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Kubernetes Risk Management: A Framework To Assess Kubernetes Security Risk In Bank XYZ

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ABSTRACT

This study aims to design and implement a Kubernetes Risk Management Framework (Kube-RMF) tailored to Bank XYZ's digital banking environment in compliance with Indonesian financial regulations. Using a qualitative descriptive method, the research integrates industry best practices such as CIS Kubernetes Benchmarks, OWASP Kubernetes Top 10, and NIST SP 800-190 with the requirements of POJK 11/POJK.03/2022. Data collection was conducted through document analysis, in-depth interviews with IT security, DevOps, and compliance teams, and technical vulnerability scanning using tools like Trivy and kube-bench. Risks were identified and assessed by mapping threats and vulnerabilities to Kubernetes assets, defining Key Risk Indicators (KRIs), and applying scenario analysis based on ISACA's Risk IT Framework. A gap analysis compared current practices with the designed Kube-RMF, followed by a pilot implementation on AWS EKS to evaluate effectiveness. Results show that misconfigurations are the most prevalent security risk, followed by exposed APIs, insufficient access controls, and unscanned container images with critical vulnerabilities. The implementation of Kube-RMF reduced high-risk vulnerabilities, improved compliance readiness, and shortened detection time from weeks to hours. Embedding security into CI/CD pipelines also enhanced collaboration across teams without slowing development cycles. Despite challenges such as resistance to change, skill gaps, and limited monitoring resources, Kube-RMF effectively bridges regulatory compliance and operational needs, strengthening resilience against evolving cloud-based cyber threats.

KEYWORDS *Kubernetes, Risk Management, Cybersecurity, Digital Banking, Regulatory Compliance, Cloud Security*

INTRODUCTION

The banking industry plays a critical role in the global financial ecosystem, facilitating economic transactions, credit allocation, and financial stability (Claessens et al., 2018; Demirgüç-Kunt et al., 2020). However, the rapid digital transformation of the banking sector introduces new risks and challenges (Vives, 2019). Traditionally, banks have faced threats such as credit risk, market risk, and operational risk (Aebi et al., 2019). In the modern digital landscape, these risks are compounded by cybersecurity threats, regulatory compliance pressures, and the need for scalable, resilient IT infrastructure (Bouveret, 2018; Chen et al., 2021; Thakor, 2020).

A significant shift in banking operations has been the adoption of cloud computing to enhance agility, cost efficiency, and service delivery (Marston et al., 2019; Raut et al., 2021). According to Egnyte (2024), 94% of financial services leaders believe that cloud is the future of IT operations, yet 68% express concerns over data security risks (Alhassan & Awudu, 2018; Gozman et al., 2018). Additionally, 92% of financial services organizations recognize that adapting to cloud operations is essential to maintaining competitiveness, but 64% struggle with regulatory compliance in cloud environments (Sarmah & Rahman, 2022; Rani et al., 2023).

These concerns are not merely theoretical. In 2022, Bank Indonesia (the central bank) confirmed a ransomware attack that resulted in data leakage by the Conti group, demonstrating the real-world vulnerability of financial institutions to cyber threats (Sharma & Chen, 2022; Lee, 2022). Similarly, in 2023, Bank Syariah Indonesia (BSI), the largest Islamic bank in Indonesia, suffered a significant ransomware attack that disrupted operations and compromised customer data (Rahman & Pratama, 2023; Sari et al., 2023). These incidents underscore the critical need for robust security frameworks in cloud-based banking infrastructure. Beyond Indonesia, several banks in Southeast Asia have faced similar challenges, including DBS Bank in Singapore, which experienced a series of digital service disruptions in 2021, and several Thai banks that reported increased cyber-attack attempts during the pandemic period (Lallie et al., 2021; Sommai & Phongpaibul, 2022; Weeratham, 2023). These real-world cases demonstrate that cloud security vulnerabilities pose tangible threats to the financial sector across the region.

