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Efficiency in Cloud Computing through Serverless and Green Computing based on Microarchitecture

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Abstract
PT Pelindo Multi Terminal is a subholding of PT Pelabuhan Indonesia (Persero), a State-Owned Enterprise (SOE). PT Pelindo Multi Terminal carries out Kesehatan dan Keselamatan Kerja (K3) or Occupational Health and Safety (OHS) monitoring, which currently still uses manual methods with paper. This method causes problems, such as delays in decision making and the inability to monitor events in real-time. This research aims to overcome these problems by proposing an application called "Portsafe+". Portsafe+ is developed using microservices architecture and micro frontend, with Progressive Web Apps (PWA) as the interface and Google Cloud Function as the backend. Portsafe+ was tested by measuring the response speed of the backend that responds to each request. The test results show that this application improves the response speed with 99% execution time of 10.502 ms. Based on the test results, Portsafe+ successfully overcomes the existing problems. The application of PWA technology facilitates access and improves the efficiency of OHS management compared to the previously used paper-based manual system.
Keywords: Golang, Google Cloud Function, Occupational Health and Safety, OHS, K3, Progressive Web Apps, microservices.

1. Introduction
PT. Pelindo Multi Terminal is a sub holding of PT. Pelabuhan Indonesia (Persero), a State-Owned Enterprise (BUMN) in Indonesia. PT. Pelindo Multi Terminal devotes to enhance its safety standards by implementing Occupational Health and Safety (K3) (PT. Pelindo Multi Terminal, 2024). However, the dynamics of modern industry introduces operational complexities, particularly in the implementation of K3 practices (Sobirin, Putra, Fertilla, & Susanti, 2022; Sugianto, 2022). The reliance on paper-based system documentation leads to several problems, such as delays in critical decision making and the inability to monitor events in real-time (Putra, Satwika, & Nirmala, 2020; Yuricha & Phan, 2024).

Accordingly, Putra, Satwika, & Nirmala (2020) and Yuricha & Phan (2024) proposed Progressive Web App (PWA) to address problems caused by paper-based systems. PWA has been proven to significantly improve the performance of a real-time application by using caching technology (Riet, Malavolta, & Ghaleb, 2023). Additionally, PWA can be used offline, does not require the installation of native applications, and compatible with multiple platforms (Ali, Grover, & Chaudhary, 2023). In the context of K3, Rasyid, Firdaus, Setiawan, Fitri, & Setialana (2022) found that PWA is useful for providing a real-time update visualization regarding worker location through the integration of a location fingerprint algorithm, known as Portable Construction Maps (PCM).

To extend the contribution of PWA, this study aims to develop an application incorporating PWA and Google Cloud Functions. This application, namely Portsafe+, is designed following the principle of green computing, attempting to enhance security and efficiency in PT. Pelindo Multi Terminal. In the case of Google Cloud Functions, Go (Golang) is employed because of its simplicity and practical compiler, providing an error message and notification, offering automatic scalability, supporting dynamic capacity, reducing ma-

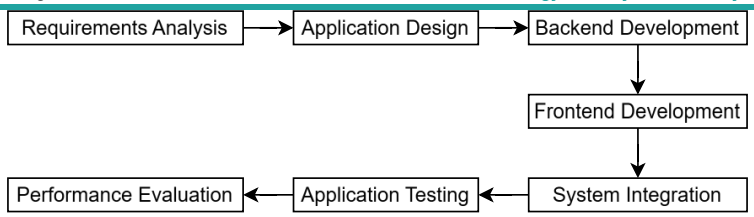

Fig. 1. Research methodology.

