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Performance and adoption of a PWA-based omnichannel application for MSMEs: Insights from *SinariUMKM*

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C H R O N I C L E

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A B S T R A C T

The rapid growth of social media use among micro, small, and medium enterprises (MSMEs) in Indonesia has created new opportunities for digital marketing. Yet, fragmented platform management remains a significant challenge. While previous studies highlight the efficiency of cross-platform integration, few have provided practical solutions tailored to MSMEs with limited technical and financial resources. The objective of this study is to develop and evaluate "SinariUMKM", a progressive web application (PWA)-based omnichannel system designed to simplify campaign management, broadcasting, and reporting across multiple social media platforms. Using a research and development framework combined with rapid prototyping, the application was calibrated and tested in numerous stages. Black-box functional tests demonstrated that all modules, campaign, broadcasting, and reporting, performed reliably, achieving an average loading time of 3s and a transition speed of less than 1 second between pages. Survey validation involving 117 MSMEs showed high acceptance, with mean scores of 4.62 for smartphone usability, 4.62 for promotional usefulness, and 4.52 for alignment with current business trends. However, technical reliability scored slightly lower at 3.55. These findings confirm that "SinariUMKM" effectively addresses key marketing needs while remaining lightweight and affordable. The study contributes a scalable model for supporting MSME digital branding and highlights the importance of improving technical stability for sustainable adoption.

1. Introduction

The digital transformation era has fundamentally altered the dynamics of small-scale business and agricultural practices, where accessibility to technology is increasingly recognized as a critical factor in improving productivity and competitiveness. In Indonesia, micro, small, and medium enterprises (MSMEs) form the backbone of the national economy, accounting for more than 60% of GDP and employing the majority of the workforce. Yet, despite their economic importance, MSMEs often face structural limitations, particularly in marketing capabilities, technical expertise, and access to efficient production technologies. Research by Jurriëns and Tapsell (2017) demonstrates that Indonesian internet penetration has reached 77% of the population, with more than 167 million active social media users, highlighting the massive potential of digital platforms to support marketing and branding. At the same time, studies by Somantri et al. (2021) emphasize that social media-based marketing strategies during the COVID-19 pandemic allowed MSMEs to maintain customer engagement and adapt to changing consumption patterns, despite resource constraints. However, these opportunities remain unevenly distributed due to the absence of integrated tools that can bridge the technological gap, especially in rural or agricultural contexts. Consequently, the challenge lies not only in increasing digital visibility but also in ensuring that technology can directly contribute to practical aspects of business and farming, including mechanization in crop cultivation. Similar observations were made by Cahyadi et al. (2024), who argued that web-based solutions such as progressive web apps (PWAs) can reduce technological barriers through lightweight platforms.

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The emergence of progressive web applications (PWA) offers a promising solution for MSMEs to address limitations in technical resources while ensuring affordability and accessibility across devices. Unlike conventional mobile applications that often require large storage and high computational power, PWAs can operate seamlessly with lightweight architecture, offline accessibility, and cross-platform adaptability (Adetunji et al., 2020). Previous findings by Panwar (2024) reported that PWA implementation increased user engagement and reduced bounce rates, highlighting its potential in digital marketing ecosystems. Moreover, API-based integrations across multiple social media platforms provide additional value by simplifying content dissemination, analytics, and campaign management (Lamothe et al., 2021). In the Indonesian context, Al-Haidari et al. (2021) demonstrated that the main challenges in adopting social media marketing in tourism and MSME sectors include inconsistent platform features and difficulties in evaluating return on investment. Such challenges resonate with findings from Bhatti et al. (2025), where MSMEs frequently report limited time and expertise to manage multiple digital platforms effectively. However, the majority of studies still focus on consumer-facing applications of PWA and omnichannel strategies. At the same time, their implications in supporting production-side decisions, such as mechanization design and soil condition classification, remain unexplored.

Existing literature has increasingly underlined the importance of digital transformation for MSMEs, particularly through omnichannel strategies and platform integration, as a way to improve branding and competitiveness. Studies such as Muhammad et al. (2025) note that fragmented platform management and limited digital literacy remain significant barriers for MSMEs in adopting social media marketing effectively. Likewise, Khanyi et al. (2024) highlighted that while API-based integrations can provide valuable insights, most existing solutions are designed for larger enterprises rather than small businesses with limited resources. Although omnichannel applications and PWA technologies have been tested in the context of digital commerce efficiency (Mishra et al., 2025), there is still a lack of practical models explicitly tailored to the conditions of Indonesian MSMEs. This indicates a clear research gap: the need for a lightweight, scalable, and user-friendly system that integrates campaign management, broadcasting, and reporting in one platform, while remaining affordable and accessible to resource-constrained enterprises.

