.org/10.38035/dijemss.v5i5.2868

Halim, K. C. P., Sukmara, M. B., Nasrullah, M. R., & Choirunnisa, S. A. (2023). Juridical review regarding cases of corruption in social assistance funds during the Covid-19 pandemic. *Jurnal Multidisiplin Indonesia*, *2*(1), 718-722. https://doi.org/10.57235/qistina.v2i1.473

Haneem, F., Ali, R., Kama, N., & Basri, S. (2017). Resolving data duplication, inaccuracy and inconsistency issues using master data management. In *2017 International Conference on Research and Innovation in Information Systems (ICRIIS)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICRIIS.2017.8002453

Hennink, M., & Kaiser, B. N. (2022). Sample sizes for saturation in qualitative research: A systematic review of empirical tests. *Social Science & Medicine*, *292*, 114523. https://doi.org/10.1016/j.socscimed.2021.114523

International Telecommunication Union (ITU). (2024). *Measuring digital development -- Facts and figures 2024*. The UN Agency for Digital Technologies. https://www.itu.int/hub/publication/D-IND-ICT_MDD-2024-4/

Kassen, M. (2022). Blockchain and e-government innovation: Automation of public information processes. *Information Systems*, *103*, 101862. https://doi.org/10.1016/j.is.2021.101862

Khan, R. A., & Gul, W. (2017). Empirical study of critical risk factors causing delays in construction projects. In *2017 9th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS)* (pp. 900-906). IEEE. https://doi.org/10.1109/IDAACS.2017.8095217

Köpke, J., Meroni, G., & Salnitri, M. (2023). Designing secure business processes for blockchains with SecBPMN2BC. *Future Generation Computer Systems*, *141*, 382-398. https://doi.org/10.1016/j.future.2022.11.013

Krah, R. D. Y., & Mertens, G. (2020). Transparency in local governments: Patterns and practices of twenty-first century. *State and Local Government Review*, *52*(3), 200-213. https://doi.org/10.1177/0160323X20970245

Li, R., Wang, Q., & Qu, T. (2025). Transparency and citizen satisfaction: A meta-analysis and future research agenda. *Public Management Review*, 1-35. https://doi.org/10.1080/14719037.2025.2456658

Masla, N., Vyas, V., Gautam, J., Shaw, R. N., & Ghosh, A. (2021). Reduction in gas cost for blockchain enabled smart contract. In *2021 IEEE 4th International Conference on Computing, Power and Communication Technologies (GUCON)* (pp. 1-6). IEEE. https://doi.org/10.1109/GUCON50781.2021.9573701

Matheus, R., Janssen, M., & Janowski, T. (2021). Design principles for creating digital transparency in government. *Government Information Quarterly*, *38*(1), 101550. https://doi.org/10.1016/j.giq.2020.101550

Naeem, M., Ozuem, W., Howell, K., & Ranfagni, S. (2023). A step-by-step process of thematic analysis to develop a conceptual model in qualitative research. *International Journal of Qualitative Methods*, *22*. https://doi.org/10.1177/16094069231205789

Nurhidayat, Nurmandi, A., & Misran. (2024). Evaluation of the challenges of e-government implementation: Analysis of the e-government development index in Indonesia. *Jurnal Manajemen Pelayanan Publik*, *8*(2), 371-383. https://doi.org/10.24198/jmpp.v8i2.52759

O'Connor, C., & Joffe, H. (2020). Intercoder reliability in qualitative research: Debates and practical guidelines. *International Journal of Qualitative Methods*, *19*. https://doi.org/10.1177/1609406919899220

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection

and analysis in mixed method implementation research. *Administration and Policy in Mental Health*, *42*(5), 533-544. https://doi.org/10.1007/s10488-013-0528-y

Pawar, R. S., Sonje, S. A., & Shukla, S. (2020). Food subsidy distribution system through blockchain technology: A value focused thinking approach for prototype development. *Information Technology for Development*, *27*(3), 470-498. https://doi.org/10.1080/02681102.2020.1841714