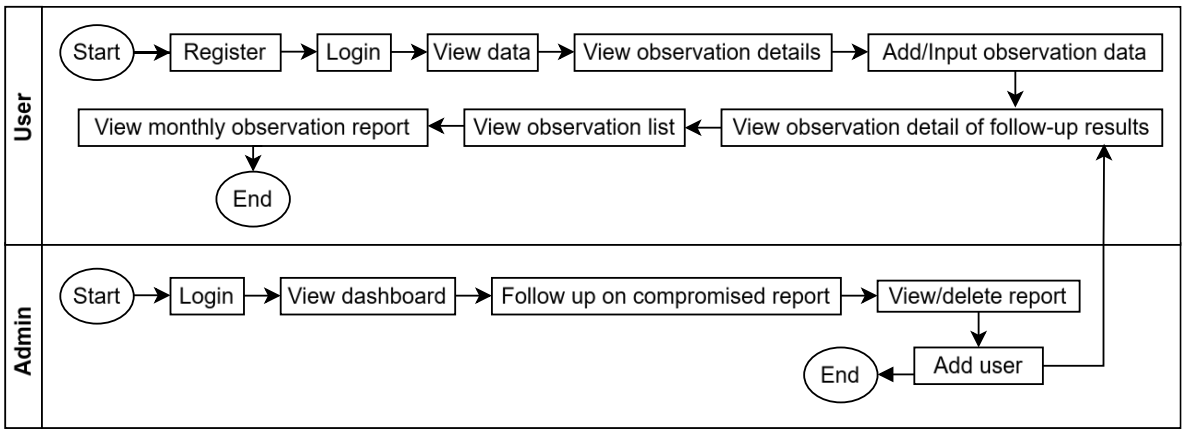

Fig. 2. Application roles flowchart.

nual management capacity, and improving efficiency in increasing workloads (Tsoukalos, 2019; Vu, 2021).

2. Methods

This study starts by analyzing requirements, particularly related to the monitoring process in PT. Pelindo Multi Terminal. This stage includes requirements analysis, application design, front-end and back-end development using PWA and Go (Golang), system integration, application testing, and performance evaluation (see Fig. 1). In terms of requirements analysis, the identification of functional and non-functional requirements is conducted. Functional requirements expect the system to document and store K3 incident reports in real-time, manage reporting data, provide role-based access tailored to user needs such as administrators and supervisors, and display dashboards featuring statistical data and analysis related to observation reports conducted by supervisors. Meanwhile, non-functional requirements specify a user-friendly interface, online accessibility, and fast response, with the latter requiring the system to complete processes within 3 seconds.

Application design focuses on designing User Interface (UI), User Experience (UX), and system architecture. User Interface and User Experience (UI/UX) is conducted mainly to ensure the responsiveness of the system. The design is also used to identify main features, including micro front-end and services architectures. For system architecture, flowchart is used to illustrate the mechanism of the expected system according to the assigned roles, admin and user (see Fig. 2).

Admin has access to manage the entire system, enabling them to login to the system through a secure authentication mechanism. They are also capable of accessing dashboard which provides a general overview of the K3 monitoring system. Furthermore, admin can access reports and feedback, add new users, edit, delete, and view list of users accordingly.

On the other hand, user has access to monitor and report K3 incidents. User can login to the system using a secure authentication mechanism and see K3 incidents monitoring. User can add new observation data, view the list of observations they have added, and access their details. Additionally, user can view their monthly report, which plays a crucial role to ensure health and safety processes in the workplace.

Portsafe+ is developed using a full-stack system. As a backend, Go (Golang) is selected because of its strong concurrency and simplicity to handle data request and processing, enabling efficient task handling and serverless management via Google Cloud Function (Jiang, et al., 2023). Google Cloud Functions allows event-driven code and functions to run automatically on Google Cloud. By configuring a Cloud Function with an HTTP trigger, it can become an HTTP endpoint that is accessible via the internet, enabling the function to execute and respond based on the written code when an HTTP request is received (Google Developers Codelabs, 2024; Google Cloud, 2024). Meanwhile, PWA principles are implemented during

front-end development to ensure accessibility and responsiveness of using application. Technically, the system is developed using HTML, CSS, dan Vanilla JS.

After development stage, the Portsafe+ is gradually integrated with existing infrastructure. Less critical functionalities are integrated prior to more complex ones. This approach is performed to minimize risk and allows testing and adjustments during the integration process.

To test application conformance, Black Box and usability testing are conducted. The tests are selected to ensure the completeness of requirements and to evaluate the performance of the application. Testing scenarios involving several crucial steps, including feature testing, role-based feature access, dashboard testing, and application performance testing. During feature testing, a documentation of K3 accident report is tested to ensure that user can input and save reports accurately in a real-time manner. Role-based feature access is conducted to verify that admin and supervisor can only access functions according to their respective authorities. Dashboard testing is performed to ensure that statistical data and analysis regarding observation reports have been displayed clearly and informatively. Meanwhile, application performance has been tested by assessing system responsiveness and stability when it is used from different kinds of devices. The results are useful to provide more insight into the effectiveness of the Portsafe+ to support K3 accident monitoring at PT. Pelindo Multi Terminal.