Based on these observations, a clear research gap emerges, including that previous studies have extensively discussed the role of PWAs and omnichannel systems in digital marketing and the importance of soil classification in agriculture. Still, there is limited integration of these two dimensions into a unified framework for decision support in agricultural mechanization. Specifically, no prior research has explicitly combined soil depth classification with the design of adaptive hand tractor wheel lugs in steep terrains. Therefore, the objective of this study is to develop and evaluate a PWA-based omnichannel application (SinariUMKM), which not only streamlines MSME marketing campaigns but also provides predictive insights for soil depth classification relevant to tractor lug design. The urgency of this research lies in addressing the dual challenge of enhancing MSME branding efficiency while simultaneously supporting agricultural productivity through improved mechanization.

2. Methodology

This study applied a research and development framework adapted from Mohanty and Mishra (2020), as illustrated in Fig. 1. The process began with preliminary research and information collection to identify user needs and contextual challenges faced by MSMEs. Based on this stage, research planning was conducted to define objectives, technical requirements, and application features. The early product development stage produced a prototype, which was then reviewed through expert validation to assess usability and functionality. Feedback from experts informed product revisions, followed by early testing with selected users to evaluate operational performance. The system was subsequently refined and advanced to a field test, providing real-world insights into its reliability and scalability. Outcomes from the field test guided the final product revision, ensuring the application's stability before being prepared for dissemination. This structured and iterative process allowed the developed system to align with both theoretical standards and the practical needs of MSMEs.

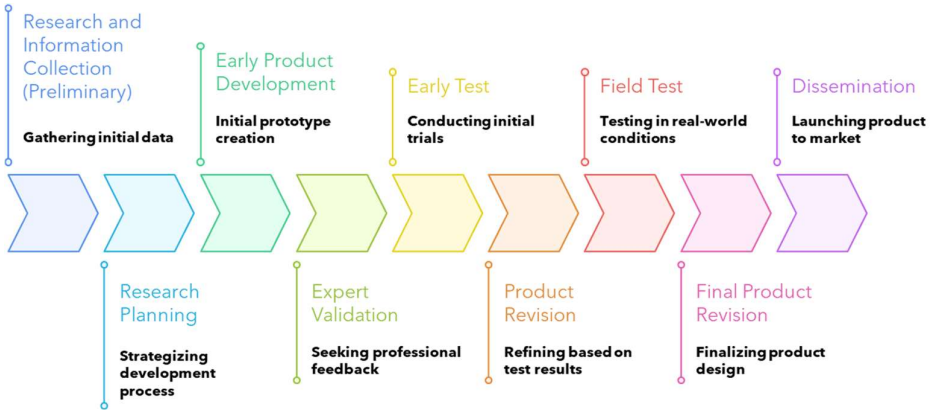

Fig. 1. Research and development framework employed for the construction and refinement of the "SinariUMKM" application

The development of the "SinariUMKM" application employed the rapid prototyping model (Lan, 2009), as illustrated in Fig. 2. This method was chosen because it emphasizes iterative design, user involvement, and early validation of features, which are crucial for ensuring that the system meets the practical needs of MSMEs. The process began with need analysis, where requirements were identified based on user expectations and business constraints. From this stage, a design concept was created to outline the system's architecture, interfaces, and data flow. The design was then transformed into a working prototype and development phase, where functional modules such as campaign creation, broadcasting, and reporting were built. Each prototype was subjected to validation by experts and selected users, enabling continuous feedback to refine system performance. This iterative loop between design, prototyping, and validation ensured that potential issues were detected and resolved early in the process. Finally, the evaluation stage assessed overall functionality and usability, confirming that the application was stable and aligned with both technical requirements and user needs.

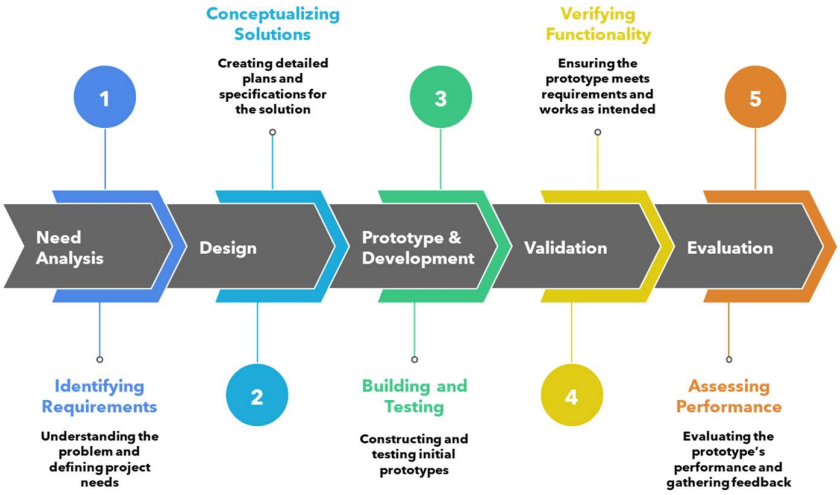

Fig. 2. Rapid Prototyping model guiding the development of application features

3. Results and Discussion

The campaign activity in the "SinariUMKM" application follows a systematic workflow that connects owners, agents, and social media platforms, as illustrated in Fig. 3. The process begins with the owner creating a campaign, which is then distributed through the omnichannel system to multiple agents. Each agent receives the campaign and disseminates it across various social media platforms, such as WhatsApp, Facebook, Instagram, TikTok, and Twitter. The system subsequently records user engagement, including views, clicks, and shares, which are stored as updated data. Finally, the owner can access these analytics in the form of an insight report, enabling informed decision-making regarding promotional effectiveness. This workflow aligns with the Rapid Prototyping model described in Fig. 2, as feedback loops between campaign broadcasting, agent interaction, and system reporting create an iterative cycle of refinement. The integration ensures that both campaign dissemination and performance evaluation are executed efficiently within a single platform.