Several recent studies have examined the intersection of cloud computing, cybersecurity, and banking operations. First, Bucchiarone et al. (2018) documented the migration from monolithic to microservices architecture in the banking domain, highlighting both opportunities and security challenges inherent in distributed systems (Dragoni et al., 2017; Taibi et al., 2020). Their research emphasized that while microservices improve scalability and agility, they also introduce complex security considerations that traditional banking security frameworks were not designed to address (Soldani et al., 2018). Second, Rajapakse et al. (2022) conducted a systematic review of challenges and solutions in adopting DevSecOps, finding that cultural resistance, tool fragmentation, and lack of security expertise are major barriers in financial institutions (Fitzgerald & Stol, 2017; Mohan & Othmane, 2019). Their study revealed that only 34% of organizations successfully integrated security into their DevOps pipelines, with the remainder struggling with implementation (Sharma & Soni, 2021). Third, Kamieniarz and Mazurczyk (2024) performed a comparative study on Kubernetes deployment security, demonstrating that default configurations in Kubernetes often contain critical vulnerabilities that can be exploited if not properly hardened (Polato et al., 2022). Their research found that 73% of Kubernetes deployments in production environments had at least one high-severity misconfiguration. Fourth, Shamim et al. (2020) systematized knowledge related to Kubernetes security practices, proposing "XI Commandments" that provide practical guidance for securing Kubernetes clusters in production environments (Almeida et al., 2021).

Despite these contributions, a significant research gap remains: there is limited literature on integrated risk management frameworks specifically designed for Kubernetes deployments in regulated financial institutions, particularly in emerging markets like Indonesia (Almeida et al., 2021; Polato et al., 2022). Existing studies tend to focus on either technical security controls or general cloud risk management, but few address the unique intersection of Kubernetes-specific risks, regulatory compliance requirements (such as POJK), and operational constraints in banking environments (Mavroeidis & Bromander, 2017; Sarmah & Rahman, 2022). Furthermore, most frameworks are designed for Western regulatory contexts and may not directly translate to Indonesian banking regulations (Sutanto & Tjahjono, 2020; Nugraha et al., 2022). This study fills this gap by developing a comprehensive, context-specific risk management framework that integrates international best practices with Indonesian regulatory requirements (Darmawan et al., 2022).

While cloud technology enhances operational efficiency and cost savings—83% of financial institutions that migrated to the cloud report significant cost reductions—the transition also introduces new cybersecurity vulnerabilities and compliance challenges.

The urgency of addressing these challenges cannot be overstated. Failure to implement robust Kubernetes security risk management can result in severe consequences across multiple dimensions (Kampa, 2024; Kannaiah, 2024). From a financial perspective, the IBM Cost of a Data Breach Report (2023) indicates that the average cost of a data breach in the financial sector is $5.97 million, with some incidents exceeding $10 million when including regulatory fines, remediation costs, and customer compensation. Reputational harm can be even more devastating and long-lasting; research by Forrester (2023) shows that 65% of customers would switch banks following a major security incident, and trust recovery can take 3–5 years. Regulatory sanctions pose another critical risk—Indonesia's OJK has the authority to impose administrative sanctions, operational restrictions, and even revoke operating licenses for non-compliance with POJK 11/POJK.03/2022. Beyond these direct impacts, inadequate security can trigger systemic risks, as demonstrated by the 2023 ransomware attack on BSI, which temporarily disrupted interbank clearing systems.

This study aims to design and implement a Kubernetes Risk Management Framework (Kube-RMF) tailored to Bank XYZ's digital banking environment in compliance with Indonesian financial regulations. This research provides practical guidance for bank IT and compliance managers by offering a structured, actionable framework that can be directly implemented in production environments. The Kube-RMF framework bridges the gap between technical security requirements and business objectives, enabling IT managers to make risk-based decisions about resource allocation and security investments. For compliance managers, the framework provides clear mappings between Kubernetes security controls and regulatory requirements, simplifying audit processes and demonstrating due diligence to regulators. The research also includes Key Risk Indicators (KRIs) that can be integrated into existing risk monitoring systems, enabling proactive risk management rather than reactive incident response. Furthermore, the framework is designed to be scalable and adaptable, allowing banks of different sizes and technological maturity levels to customize the approach to their specific contexts.

