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Design and development of the spacelog web application for inventory management and asset tracking using QR codes at the Cyber Defense Center of the Ministry of Defense

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ABSTRACT

SpaceLog is a web-based inventory information system developed for the Cyber Defense Center of the Indonesian Ministry of Defense to address the limitations of spreadsheet-based management, which is static, non-real-time, and lacks accountability. This study proposes a novel approach by implementing a unit-centric architecture combined with Role-Based Access Control (RBAC) specifically tailored for the high-security requirements of the defense sector. The system development utilizes the Rapid Application Development (RAD) method, built upon Laravel, MySQL, and Bootstrap frameworks. Key features include unique QR Code tracking for individual assets, hierarchical location mapping, and a comprehensive audit trail. Testing results using the Black-Box method demonstrate that all functional scenarios, including item tracking and tiered access rights (Superadmin, Section Head, Staff), operate with 100% validity. Furthermore, the implementation significantly improves operational success by transforming asset management from a manual, error-prone process into a real-time, fully auditable digital ecosystem, thereby meeting the strict accountability standards of the Ministry of Defense.

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1. INTRODUCTION

The Ministry of Defense of the Republic of Indonesia, through the Cyber Defense Center (Pushansiber), is responsible for supporting cyber operations and managing vital information infrastructure as mandated by Presidential Regulation Number 82 of 2022. In carrying out these duties, Pushansiber manages various inventories and assets used to support operational activities. However, the inventory process, which is still conducted using Microsoft Excel, presents several challenges, such as non-real-time recording, data inaccuracy, difficulty in tracking item locations, and limitations in auditing and reporting. These conditions indicate the need for a more structured, accurate, and integrated system to support accountability and efficiency in asset management, particularly in light of contemporary research emphasizing the critical role of digital transformation in enhancing public sector efficiency (Adam & Tsarsitalidou, 2023; Afonso & Jalles, 2023).

The need for digital transformation in inventory management has been widely recognized in both academic literature and practical implementations. Studies by Nanang and Rahmah (2024) and Widya & Priawati (2022) have demonstrated that web-based inventory information systems can

significantly improve the accuracy and effectiveness of data management compared to manual methods. Furthermore, Rana and Shanmugam (2023) and Rana (2020) showed that the integration of IoT-based tracking systems produces promising results in enhancing real-time monitoring capabilities and operational efficiency. In the context of public sector organizations, Siuko Myllärniemi (2023) found that digital transformation initiatives are essential for optimizing asset lifecycle management, where knowledge management serves as a key enabler in public sector asset lifecycle processes.

The implementation of QR Code technology in asset management has emerged as a particularly effective solution for addressing inventory tracking challenges. Benrahman (2021) demonstrated that QR Code-based asset management systems improve identification processes and reduce recording errors through human-centered design approaches. This finding is further supported by international research conducted by Deepali and Monika (2024) , who showed that integrating barcode technology into warehouse management systems enhances efficiency and inventory accuracy, while (Maulana and Wijayanti (2025) confirmed that barcode usage in modern inventory systems significantly improves accuracy and operational speed. Additionally, Hugo (2024) developed innovative blockchain-integrated QR Code systems to ensure data integrity and security in procurement and asset management. In the Indonesian context, Nugroho and Solehudin (2021) successfully implemented QR Code solutions at the National Narcotics Agency in Karawang, demonstrating the technology's applicability in government agency environments.

To address these limitations, the Spacelog web application was developed as an inventory management system built using Laravel framework with a unit-centric approach. As demonstrated by Kurniawan and Rahmawati (2024) in their implementation of a web-based public service information system, Laravel has been widely adopted in developing robust information systems due to its efficient architecture and comprehensive features for web application development. Each item unit in Spacelog has a unique identity, modern QR Code, photo, hierarchical location, and a complete history of movement and condition.

