Enhancing Community Connectivity and Access to Information in Underprivileged Areas: The Role of Mobile Applications in the iNethi Project

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Abstract

This literature review critically analyses the iNethi project's efforts to bridge the digital divide in underprivileged areas through a Community Wireless Network (WCN). It examines the network's current state, its community impact, and challenges in digital content access. Furthermore, it evaluates the effectiveness of content access via URLs through browsers connected to the iNethi Hotspot. Synthesizing findings from iNethi project papers and relevant literature, the review identifies a need for a mobile application to enhance digital literacy and information access efficiently. This proposed app aims to overcome the current system's limitations, providing a user-friendly way for digital resource engagement.

CSS CONCEPT

- **Networks, Human-cantered computing, Empirical studies in collaborative and social computing, Applied computing behavioural sciences.**

KEY WORDS

- Wireless Community Networks (WCNs), Digital Divide, Underprivileged Areas, Mobile Applications, TV White Spaces, Community, Engagement, Digital Literacy, Infrastructure Sustainability, Participatory ,Design, Mobile Edge Caching, Educational, Disparities, Access to Information

1. Introduction

The dawn of the digital age has heralded unprecedented access to information, fundamentally reshaping how societies operate, communicate, and evolve. Internet access, once a luxury, has transformed into a cornerstone of modern societal participation, underpinning education, healthcare, commerce, and democracy itself. Yet, this digital revolution has not been uniform, leaving significant segments of the global population in shadow, particularly in underprivileged areas. These regions, characterized by their limited connectivity, confront a stark digital divide that impedes their full participation in the digital world.

The iNethi project emerges as a beacon of innovation against this backdrop, orchestrated by a multidisciplinary team dedicated to weaving the digital fabric into the very heart of underserved communities through the development of a Wireless Community Network (WCN). Community networks can support the building of local economies and open up new possibilities for underserved areas [10]. This endeavour is not merely about providing internet access but about enabling seamless digital inclusion. Despite its commendable strides towards digital empowerment, the project navigates a maze of usability challenges and the inherent limitations of constant connectivity requirements. This literature review ventures deep into the iNethi project, unravelling its complexities, evaluating its community impact, and critically exploring the transformative potential of a mobile application designed to surmount these barriers and catalyse digital inclusivity [1].

2. Existing Efforts and Their Limitations

The iNethi project's venture into utilizing TV white spaces in Masiphumelele township stands as a testament to the innovative spirit driving efforts to connect the unconnected. This initiative leverages the underused television broadcasting bands, aiming to deliver robust internet access to rural locales. The choice of TV white spaces is propelled by their superior propagation characteristics, which promise broader and more reliable connectivity compared to traditional Wi-Fi bands. Such a move could revolutionize access in areas marred by poor connectivity, illuminating digital pathways where none existed before [2].

However, the journey of the iNethi project through the landscape of TV white spaces is not without its hurdles. The venture into this relatively uncharted territory brings to light significant challenges that could potentially dampen its impact. Faced with increased network congestion from both the rise in bandwidth intensive applications and the growing number of Internet users [3]. Moreover, the regulatory environment surrounding TV white spaces remains complex and, at times, restrictive, posing additional barriers to the seamless deployment of this technology.

The onset of the COVID-19 pandemic further underscored the critical nature of these limitations. As van Zyl and Johnson [12] elucidate in their exploration of the iNethi project's response to the pandemic, South Africa, like many countries, faced unprecedented educational disruptions, compelling a shift to online learning. Despite the potential of digital platforms to bridge educational gaps, the reality in South Africa revealed stark disparities. High data costs, limited internet access, and a lack of technical literacy among educators and students highlighted the digital divide's depth. The iNethi project's initiative to provide low-cost, community-owned network infrastructure emerges as a vital countermeasure to these challenges. By offering affordable internet access and locally hosting educational content, iNethi endeavours to mitigate the adverse effects of the pandemic on education for bandwidth-constrained learners [12].

This scenario encapsulates the multifaceted barriers to digital inclusivity in underprivileged areas, affirming the necessity for innovative solutions that extend beyond mere connectivity to consider the socio-economic and educational frameworks within which these technologies operate.

