

# An Enterprise Architecture Blueprint for HL7-Based RIS–PACS Integration Using TOGAF ADM: A Mobile Diagnostic Access Framework

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**Abstract:** The shift to digital radiology is frequently hindered by data fragmentation and restricted mobility for healthcare professionals. This research addresses these deficiencies by developing an Enterprise Architecture (EA) blueprint for hospital radiology departments using the TOGAF ADM framework. The design emphasizes HL7 standards for administrative data transfer and DICOM protocols for imaging, featuring a web-based Mobile Viewer using the WADO protocol for remote high-resolution access. Architectural validation via gap analysis demonstrates that the proposed integration can theoretically eliminate manual data entry between HIS and RIS-PACS through an HL7 broker mechanism, potentially shortening clinical report turnaround times. However, this study is limited to architectural validation and does not include live clinical deployment. The proposed architecture offers a scalable roadmap for "film-less" environments, though further longitudinal studies are required to assess long-term clinical user satisfaction.

**Keywords:** Enterprise Architecture, TOGAF ADM, HL7 Interoperability, RIS-PACS Integration, Health Informatics.

## INTRODUCTION

The swift advancement of healthcare technology has rendered digital transformation an essential foundation for operational excellence and patient safety. In the particular context of Indonesia, the government's initiative for the "SatuSehat" platform requires uniform digital maturity among all healthcare institutions. Nonetheless, recent assessments reveal substantial variances in Information and Communication Technology (ICT) preparedness among different provinces, presenting a significant obstacle for nationwide system alignment (Aisyah et al., 2024). Modern clinical imaging is fundamentally characterized by the integration of Radiology Information Systems (RIS) and Picture Archiving and Communication Systems (PACS). While these digital platforms are intended to liberate medical personnel from the burden of physical film and tedious manual record-keeping, their success is not automatic. As Alghamdi (2024) points out, the true effectiveness of this transition depends on a robust Enterprise Architecture (EA) that harmonizes the daily clinical workflows of staff with the hospital's technical infrastructure.

The immediacy of this study arises from the essential function of radiology in the diagnostic process. Poor data management in radiology results in clinical delays, including repetitive data entry and extended turnaround times (TAT) for diagnostic reports. Contemporary clinical settings necessitate a smooth integration where specialists can access medical images and patient information immediately (Fang et al., 2025). Interoperability serves as the main answer to these challenges, but attaining it proves difficult without a strict architectural framework. By implementing global data standards like Fast Healthcare Interoperability Resources (FHIR), hospitals can guarantee that different systems stay aligned and that medical imaging data is usable for extended clinical application (Tabari et al., 2024). Additionally, with the rising need for remote diagnostics, the incorporation of mobile visualization tools has become essential to aid radiologists in making quick decisions beyond conventional workstations (AboArab et al., 2024).

Even with the current research on hospital information systems, there is a notable gap in research concerning the real-world implementation of HL7-based messaging in a TOGAF-structured setup that is specifically tailored for mobile use. Numerous current EA blueprints emphasize high-level business alignment yet neglect the technical

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details of HL7-FHIR synchronization between RIS and PACS for mobile end-users. Contemporary studies frequently address PACS deployment separately, neglecting to offer a comprehensive strategy that tackles the shift from outdated data silos to a completely interoperable mobile diagnostic setting (Clunie et al., 2024). As a result, hospitals frequently adopt piecemeal solutions that do not possess the scalability necessary for contemporary digital health environments (Mutasa et al., 2025).

To bridge these existing voids, this study orchestrates a holistic Enterprise Architecture for RIS-PACS integration, anchored in HL7 protocols and the TOGAF ADM methodology. Our primary objective is to design a framework that facilitates frictionless data exchange while empowering specialists through remote diagnostic capabilities via a dedicated Mobile Viewer. This work contributes in two significant ways: theoretically, it demonstrates a specialized execution of TOGAF ADM tailored for the complexities of radiological interoperability (Kornysheva & Deneckère, 2022); and practically, it offers a scalable blueprint to help hospitals transition into a truly 'film-less' environment. By aligning with global health data standards, this architecture not only elevates diagnostic precision but also prepares the human-technical landscape for future innovations like AI-assisted reporting (Xu et al., 2025).

Despite extensive studies on PACS and FHIR-based interoperability, there is limited work that operationalizes HL7-based RIS-PACS integration within a structured TOGAF ADM framework while explicitly supporting mobile diagnostic workflows.

### LITERATURE REVIEW

The role of Enterprise Architecture (EA) in healthcare has evolved significantly, moving beyond mere technical support to become a primary catalyst for digital transformation (Alghamdi, 2024). Within the intricate landscape of clinical operations, the TOGAF ADM framework is widely regarded as the premier methodology. Its strength lies in its iterative cycle, which ensures that technical implementations remain deeply rooted in the institution's overarching business objectives (Kornysheva & Deneckère, 2022). Furthermore, as noted by Mutasa et al. (2025), adopting a comprehensive EA strategy is no longer optional, it is a vital necessity for merging isolated health systems into a unified, sustainable ecosystem that can adapt to future demands.

Effective diagnostic services depend on the seamless interaction between RIS and PACS, which is primarily governed by interoperability standards. Although traditional HL7 continues to serve as the structural foundation for administrative data, recent advancements have significantly enhanced the way different platforms communicate (Tabari et al., 2024). According to Tang et al. (2023), the true clinical value of medical imaging is unlocked only when integration protocols prioritize standardized communication and intuitive workflow orchestration (Fang et al., 2025). This synergy is vital for creating an environment where information moves effortlessly from the initial patient registration to the final diagnostic report, liberating clinicians from the need for manual data entry.