The system incorporates several critical features to ensure secure and efficient asset management. It provides comprehensive item-unit management, categories, locations, Excel/PDF reporting capabilities, and contract management functionalities. A key security feature is the implementation of role-based access control (RBAC) with three hierarchical levels: Superadmin, Administration Head, and Staff. According to Khan (2024), RBAC has been proven effective in enhancing information security and accountability in web-based systems, while Hasegawa and Takakura (2021) developed dynamic access control systems based on user situations to improve security flexibility. Recent research by Logrippo (2025) on data flow security in RBAC further validates the effectiveness of this approach in maintaining system integrity. Moreover, Zhang and Zhu (2022) demonstrated that the implementation of hierarchical RBAC models with department-specific attributes shows significant improvements in access control management for organizational systems. This multi-level access control architecture ensures that only authorized personnel can perform specific operations, thereby maintaining data integrity and supporting compliance with security protocols in defense environments.

However, despite the extensive literature on QR codes and RBAC, a significant research gap remains regarding the integration of these technologies within a 'unit-centric' architecture specifically tailored for the high-security defense sector. Most previous studies (Benrahman, 2021; Deepali et al., 2024) focus on bulk inventory management in commercial or general public settings, often overlooking the strict requirements for granular audit trails and hierarchical data security mandated by defense institutions. Azhar et al. (2022) identified that the integration of asset management in the Indonesian National Armed Forces is still not centralized, which requires more time to collect material asset data and impacts military readiness. Existing systems rarely address the specific need to track the complete lifecycle and movement history of individual unit assets in a secure cyber defense environment..

To address this gap, this research aims to develop 'SpaceLog', a web-based inventory management system designed to support accountability at the Cyber Defense Center (Pushansiber). Specifically, the objectives of this study are to design a unit-centric tracking architecture that assigns a unique identity to every single asset, implement a strict Role-Based Access Control (RBAC) mechanism combined with activity logging to ensure data security, and validate the system's functionality and operational readiness through Rapid Application Development (RAD) and Black-Box testing.

The main scientific contribution and novelty of this article lie in the implementation of the unit-centric approach integrated with a comprehensive audit trail system specifically within the Ministry of Defense environment. As demonstrated by Kant et al. (2025), digital transformation in accounting significantly enhances public sector accountability through digital innovations, revealing substantial positive associations between digital technology adoption and transparency in public financial management. This research offers a proven blueprint for digital transformation in sensitive public sector organizations, ensuring that asset management is not only efficient but also fully transparent and secure according to defense standards.

2. RESEARCH METHOD

2.1 Type Of Research

This research uses the Rapid Application Development (RAD) approach, a software development methodology that emphasizes speed and efficiency in its processes. This methodology differs from traditional models because it allows software to be developed within a relatively short period. While conventional system development typically requires at least 180 days, the RAD approach enables a system to be completed within approximately 60 to 90 days Mishra & Dubey (2013). RAD adopts an iterative and incremental approach, focusing on strict deadlines and fulfilling user requirements. Its main objective is to accelerate the development cycle through repeated prototyping and continuous testing, allowing the application to be deployed more quickly Rizky Parlika (2023).

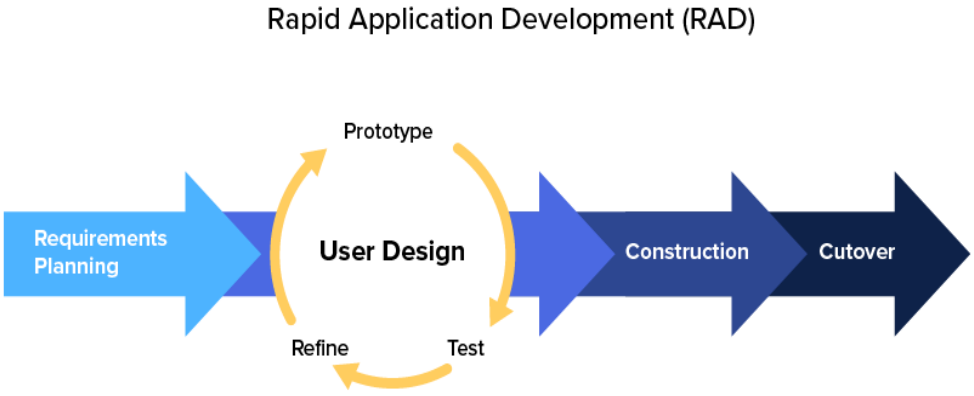

Figure 1. Rapid Application Development (RAD)

The RAD stages in this Figure1 are structured to produce specific outputs, beginning with the requirements planning phase which results in user stories and functional requirements. This is followed by the user design phase that produces the Entity Relationship Diagram (ERD), system architecture, and UI prototypes, which then lead into the construction phase where the functional Laravel-based application is developed. Finally, the process concludes with the cutover phase involving final testing and deployment, ensuring an iterative flow where each feature directly addresses the operational gaps identified at Pushansiber.

