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Oriented Enterprise Architecture for Enhancing Digital Governance and Technopreneurship in Regional Governments

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ABSTRACT

This study examines disparities in the implementation of Indonesia's Electronic-Based Government System (SPBE) which remain fragmented across regional governments and hinder efficient service delivery. **The purpose** of this research is to develop a hybrid enterprise architecture planning framework that combines TOGAF, Zachman, FEAF, and Gartner models to achieve more harmonized and interoperable SPBE adoption. **A quantitative** explanatory method was used with Partial Least Squares Structural Equation Modeling (PLS-SEM), involving data from 337 valid respondents across nine district and city governments in West Java Province. Four main constructs were examined, including SPBE implementation standardization, operational procedure clarity, technology harmonization, and institutional collaboration. **The findings** show that all constructs significantly improve digital governance effectiveness, with standardization being the strongest influencing factor with a coefficient value of 0.423 and significance level below 0.01. In addition to statistical validation, the study presents an operational framework containing procedural flow, logic matrix, and pseudocode that bridges theoretical concepts and practical implementation in SPBE planning. **This hybrid** framework provides a structured but also flexible approach suitable for Indonesia's decentralized governance by enhancing interoperability, transparency, and coordination between agencies. Overall, the research contributes both theoretically and practically by demonstrating how the integration of enterprise architecture principles can strengthen SPBE implementation and support sustainable digital transformation within local governments.

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1. INTRODUCTION

In the current era, disruptions are the norm across all sectors, spurred by the Fourth Industrial Revolution [1, 2]. The convergence of digital technologies such as the Internet of Things (IoT), mobile internet [3], and artificial intelligence has drastically transformed traditional service delivery models [4, 5] including public governance. Citizens now demand fast, transparent, and data-driven services, pushing governments to adopt innovative digital approaches [6, 7] in managing their administrative and service functions. Within this global context, the concept of a Smart City has gained momentum as a holistic framework for urban transformation

[8]. The Smart City paradigm also aligns closely with the United Nations' Sustainable Development Goals (SDGs), particularly Goal 9 (Industry, Innovation, and Infrastructure), Goal 11 (Sustainable Cities and Communities), and Goal 16 (Peace, Justice, and Strong Institutions). By promoting transparent governance, digital inclusivity, and resilient infrastructure, Smart City initiatives contribute directly to advancing these global targets. Thus, integrating SPBE with Smart City development is both a national priority and part of the global agenda for sustainable and inclusive digital transformation.

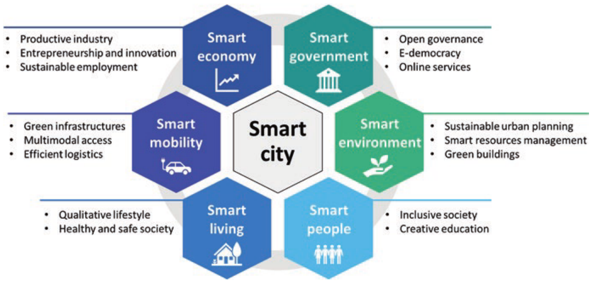


Figure 1. The six Pillars of Smart Cities [9]

At the core of this transformation is the Smart City concept, which integrates technology, governance, sustainability, and citizen participation to enhance urban quality of life [10–12]. As illustrated in Figure 1, the framework consists of six domains Smart Economy, Smart Government, Smart Environment, Smart Mobility, Smart People, and Smart Living each contributing to resilient and intelligent urban systems [13, 14]. These domains encourage innovation, open governance, sustainable planning, green mobility, improved quality of life, and inclusive education, while collectively forming an interconnected ecosystem reliant on interoperability and data exchange [15].

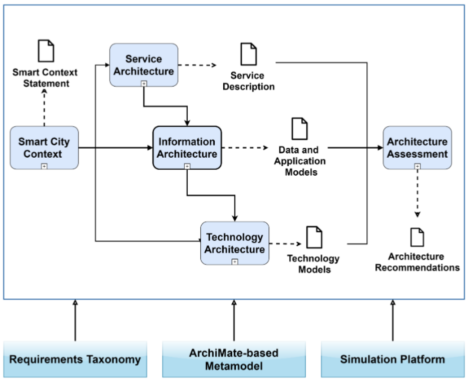


Figure 2. Smart City Architecture Showing Flow Across Key Domains
Source: Enterprise Architecture Management for Smart Cities [16]

Figure 2 illustrates how Smart City Context drives the development of architectural components across multiple layers. The contextual needs of the city first guide the formation of service descriptions, which define what services must be delivered to stakeholders. These service requirements are then supported by the Information Layer, where core data and application models [17] structure the information needed for service execution. The Technology Architecture translates these information needs into technological models that ensure the required systems and infrastructures can operate effectively. Finally, the Architecture Assessment layer provides evaluation outputs that help verify whether the overall architecture remains aligned with contextual goals, interoperable across layers, and suitable for continuous improvement.