The demand for diagnostic mobility has shifted the paradigm toward web-based visualization. Recent advancements in DICOMweb and Progressive Web Applications (PWA) demonstrate that high-resolution imaging can be effectively delivered to mobile devices (AboArab et al., 2024). However, enabling mobile access introduces challenges in data integrity and system efficiency (Behnam et al., 2024). Furthermore, future-proofing these architectures requires adaptability for emerging technologies, including AI-driven information extraction (Xu et al., 2025).

Despite extensive research on medical imaging and interoperability, a significant gap remains in the architectural orchestration that simultaneously addresses administrative HL7 synchronization, DICOM image management, and mobile accessibility within a single enterprise framework. Most existing studies focus on isolated technical implementations either focusing exclusively on mobile viewers or on backend storage.

As shown in Table 1, this study fills the gap by providing a comprehensive blueprint. The novelty lies in the synergistic application of TOGAF ADM to bridge the gap between backend HL7-based administrative workflows and frontend WADO-based mobile visualization.

Table 1. Comparative Analysis of Related Research

Authors	Focus Area	Framework	Interoperability	Mobility	Gap Addressed by This Study
Tang et al. (2023)	Workflow	FHIR/DICOM	High	Low	Lacks a structured EA framework (TOGAF)
AboArab et al. (2024)	PWA Mobile	DICOMweb	Medium	High	Focuses on UI/UX, not enterprise integration.
Behnam et al. (2024)	Cloud PACS	Storage	High	Medium	Lacks administrative integration (RIS/HIS).

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This Study	RIS-PACS Integration	TOGAF ADM	HL7/DICOM	WADO/Mobile	Comprehensive integration for mobility.	EA-based for clinical
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**METHOD**

The methodology of this study is organized into a systematic five-phase process aimed at achieving a thorough architectural design for the radiology department. The study focuses on a Type B General Hospital in Indonesia as a case study to ensure the practical relevance of the blueprint.

The process initiates with an extensive Literature Review, where existing academic resources and worldwide benchmarks concerning HL7 and RIS-PACS integration are examined to create a theoretical basis. This is followed by the Data Collection phase, which entails obtaining particular organizational needs, clinical processes, and current IT infrastructure information. Primary data were gathered through direct observations of clinical workflows and technical documentation analysis of the existing Hospital Information System (HIS). The architectural requirements were refined through semi-structured interviews designed to capture the unique perspectives of radiologists and IT technicians. By prioritizing these human insights, the study was able to pinpoint specific integration hurdles that directly impact the efficiency of medical personnel.

The foundation of this research is built upon a human-centric adaptation of the TOGAF ADM framework. We meticulously navigated the development cycle—from the initial Preliminary Phase through the Technology Architecture (Phase D)—to ensure the resulting blueprint is not just a technical document, but a practical solution for the radiology staff. By utilizing ArchiMate 3.1, we bridged the gap between complex business needs and technical possibilities, ensuring the system feels intuitive for the medical practitioners. This process culminated in a rigorous gap analysis and discussion, where we evaluated how these proposed changes directly improve the daily professional lives of stakeholders, ultimately leading to strategic recommendations that resonate with long-term institutional health.

At the heart of our architectural evolution is the TOGAF ADM framework, which we utilized as an iterative guide to harmonize hospital business goals with emerging technical capabilities. As depicted in Figure 1, the journey commenced with a Preliminary Phase, where we collaborated with stakeholders to define the ethical and operational boundaries of the hospital's digital environment. This led to Phase A (Architecture Vision), a stage dedicated to establishing a shared strategic direction for the RIS-PACS ecosystem. In Phase B (Business Architecture), we shifted our focus to the human element, re-evaluating clinical workflows to alleviate the manual burdens currently faced by radiology staff. The technical transition occurred in Phase C (Information Systems Architecture), where we designed a robust data framework using HL7 messaging to ensure seamless communication. Finally, the process reached Phase D (Technology Architecture), where we specified the hardware and mobile infrastructure necessary to empower clinicians with remote, high-resolution diagnostic access via the Mobile Viewer.