2.2 Data Collection Method

Data collection was carried out through:

1. **Observation:** Directly observing the inventory recording process, archiving procedures, and asset management workflows.
2. **Interviews:** Conducted with the Administration Subdivision Head and inventory management staff to gather system requirements and identify operational challenges.
3. **Literature Study:** Reviewing journals, books, and research related to inventory systems, Laravel, and QR Code technology.

4. **Documentation:** Collecting secondary data such as inventory lists, contract documents, annual reports, and organizational structure to support database design.

2.3 System Development Method

The system development method used in this study is Rapid Application Development (RAD), which is an approach that focuses on fast development through iterative processes and close collaboration between developers and users. The initial stage begins with requirements planning to identify problems and the necessary system functions for Pushansiber through observations and interviews. The next stage involves designing and creating prototypes to visualize workflows, data structures, and the application interface. These prototypes are tested and evaluated regularly so that user feedback can be directly integrated into the system development process. This intense, continuous feedback loop, where end-users actively participate in refining the prototype interfaces and core functionalities, is paramount to the success of the RAD methodology, significantly reducing the risk of major requirement discrepancies that often plague traditional, sequential development models. Once the design is considered appropriate, the development phase is carried out using Laravel, MySQL, and Bootstrap until all features function as intended. The final stage includes functional testing and data validation to ensure that the application is stable and meets operational needs before being implemented in the working environment of the Cyber Defense Center of the Ministry of Defense of the Republic of Indonesia.

2.4 System Testing

Black-Box Testing is a software testing method that evaluates functional specifications without examining the internal design or program code (Kıraç & Aktemur, 2019). As demonstrated by Ayuningtyas and Atmodjo (2023) , this testing approach is carried out to ensure that the system's functions, inputs, and outputs align with predetermined specifications. To ensure transparency, the test subjects involved include the Superadmin (IT Manager), Section Head (Validator), and Staff (Asset Operator), with success criteria defined as 100% fulfillment of functional requirements where the 'Expected Result' matches the 'Actual Result' across all scenarios. The test scenarios are comprehensively categorized into five key modules: Authentication & RBAC to ensure access rights are restricted according to roles; Asset Management for testing the unit-centric CRUD functions; QR Code Integration to validate generation and scanning accuracy; Movement & History to test the audit trail and inter-location transfer logs; and Reporting to validate the export accuracy of PDF and Excel data.

3. RESULTS AND DISCUSSIONS

The research results show that the Spacelog web application focuses on developing a system to support inventory management at Pushansiber Kemhan. The system was built using the Laravel framework, which enables a more structured, secure, and maintainable development process. All backend services are operated using the XAMPP environment, providing a stable local server during the development and testing phases. Meanwhile, the user interface is designed with Bootstrap to produce a responsive layout that is easy for all user levels to navigate.

Functional testing using the Black-Box Testing method showed that the system’s main features worked as expected. Inventory modules such as item management, categories, locations, responsible personnel, and contract management operated without issues. The QR Code scanning mechanism also functioned well in displaying item information quickly. In addition, the role-based access control (RBAC) system proved effective in distributing access rights among the Super Admin, Head of Administration (Kasubbag TU), and Staff, ensuring that workflows run more structured and securely.

3.1 Requirement Planning

At this stage, information gathering was carried out to identify the needs for developing a web-based inventory management system, SpaceLog. The data collection process involved observations and direct interviews with administrative staff and asset managers at the Cyber Defense Center (Pusansiber), Ministry of Defense. The findings from the interviews and observations were then used to create User Stories that represent the system requirements to be developed Xuen (2025).

The process began by identifying the system users, followed by the formulation of User Stories summarizing all user needs for the designed system Ferrari (2024). Based on the conducted interviews, the main requirements were categorized into three primary actors who would use the SpaceLog application: Super Admin, Staff (asset managers), and Administrative Subdivision Head (Kasubbag TU). These requirements include key functionalities such as item-unit management, QR code tracking, role-based access control, and PDF/Excel report generation. These documented requirements subsequently served as the primary foundation for the system design and database architecture in the next phase of development.