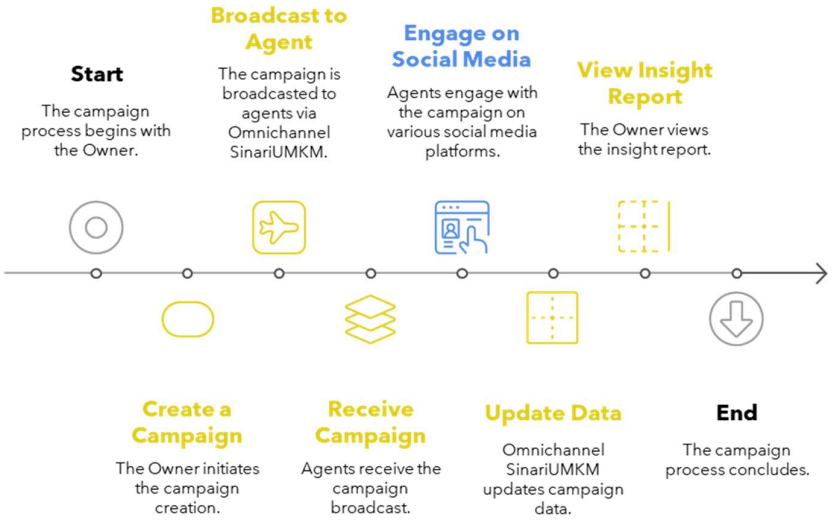

Fig. 3. The campaign activity framework showing interactions across multiple platforms

Research from Kumar and Nanda (2023) emphasized that MSMEs often face challenges in managing diverse social media accounts, which can be mitigated through integrated broadcasting features. Similarly, Kartini and Hermawan (2025) reported that Indonesian MSMEs benefit substantially from digital tools that simplify data-driven decision-making, particularly in evaluating promotional outcomes. The present study contributes to this discourse by demonstrating that "SinariUMKM" not only enables campaign distribution but also provides real-time insight reporting. This feature has been highlighted as critical by previous works such as Lamothe et al. (2021), who underlined the importance of API-driven analytics for effective platform integration. Compared with these earlier studies, the novelty of "SinariUMKM" lies in combining campaign broadcasting with automated reporting features tailored for MSMEs.

The workflow of the omnichannel broadcast in the "SinariUMKM" system is illustrated in Fig. 4. At the core of this architecture lies the broadcast module, which coordinates the flow of information between different system components. The process begins with the user interface, where campaign data is input by the owner, before being routed through the API gateway that regulates communication and ensures secure transactions. Once processed, the data enters the backend application, which manages logic operations and organizes broadcasting tasks. The backend interacts with the social media APIs to distribute content simultaneously across multiple platforms, including WhatsApp, Facebook, Instagram, TikTok, and Twitter. Meanwhile, all activity logs and campaign outcomes are stored in the data storage unit for future retrieval and reporting.

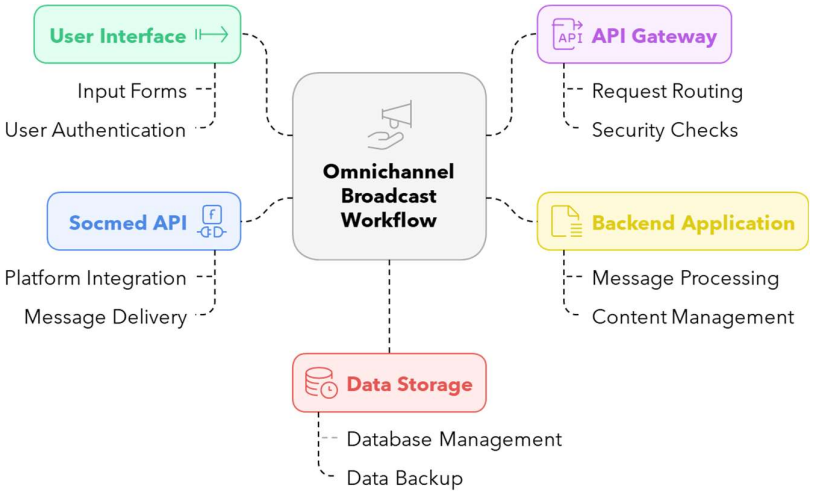

Fig. 4. Omnichannel broadcast workflow

In comparison with previous studies, the workflow developed in this research strengthens the role of omnichannel systems as an enabler of MSME digitalization. Liu et al. (2024) observed that the main challenges in MSME digital adoption lie in fragmented platform management, which this study addresses through centralized broadcasting. Similarly, Rahman and Arifur Rahman (2022) highlighted that data-driven decision-making is critical for MSMEs, where integration of data storage and automated reporting functions, as demonstrated in this workflow, supports evidence-based strategies. Furthermore, Habibi and Leon-Garcia (2024) underlined the importance of well-structured API orchestration for system scalability.