METHOD

The research applied a qualitative descriptive approach, structured around the development and validation of the Kubernetes Risk Management Framework (Kube-RMF) tailored for Bank XYZ's digital banking environment. The methodology comprised:

Framework Design

Adapting existing industry standards (CIS Kubernetes Benchmarks, OWASP Kubernetes Top 10, NIST SP 800-190) and integrating them with Indonesian banking regulatory requirements (e.g., POJK 11/POJK.03/2022).

Data Collection

1) Document Analysis: Internal IT policies, risk assessments, compliance reports, and incident records from Bank XYZ.
2) Interviews: Conducted with IT security staff, DevOps engineers, and compliance officers.

3) Security Scans: Using tools like Trivy and kube-bench to detect vulnerabilities and misconfigurations.

Risk Identification and Assessment

Mapping threats and vulnerabilities to Kubernetes assets, defining Key Risk Indicators (KRIs), and applying both top-down and bottom-up scenario analysis based on ISACA's Risk IT Framework.

Gap Analysis

Comparing current security practices against the designed framework to identify compliance gaps and areas of weakness.

Validation

Implementing Kube-RMF on a pilot scale within Bank XYZ's AWS EKS environment and evaluating its effectiveness in improving security posture and compliance readiness.

RESULT AND DISCUSSION

The application of Kube-RMF to Bank XYZ's Kubernetes environment produced several key findings:

Risk Landscape

Misconfigurations accounted for the majority of security risks (over 50%), followed by API exposure vulnerabilities, insufficient access control, and unscanned container images containing critical vulnerabilities. This finding aligns with the research by Kamieniarz & Mazurczyk (2024), who found that 73% of Kubernetes deployments in production contain at least one high-severity misconfiguration. The prevalence of misconfigurations can be explained through the lens of Configuration Drift Theory (Puppet Labs, 2020), which posits that in complex, dynamic systems like Kubernetes, manual configuration management inevitably leads to deviations from security baselines over time. Furthermore, according to the Defense-in-Depth security model, reliance on a single security control layer is insufficient; the high rate of misconfigurations observed in this study underscores the need for multiple overlapping security controls.

Compliance Gaps

While Bank XYZ had strong governance for traditional IT systems, Kubernetes-specific controls (e.g., Pod Security Policies, Role-Based Access Control fine-tuning, and centralized logging) were lacking or inconsistently applied. Research by Rajapakse et al. (2022) identified similar gaps in their systematic review of DevSecOps adoption, noting that 66% of organizations struggle to adapt existing security frameworks to cloud-native technologies. The compliance gaps identified in Bank XYZ reflect a broader industry challenge: traditional IT governance frameworks like COBIT and ITIL were designed for monolithic, on-premises infrastructure and require significant adaptation for container orchestration platforms (Leite et al., 2020). The ISO/IEC 27001 framework emphasizes the importance of context-specific security controls (ISO, 2022), and our findings demonstrate that generic IT security policies are insufficient for Kubernetes environments.

Security Improvements

After implementing the framework, there was a measurable reduction in high-risk vulnerabilities. Automated compliance scans and continuous monitoring increased detection speed for misconfigurations from weeks to hours. This improvement is consistent with the principles of Continuous Security Monitoring advocated by NIST SP 800-137 (NIST, 2011), which emphasizes that automated, real-time security assessment is critical for dynamic cloud environments. The reduction in detection time from weeks to hours represents a 98% improvement, which aligns with the findings of Bringhenti who demonstrated that automated security orchestration in cloud environments can reduce mean time to detection (MTTD) by 95% or more. From a theoretical perspective, this validates the application of Feedback Control Theory to cybersecurity: faster detection creates a tighter feedback loop, enabling more effective security control adjustments (Wiener, 1948; applied to cybersecurity by Anderson, 2001).

Operational Impact

The framework enabled clearer risk prioritization aligned with the bank's defined risk appetite and tolerance. Critical risks exceeding thresholds were remediated immediately, while tolerable risks were monitored systematically. This approach operationalizes the Risk Appetite Framework concept developed by COSO (2012) and adapted for IT environments by ISACA's Risk IT Framework (2020). The ability to align technical security metrics with business risk tolerance represents a key advancement over traditional security approaches that often operate in isolation from business objectives. Research by Djemame demonstrated that risk-based prioritization in cloud environments can reduce security-related operational costs by 40-60% compared to treating all vulnerabilities with equal urgency.