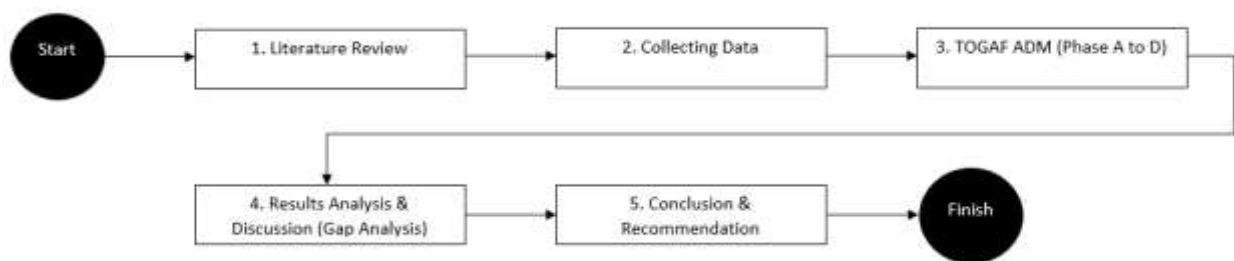


Fig. 1 Research Methodology

To guarantee the technical soundness and operational feasibility of the suggested design, the study includes a clear assessment and confirmation phase. The architectural outcomes are assessed through Gap Analysis, which methodically contrasts the "As-Is" current state with the "To-Be" desired architecture to pinpoint required changes and possible risks. Additionally, the design is confirmed via Business Requirement Mapping, guaranteeing that each technical element especially the HL7 messaging protocols and Mobile Viewer functionalities directly meets the clinical requirements recognized during the data gathering stage. To ensure the structural coherence of the architecture, the models are visualized and validated using ArchiMate notation, which offers a uniform verification of the connections among the business, application, and technology tiers. This comprehensive validation procedure guarantees that the final blueprint is both theoretically robust and prepared for clinical application.

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### RESULT

The design process initiates with the creation of the Architecture Vision, acting as the strategic framework for the digital transformation of the radiology department. As shown in Figure 2, this model illustrates the connection among overarching outcomes, strategic objectives, and the required resources. The focus is on attaining "Operational Excellence" and "Digital Maturity" through the integration of systems to guarantee speed, mobility, and security. The model recognizes essential stakeholders comprising hospital management, radiologists, and IT experts and matches their needs with the technological setup, including PACS storage and high-speed networks.

Moreover, the Architecture Vision creates a foundation for organizational preparedness by linking long-term objectives with particular technological achievements. By establishing "Clinical Excellence" and "Interoperability" as key motivators, the framework guarantees that all architectural expenditures from the creation of HL7 middleware to cloud infrastructure contribute to the overarching aim of enhancing the quality of patient care. This strategic alignment includes the human factor, recognizing that shifting to a digital radiology environment necessitates a well-defined plan for change management and skill enhancement for medical personnel. As a result, this vision serves not only as a technical reference but also as a management tool that allows hospital leaders to track the advancement of digital maturity and preserve the integrity of medical data throughout the complete diagnostic process.

The validation of this architectural vision is conducted through a rigorous Business Requirement Mapping, ensuring each technological component directly addresses identified clinical pain points. Technologically, the adoption of HL7 and DICOM standards within this framework is not merely a protocol selection but a strategic instrument to guarantee end-to-end data integrity. By integrating an HL7 Broker as middleware, the design logically eliminates data redundancy the primary cause of diagnostic delays in legacy systems thereby providing a verifiable foundation for operational excellence.

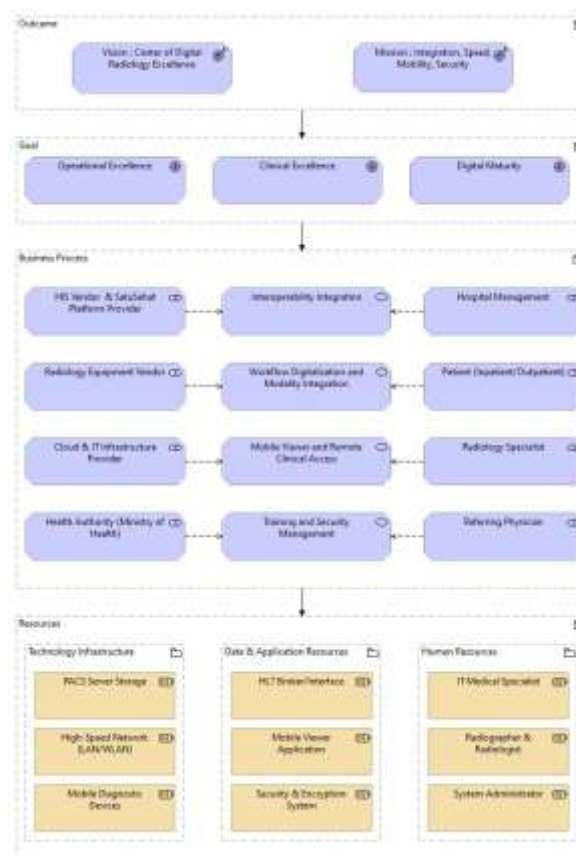


Fig. 2 Architecture Vision Model

To connect the strategic vision with technical implementation, the architecture is broken down into four essential processes that put the high-level goals into action. These processes illustrate the shift from conceptual institutional goals to concrete technical workflows, making certain that every digital action stays connected to the original vision of efficiency and interoperability. The initial phase of this operational change is aligning administrative data, which acts as the entry point for all following clinical tasks.

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The initial key process, illustrated in Figure 3, concentrates on Integration for HL7-Based Interoperability. This framework outlines the automated data transfer from patient entry to the Hospital Information System (HIS). Employing an HL7 Broker along with an Integration Server allows for real-time synchronization of patient demographic information. This guarantees that the administrative and clinical protocols are seamlessly aligned, removing the necessity for manual data reconciliation among various hospital departments.

This interoperability layer is further improved by the deployment of a middleware solution that serves as a translator between different systems, guaranteeing that message exchange adheres to the HL7 messaging protocol standards. Centralizing the data admission service establishes a unified source of truth for patient demographic information, which is subsequently transmitted to the integration server for real-time verification.

This system not only speeds up the admission-to-clinical process but also ensures a strong level of auditability and data reconciliation, since each transaction is recorded within the HL7 service layer. Thus, eliminating manual data entry at this point acts as an essential protection against human mistakes, guaranteeing that the patient's digital identity stays consistent throughout the HIS, the HL7 broker, and ultimately the entire radiology network.