3.2 Design

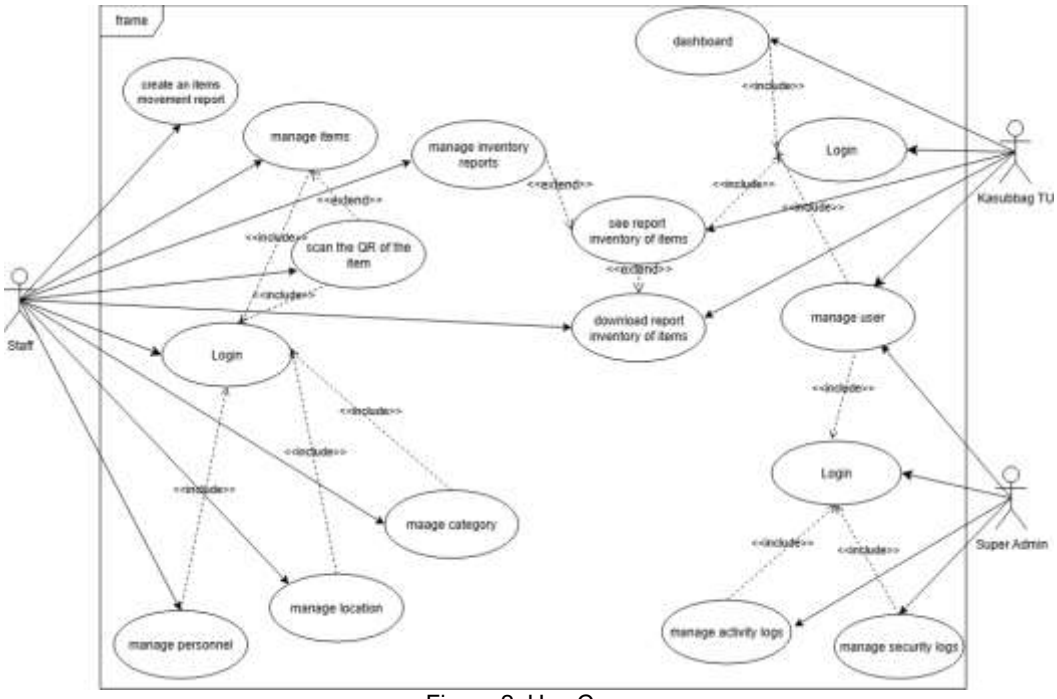

Figure 2. Use Case

The Use Case Diagram in Figure 2 illustrates the interaction between users (actors) and the system in performing various core functions such as inventory data management, report generation, QR code scanning, and user management. The system consists of three main actors: the Administrative Subdivision Head (Kasubbag TU), Staff, and Super Admin. Each actor has distinct roles and access rights according to the organizational structure and their respective responsibilities within the Cyber Defense Center of the Ministry of Defense.

