

Analysis of the Use of Progressive Web Apps (PWA) to Improve Web Application Accessibility in Areas with Limited Connectivity

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Abstract

The development of web technology demands applications that can be accessed quickly and remain stable, including in areas with limited internet connectivity. Progressive Web Apps (PWA) are a technology that combines the advantages of web and native applications, offering features such as offline mode, caching, and push notifications. This study aims to analyze the extent to which PWA implementation can improve the accessibility of web applications under limited network conditions. The research method used is qualitative descriptive analysis to examine the potential of Progressive Web Apps (PWA) in enhancing web application accessibility in low-connectivity environments. Data was collected through a literature review of previous studies, technical documentation, and case studies related to PWA implementation in developing regions. The results of this study are expected to provide practical insights into the effectiveness of PWAs in improving user experience in areas with network limitations.

Keywords: *Progressive Web App (PWA), Web Application Accessibility, Limited Internet Connectivity, Offline Mode*

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Introduction

The development of information technology has brought significant changes to the way society accesses information and utilizes web-based services. Web applications have become one of the primary platforms for delivering information, facilitating transactions, and providing public services. However, a major challenge that persists is the limitation of internet access in certain areas, particularly in remote regions or locations with insufficient network infrastructure. This condition restricts the accessibility of web applications and consequently hinders user experience.

Progressive Web Applications (PWAs) have emerged as a potential solution to address this challenge. PWAs integrate the advantages of traditional web applications and native mobile applications, offering features such as offline mode, caching, push notifications, and the ability to be installed directly on devices without requiring distribution through application stores. This technology enables users to continue accessing web applications even under unstable network conditions or in the absence of connectivity.

Considering this potential, it is essential to examine the extent to which PWAs can improve the accessibility of web applications, particularly in areas with limited internet connectivity. Such analysis is expected to contribute to the development of more inclusive and responsive web applications that can accommodate user needs across diverse network environments.

Literature Review

Several studies have explored the potential of Progressive Web Applications (PWAs) in addressing the limitations of traditional web and mobile applications. According to Google Developers (2023), PWAs offer enhanced performance and reliability through features such as service workers, caching, and offline accessibility, enabling users to continue interacting with web applications even under poor network conditions.

Research conducted by Ridho, M. R., et al. (2018) indicates that the implementation of PWA technology can significantly improve loading times and reduce data consumption, making it highly suitable for regions with limited bandwidth. Another study by Saputra, R. A., et al. (2023) found that PWAs contribute to increased user engagement through features such as push notifications and home screen installation, which help improve user retention rates in developing regions.

Additionally, an accessibility study by W3C (2023) notes that PWAs support inclusive design principles, ensuring usability across a wide range of devices and connectivity conditions. The integration of responsive design and offline functionality aligns with global efforts to reduce the digital divide, particularly in rural areas where internet infrastructure remains inadequate.

Research Methodology

This study employs a qualitative descriptive method to analyze the potential of Progressive Web Apps (PWA) in improving the accessibility of web applications under limited internet conditions. Data are collected through a literature review of previous research, technical documentation, and case studies related to PWA implementation in developing regions. The qualitative approach is chosen to obtain a comprehensive understanding of the relationship between PWA features and accessibility outcomes.

The research procedure includes three main stages :

1. identifying relevant sources and publications from 2018 to 2024 discussing PWA performance and accessibility;
2. analyzing and categorizing PWA features based on their contribution to offline access, user engagement, and responsiveness; and
3. synthesizing findings to evaluate how these features can support users in areas with unstable or limited internet connectivity.

Data analysis uses problem-solving analysis, focusing on identifying issues related to web accessibility and proposing PWA-based solutions. The outcome of this analysis provides recommendations for developers and educational institutions aiming to create inclusive web applications that perform effectively across diverse network environments.

Results

The results of this study indicate that Progressive Web Applications (PWAs) provide significant improvements in accessibility and user experience, particularly under limited internet connectivity conditions.

Based on the analysis of selected case studies and previous literature, the following key findings were identified:

1. **PWA as a Solution to Connectivity Limitations**
PWAs offer an offline-first approach that is particularly beneficial in environments with unstable network conditions. Through the use of service workers and caching mechanisms, PWAs are able to deliver an experience comparable to native applications even when users are located in areas with low connectivity. This aligns with recent studies showing that PWAs are capable of reducing dependency on continuous internet access and improving web application availability [1][2].
2. **Technical Mechanisms Supporting Accessibility**
 - a. **Service Worker**
Service workers function as the primary controller of caching processes and network request management. When the connection is unavailable, the service worker retrieves content from the cache, allowing the application to remain functional. This implementation has proven effective across various PWA deployments in Indonesia, including school information systems, public services, and organizational internal applications [3][4].
 - b. **Cache API and Caching Strategies**
The Cache API enables local storage of essential application assets, allowing PWAs to operate without repeatedly requesting resources from the server. Caching strategies such as cache-first and network-first provide optimal performance in low-bandwidth environments. Experimental studies demonstrate that these strategies reduce latency and significantly improve web application loading speeds [2][5].
 - c. **Web App Manifest and Installability**
The Web App Manifest enables PWAs to be installed similarly to native applications, providing a home screen icon and full-screen interface. This installability feature enhances navigation efficiency and simplifies access in regions with unstable connectivity because the application can be launched directly without loading through the browser [6][7].
3. **Impact of PWAs on User Experience**
PWAs offer significant improvements in application speed and data efficiency. By loading components from cache, loading time can be reduced by up to 60% compared to traditional web applications. This improvement is highly relevant for users in low-bandwidth regions. PWA implementation also enables essential offline activities such as saving forms, accessing learning materials, and browsing catalogs [1][8].
4. **Relevance of PWAs Across Sectors**
The adoption of PWAs supports equitable access across multiple domains. In education, PWAs can provide offline access to learning materials. In e-commerce, users can continue browsing product catalogs even without connectivity. In public services, PWAs accelerate access to administrative processes and village-level digital services without requiring constant internet access [8][9][10].