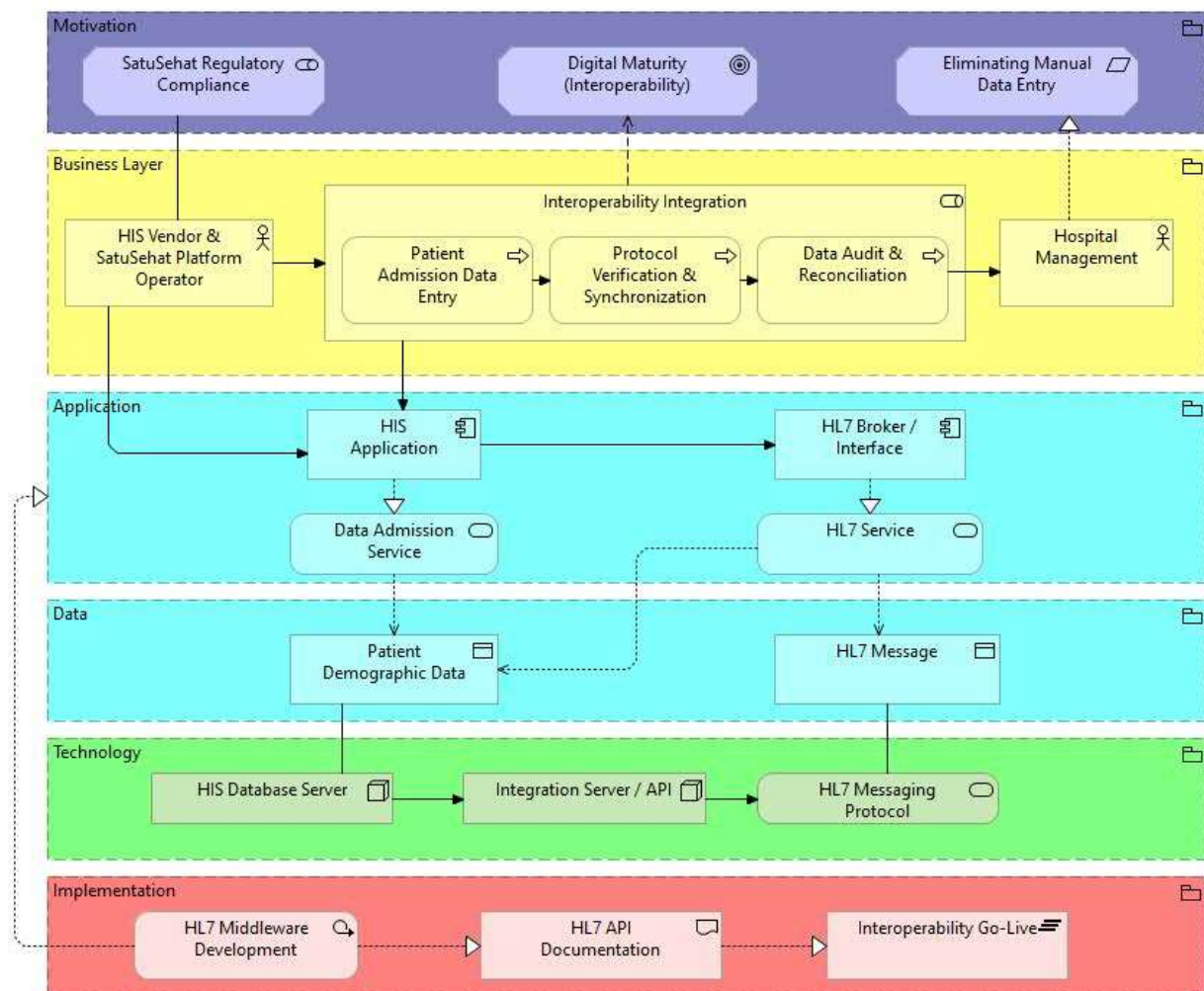


Fig. 3 Interoperability Integration

Leveraging the effective integration of administrative data, the architecture now emphasizes the clinical setting to guarantee that the patient's digital identity is preserved throughout the diagnostic journey. This operational shift is accomplished by connecting the information system with the physical imaging devices.

The second main process emphasizes the Digitalization of Clinical Workflows via Modality Integration, as illustrated in Figure 4. This model enhances the collaboration among the clinician, the radiographer, and the imaging technique by automating the order management system. By implementing a Modality Worklist (MWL), digital radiology requests created in the HIS are sent directly to the radiology machines using the DICOM standard. This automation guarantees that patient identity and exam information are verified immediately at the modality level, greatly minimizing the chances of identity mistakes and enhancing the overall speed of the imaging acquisition process.

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In addition to identity verification, this digital transformation creates a smooth cycle for managing imaging metadata. When the radiographer starts a scan, the modality automatically adopts the patient's demographic information from the HIS/RIS system, confirming that each image captured is accurately labeled with the appropriate medical record number. The removal of manual input at the modality level boosts operational efficiency and guarantees that the clinical outcomes align with the patient's longitudinal record in real-time. By converting the modality from an independent device into an integrated component of the network, the architecture establishes a basis for automated data storage and later diagnostic availability.