Organizational Benefits

Adoption of Kube-RMF improved collaboration between DevOps, security, and compliance teams, embedding security checks into the CI/CD pipeline without slowing development cycles. This outcome validates the DevSecOps philosophy articulated by Rajapakse et al. (2022), which argues that security integration should enhance rather than impede development velocity when implemented correctly. According to Accelerate State of DevOps Report (DORA, 2023), organizations that successfully integrate security into CI/CD pipelines deploy 208 times more frequently and recover from incidents 106 times faster than low performers. The collaborative benefits observed at Bank XYZ also reflect principles from Organizational Learning Theory (Senge, 1990), which emphasizes that cross-functional integration leads to improved organizational performance through shared mental models and collective problem-solving capabilities.

Challenges

Resistance to change from operations staff, the learning curve for Kubernetes-specific tools, and the need for continuous training were identified as barriers. Limited resources for 24/7 monitoring also constrained full automation. These challenges are well-documented in change management literature, particularly Kotter's 8-Step Change Model (Kotter, 1996) and the Technology Acceptance Model (Davis, 1989). Research by Megargel et al. (2020) on banking sector cloud migration found that organizational readiness and cultural factors are

often more significant barriers than technical challenges. The learning curve issue specifically relates to the Cognitive Load Theory (Sweller, 1988), which suggests that Kubernetes' inherent complexity can overwhelm practitioners who must simultaneously master container orchestration, security concepts, and banking domain knowledge. Studies show that effective Kubernetes security requires 200-300 hours of specialized training (CNCF, 2023), representing a significant investment for financial institutions.

Strategic Alignment

The framework not only met OJK regulatory requirements but also positioned Bank XYZ to handle future expansion of its digital services with stronger operational resilience. This strategic positioning aligns with the concept of Dynamic Capabilities Theory (Teece et al., 1997), which emphasizes organizations' ability to integrate, build, and reconfigure competencies to address rapidly changing environments. By implementing Kube-RMF, Bank XYZ developed what Eisenhardt & Martin call "strategic flexibility"—the capacity to rapidly respond to environmental changes while maintaining operational stability. Furthermore, this outcome supports the Resource-Based View (RBV) of competitive advantage (Barney, 1991), suggesting that security capabilities embedded in organizational processes can become sources of sustainable competitive advantage in digital banking.

In conclusion, the study demonstrated that a tailored Kubernetes security risk management framework could effectively bridge the gap between regulatory compliance and practical operational needs, significantly enhancing the security posture of cloud-managed banking workloads. The successful implementation at Bank XYZ provides empirical evidence supporting the theoretical framework proposed by Gritzalis, who argued that cloud-specific risk assessment methodologies are essential for effective security management in modern financial institutions.

CONCLUSION

This study validated the proposed *Kube-RMF* framework as a comprehensive and practical solution for managing Kubernetes-specific risks in financial institutions like Bank XYZ by integrating technical, operational, and governance practices, leveraging methodologies such as OCTAVE Allegro, and adopting best practices from CIS Kubernetes Benchmarks and the OWASP Kubernetes Top 10. The framework enables the identification and prioritization of critical risks—such as RBAC misconfigurations, API vulnerabilities, and runtime threats—while introducing tailored Key Risk Indicators (KRIs) for continuous monitoring and proactive risk management. By incorporating recommendations for CI/CD pipeline integration and hybrid cloud documentation, the research enhances both security maturity and compliance readiness, strengthening operational resilience and reducing legal, financial, and reputational risks. Beyond practical outcomes, the study provides a replicable model for Kubernetes-native risk management in financial institutions and contributes to theoretical knowledge by adapting established methodologies for dynamic Kubernetes environments. Future research could explore the application of *Kube-RMF* across diverse regulatory landscapes and emerging banking technologies, such as multi-cloud ecosystems and AI-driven operational models, to further refine its scalability and global applicability.

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