In the Indonesian context, the integration of Smart City elements has been pursued through SPBE. Initially introduced via Presidential Instruction No. 6 of 2001 [18] and refined through Presidential Instruction No. 3 of 2003 [19], the initiative was formally institutionalized under Presidential Regulation No. 95 of 2018 [20]. This regulation requires transforming public governance into a digital, connected, and efficient system, with coordinated ICT planning and evaluation across all government levels.

The SPBE framework is composed of a National Master Plan, SPBE Architecture, SPBE Governance, and SPBE Management [21]. The SPBE architecture serves as the blueprint for integrating business processes, information systems, infrastructure, and security protocols across institutions [22]. Governance elements provide direction in planning, budgeting, and process standardization, while management layers handle risk, HR, data, services, and assets. This comprehensive structure is intended to ensure consistency, accountability, and sustainability in Indonesia's digital transformation journey.

Despite its promise, however, SPBE implementation across ministries and regional governments remains uneven. According to the 2019 SPBE Evaluation by KemenPAN-RB, only 19% of government institutions achieved a "Good" score, while 81% of central agencies and 92% of regional governments lagged behind [23, 24]. Challenges identified include inefficient ICT investments, lack of integration between systems, and absence of a standardized digital architecture all of which lead to duplicated efforts, data silos, and inconsistent service quality. This situation significantly hinders the realization of integrated smart services that are envisioned in national and regional development plans.

These issues are particularly critical when local governments adopt Smart City solutions. As shown in Figure 1 and Figure 2, the success of smart mobility, e-democracy, green planning, and real-time citizen services relies on harmonized architecture and data interoperability. Fragmented systems hinder data exchange and service execution, leaving initiatives disjointed. To address this, Enterprise Architecture (EA) provides a strategic approach to align ICT with institutional goals. Frameworks such as TOGAF, Zachman, FEAF, and Gartner offer methods for building scalable and interoperable systems. However, EA adoption in Indonesia's public sector remains limited in standardization, adaptability, and integration with SPBE, especially at regional levels. This study develops a hybrid EA planning framework that unifies multiple models into an SPBE-aligned approach to improve interoperability, streamline G2G interactions [25], and provide a standard foundation for Smart City transformation [26]. Beyond technical standardization, the framework emphasizes organizational alignment and digital service harmonization, offering both theoretical and practical contributions to integrated digital governance.

2. LITERATURE REVIEW

2.1. Electronic-Based Government System (SPBE) in Indonesia

The adoption of the SPBE in Indonesia represents a significant milestone in the national agenda to digitize governance. Enacted through Presidential Regulation No. 95 of 2018 [20], SPBE is framed as a strategic policy instrument aimed at creating an integrated, secure, and high-performing public sector. It mandates the establishment of a comprehensive digital governance ecosystem across central and regional agencies, with the intent of achieving greater institutional efficiency, service accessibility, and citizen trust.

Table 1. Enterprise Architecture

Title	Research Objective	Finding
Enterprise Architecture Planning for Village-Level E-Government Based on Gartner Framework [27]	To adapt Gartner's framework for village government contexts in Indonesia.	Found that Gartner's flexible, business-value focused approach was more appropriate in low-resource settings.
Strategic ICT Architecture Development in a District Government Using Gartner Model [28]	To support ICT strategic planning using Gartner's enterprise design principles.	Demonstrated that Gartner's layered model enabled clearer ICT prioritization and institutional adaptability.

However, despite this regulatory clarity, the translation of SPBE principles into actionable frameworks at the local level has revealed substantial inconsistencies. As evidenced in Table 1 of this study, government institutions exhibit wide variation in their SPBE maturity, with many failing to achieve alignment in architectural design, ICT governance, or inter-agency interoperability. This suggests that while the SPBE policy is top-down in its formulation, its implementation demands more nuanced, context-sensitive approaches particularly in regions with uneven digital capacities and fragmented legacy systems. These variations highlight the importance of adopting a structured enterprise architecture approach, such as the Gartner framework, to ensure consistent governance alignment and improved digital transformation outcomes across regional administrations.

2.2. Enterprise Architecture in Public Sector Governance

The application of Enterprise Architecture (EA) has long been associated with institutional reform, particularly in environments characterized by complexity, regulatory constraints, and technological heterogeneity. EA is not merely a technical framework, it is a strategic tool that supports the alignment of ICT systems with institutional goals, facilitates coordinated service delivery, and enables long-term digital resilience. Within the public sector, such as [29] and [30] have underscored EA's role in mitigating redundancies, standardizing infrastructure, and guiding innovation.