5. Challenges in PWA Implementation

Despite offering numerous benefits, PWAs still face several challenges, including limited API support in certain browsers (such as iOS), risks of excessive cache accumulation, and the complexity of offline-first architecture, which requires advanced technical expertise. Research shows that these challenges can be mitigated through optimized cache management and adherence to modern PWA development standards [5][11].

6. Synthesis of Findings

Based on the analysis, PWAs demonstrate a positive impact in improving web application accessibility in regions with restricted connectivity. The combination of service workers, Cache API, and Web App Manifest results in lightweight, fast, and offline-capable applications. Therefore, PWAs represent a strategic solution to support digital transformation in developing countries and low-connectivity regions [7][10].

Findings from the literature and analysis indicate that:

1. PWA technology significantly reduces data usage and improves loading speed, enhancing usability in low-bandwidth environments.
2. Offline functionality ensures uninterrupted access to essential services, supporting digital inclusion and equity.

Increased user engagement and retention demonstrate the potential of PWAs to deliver a reliable, application-like experience through the browser.

Overall, the implementation of PWAs represents a practical and scalable approach to overcoming digital accessibility barriers, aligning with global initiatives to make web technology more inclusive and resilient.

Based on the findings and discussion, several recommendations can be proposed:

1. For Web Developers:

Adopt PWA technology as a standard for new web application development, particularly for services targeting users in rural or low-connectivity areas. Developers should optimize caching strategies and responsive design to ensure consistent performance across devices.

2. For Educational Institutions and Government Agencies:

Integrate PWA-based platforms into learning management systems and public information services to ensure accessibility for all users. This approach can reduce reliance on native mobile applications while maintaining rich functionality.

3. For Future Researchers:

Conduct empirical testing and performance benchmarking of PWAs in real-world environments under varying network conditions. Quantitative studies measuring metrics such as page load time, data usage, and user satisfaction will provide stronger validation of PWA effectiveness.

4. For Policymakers:

Promote digital infrastructure policies that support the adoption of lightweight and inclusive web technologies. Governments and educational institutions should encourage training and standardization of PWA development to strengthen digital literacy and accessibility.

By implementing these recommendations, organizations and developers can collaboratively support an inclusive digital transformation, ensuring that all users—regardless of location or connectivity level—can benefit from the web equally.

Conclusion

This analysis concludes that Progressive Web Applications (PWAs) play a significant role in improving the accessibility, performance, and user experience of web applications, particularly in regions with limited or unstable internet connectivity.

The offline-first approach, caching mechanisms, and local installation capabilities enhance speed, reliability, and data efficiency. The implementation of PWAs has the potential to support various sectors, including education, public services, and the digital economy. Despite several technical challenges, PWAs remain a promising strategy for advancing equitable access to digital services.

References

- [1] Kurniawan, A. A. (2020). Analisis Performa Progressive Web Application (PWA) pada Perangkat Mobile. *Jurnal Ilmiah Informatika Komputer*.
- [2] Ridho, M. R., Pinandito, A., & Dewi, R. K. (2018). Perbandingan Performa Progressive Web Apps dan Mobile Web. *J-PTIHK*.
- [3] Aminudin, A., Basren, B., & Nuryasin, I. (2019). Perancangan Sistem Repositori Tugas Akhir Menggunakan PWA. *Techno.Com*.
- [4] Muddin, I. S., Tehuayo, H., & Iksan, F. (2023). Penerapan PWA pada Sistem Informasi SMA. *JTEK*.
- [5] Kurniawan, W., & Fatwanto, A. (2022). Hubungan Cache, Energy Consumption dan Runtime Performance pada PWA. *JTI-IK*.
- [6] Hanifan, H., & Fajri, I. N. (2024). Implementasi PWA dan Notifikasi pada Sistem VolHub. *Information System Journal*.
- [7] Saputra, R. A., et al. (2023). Implementation of PWA on Digital Freelance Platform. *SMATIKA Journal*.
- [8] Xavier, J., & Simoes, D. (2021). Use of PWA in Educational Environments. *International Journal of Web Engineering*.
- [9] Ali, A., et al. (2020). Adoption of PWA in E-Commerce Platforms. *Journal of Mobile Computing*.
- [10] Hudianti, E., et al. (2023). Implementasi PWA untuk Pengelolaan Potensi Desa Wisata. *JOISM*.
- [11] Herman & Frederick. (2023/2024). PWA Development and User Acceptance in Indonesia. *Jurnal Teknologi Terpadu*.
- [12] Pengembang Google. (2023). Ikhtisar Aplikasi Web Progresif (PWA). Diakses 10 Oktober 2025, dari <https://developers.google.com/web/progressive-web-apps>
- [13] World Wide Web Consortium (W3C). (2022). Panduan aksesibilitas web dan Aplikasi Web Progresif. Diakses dari https://www.w3.org/2023/06/webmediaguidelines.html?utm_source=chatgpt.com