3. Results and Discussion

3.1. Results

To support K3 accident reports, PortSafe+ offers various environmental-friendly features to ensure operational continuity. The features are intended to identify and prevent potential risks in a workplace while establishing a strong and secure health and safety (K3) culture. Furthermore, those enable users to actively contribute to monitoring and improving K3 culture, creating a participatory platform that facilitates workplace safety. The features are: 1) selecting dangerous activities and determining preventive actions to avoid repetitive accidents. 2) reporting observation details while monitoring K3 activities in the workplace.

Based on a Black Box test, it was demonstrated that the features of PortSafe+ work as expected and are in accordance with user needs. The test was conducted on several features, including real-time documentation for K3 reports, data management, role-based access, and dashboard visualization. Usability testing indicates that PortSafe+ is user-friendly, easy to use, and intuitive, with an average satisfaction score of 4.5. Regarding responsiveness, PortSafe+ demonstrates an average response time of 2.5 seconds, meeting the maximum threshold of 3 seconds. Furthermore, it is confirmed that PortSafe+ ensures 99.99% service availability, while maintaining an average workload of 20%, indicating that the system can handle most requests without degradation.

According to Fig. 3, it is concluded that PortSafe+ adequately supports K3 incident monitoring in PT. Pelindo Multi Terminal, with the average performance is 91.5%. The system performance was assessed using several metrics, including the maximum response time allowed of 3 seconds, service availability exceeding 99%, and workload system performance below 30%.

The results show that K3 indicent reports can be accurately documented in real-time. The result depicted that the K3 report documentation feature works well and conform with the expected specification. The role-based access feature testing verifies that system functionality works accordingly, where admin and supervisor can access corresponding functions accordingly. Regarding dashboard functionality, the test shows that statistical data and analysis features can provide observational reports clearly and informatively as expected. Finally, application performance testing on speed and stability demonstrates an average response time of 2.5 seconds, which is acceptable.

The user interface of PortSafe+ is illustrated in Fig. 4 and Fig. 5. In Fig. 4, users need to register on the website and make a new account. Afterwards, they can log in to the system. At the main page, users see a dashboard page providing various information, including K3 incident statistics, top three violations, and latest news functions. There are several navigations features to access observation, report, and main page.

On “view data” page, users can see K3 incident statistics, top violations, and latest news. Users can also use navigation buttons to access different features, such as main page, observational data input, and view monthly reports. Users can input observational data and monitor action reports following several steps. In the action reports, observations are conducted, witnesses are observed, non-standard behaviours ara observed, and preventive measures are reported. In every step, users are required to complete relevant information, such as working unit, observation area, description, and next steps. Users can actively contribute to the K3 observation. Users can view statistical reports, top violations, and report observational

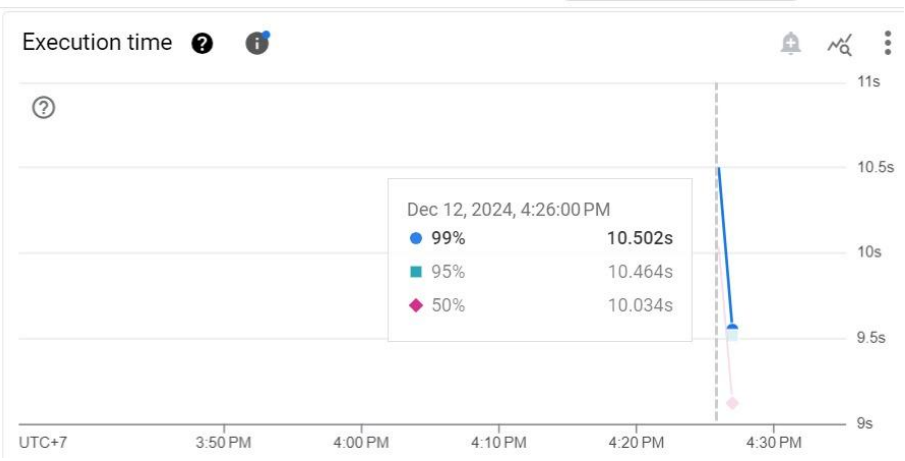

Fig.3. PortSafe+ testing results.