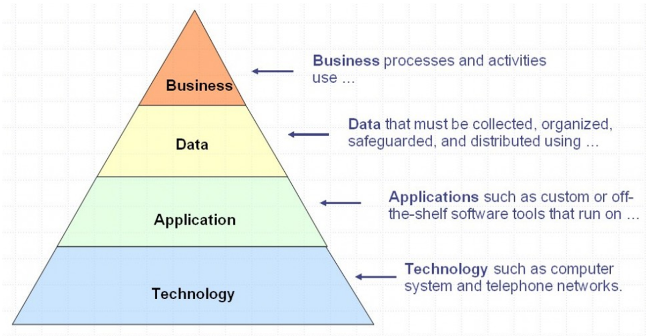


Figure 3. Enterprise Architecture

Source: Enterprise Architecture [31]

In the context of SPBE, EA is not just desirable, it is imperative. As illustrated in Figure 3, a robust EA structure underpins the SPBE architecture, serving as the connective tissue between governance ambitions and operational reality. Without such a foundation, efforts to digitize public services remain piecemeal, vulnerable to fragmentation, and misaligned with broader developmental objectives such as Smart City transformation.

2.3. Comparative Analysis of Leading EA Frameworks

Numerous EA frameworks have been proposed and adopted globally, each with distinctive philosophies, methodological structures, and suitability for specific institutional contexts. This study draws upon four prominent frameworks TOGAF, Zachman, FEAF, and Gartner not as isolated systems, but as complementary lenses through which a hybridized architecture for SPBE can be developed.

2.3.1. The TOGAF Framework

TOGAF is among the most extensively adopted frameworks globally, particularly in government and large-scale organizations [32]. It is best known for its Architecture Development Method (ADM), an iterative, phase-based lifecycle model that guides practitioners from architecture vision through to implementation and change management. TOGAF emphasizes four key architectural domains including business, data, application, and technology, supported by governance structures that align IT planning with enterprise strategy.

In the context of SPBE, TOGAF's methodological rigor and formal governance models offer a structured pathway for institutions to transition from fragmented digital systems toward integrated, service-oriented architectures. Its emphasis on stakeholder involvement, architectural governance, and capability-based planning aligns with SPBE's demand for institution-wide coordination and long-term digital investment alignment.

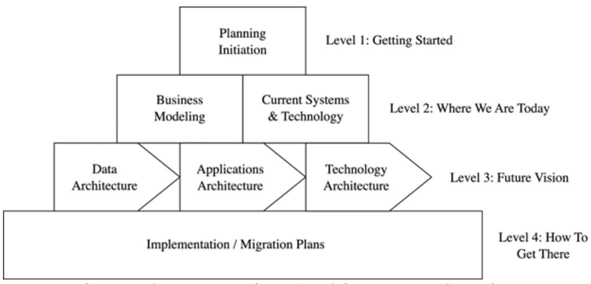


Figure 4. Enterprise Architecture Planning

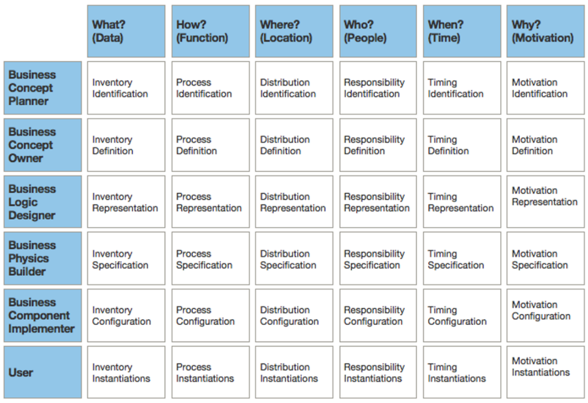
Source: Enterprise Architecture Planning [33]

However, TOGAF's strength in process management can become a limitation in low-resource environments, such as regional governments with limited IT maturity. The application of TOGAF in this study is therefore selective, retaining its ADM lifecycle and governance principles, while adapting the complexity of implementation to the institutional capacity of local governments, as illustrated in Figure 4. The dissertation maps TOGAF's ADM stages against SPBE's national digital development phases, showcasing its suitability for formal public sector transformation. Figure 4 is intended to illustrate how TOGAF's Architecture Development Method (ADM) aligns with Indonesia's SPBE phases. It functions as a conceptual mapping that highlights the suitability of TOGAF in formalizing government digital transformation. Its role is explanatory, showing the methodological rigor of TOGAF in bridging strategic vision and implementation steps within the SPBE context.

2.3.2. Zachman Framework

The Zachman Framework offers a fundamentally different perspective. It is a taxonomy rather than a methodology, a structured matrix that categorizes architectural artifacts across two dimensions namely six stakeholder perspectives (planner, owner, designer, builder, subcontractor, user) and six interrogatives (what, how, where, who, when, why) [34]. This results in a 6x6 grid that ensures architectural completeness by identifying and classifying all essential elements of an enterprise system, as illustrated in Figure 5.