3.1 Scenario of SinariUMKM application users

The scenario of user interaction with the "SinariUMKM" application is illustrated in Fig. 5. The process begins when MSME users access the application through their smartphone (Step 1), after which the request is forwarded to the application server (Step 2). To ensure secure interaction with social media, "SinariUMKM" requests access tokens and permissions through the social media server (Step 5), where the authorized tokens and actions are subsequently stored in the Application Server (Step 6). Before users can fully access the service, an authentication process is conducted via WhatsApp Gateway, where an OTP (one time password) is sent to the user's WhatsApp (Steps 3 to 4). Once authentication is successful, MSME users can broadcast campaign messages across multiple channels. The application server communicates with both telegram gateway server (Steps 7 and 11) and WhatsApp gateway server (Steps 8 and 10) to distribute campaign content to agents or campaign teams. In addition, campaign messages can also be sent through email and other instant messaging platforms, facilitated by the application server (Step 9). This workflow demonstrates the tight integration between backend systems and multiple communication gateways, providing MSMEs with an efficient and automated method for disseminating information. By consolidating access to widely used platforms such as WhatsApp, Telegram, and email, "SinariUMKM" effectively reduces the technical barriers that often hinder small enterprises from managing diverse communication channels, while simultaneously enhancing the scalability of digital campaign strategies.

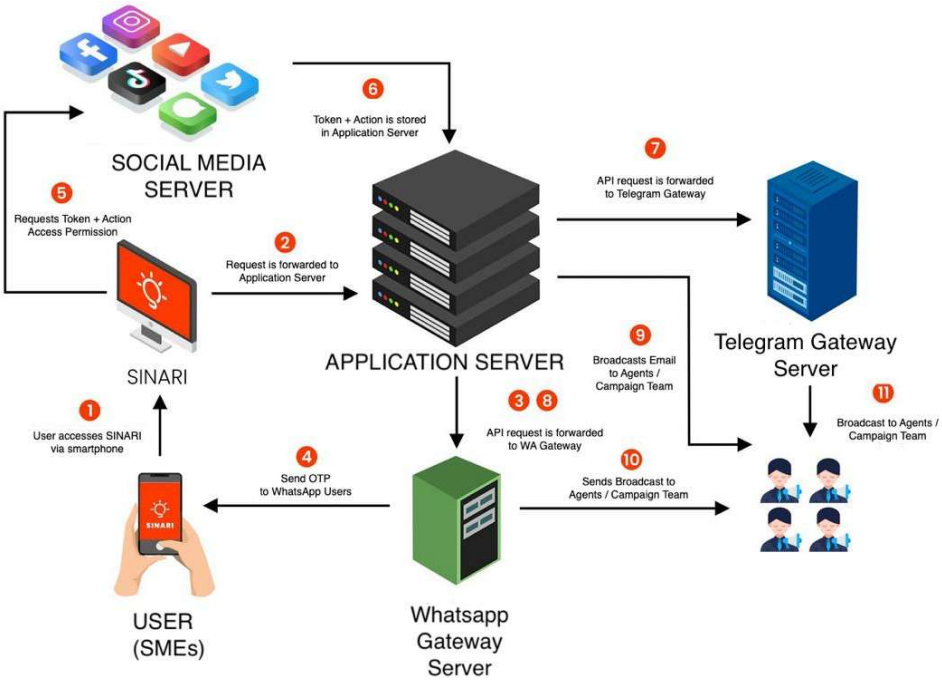

Fig. 5. Scenario of *SinariUMKM* application users

The multi-channel broadcasting capability of "SinariUMKM", as presented in this study, reflects and extends the findings of previous works on MSME digitalization. Peter and Dalla Vecchia (2020) highlighted that fragmented platform management is a critical barrier to effective digital marketing. Similarly, Bousdekis et al. (2021) emphasized the importance of adopting integrated tools that support data-driven decision-making. Furthermore, earlier studies by Shethiya (2025) underscored that robust API orchestration is essential for ensuring both scalability and sustainability in digital applications. Compared with these prior findings, "SinariUMKM's" novelty lies in providing a concrete implementation scenario tailored to MSMEs, where user authentication, campaign broadcasting, and multi-platform integration are seamlessly embedded into a single, user-friendly system.

3.2 Entity relationship diagram

The entity relationship diagram (ERD) is presented in Fig. 6.