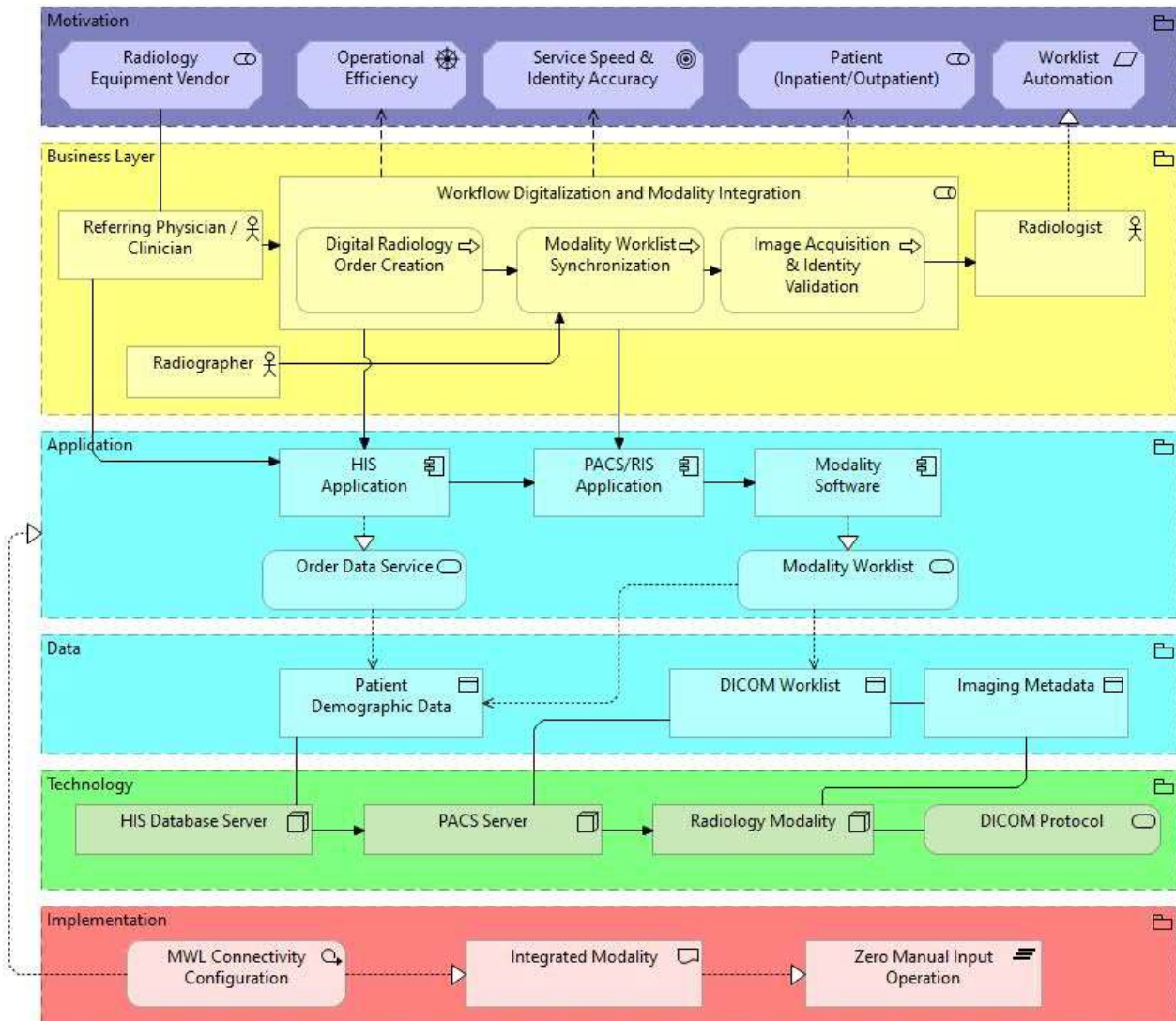


Fig. 4 Workflow Digitalization and Modality Integration

After the imaging data is effectively collected and stored, the framework meets the essential requirement for diagnostic accessibility and clinical mobility. This shift guarantees that the digital workflow reaches beyond the radiology area, enabling specialists to engage with medical information no matter where they are.

The third essential process focuses on the need for Remote Accessibility through a Mobile Viewer, as shown in Figure 5. This architectural layer aims to facilitate clinical mobility by granting specialists access to medical images "anytime and anywhere." The procedure includes a Zero-Footprint Viewer that transmits compressed DICOM files from the PACS server to mobile devices through a secure VPN/SSL connection. This setup enables quick clinical cooperation and remote diagnostic assessment, guaranteeing that urgent cases can be examined by specialists even when they are away from the hospital.

Moreover, this mobile-focused process is enhanced by an Image Streaming Engine that achieves a balance between high-resolution diagnostic quality and low-bandwidth efficiency. By sending compressed DICOM images and clinical report metadata straight to the specialist's mobile device, the system greatly minimizes the "time-to-diagnosis" for urgent patients. This accessibility is safeguarded by a multi-tiered security system, featuring secure

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web access to DICOM files, which guarantees that patient confidentiality is upheld while offering radiologists the necessary flexibility in a contemporary, dynamic clinical setting.