Its primary strength lies in ensuring comprehensiveness and traceability. In SPBE settings, where government institutions operate with overlapping responsibilities, unclear ownership, and distributed authority, Zachman provides a useful reference to align stakeholder roles with system artifacts. Particularly in regions where systems evolve independently, the Zachman matrix ensures that business processes, data models, and user roles are well mapped, reducing duplication and ambiguity.



	What? (Data)	How? (Function)	Where? (Location)	Who? (People)	When? (Time)	Why? (Motivation)
Business Concept Planner	Inventory Identification	Process Identification	Distribution Identification	Responsibility Identification	Timing Identification	Motivation Identification
Business Concept Owner	Inventory Definition	Process Definition	Distribution Definition	Responsibility Definition	Timing Definition	Motivation Definition
Business Logic Designer	Inventory Representation	Process Representation	Distribution Representation	Responsibility Representation	Timing Representation	Motivation Representation
Business Physics Builder	Inventory Specification	Process Specification	Distribution Specification	Responsibility Specification	Timing Specification	Motivation Specification
Business Component Implementer	Inventory Configuration	Process Configuration	Distribution Configuration	Responsibility Configuration	Timing Configuration	Motivation Configuration
User	Inventory Instantiations	Process Instantiations	Distribution Instantiations	Responsibility Instantiations	Timing Instantiations	Motivation Instantiations

Figure 5. Zachman Framework

Source: Zachman Framework Foundations [35]

That said, the Zachman Framework does not provide implementation guidance, and by itself lacks the procedural depth required for systemic transformation. In this study, Zachman is not used as a standalone architecture tool but rather as a complementary classification framework. It helps structure the roles, responsibilities, and data relationships within the broader EA design, particularly in aligning SPBE artifacts with stakeholder mandates.

2.3.3. Federal Enterprise Architecture Framework (FEAF)

FEAF was developed by the United States Office of Management and Budget as a dedicated EA framework for federal-level public institutions [36]. Its central contribution lies in the introduction of five interrelated reference models Performance, Business, Service, Data, and Technical. These models provide standard structures for evaluating government ICT investments and aligning them with mission outcomes and public value.

In relation to SPBE, FEAF is particularly relevant due to its performance-oriented nature and policy integration capabilities. One of the persistent weaknesses in Indonesia's SPBE implementation is the lack of measurable impact assessment. FEAF's Performance Reference Model (PRM) directly addresses this issue, offering a framework to link IT initiatives to institutional performance metrics, such as service delivery speed, operational efficiency, and stakeholder satisfaction [37]. Moreover, FEAF fosters cross-agency interoperability through its Service and Data Reference Models, which encourage standardization and shared services [38]. For SPBE's G2G objectives, this enables a foundation for collaboration across agencies that currently operate in silos.

However, FEAF can be considered rigid and resource-intensive, which limits its feasibility for full-scale deployment in smaller local governments. In this study, FEAF is selectively applied to the evaluation and performance management components of the hybrid model [39]. It is particularly useful in structuring SPBE performance audits and interoperability assessments.

2.3.4. Gartner's EA Practice

Unlike the previous frameworks, Gartner's approach is more pragmatic, outcome-driven, and organizationally responsive. It shifts the focus from documentation to business value realization, emphasizing agility, stakeholder communication, and governance simplification.

Its inclusion in this study is both strategic and contextual. In decentralized settings such as Indonesia's regional governments, rigid frameworks often fail to adapt to local resource constraints and political realities. Gartner's emphasis on continuous value delivery and iterative adaptation complements the more rigid structures of TOGAF and Zachman.

Table 2. Comparison of Enterprise Architecture Frameworks Components

No	Component	TOGAF	Zachman	FEAF	Gartner
1	Structural Orientation	ADM lifecycle with process sequencing	Taxonomy-based classification matrix	Reference model layering	Layered and value-driven strategic model
2	Stakeholder Role Definition	Moderate (business-IT alignment focus)	Very detailed (planner–builder matrix)	Strong in governance and oversight	Emphasizes communication and buy-in
3	Implementation Guidance	Comprehensive and prescriptive	Lacks execution roadmap	Moderate (policy-focused)	High (outcome-oriented, adaptive execution)
4	Suitability for Public Sector	High – proven in government projects	Medium – useful for design clarity	Very High – purpose-built for public orgs	High – ideal for decentralized adaptation
5	Flexibility & Adaptability	Moderate – requires tailoring	High – context-neutral framework	Low – formalized and rigid	Very High – responsive to organizational change

As shown in Table 2, each enterprise architecture framework offers distinct advantages TOGAF with methodological rigor, Zachman with structural completeness, FEAF with sector-specific tools, and Gartner with agility and alignment. However, no single framework can fully address the administrative, technical, and political complexities of implementing SPBE within Indonesia's decentralized governance system.