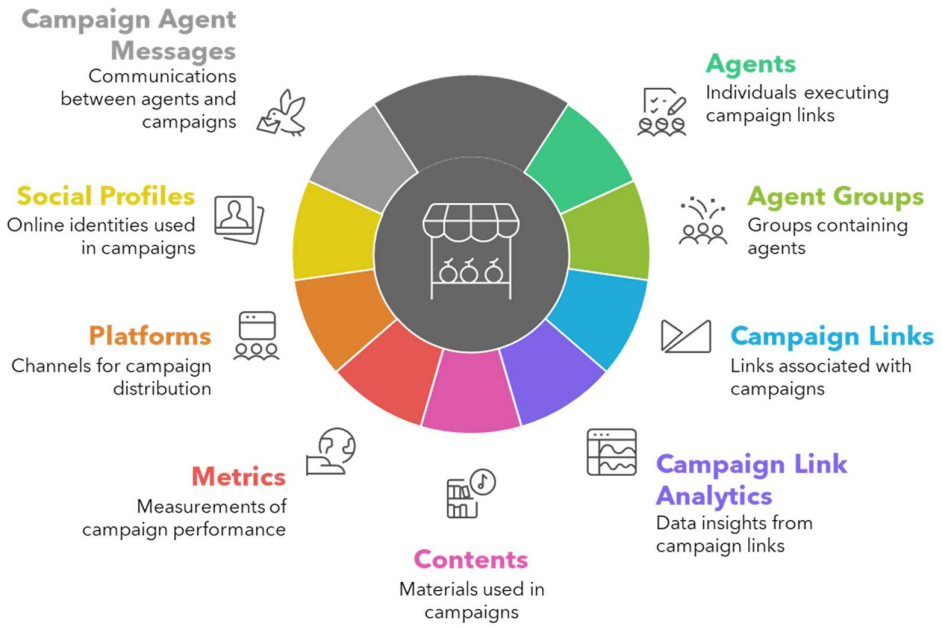

Fig. 6. ERD of the Sinari UMKM Application

ERD of the "SinariUMKM" application illustrates the interconnected components that form the backbone of the system's marketing campaign and analytics functions for MSMEs. At its core, the diagram highlights the campaign's entity, which stores essential information such as campaign names, descriptions, and objectives. Campaigns are associated with agents and organized into agent groups, facilitating more efficient management of dissemination tasks. To extend reach, each campaign can be linked to content, consisting of text, images, or videos distributed across multiple platforms and social profiles. The ERD also integrates campaign links and campaign link analytics, where link performance data, such as clicks, time spent, and user actions, are recorded to evaluate effectiveness. In addition, metrics entities act as repositories for measuring campaign success, while campaign agent messages and campaign agent analytics capture the communication and performance data of individual agents. Together, these relationships form a comprehensive and integrated ecosystem in which every entity contributes to managing, executing, and evaluating campaigns. The modular design of this ERD reflects a system optimized not only for broadcasting promotional content but also for ensuring that performance insights are accessible to MSME users in real time.

Compared with earlier studies, this ERD design demonstrates a higher level of integration and analytical depth for supporting MSME digital marketing. For instance, Mondal et al. (2025) identified fragmented data management and limited analytics as barriers to social media adoption in MSMEs. In contrast, the ERD in this study explicitly addresses these issues by embedding metrics and link analytics directly within the campaign framework. Similarly, Kedi et al. (2024) emphasized that practical MSME digital tools must go beyond content distribution to include actionable insights, aligning with the role of campaign link analytics and campaign agent analytics in this system. Moreover, Ekundayo (2023) noted the importance of scalable API and database structures for sustaining application growth, which resonates with the modular ERD design of "SinarUMKM". By integrating content, performance metrics, social profiles, and agent-level analytics in one relational model, this study extends prior frameworks.

3.3 Architectural design

The system architecture of the "SinariUMKM" application is presented in Fig. 7. The architecture of "SinariUMKM" illustrates a comprehensive integration of front-end and back-end technologies designed to support multi-platform access and cross-channel communication. The application can be accessed seamlessly across Android, iOS, and Windows devices through progressive web application (PWA) technology, which ensures a consistent user experience and offline accessibility through cache management. On the front-end, the architecture leverages react.js for building interactive interfaces, node.js as the server-side runtime environment, and tailwind CSS for efficient and consistent user interface design. A key feature lies in the service worker, which intercepts requests and serves cached data when available, thereby reducing reliance on unstable networks and improving response times. On the back-end, the application runs on ubuntu server 22.04, with nginx handling HTTP requests and mariadb serving as the primary database for storing user information, campaign data, and configurations. Business logic and API functionalities are managed by the codeigniter framework, enabling smooth communication between the user interface and database. In addition, the architecture integrates dovecot mail server and fonnte whatsapp gateway, supporting email and WhatsApp broadcasting to strengthen the omnichannel messaging capability of the system.