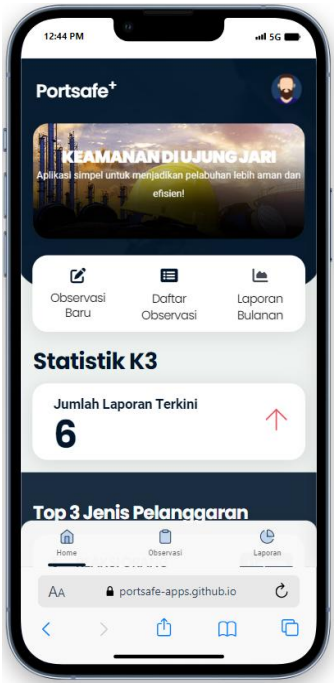

Fig. 4. User dashboard view.

findings to improve health and security in the workplace. By doing these actions, it is hoped that users can contribute to establishing a more secure and structured workplace. Additionally, users have access to views and reports K3 incicents recently.

Fig. 6 demonstrates PortSafe+ user interface using Administrator viewpoint. The figure shows that Admin responsibles to manage and observe users. Admin can view and delete statistical reports, both unsafe and compromised incident reports. Admin can also delete reports and perform follow-up actions for compromised reports. Admin has authority to manage user data, including view, add, edit, and delete user data. This feature allows admins to maintain data integrity and manage access accordingly.

Like users, admins can view statistical reports in the dashboard. However, admin has an exclusive feature, which is compromised report follow-up. Using this feature, admin can input and update follow-up actions and upload some pictures to respond to the observational reports. Therefore, admin has a crucial role to ensure that Occupational Health and Safety is optimally implemented in the workplace while providing data integrity and PortSafe+ continuity.

3.2. Discussion

PortSafe+ is designed to document and monitor K3 report incident real-time. It enables users to select different actions to potentially dangerous activities, report detail observations, and monitor managerial ac-

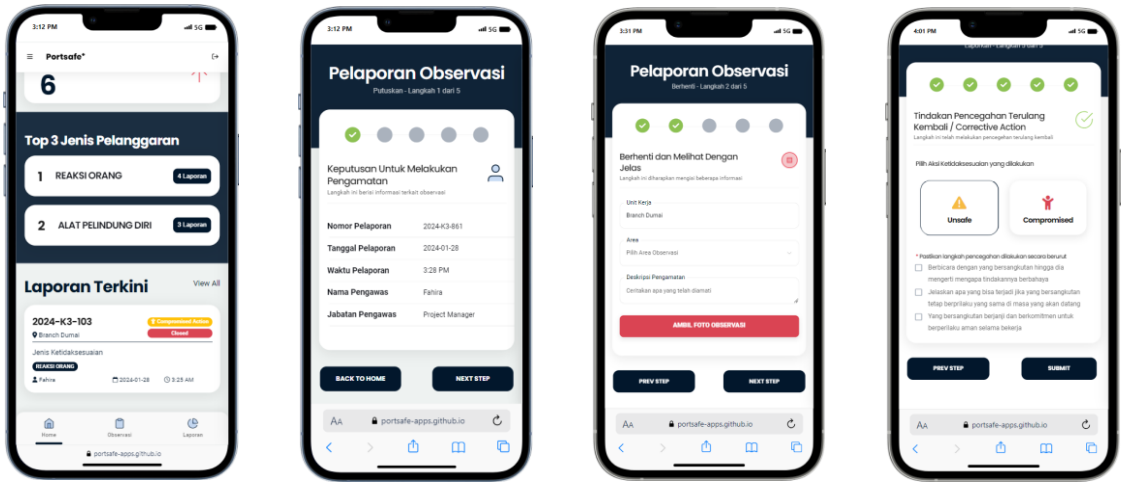

Fig. 5. The PostSafe+ user interface with a "User"-level.