The novelty of this research lies in its strategic integration of these four frameworks into a hybrid enterprise architecture planning model, purpose-built to support SPBE deployment at the regional government level. Unlike prior studies that rely solely on a single framework, this research offers a contextual synthesis that combines process rigor, architectural completeness, governance evaluation, and organizational adaptability. Moreover, the designed model is intentionally aligned with Indonesia's regulatory and institutional context in public administration, addressing a crucial gap in both theory and practice. The main innovation of this study lies in integrating several frameworks that are grounded in empirical findings and adjusted for national implementation. TOGAF provides structure and governance, while Gartner contributes flexibility and a focus on value. Zachman strengthens architectural clarity, and FEAF enhances performance and interoperability. Possible tensions such as TOGAF's complexity compared to Gartner's simplicity are managed through selective adaptation. As a result, this hybrid model achieves a balanced combination of structure and flexibility, making it well-suited for Indonesia's decentralized governance.

3. METHOD

This study employs a quantitative explanatory design with Structural Equation Modeling (SEM) to test a conceptual model for improving SPBE implementation in Indonesian regional governments [40]. Grounded in design science methodology, it validates theoretical constructs while systematically developing an integrated Hybrid Enterprise Architecture Planning Framework [41].

The proposed framework integrates TOGAF, Zachman, FEAF, and Gartner to overcome fragmentation and lack of interoperability in SPBE initiatives [42, 43]. Using SEM analysis, it shows that strategic alignment, procedural clarity, technological harmonization, and inter-agency collaboration significantly improve local e-government integration [44].

3.1. Object and Unit of Analysis

The object of analysis in this study is the SPBE implementation framework as applied by local government institutions. The research investigates how institutional capabilities, architectural planning, and technological strategies contribute to the success of digital government transformation. The unit of analysis is at the organizational level, specifically targeting government departments or agencies at the district/city level responsible for managing SPBE-related functions.

3.2. Population, Sample, and Research Sites

This research in Table 3 was conducted across 9 (Nine) district and city governments in West Java Province, selected using purposive sampling to reflect variation in SPBE maturity levels and administrative structures. The choice of West Java Province was based on its position as one of Indonesia's most populous and administratively diverse regions, representing a wide spectrum of digital maturity among local governments. West Java also serves as a national pilot region for several SPBE initiatives, making it a relevant and strategic area for examining the challenges and opportunities of hybrid enterprise architecture adoption. Furthermore, the province has both urban and rural districts, allowing for comparative insights across different governance and infrastructure contexts while maintaining research feasibility within a single provincial boundary [45]. A total of 371 responses were initially collected from participants across the nine selected regional government institutions. However, following data screening procedures, only 337 responses were retained for final analysis from public officials responsible for digital transformation, information systems, policy development, and governance. The remaining 34 responses were excluded due to identifiable issues related to response bias and data quality, such as uniform answering patterns (straight lining), unrealistic completion times, or inconsistencies in key construct responses. These exclusion criteria were applied to ensure the validity and robustness of the measurement and structural models used in the Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis [46].

Table 3. Nine District Respondent

No	Government Institution	Unit
1	Regional Government of Kutai Kartanegara	Government Affairs Division
2	Regional Government of Berau	Government Affairs Division
3	Regional Government of West Kutai	Government Affairs Division
4	Regional Government of East Kutai	Government Affairs Division
5	Regional Government of North Penajam Paser	Government Affairs Division
6	Regional Government of South Bengkulu	Government Affairs Division
7	Regional Government of South Hulu Sungai	Government Affairs Division
8	Regional Government of Badung	Government Affairs Division
9	Municipal Government of Pontianak	Government Affairs Division

Data were collected through a structured questionnaire, distributed both digitally and in hard copy during coordination meetings and targeted outreach to SPBE working groups. Each survey item was rated using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The instrument was pre-tested for content validity and internal consistency. Respondents were selected based on their direct involvement in SPBE implementation and digital governance coordination within their respective regional institutions, ensuring that the data collected represented informed perspectives on organizational readiness and policy alignment. The questionnaire measured four main constructs derived from Presidential Regulation No. 95/2018 [20], SPBE evaluation indicators, and literature on digital governance:

Table 4. Indicators of Latent Constructs in PLS-SEM Analysis

Construct	Indicators	Description
SPBE Implementation Standardization	ST1, ST2, ST3, ST4	Measures the degree to which agencies follow national SPBE frameworks, regulatory compliance, and standardized digital service models.
Operational Procedure Clarity	OP1, OP2, OP3, OP4	Captures the extent of process transparency, clarity of SOPs, and consistency in digital workflow execution.
Technology Harmonization	TH1, TH2, TH3	Evaluates system interoperability, compatibility of ICT infrastructure, and standardization of data protocols across agencies.
Institutional Collaboration	IC1, IC2, IC3, IC4	Assesses coordination across departments, joint planning, data-sharing practices, and collective decision-making in SPBE initiatives.