These limitations not only impact the efficacy of the project but also reflect broader issues inherent in deploying telemedicine and digital inclusion initiatives in underprivileged regions. Luk, Ho, and Aoki's [9] examination of remote medical consultation systems in Ghana highlights similar challenges, from sustaining community participation to overcoming infrastructural and connectivity barriers, thus providing a pertinent comparison and reinforcing the critical need for innovative solutions that circumvent these pervasive issues.

Similarly, the deployment of Libre mesh Wi-Fi access points in Ocean View has enhanced internet access affordability for approximately three hundred residents. This initiative is part of a broader effort to bridge the digital divide, showcasing the potential of community-driven solutions in under-resourced areas. Despite the progress made, this network, like many others attempting to serve underprivileged communities, grapples with a set of challenges that underscore the complexity of providing reliable and widespread digital access.

The issues of network congestion and reliability are significant obstacles. As the number of users grows and the demand for bandwidth-intensive services increases, these networks often struggle to maintain a level of service that meets users' expectations. This is particularly challenging in areas where the infrastructure may not support the latest technology or where environmental factors, such as physical obstructions and variable weather conditions, can affect signal strength and network reliability [1].

The other issue is improving user experience, finding ways to enhance connectivity since number of users are increasing meaning low bandwidth. To increase speed requires the contributors to the project to have unique strong skills which are not easy to acquire. This makes it harder for more contributors to emerge and help in upgrading the network. Some of the iNethi projects were not finished due to lack of contributors with the skills needed [1]. These are issues that have already been documented in many other open-source projects [6] [7] [8].

3. What has not been written (or is written in such a way that it is conceptually or methodologically inadequate)

In the exploration of Wireless Community Networks (WCNs) like the iNethi project, a critical gap emerges in the literature concerning the scalability and sustainability of such initiatives. While there have been numerous papers addressing the benefits of WCNs in Africa and examining their architecture [4] [5] [15] [16], there's a conspicuous absence of detailed analysis on creating a robust ecosystem that ensures these projects not only thrive but also expand. This oversight extends to a lack of strategic planning for engaging community members in a manner that promotes self-organizing growth, a sustainable model of operation, and adaptability to the evolving needs of the community. Addressing this gap would involve investigating models that incorporate both technological infrastructure and community dynamics, ensuring that WCNs can scale effectively without compromising their core mission of digital inclusivity.

Furthermore, the existing discourse often overlooks the critical role of user experience and engagement in the success and adoption of WCNs. Technical discussions around bandwidth, connectivity, and infrastructure are prevalent, yet there's a dearth of insight into how these networks cater to and evolve with their users' needs. Enhanced user experience, through more intuitive interfaces and accessible platforms, is essential for wider adoption and utilization. The absence of comprehensive strategies to enhance user engagement, particularly for non-technical contributors, signifies a methodological

gap. Future research should delve into designing participatory and inclusive platforms that lower entry barriers, making it easier for a broader spectrum of community members to contribute to and benefit from these networks.

The development of a supportive socio-technical ecosystem around projects like the iNethi initiative represents another significant gap in the literature. Current discussions around technical and regulatory challenges lack an integrated view that encompasses the socio-political, educational, and collaborative frameworks necessary for these projects' longevity and impact. There's a pressing need for research that bridges this divide, offering insights into policy development, community engagement strategies, and educational programs that together foster a conducive environment for the growth and sustainability of WCNs.

4. Critical Analysis of Prior Work

The literature on Wireless Community Networks (WCNs) presents a variety of approaches and methodologies aimed at addressing the digital divide in underprivileged areas. While the iNethi project represents a significant endeavour in this domain, leveraging TV white spaces and community engagement to enhance connectivity, it is crucial to juxtapose this initiative against other efforts to identify strengths, weaknesses, and opportunities for synergy.