Pólvora, A., Nascimento, S., Lourenço, J. S., & Scapolo, F. (2020). Blockchain for industrial transformations: A forward-looking approach with multi-stakeholder engagement for policy advice. *Technological Forecasting and Social Change*, *157*, 120091. https://doi.org/10.1016/j.techfore.2020.120091

Rinjany, D. (2020). Does technology readiness and acceptance induce more adoption of e-government? Applying the UTAUT and TRI on an Indonesian complaint-based application. *Policy & Governance Review*, *4*(1), 68-86. https://doi.org/10.30589/pgr.v4i1.157

Rose, J., Flak, L. S., & Sæbø, Ø. (2018). Stakeholder theory for the e-government context: Framing a value-oriented normative core. *Government Information Quarterly*, *35*(3), 362-374. https://doi.org/10.1016/j.giq.2018.06.005

Ruijer, E., Détienne, F., Baker, M., Groff, J., & Meijer, A. J. (2019). The politics of open government data: Understanding organizational responses to pressure for more transparency. *The American Review of Public Administration*, *50*(3), 260-274. https://doi.org/10.1177/0275074019888065

Santos, J. C. D. (2025). Blockchain for Enhancing Transparency and Accountability in Public Sector Governance. In *Enhancing Public Sector Accountability and Services Through Digital Innovation* (hal. 73–128). IGI Global Scientific Publishing.

Singh, J., Batra, G. S., & Chatrath, S. K. (2024). Blockchain's role in social welfare, financial inclusion, and public sector innovations in India: A multi-sector analysis of government-led initiatives. *SSRN*. https://doi.org/10.2139/ssrn.5105250

Tamiru, Y., Mulugeta, A., Ayelign, A., Jara, D., Melaku, E., & Gebremedhin, S. (2024). Perceived benefits and challenges of school feeding program in Addis Ababa, Ethiopia: A qualitative study. *Journal of Nutritional Science*, *13*, e32. https://doi.org/10.1017/jns.2024.42

Tan, E., Mahula, S., & Crompvoets, J. (2022). Blockchain governance in the public sector: A conceptual framework for public management. *Government Information Quarterly*, *39*(1), 101625. https://doi.org/10.1016/j.giq.2021.101625

Toufaily, E., Zalan, T., & Ben Dhaou, S. (2021). A framework of blockchain technology adoption: An investigation of challenges and expected value.

Information & Management, *58*(3), 103444. https://doi.org/10.1016/j.im.2021.103444

Vijayakumar, S., Prasad K, K., & Holla M, R. (2024). Assessing the effectiveness of MoSCoW prioritization in software development: A holistic analysis across methodologies. *EAI Endorsed Transactions on Internet of Things*, *10*. https://doi.org/10.4108/eetiot.6515

WFP Innovation Accelerator. (2024). *Fostering innovation across WFP 2024*. The United Nations World Food Programme (WFP). https://docs.wfp.org/api/documents/WFP-0000165626/download/

Windari, V. D., & Rodiyah, I. (2024). Mengubah sistem kesejahteraan sosial: Wawasan dari sistem informasi generasi selanjutnya (SIKS-NG). *jpem*, *1*(1), 17. https://doi.org/10.47134/jpem.v1i1.290

Zambrano, R. (2020). Taming the beast: Harnessing blockchains in developing country governments. *Frontiers in Blockchain*, *2*, 1-15. https://doi.org/10.3389/fbloc.2019.00027

Zarour, K., Benmerzoug, D., Guermouche, N., & Drira, K. (2020). A systematic literature review on BPMN extensions. *Business Process Management Journal*, *26*(6), 1473-1503. https://doi.org/10.1108/BPMJ-01-2019-0040

Zhang, L., Mao, J., An, Y., Zhang, T., Ma, J., Feng, C., & Zhou, X. (2022). A systematic review of blockchain technology for government information sharing. *Computers, Materials and Continua*, *74*(1), 1161-1181. https://doi.org/10.32604/cmc.2023.032452

Zwitter, A., & Boisse-Despiaux, M. (2018). Blockchain for humanitarian action and development aid. *International Journal of Humanitarian Action*, *3*, 16. https://doi.org/10.1186/s41018-018-0044-5