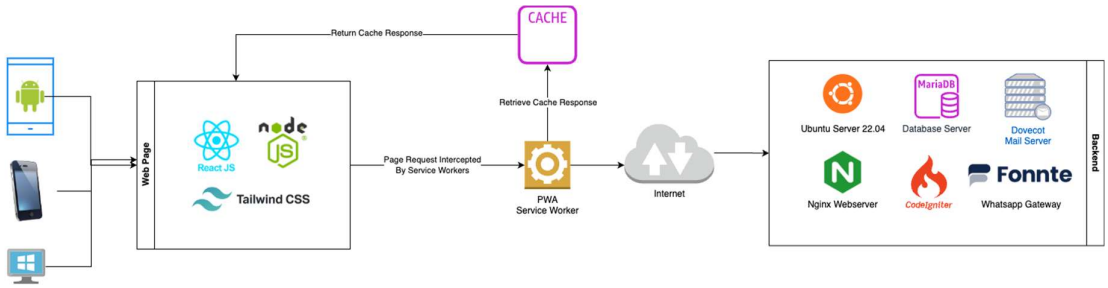

Fig. 7. Architecture of *SinariUMKM*

In comparison to prior studies, the proposed architecture highlights an advancement in combining PWA technologies with backend orchestration tailored for MSMEs. Previous research by Pflughoeft et al. (2003) underlined the benefits of PWAs in reducing technical barriers for small businesses, while Roumeliotis and Tselikas (2022) reported significant increases in engagement metrics following PWA adoption. Similarly, Huda and Rozi (2022) demonstrated the role of rapid prototyping in improving the adaptability of web-based systems, although their implementation lacked offline caching mechanisms and cross-channel integration. The integration of service workers for cache-first strategies in "SinariUMKM" extends these findings by addressing network instability issues commonly faced in rural contexts. At the same time, the combination of dovecot mail server and fonnte WhatsApp gateway aligns with Owen (2025) assertion that robust API and service integration are crucial for scalable architectures.

3.4 Testing Scenario

The functional testing of the "SinariUMKM" application is summarized in Table 1. Testing Scenario demonstrates that all core modules, campaign, broadcast, and report, operated successfully, with each test case passing as expected. In the campaign scenario, both direct and scheduled campaigns ran smoothly, confirming that the system could handle instant as well as time-bound message dissemination. The Broadcast scenario validated three essential functions: registering social media accounts, creating direct posts, and scheduling posts, all of which were completed successfully, including the connection of six Facebook fan pages and five Instagram business accounts. Meanwhile, the Report scenario verified that campaign outcomes could be monitored both at the general and detailed levels, capturing metrics such as shares, clicks, and views. These results indicate that the omnichannel application effectively supports end-to-end campaign management, from creation and dissemination to performance monitoring. Compared with earlier studies, these findings align with Yang et al. (2023), who highlighted the robustness of PWA in maintaining lightweight yet reliable performance, and with Somantri et al. (2021), who emphasized the importance of multi-platform integration for sustaining MSME engagement during the covid-19 pandemic. However, unlike prior works that primarily focused on consumer-facing interfaces, "SinariUMKM" demonstrates how functional testing across multiple social media gateways and reporting tools can provide MSMEs with a scalable and data-driven solution.

Table 1
Testing scenarios and outcomes of the *SinariUMKM* application

ID	Test scenario	Number of test	Test case Id	Test case name	Result
TS1	Campaign	2	TC01	Create Direct Campaign	passed
			TC02	Create Schedule Campaign	passed
TS2	Broadcast	3	TC03	Register Social Media Account	Passed
			TC04	Create Direct Post	Passed
			TC05	Create Schedule Post	Passed
TS3	Report	2	TC06	View Report	passed
			TC07	View detail report	passed

3.5 Cache management in progressive web application

The implementation of cache management in the "SinariUMKM" application adopts a cache-first strategy with network fallback, as illustrated in Fig. **8**. In this approach, static resources such as CSS and JavaScript are constantly retrieved from the cache to ensure rapid page rendering, while dynamic data, including campaign content and updates, is accessed through the network with a fallback mechanism in case the cache becomes outdated. The service worker plays a central role by intercepting all requests, checking the cache, and retrieving fresh content from the network when available, after which the cache is automatically updated. This mechanism strikes a balance between speed and data relevance, ensuring MSME users experience smooth interactions even under unstable connections. Compared with earlier studies, these results are consistent with Correia et al. (2021), who highlighted the role of PWA caching in improving application responsiveness, and extend the findings of Google Developers (2020), which demonstrated performance gains and increased engagement from cache-enabled PWAs. At the same time, the integration of cache-first with network fallback addresses challenges noted by Candan et al. (2001), who observed that many web-based systems lack reliable mechanisms for cache expiration and dynamic updates. By combining fast offline accessibility with automatic synchronization of campaign data, "SinariUMKM" introduces a more robust caching solution tailored to the realities of MSMEs, particularly in regions with limited network infrastructure.