3.3 Implementation

a. Login User

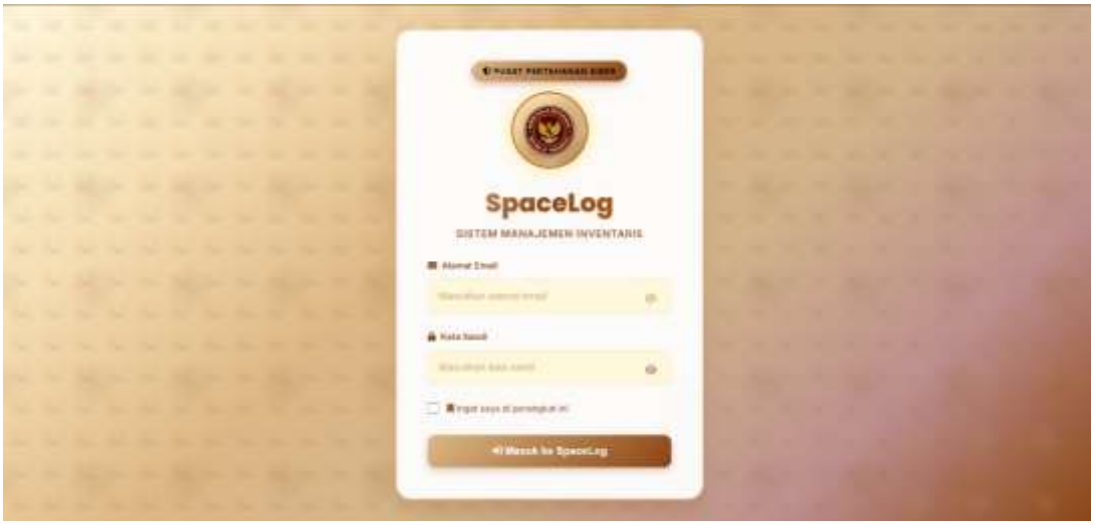

Figure 3. Halaman Login User

Figure 3 shows the User Login page, which is accessed by all registered users. Users enter their email address and password in the provided fields. Afterward, account validation is performed to verify whether the user is registered. If the account is verified, the user will be redirected to the dashboard page according to their respective role.

b. Dashboard

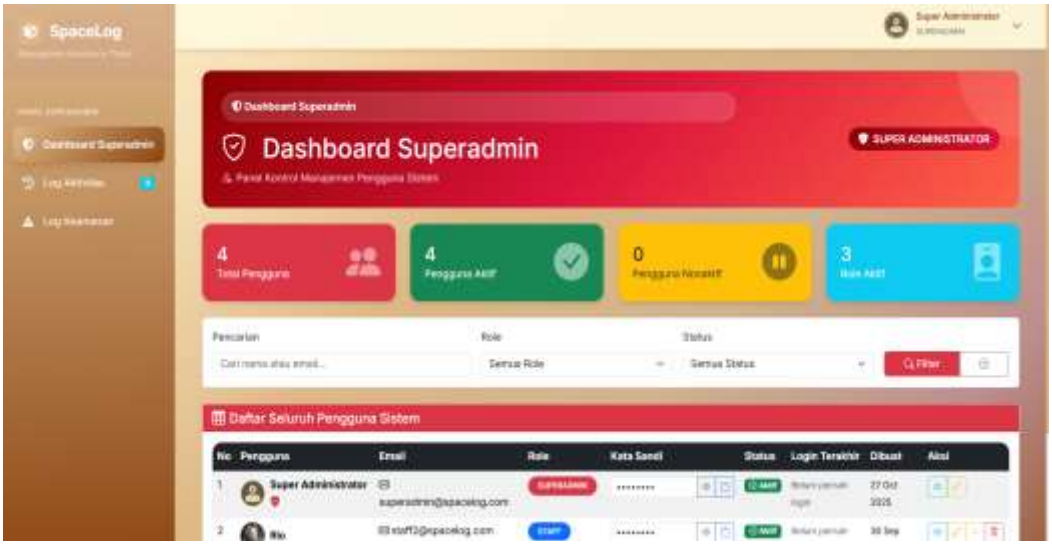

Figure 4. Superadmin Dashboard

Figure 4 displays the Super Admin Dashboard page of the SpaceLog system, which serves as the main control panel for managing user accounts. It shows summary statistics such as the total number of users, active users, inactive users, and active roles, along with detailed user information and management options.

Figure 5. Kasubbag TU & Staff dashboard

Figure 5 shows the Dashboard page for the Administrative Subdivision Head (Kasubbag TU) and Staff in the SpaceLog system. This page provides an overview of key inventory data, including the total number of items, units, categories, and locations. It functions as a monitoring interface that allows users to track inventory movements, analyze stock data, and access real-time information through an integrated QR code tracking system.

c. QR Code

Figure 6. Menu QR Code Unit

Figure 6 shows the QR Code feature of the SpaceLog inventory management system, which provides a unique identifier for each item. This QR Code simplifies the process of recording, tracking, and scanning assets using a camera or scanner. Users can also print or download the QR Code to label physical items, making the inventory process more efficient and accurate.