Firstly, the iNethi project's use of TV white spaces, as detailed by Hadzic, Phokeer, and Johnson [2], underscores an innovative approach to circumvent traditional connectivity barriers. This method contrasts with Rey-Moreno et al.'s [10] exploration of WCNs that primarily rely on standard Wi-Fi technology. The use of TV white spaces offers superior propagation characteristics, potentially providing broader and more reliable coverage. However, it also introduces unique regulatory and technical challenges not encountered with conventional Wi-Fi deployments. This distinction highlights a trade-off between innovation and the complexity of implementation.

Moreover, the examination of mobile Internet use in township communities by Phokeer, Densmore, and Johnson [13] offers insights into user behaviour that are critical for the design and deployment of WCNs. Their findings suggest a preference for cellular data

over Wi-Fi due to perceived reliability and ease of access, despite the higher costs. This observation contrasts with the iNethi project's emphasis on building Wi-Fi-based community networks, indicating a potential gap in aligning network solutions with user preferences and behaviours. Addressing this gap requires a nuanced understanding of the target community's needs and may necessitate incorporating cellular data strategies alongside Wi-Fi deployments.

Furthermore, the work by Yao, Han, and Ansari on mobile edge caching [14] introduces a complementary technological approach that could enhance the effectiveness of WCNs like iNethi. While iNethi focuses on the macro-level infrastructure for community connectivity, the incorporation of edge caching could address micro-level challenges related to data access speed and network congestion. This synergy between different technological strategies underscores the importance of a multifaceted approach to digital inclusion, combining infrastructure development with advanced data management techniques.

In addition, Lorini et al.'s exploration of community-owned platforms [11] emphasizes the socio-technical ecosystem necessary for the sustainability of WCNs, a critical aspect that extends beyond the technical focus of the iNethi project. Their emphasis on co-design and local content creation presents a methodology that could strengthen iNethi's community engagement and content relevance. This comparison reveals a potential area for the iNethi project to expand its approach, incorporating more explicit co-design principles to ensure the network's offerings are closely aligned with community needs and aspirations.

Through this critical comparison, it becomes evident that while the iNethi project represents a significant stride towards bridging the digital divide, there is room for integrating additional technological strategies and community engagement methodologies from other studies. This comprehensive approach not only addresses the connectivity challenges but also ensures the network's offerings are relevant, accessible, and sustainable, ultimately fostering a more inclusive digital ecosystem in underprivileged areas.

5. Implementation of mobile development to silence the gaps mentioned.

The literature reveals a significant gap in understanding how Wireless Community Networks (WCNs) like the iNethi project can be scaled and sustained over time. The proposal for a mobile application directly addresses this gap by presenting a solution that is inherently scalable. Unlike physical network infrastructure, which faces logistical and financial constraints, mobile applications can be distributed and adopted widely with minimal additional cost. Furthermore, by focusing on digital literacy and access to information, the mobile application supports the development of a socio-technical ecosystem that enhances the sustainability of the network by fostering a community of informed and engaged users.

The principles discussed in Lorini [11]'s paper regarding community engagement, co-design, and local content creation are highly relevant which is lacking in these iNethi projects. The proposed mobile application addresses this by prioritizing the design of intuitive interfaces and accessible platforms. This focus not only aims to improve the ease of access to digital resources but also encourages broader community participation. By lowering the barrier to entry for non-technical users, the application seeks to expand the network's user base and foster a more inclusive digital community.

Addressing the identified gaps, particularly the high cost of mobile data and the unique consumption patterns in township communities, necessitates the development of a mobile application that aligns closely with the needs and behaviours of its users. The insights provided by Phokeer, Densmore, and Johnson [13] into mobile data usage patterns within South African townships, including the reliance on cellular data over Wi-Fi due to its accessibility and the significant expenditure on mobile data despite financial constraints, underline the urgent need for a more cost-effective digital solution.

The proposed mobile application aims to alleviate these challenges by optimizing data usage and ensuring that essential services and content updates

can be accessed affordably. By incorporating mechanisms for efficient data management and offline accessibility, the application addresses the prohibitive cost of mobile data, making digital resources more accessible to underprivileged communities. Furthermore, understanding that township users prioritize mobile data for application updates suggests that the application could provide a platform for localized content sharing and updates, minimizing data costs and enhancing the digital inclusivity of these communities.