Table 4 summarizes the indicators used to measure the four latent constructs in the PLS-SEM analysis, namely SPBE Implementation Standardization (ST1–ST4), which reflects compliance with national SPBE frameworks and regulations, Operational Procedure Clarity (OP1–OP4), which captures transparency and consistency in digital SOPs, Technology Harmonization (TH1–TH3), which assesses system interoperability and data protocol standardization, and Institutional Collaboration (IC1–IC4), which emphasizes inter-agency coordination, joint planning, and data-sharing practices in SPBE implementation [47].

Guided by the challenges of fragmented SPBE implementation and inconsistent technology adoption, the study posits the following hypotheses:

The hypotheses of this study are developed from the core concepts of enterprise architecture and digital governance. Standardization plays a vital role in minimizing redundancy and aligning ICT with institutional objectives, forming the foundation of H1. Well-defined operational procedures are required to maintain transparency and service consistency, supporting H2. The harmonization of technology enhances interoperability among agencies and facilitates system integration, providing the rationale for H3. Lastly, inter-agency collaboration improves resource efficiency and policy coordination, making it the basis for H4.

- **H1**: SPBE implementation standardization positively influences the effectiveness of digital governance.
- **H2**: The existence of clear operational procedures significantly contributes to successful e-government implementation.
- **H3**: Harmonization and standardization of technology across agencies enhance system interoperability and integration.
- **H4**: Inter-agency collaboration supports the efficiency and optimization of technology adoption in local governments.

These hypotheses are tested through the structural paths of the hybrid enterprise architecture framework using Partial Least Squares Structural Equation Modeling (PLS-SEM), which is suitable for complex models with latent variables and smaller samples. Data were processed with SmartPLS 4 software [48]. The procedure includes two stages: assessing the measurement model for reliability and validity (convergent, internal consistency, and discriminant validity) and evaluating the structural model to test hypotheses through path coefficients, t-values, and p-values.

4. RESULT AND DISCUSSION

4.1. Evaluation of Measurement and Structural Models

To assess the validity of the conceptual framework and its empirical relevance to the context of SPBE implementation in Indonesian local government, data collected from 337 respondents were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4 software. The analytical process was conducted in two distinct stages, first, evaluating the measurement model to ensure the reliability and validity of each latent construct, and second, testing the structural model to examine the strength and significance of the hypothesized relationships.

The results of the measurement model, as shown in Table 5, indicate that all constructs meet or exceed the recommended thresholds. Cronbach's Alpha values ranged from 0.79 to 0.84, demonstrating strong internal consistency. Meanwhile, Composite Reliability values exceeded 0.85, and Average Variance Extracted (AVE) values were all above 0.50, confirming acceptable convergent validity. These findings confirm that the instrument used in this study is statistically robust and that the constructs SPBE Implementation Standardization, Operational Procedure Clarity, Technology Harmonization, and Institutional Collaboration are measured reliably.

Table 5. Measurement Model: Reliability and Convergent Validity

Construct	Cronbach's Alpha	Composite Reliability	AVE
SPBE Implementation Standardization	0.84	0.88	0.62
Operational Procedure Clarity	0.81	0.87	0.59
Technology Harmonization	0.79	0.85	0.57
Institutional Collaboration	0.83	0.89	0.61

Following the satisfactory validation of the measurement model, the structural model was assessed through a bootstrapping procedure (5,000 subsamples) to determine the significance of the hypothesized relationships among the constructs. As presented in Table 6, all four hypotheses were supported at high levels of statistical significance ($p < 0.01$), with path coefficients ranging from 0.289 to 0.423. These results offer empirical support for the theoretical proposition that strategic alignment, procedural clarity, technological compatibility, and inter-agency collaboration significantly enhance the success of SPBE implementation.

Table 6. Structural Model Results and Hypothesis Testing

Construct	Path Coefficient (β)	t-Value	p-Value	Result
H1: Standardization → Governance Effectiveness	0.423	9.18	0.0004	Supported
H2: Clear Operational Procedures → E-Government Success	0.358	7.85	0.0007	Supported
H3: Technology Harmonization & Standardization → Interoperability & Integration	0.289	6.23	0.0013	Supported
H4: Inter-Agency Collaboration → Technology Adoption Efficiency	0.311	7.12	0.0009	Supported

The validation of these hypotheses reflects a well-structured relationship between institutional architecture practices and the quality of digital governance. Most importantly, it confirms the theoretical assumption that a hybrid enterprise architecture when properly implemented can significantly support the performance and scalability of SPBE initiatives in decentralized public administration settings.

For example, in Pontianak City, the hybrid EA model improved coordination between the Government Affairs Division and the ICT unit. Before adoption, fragmented systems delayed services, but by consolidating three applications into one platform, redundancy was reduced and interoperability increased. As a result, permit requests that once took five days could now be processed in just two to three days, showing clear improvements in service delivery.