Figure 7. Detail QR Code

Figure 7 displays the detailed view of one of the QR Codes used in the inventory management system. The QR Code serves as a unique identifier for a specific inventory item, allowing it to be easily scanned using a mobile device or QR scanner. At the center, it includes the official logo of the Ministry of Defense of the Republic of Indonesia, indicating that the item is part of an authorized institutional inventory. This visual integration enhances authenticity, facilitates quick data retrieval, and ensures that each asset can be accurately tracked and verified within the system.

d. Scanner

Figure 8. Scanner

The Unit QR Code Scanner page, shown in Figure 8, is the main interface that allosws Staff users to track and verify inventory assets in real-time. This page provides a scanning area to activate the device's camera and read the QR Code attached to the item unit. The available Scanner Instructions guide Staff through the step-by-step scanning process, from camera activation to the automatic display of the scanning results. The system is developed to support various code formats, including the QR Code with the Kemhan logo, ensuring compatibility and accuracy in the rapid tracking of unit assets.

3.4 System Testing

The SpaceLog Inventory Management System, once developed, proceeded to the testing phase to ensure its functionality and reliability. The testing method employed was black box testing, which was applied to all system features to verify that every function operates according to the established requirements and design specifications. This testing process involved several users representing the relevant parties, including the Super Admin, Staff, and Kasubbag TU. The results of the tests are presented in the following black box testing table at table 1 below.

Table 1. Black Box Testing – System Functionality

No	Test Scenario	Succes Criteria	Remarks
1	Authentication & Login (All Users)	The system validates credentials and directs the user to the dashboard corresponding to their access rights (Admin/Staff/Kasubbag TU	Passed
2	Access Control Security (RBAC)	Middleware prevents Super Admin from accessing the Inventory menu and prevents Staff from accessing the User Management menu	Passed
3	User Management (Super Admin)	The Super Admin successfully adds new users, passwords are automatically encrypted, and user activity details are viewable	Passed
4	Activity & Security Log Monitoring	The system successfully records and displays the history of logins, logouts, failed login attempts, and data changes in real-time	Passed

5	Item & Unit Data Input (Staff)	*Item data is saved to the database, and a unique QR Code is automatically generated by the system for each new unit*	Passed
6	QR Code Scanning (Staff)	The camera feature activates, successfully scans the physical code, and the system accurately displays the unit's information and location details	Passed
7	Invalid QR Code Validation	The system displays an "Invalid QR Code" error message if the scanned code is not registered in the system	Passed
8	Asset Transfer / Mutation (Staff)	The unit's location is successfully updated, and the movement history is recorded in the item mutation log	Passed
9	Master Data Management (Staff)	Staff successfully manages (adds/edits) data for Categories, Locations, Personnel, and Contracts linked to item units	Passed
10	Reporting & Data Export (Kasubbag TU & Staff)	Inventory and mutation reports are displayed based on filters and are successfully exported/printed	Passed

3.5 Discussion and Practical Implications

The successful implementation of SpaceLog directly answers the research objectives by establishing a unit-centric architecture that overcomes the limitations of bulk inventory management. Unlike general inventory studies Benrahman (2021) that focus primarily on stock availability, this research demonstrates that integrating QR Codes with strict RBAC provides the granular visibility required in a high-security environment. The system ensures that every movement of a cyber defense asset—whether a server or a laptop is recorded not just as a change in quantity, but as a specific event linked to a responsible user.

The practical implications for the defense sector are significant. SpaceLog transforms asset management from a passive administrative task into an active security component. By enforcing a digital audit trail, the system fosters a culture of accountability where every asset transfer is transparent and traceable. This contributes to the readiness of the Cyber Defense Center (Pushansiber) by ensuring that critical hardware locations are known in real-time, thereby minimizing the risk of asset loss and supporting rapid logistics decision-making during operations.

4. CONCLUSION

This study successfully developed 'SpaceLog', a web-based inventory information system that addresses the critical need for accountability in the Cyber Defense Center. The primary scientific contribution of this research lies in the shift from conventional bulk-based inventory methods to a specific unit-centric architecture integrated with strict Role-Based Access Control (RBAC), which ensures that every individual asset is traceable with a high degree of security suitable for the defense sector, practically resulting in eliminated data redundancy and significantly reduced search times compared to manual recording. However, acknowledging that the current system is limited by its reliance on manual QR scanning and local network restriction, future research is recommended to explore the integration of Internet of Things (IoT) technologies such as RFID for automation and Blockchain for immutable audit logging, as well as expanding interoperability with national inventory databases to further support organizational goals.

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