Additionally, the paper's findings on the types of applications favoured by township residents, such as social media and informational resources, guide the proposed application's content strategy. Integrating functionalities that support community engagement, education, and access to vital information within a single, user-friendly platform can significantly enhance the utility and adoption of the application among its intended users.

By grounding the mobile application's design in the realities of mobile internet use in townships, as detailed by Phokeer et al. [13], this proposal aims to deliver a practical, impactful solution that directly addresses the digital divide in underprivileged areas. The application not only seeks to provide more equitable access to digital resources but also empowers users by catering to their specific needs and consumption behaviours, thus fostering greater digital literacy and participation within these communities.

The exponential growth in mobile data traffic, underscored by the pervasive adoption of mobile applications, presents a formidable challenge to the existing mobile network infrastructure, necessitating innovative solutions to manage the increased load effectively. Mobile edge caching, as elucidated by Yao, Han, and Ansari [14], offers a compelling strategy to mitigate these challenges by leveraging cache storages at the mobile edge, thus reducing the burden on mobile core networks and backhaul links. This technological paradigm shift underscores the importance of developing a mobile application that seamlessly integrates with mobile edge caching mechanisms to enhance content delivery and accessibility for users in underprivileged areas.

The proposed mobile application, by harnessing the advantages of mobile edge caching, aims to significantly reduce content access latency, a critical factor in user experience, especially in regions with constrained network infrastructure. By storing popular content closer to the end-users, the application can facilitate quicker access to information and educational resources, thereby addressing one of the key barriers to digital literacy and information access in these communities.

6. Conclusions

Through the comprehensive analysis presented in this literature review, we can draw several key conclusions regarding efforts to bridge the digital divide in underprivileged areas, focusing on the iNethi project and the broader landscape of Wireless Community Networks (WCNs). The innovative use of technology such as TV white spaces by the iNethi project marks a significant step toward overcoming infrastructural limitations in underprivileged areas. This technology, due to its superior propagation characteristics, offers a promising avenue for expanding internet access. However, it also presents challenges related to regulatory approval and technical implementation, highlighting the need for approaches that balance innovation with feasibility.

The success of WCNs is deeply tied to community engagement and ownership. The iNethi project, by prioritizing participatory design, showcases the potential for community networks not only to provide connectivity but also to empower communities to manage and sustain these networks themselves. Enhancing community engagement and co-design can significantly improve the relevance, adoption, and sustainability of WCNs.

Understanding and addressing user preferences and behaviours within underprivileged communities are crucial for the adoption of WCNs. Insights into preferences for cellular data over Wi-Fi due to its perceived reliability and ease of access, despite higher costs, point to the importance of aligning network solutions with user needs. Future initiatives should consider strategies that cater to these preferences, potentially by integrating cellular data options or optimizing Wi-Fi deployments.

The integration of complementary technologies such as mobile edge caching can significantly enhance the performance and user experience of WCNs. By reducing latency and alleviating network congestion, these technologies address critical challenges faced

by users in bandwidth-constrained environments. Future efforts should aim to explore the synergy between various technological solutions to optimize network efficiency and accessibility.

Achieving digital inclusion in underprivileged areas requires a holistic approach that extends beyond mere connectivity. The need to consider the socio-economic, educational, and cultural contexts in which these networks operate is paramount. Initiatives like iNethi play a vital role in this effort, but their impact can be amplified through collaborative efforts that encompass policy development, educational programs, and infrastructure investment.

Furthermore, there is a clear need for further research to explore the scalability and long-term sustainability of WCNs, including investigating models for self-organizing growth, assessing the socio-economic impacts of network access on local communities, and developing frameworks that support the integration of advanced technologies with community-driven design principles.

In conclusion, bridging the digital divide in underprivileged areas is a complex endeavour that requires a blend of technological innovation, community engagement, and systemic support. The iNethi project, along with similar initiatives, represents a significant step forward. However, the path ahead is paved with challenges that demand continued exploration, adaptation, and collaboration to unlock the full potential of digital inclusion for everyone.

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