This mobile diagnostic integration fundamentally changes the radiology department into an interconnected hub, where geographic limitations no longer influence the speed of clinical intervention. By equipping radiologists with a high-quality interface on portable devices, the system guarantees that essential imaging results can be relayed to surgical or emergency teams instantly, directly from the care location. Additionally, employing a Zero-Footprint architecture removes the requirement for intricate software setups on personal devices, allowing the system to stay scalable and effortlessly manageable by the IT team. This uninterrupted accessibility not only enhances the hospital's internal resources but also encourages a more responsive healthcare setting where data-informed decisions are made precisely when they are most essential.

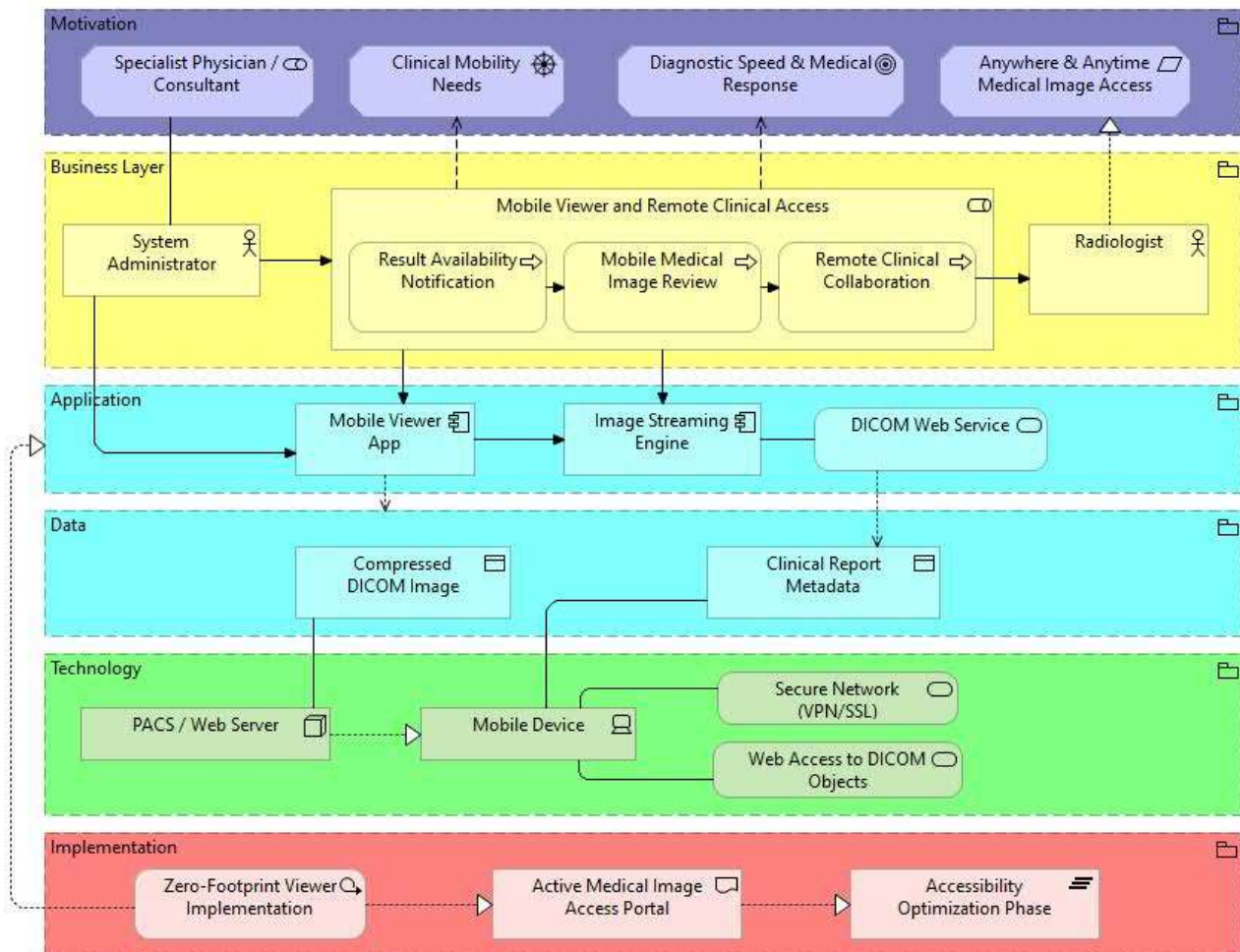


Fig. 5 Mobile Viewer and Remote Clinical Access

Although the technological framework offers essential instruments for digital transformation, the effectiveness of the combined system ultimately relies on the preparedness of human resources and the strength of the data security measures. This concluding phase connects technical deployment with operational sustainability by making certain that the system is secure and efficiently employed by clinical personnel.

The fourth essential process centers on Security Management and Training, as illustrated in Figure 6. This framework guarantees that every medical staff member, such as radiographers, radiologists, and system administrators, receives extensive training to excel at the new digital workflow. Aligning the "Human Resources" pillar with "Technology Infrastructure" ensures that professionals can effectively use the HL7-based interfaces and mobile access tools. This educational method minimizes operational barriers and guarantees that the sophisticated capabilities of the RIS-PACS integration are entirely utilized to enhance patient results.

Simultaneously with personnel preparedness, this process creates a rigorous security structure to protect the reliability of the diagnostic lifecycle. The "Security & Encryption System" is embedded at all levels, ranging from the HIS database server to mobile diagnostic tools, guaranteeing that sensitive patient demographic information

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and medical images are safeguarded from unauthorized access. Through the use of robust encryption and well-documented API protocols, the architecture upholds a strong level of data privacy and clinical responsibility. This combined emphasis on education and safety offers the essential oversight to guarantee that the radiology department's digital environment stays both robust and adheres to changing healthcare regulations.