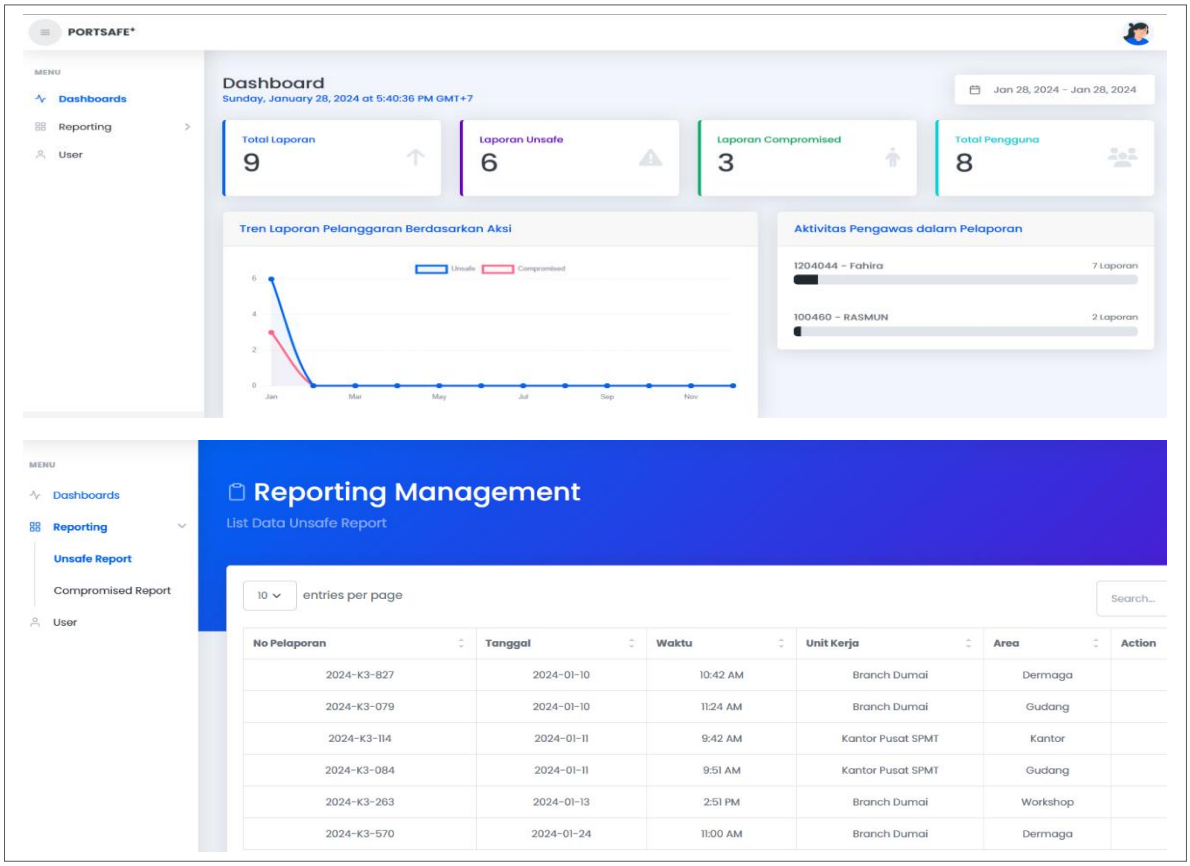

Fig. 6. The PostSafe+ user interface with an "Admin" level.

tion progress, without sacrificing integrity and application performance. PortSafe+ is useful to enhance the effectiveness of business processes at PT. Pelindo Multi Terminal by increasing transparency, management responsiveness, and user empowerment, establishing a more secure, efficient, and sustainable workplace.

As a result of integrating Could Computing and serverless approaches, it reduces the need for infrastructure as well as contributing to energy efficiency and environmental sustainability. The utilization of Go (Golang) offers high performance and development efficiency, facilitates high speed execution and strong concurrency support. This way, critical tasks, including K3 reports and serverless maintenance, can be effectively performed. PortSafe+ is developed using PWA approach, enabling more efficient access to the application. By accessing PortSafe+ directly through a website browser without the need for additional novice application installation, thus expanding application's reach and reducing the obstacles to accessing the application.

4. Conclusions

PortSafe+ is designed using a combination of PWA and Go (Golang) programming language to monitor K3 potential incidents at PT. Pelindo Multi Terminal. It offers technological innovation in Occupational Health and Safety context by incorporating micro front-end and micro service architectures and design and Fullstack development approaches. The black box and usability testing indicates that the application is useful to help users in maintaining potential incidents while documenting feedback and follow up actions.

Several testing advocates that the application provide clear functionalities for both admin and user levels. Admin has authorization to monitor K3 incident reports, manage feedback, and manage user accounts. Meanwhile, user accounts have access to view K3 data, add new observations, and access detail reports. It is important to note that PortSafe+ is an effective solution that can improve workplace transparency and improve employee responsiveness to K3-related issues.

5. CRediT Authorship Contribution Statement

Fahira: Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, and Writing – review & editing. **Rolly Maulana Awangga**: Validation, Visualization, Writing –3 original draft, and Writing – review & editing. **Sundaram Gopikrishnan**: Validation, Visualization, Writing – original draft, and Writing – review & editing.

6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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