4.2. Operationalizing the Framework

While empirical validation confirms the framework's conceptual robustness [49], the next challenge is translating validated constructs into actionable planning procedures. Many academic studies fall short here, as statistically valid models often lack operational applicability in real-world governance. This study addresses this gap by providing not only a conceptual model but also an implementation-oriented architecture execution logic for government use. Figure 6 illustrates the operational steps derived from the integration of TOGAF, Zachman, FEAF, and Gartner, converging at the Prosedur layer as a centralized, rule-driven base for generating government architecture plans. Unlike Figure 4, which is primarily conceptual, Figure 6 operationalizes the frameworks into a rule-driven planning model. Each framework contributes a key structural pillar: TOGAF ensures long-term strategic alignment, Zachman formalizes stakeholder perspectives, FEAF supports performance reference modeling and process standardization, and Gartner aligns IT strategies with institutional objectives [50]. These pillars form a procedural node that guides system planning and interoperability management at the regional government level.

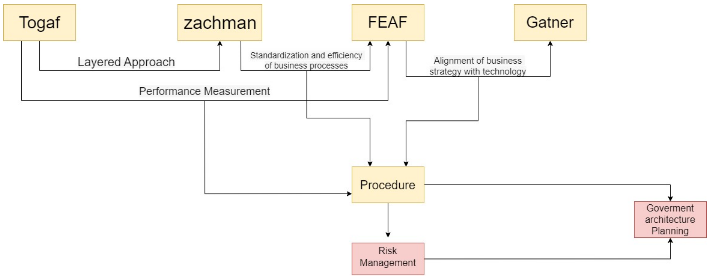


Figure 6. Proposed Architecture Framework

This diagram captures the logical progression from validation of inputs (architecture readiness) to the generation and deployment of architecture planning documents. If all framework conditions are fulfilled, the system proceeds to generate a unified digital procedure and deploys it to guide SPBE integration. If any element is missing, the system provides a loopback mechanism for institutional correction or resubmission. This reflects a dynamic, reflexive architecture model aligned with adaptive governance principles.

4.3. Implications for Technopreneurship and Economic Innovation

Beyond administrative reform, the hybrid enterprise architecture framework also strengthens technopreneurship and economic growth. Standardized digital governance fosters an innovation ecosystem that links government, academia, and industry. It reflects public sector entrepreneurship, where efficiency drives new services and socio-economic value. By improving interoperability, the framework supports edupreneurship and socialpreneurship through the use of government data for sustainable digital solutions, expanding its impact toward inclusive economic innovation.

4.4. Building a Rule-Driven Planning System

To further operationalize this model into implementable systems, the following pseudocode illustrates how a rule-based logic engine can be integrated into a regional government dashboard or internal planning system. The code below is designed to automate the generation of SPBE procedures only when the four core architecture domains are satisfied.

```
# SPBE Architecture Planning Validator

class SPBEFrameworkExecutor:
    def __init__(self, togaf, zachman, feaf, gartner):
        self.togaf = togaf
        self.zachman = zachman
        self.feaf = feaf
        self.gartner = gartner

    def validate_framework(self):
        return all([self.togaf, self.zachman, self.feaf, self.gartner])

    def execute_planning(self):
        if self.validate_framework():
            return " ✅ Procedure Generated. Architecture Plan Initiated."
        else:
            return "⚠️ Incomplete Inputs. Please review framework status."

# Example usage:
agency = SPBEFrameworkExecutor(True, True, True, True)
```

```
print(agency.execute_planning())
```

Each variable denotes an architecture readiness domain. If any domain is incomplete (Zachman mapping not conducted), the system halts execution and prompts administrators to revise inputs. To guide automated decision-making, Table 7 outlines a rule-based matrix that links readiness states to system actions, supporting real-time compliance validation in SPBE planning [51, 52].

Table 7. Framework Validation and System Response

Rule ID	TOGAF	Zachman	FEAF	Gartner	System Response
R1	✓	✓	✓	✓	Generate Procedure & Deploy Architecture Plan
R2	✓	✗	✓	✓	Request Role Mapping via Zachman
R3	✗	✓	✓	✓	Initiate Strategic Planning Workshop (TOGAF)
R4	✓	✓	✗	✓	Standardize Business Processes (FEAF)
R5	✓	✓	✓	✗	Align ICT Roadmap (Gartner)

Table 7 illustrates how the system adapts to different maturity levels, enabling agencies to self-assess readiness or embed the logic into SPBE guidance modules. This study not only validates a hybrid enterprise architecture framework but also introduces an operational layer that bridges academic models with executable procedures, addressing the long-standing gap between theory and practice in digital governance. Although SPBE requirements are formalized under Presidential Regulation No. 95/2018 [20], implementation remains uneven due to the lack of practical tools that translate concepts into action.

Through its rule-based modeling and logical flow integration, this study proposes a blueprint for moving beyond conceptual compliance and into operational planning. Future SPBE systems can incorporate this logic as a planning validator, interoperability checker, or digital SOP generator bridging the divide between fragmented infrastructure and the vision of integrated governance.