Additionally, this governance framework serves as a preventive step to guarantee the enduring sustainability of the digital radiology environment against new cyber threats and changes in operations. Creating a persistent feedback mechanism between system administrators and clinical users enables the architecture to facilitate frequent security assessments and gradual training updates as software versions or HL7 standards progress. This strategic outlook guarantees that the hospital's investment in RIS-PACS integration stays robust, reducing downtime and avoiding data breaches that might jeopardize institutional reputation. In the end, combining security and training fosters a culture of digital responsibility, in which technology acts as a dependable and safe extension of the clinical team's diagnostic skills.

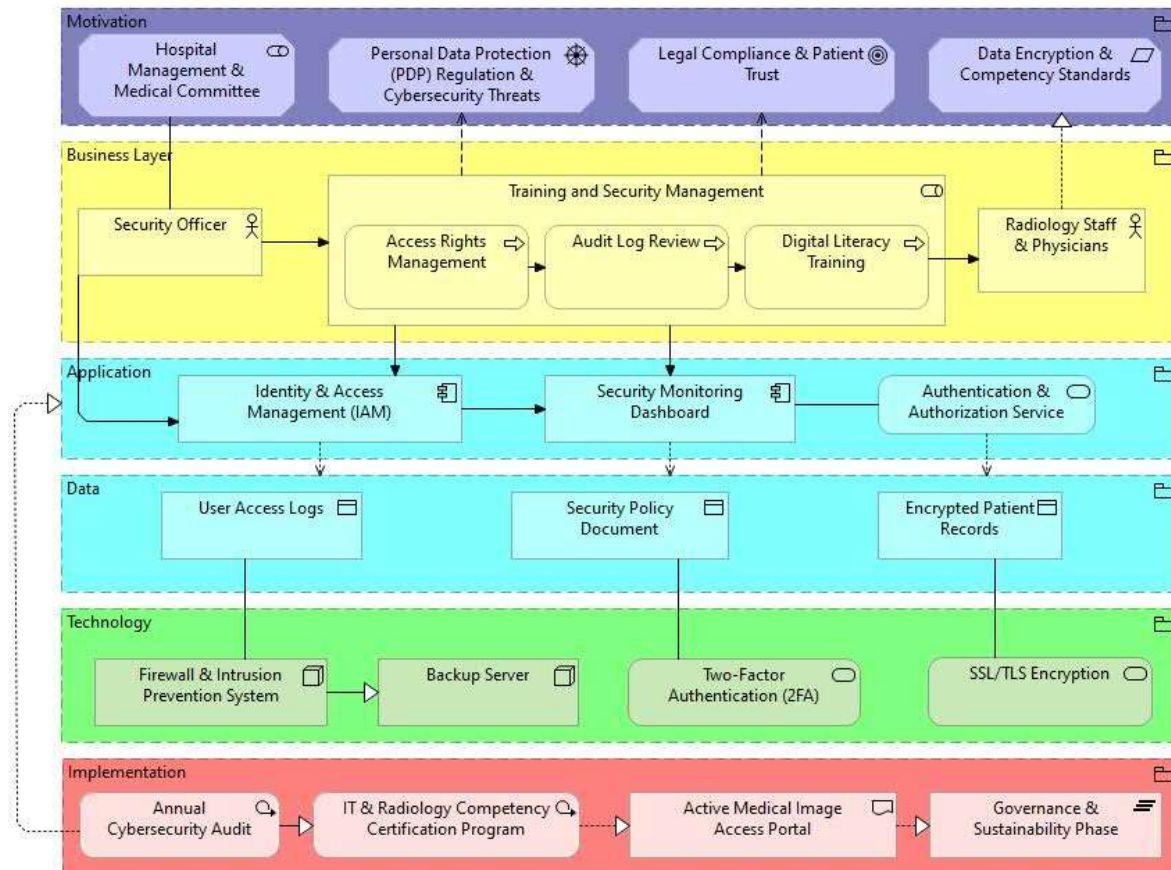


Fig. 6 Training and Security Management

A Gap Analysis was performed to assess the efficacy of the suggested architecture by contrasting the existing "As-Is" baseline with the desired "To-Be" target environment. This assessment underscores the strategic changes necessary for implementing the unified RIS-PACS framework. According to Table 1, the main gaps noted were the absence of standardized interoperability (HL7), issues with manual modality worklists, and restricted access to remote diagnostics. The suggested design effectively closes these gaps by implementing an automated integration layer and mobile-focused diagnostic tools, guaranteeing that all clinical and administrative needs identified in the initial phase are completely met.

Table 2  
Gap Analysis of Radiology Enterprise Architecture

Architectural Layer	Baseline (As-Is)	Target (To-Be)	Gap / Solution
Business	Manual data entry and physical coordination.	Automated HL7-based workflow.	Eliminating clerical errors via integration.

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<b>Application</b>	Isolated RIS and PACS systems.	Integrated RIS-PACS with HL7 Broker.	Real-time data synchronization.
<b>Technology</b>	Desktop-based diagnostic stations only.	Mobile Viewer with VPN/SSL security.	Anywhere-anytime diagnostic access.