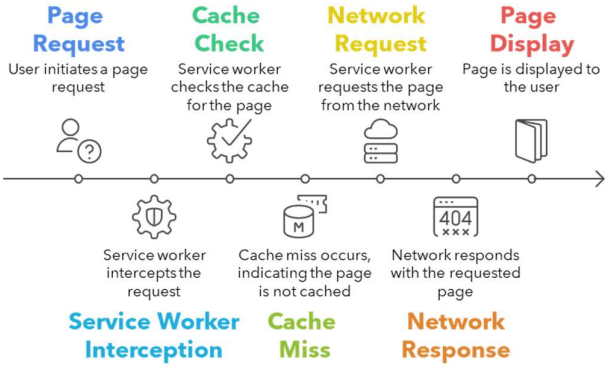

Fig. 8. Cache-First Strategy, Network Fallback Strategy

3.6 Performance optimization

The interface and functionality of the "SinariUMKM" application are shown in Fig. 9. Users can design campaigns by entering titles, descriptions, timelines, and associated teams, while simultaneously attaching visual content such as product images to enhance engagement. The interface also supports real-time monitoring of campaign metrics, including delivery, open rates,

clicks, and shares, enabling MSME users to make informed adjustments during ongoing campaigns. However, given that each broadcast may require up to 21 API connections for a single post on a single account, optimization is critical to maintain responsiveness, particularly on devices with limited processing resources. This approach aligns with findings from Rêgo et al. (2019), who emphasized the importance of PWA frameworks in balancing performance and usability, and resonates with the case study by Darejeh and Singh (2013), which reported increased user retention when applications provided lightweight yet visually compelling interfaces. Furthermore, Dhaiya et al. (2021) noted that without careful optimization, applications with intensive API calls risk decreased performance, an issue that the caching and service worker strategies embedded in "SinariUMKM" help mitigate.

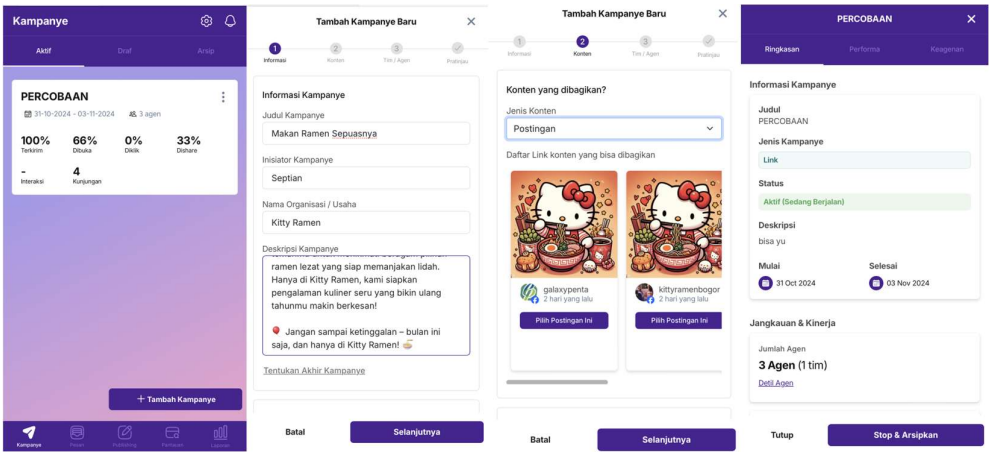

Fig. 9. View of the *SinariUMKM* application

The performance testing of "SinariUMKM" is illustrated in Fig. 10. Average initial load of the application shows that the system successfully achieved an average page load time of approximately 3 seconds, with page transitions occurring in less than 1 second. This optimization was accomplished through the implementation of lazy loading for images and non-critical content, image compression, and code minimization for CSS and JavaScript using tools such as webpack. In addition, the adoption of Tailwind CSS further reduced file sizes and enhanced rendering efficiency, ensuring lightweight yet visually consistent interfaces. The results demonstrate that the application can deliver rapid responsiveness despite handling multiple network requests and visual elements, thereby enhancing the overall user experience for MSMEs. These findings resonate with the work of Rêgo et al. (2019), who emphasized the role of PWA frameworks in improving performance on devices with limited resources, and are consistent with the case study by Liu et al. (2013), which reported that load times under 3 seconds significantly increased user retention rates. Furthermore, this study addresses performance concerns raised by Drofa (2025), who observed that unoptimized resource loading often hampers web-based applications, especially when integrating heavy data traffic and API connections.

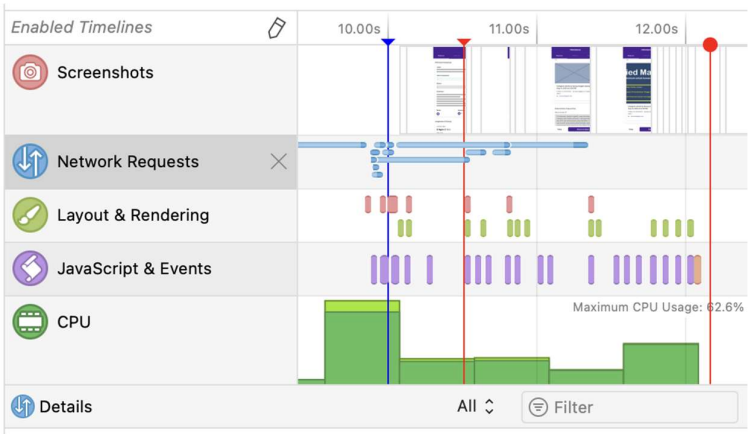

Fig. 10. Average Initial Load Of The App

3.7 Application usage survey

The results of a survey conducted among MSMEs showed a very positive response to the "SinariUMKM" application. Nearly all indicators received an average score above 4.0 (on a Likert scale of 1–5), indicating a high level of acceptance. The indicators with the highest scores were respondents' ability to use smartphones (4.615), the application's usefulness for product promotion (4.615), and its suitability with current business trends (4.523). These scores indicate that users are not only familiar