- **H1**: Does standardization of SPBE frameworks influence digital governance effectiveness? Yes. With a path coefficient of β = 0.423 (p = 0.0004), standardization was found to be the strongest predictor among all constructs. This indicates that agencies that adopt uniform guidelines, reference models, and national frameworks (Presidential Regulation No. 95/2018) [20] demonstrate significantly better digital governance outcomes. The result affirms the importance of architectural alignment using TOGAF principles.

- **H2**: Does the clarity of operational procedures improve e-government implementation? Yes. The clarity of standard operating procedures (SOPs) had a strong and significant impact on implementation success (β = 0.358; p = 0.0007). This supports the argument that bureaucratic transparency and clearly defined digital workflows aligned with Zachman's stakeholder-oriented layers are crucial to minimizing ambiguity, reducing resistance, and supporting consistent digital execution.

- **H3**: Does harmonization of technology across agencies enhance integration and interoperability? Yes. Technology harmonization exhibited a significant effect (β = 0.289; p = 0.0013), suggesting that technical compatibility is a prerequisite for system integration. This validates the use of FEAF reference models and supports the Gartner approach to aligning IT infrastructure with functional needs. Agencies with common ICT platforms, data protocols, and interoperability standards perform better in cross-departmental collaboration.

- **H4**: Does inter-agency collaboration optimize the integration and use of digital systems? Absolutely. Institutional collaboration showed a significant positive effect (β = 0.311; p = 0.0009), confirming that collective planning, data sharing, and joint decision-making enhance the scalability and sustainability of SPBE infrastructure. The result affirms the importance of multi-agency governance mechanisms emphasized in TOGAF's architecture governance cycle and FEAF's collaborative models.

All four hypotheses were statistically supported, each representing a crucial pillar of the proposed hybrid framework. These results confirm that a holistic approach to enterprise architecture planning, encompassing strategy, people, process, and technology, leads to more effective digital transformation in government settings. Furthermore, the integration of procedural logic and system automation (as demonstrated via flowchart and pseudocode) provides a much-needed bridge between architectural theory and real-world SPBE implementation thereby directly addressing the practical gap in Indonesia's current digital governance reform.

5. MANAGERIAL IMPLICATIONS

The findings indicate that successful SPBE implementation depends on managerial efforts to strengthen standardization, procedural clarity, and technology harmonization across agencies. These elements ensure interoperability, minimize redundancy, and enhance service efficiency within regional governments. Policymakers should align digital transformation strategies with the hybrid enterprise architecture framework to promote consistency, transparency, and measurable outcomes in public service delivery.

For local administrators, the framework provides a structured and adaptable tool to evaluate institutional readiness, identify organizational gaps, and implement targeted improvements. Encouraging collaboration among departments and applying rule-based validation mechanisms can accelerate SPBE maturity and foster innovation-driven governance. Ultimately, managers are expected to cultivate a digital culture that emphasizes continuous improvement, data-based decision-making, and sustainable public value creation.

6. CONCLUSION

This study developed and validated a novel hybrid enterprise architecture framework to improve SPBE implementation in Indonesia's regional governments. It integrates TOGAF, Zachman, FEAF, and Gartner to address fragmentation, inefficiency, and limited interoperability. Analysis of 337 responses from officials in nine West Java city and district governments confirmed the validity of four constructs, standardization, operational clarity, technology harmonization, and institutional collaboration. The framework is operationalized through procedural flow, logic matrix, and pseudocode to connect conceptual modeling with practical system design.

The constructs show that standardization aligns local practices with national regulations, operational clarity formalizes workflows, technology harmonization breaks institutional silos, and institutional collaboration supports sustainable digital infrastructure. The framework provides a practical and novel tool for agencies to evaluate SPBE readiness, guide implementation, and improve coordination across departments, especially in regions with uneven digital maturity. In addition, the operational components introduced in this study help institutions translate architectural concepts into clear, executable procedures. This strengthens interoperability efforts and supports more consistent digital transformation outcomes across diverse regional contexts.

Limitations include the provincial focus and the need for a full digital decision-support system. Future research should test the model in other regions, incorporate AI, ontology, or blockchain for enhanced interoperability and security, and conduct longitudinal studies to assess long-term impacts on service quality, public trust, and bureaucratic agility. This study bridges the gap between conceptual enterprise architecture and practical digital governance while highlighting its novelty in offering an operational framework for regional governments to advance SPBE initiatives.

7. DECLARATIONS

7.1. About Authors

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7.2. Author Contributions

Conceptualization: RG; Methodology: OD; Software: RG; Validation: RG and OD; Formal Analysis: RG and DM; Investigation: RG; Resources: OD; Data Curation: OD; Writing Original Draft Preparation: RG and DM; Writing Review and Editing: OD and DM; Visualization: OD; All authors, RG, OD, and DM, have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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