**DISCUSSIONS**

This study's creation of the integrated RIS-PACS enterprise architecture greatly enhances the digital transformation of radiology processes, particularly in the Indonesian healthcare setting. In contrast to the study by Kawa et al. (2022), which mainly emphasized the use of cloud-based PACS for storage optimization, our research broadens the architectural framework by incorporating the Hospital Information System (HIS) through the HL7 messaging protocol. This integration guarantees that patient data is not just recorded but is updated in real-time starting at admission, tackling the interoperability issues that frequently obstruct clinical efficiency in extensive hospital settings.

In addition, incorporating a Mobile Viewer and Remote Clinical Access in our target architecture corresponds with the recent developments highlighted by AboArab et al. (2024) on utilizing medical imaging for visualization in progressive web applications. While AboArab et al. concentrated on the software development and validation of image reconstruction, this research offers a more extensive architectural framework utilizing TOGAF ADM, which connects the technology layer with business processes and workforce preparedness. This comprehensive strategy guarantees that the mobile accessibility feature functions as an integrated element rather than an isolated tool, serving as a secure, VPN-encrypted extension of the hospital's primary diagnostic system.

The operational efficiency gained from the Modality Worklist (MWL) in our approach further supports the conclusions of Fang et al. (2025), who showed that smart information management greatly improves user satisfaction and workflow speed. Our study introduces a distinct dimension of "Training and Security Management" as an essential process, frequently neglected in entirely technical frameworks. This study provides a more sustainable and culturally tailored transition for hospitals advancing toward digital maturity by integrating the technical needs of HL7 and DICOM with a specific emphasis on staff training, in line with the situational approach proposed by Kornyshova & Deneckère (2022). Thus, the suggested architecture serves as a contemporary, cohesive solution that connects fragmented legacy systems with a completely interoperable digital radiology excellence center.

Table 3 Comparative Analysis with Previous Research

Feature	Kawa et al. (2022)	AboArab et al. (2024)	This Study (Target Architecture)
<b>Primary Focus</b>	Cloud PACS Storage	Web-based DICOM Viewer	Holistic Enterprise Architecture
<b>Interoperability Framework</b>	Limited Technical Implementation	Not Explicit Software Validation	Full HL7 Broker Integration TOGAF ADM (Phase A-D)
<b>Security Layer</b>	Cloud Encryption	PWA Standards	VPN/SSL & Security Protocols
<b>Sustainability</b>	System Maintenance	Performance Testing	Human Resource Training Mapping

Although the proposed architecture is thorough, it is important to recognize various limitations and potential threats to validity. Initially, the Scope of Design mainly concentrates on the internal workflows of the radiology department and their direct integration with the HIS. Though this promotes thorough expertise, it might not adequately consider the intricate interoperability needs of other demanding departments, like cardiology or pathology, which may employ various imaging standards outside the existing RIS-PACS framework.

Moreover, a major threat to internal validity stems from the dependence on simulated or observational data during the validation phase. While the architecture was confirmed via Gap Analysis and ArchiMate modeling, the absence of a complete pilot implementation implies that actual performance issues like network delays during busy times or user pushback against the new mobile interface remain untested in practice. Moreover, the External Validity of this framework could be affected by the particular technological advancement of the hospital being examined. In medical facilities with considerably lower digital infrastructure or varying national health regulations, additional customization of the HL7 integration and security layers may be necessary.

Ultimately, the Human Element continues to be a possible factor. Although the framework encompasses a fundamental process for training and security oversight, the true efficacy of these initiatives relies on the dedication

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of the institution and the involvement of its personnel. Future studies might tackle these shortcomings by performing a longitudinal analysis after implementation to assess the real effects of the TOGAF-based design on clinical throughput and diagnostic precision across various clinical environments.

## CONCLUSION

This study successfully delivers a strategic architectural roadmap designed to unify Radiology Information Systems (RIS) and Picture Archiving and Communication Systems (PACS) through the lens of the TOGAF ADM framework. Beyond technical merging, the proposed blueprint addresses the human frustration caused by fragmented data and isolated workflows. We have established four transformative pillars: fostering HL7-based interoperability, modernizing clinical tasks via modality synchronization, empowering physicians with mobile diagnostic mobility, and ensuring a safe, supportive environment through dedicated training and security. By harmonizing organizational goals with technical execution, this plan provides a clear path for hospitals to transition from exhausting manual processes into a cohesive digital diagnostic culture.

The findings from architectural validation and comparisons with current literature show that incorporating an HL7 broker and DICOM Modality Worklist greatly improves diagnostic speed and data accuracy. In contrast to independent PACS implementations, this comprehensive design guarantees that patient data stays uniform throughout the entire diagnostic process from admission to remote reporting. The addition of "Training and Security" as a strategic pillar guarantees that the technological progress is accompanied by human preparedness and strict data protection, ensuring the system is both sustainable and adheres to contemporary healthcare regulations.

According to the results of this study, various suggestions are offered to guarantee the effective execution of the architecture. Initially, it is advised that hospital administration focus on forming a specialized IT-Radiology task force to facilitate the transition and handle the HL7 integration server. Secondly, a gradual implementation strategy should be utilized, beginning with the fundamental interoperability layer and then extending to mobile accessibility. Ultimately, upcoming studies ought to concentrate on a long-term assessment of this architecture's effects on clinical results and investigate the possible incorporation of Artificial Intelligence (AI) components into the current RIS-PACS system to enhance diagnostic precision.

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