with digital devices but also see the application as relevant to their business needs. Furthermore, the application's level of ease of use also received a perfect rating (4.246), confirming the success of its simple and easy-to-understand interface design.

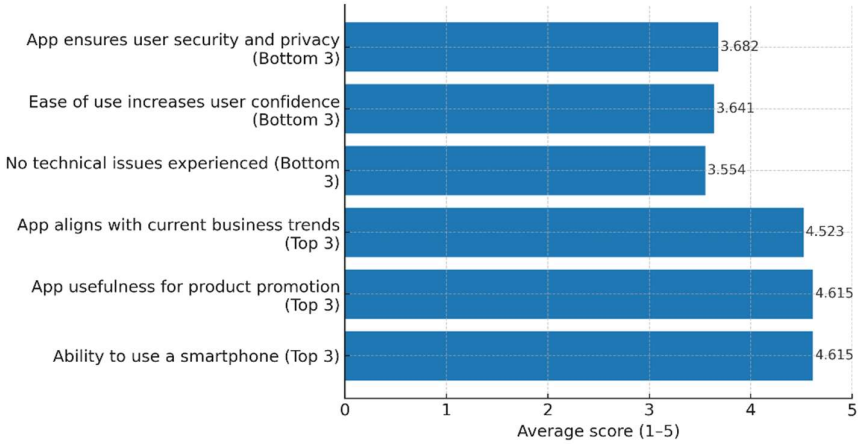

Fig. 11. Top 3 vs Bottom 3 Survey Indicators

Other indicators that scored highly included the likelihood of recommending the application to other MSMEs (4.379) and the belief that the application can improve business outcomes (4.359). These findings suggest strong potential for a word-of-mouth effect, where satisfied users encourage broader adoption among MSMEs. This aligns with prior research emphasizing that peer recommendations from business owners experienced in technology use are critical drivers in the diffusion of digital innovations. However, some indicators, while still rated positively, scored comparatively lower. For example, “no technical issues” received a score of 3.554, and “ease of use,” which directly influences user confidence, scored 3.641. These results indicate that certain users continue to face technical challenges, possibly due to device limitations or integration issues with messaging gateways and internet networks. Technical stability is a key determinant of an application’s long-term sustainability, making these findings particularly important.

From an interpretive standpoint, the survey echoes previous technical tests revealing that core features such as campaigns, broadcasting, and reporting generally function well but still encounter issues with cache management and third-party service integration. Respondents reported significant challenges, especially in authentication and data synchronization. Overall, the survey provides further evidence that while the application effectively meets MSMEs’ core needs, technical enhancements remain a priority. These findings are consistent with literature highlighting the advantages of progressive web applications (PWAs) in enhancing user experience and business efficiency. For instance, Adetunji et al. (2020) noted PWAs overcome limitations of traditional mobile apps through lighter performance, while Panwar (2024) reported up to a 52% increase in user engagement post-PWA adoption. In the MSME context, Somantri et al. (2021) identified ease of access and low cost as key drivers of digital application uptake during the pandemic. Similarly, Huda and Rozi (2022) pointed out that integration with external services, particularly APIs, remains the biggest challenge for non-technical users developing web-based systems.

Taken together, these insights reinforce the relevance and effectiveness of PWA applications like “SinariUMKM” in supporting MSME digitalization, while underscoring that ongoing technical optimization is essential for sustainable use.

4. Conclusion

This study successfully developed and evaluated “SinariUMKM”, a PWA-based omnichannel system that simplifies campaign management, broadcasting, and reporting for MSMEs, thereby addressing the dual challenge of digital branding and business scalability. Functional testing confirmed the reliability of all core modules, with average load times of 3 seconds and smooth page transitions, while survey validation from 117 MSMEs indicated strong acceptance, particularly regarding smartphone usability, promotional effectiveness, and alignment with business trends. Theoretically, these findings contribute to the literature on digital transformation and omnichannel integration by demonstrating how PWA technology can balance performance, usability, and affordability for small enterprises. Practically, the system provides MSMEs with a lightweight, scalable, and cost-efficient tool to manage campaigns across multiple social media platforms. However, technical reliability, especially in cache management and API integration, remains an area for improvement. This limitation highlights the need for further optimization to ensure long-term stability and broader adoption. Future research should focus on strengthening technical resilience, expanding integration with additional platforms, and exploring cross-sector applications, including agricultural mechanization and precision farming.

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