Beyond Connectivity: Designing Inclusive Experiences for Community Networks

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Abstract

This paper explores the design and implementation of inclusive experiences within community networks, particularly focusing on the iNethi project in Ocean View, Cape Town. It highlights the pivotal role of community-owned wireless networks in bridging the digital divide by providing affordable internet access and integrating essential digital services through an application-based solution. The study emphasizes the importance of usability and accessibility, proposing strategies to make community networks more intuitive and engaging for users with diverse technical backgrounds. By examining user interaction and network management challenges, it aims to foster a more connected and empowered digital community, ensuring equitable access to information and services.

Keyword: Community Network, Usability, Access, Visibility

1. Introduction

In an era where digital connectivity is as crucial as water or electricity, the divide between the connected and the disconnected widens, particularly in low-income African regions [4]. This gap not only limits access to essential information but also silences those who need a platform the most for local and worldwide conversations.

High data costs and inadequate infrastructure serve as formidable barriers, leaving many communities stranded on the wrong side of the digital divide, unable to participate in the ever-evolving digital landscape [2,4,19].

Community-owned wireless networks utilize technologies like Wi-Fi and mesh networking to create a shared internet infrastructure within a specific geographic location. This allows community members to **own their internet**, meaning they have a direct stake in its development, governance, and pricing [17]. a beacon of hope and innovation in addressing this disparity. This approach aims to make the internet accessible and fair for all communities, especially those with limited bandwidth or resources. It enables these communities to access affordable internet, allowing users to share, store, and access files and resources, and communicate through a wireless network that operates independently of traditional telecom and commercial wireless networks [3].

This paper is dedicated to exploring the user experience in community-owned wireless networks, with a special focus on improving how easy and accessible these networks are for everyone involved. It looks into how users perceive the network's condition and aims to improve their interaction with the network. Moreover, this review broadens its scope to

consider the challenges faced by home network users, with the aim of drawing lessons from these experiences to shape effective strategies for community networks. The goal is to develop approaches that make community networks more intuitive, engaging, and empowering for individuals across diverse technical backgrounds, thereby fostering a more inclusive and connected digital community.

This literature review forms a segment of a larger effort to implement an app-based solution designed to augment a community-owned wireless network known as iNethi. The iNethi initiative is a community-driven, open-source project that empowers communities to create their own internet service providers through the use of Docker containers. It emphasizes easing the process of establishing Wireless Community Networks and fostering community ownership. A notable implementation in Ocean View, Cape Town, has resulted in the installation of ten Libremesh WiFi access points, providing internet access to approximately three hundred residents at a cost of R20 per gigabyte. The application seeks to offer vital services like digital radio, a business directory, and local e-commerce, enabling these services, which were previously available only via the iNethi network, to be accessible offline through a mobile app[20]. This initiative aims to promote the development of community-owned wireless networks in Ocean View, an economically disadvantaged area in Cape Town, South Africa.

2. User Experience in Network Interaction

With the rise of home networks, much like community-owned wireless setups, the task of managing these networks has transitioned from IT experts in professional settings to everyday individuals at home. This shift has brought the challenge of network management into the living rooms of the average homeowner, who may possess a wide range of technical skills. These individuals now find themselves grappling with the complexities of network settings and terminology that were previously the domain of professional network managers, turning the management of a home network into a source of frustration and difficulty for many [5].

Another challenge is that not everyone at home understands how the network operates, making it tough to solve problems together. Studies have shown that when facing issues with the internet, many families turn to a tech-savvy teenager or call for professional help [9]. Information needed to set up the network or make adjustments is often hard to find and understand, making it tricky to get everything working right from the start. When problems do happen, figuring out what's wrong and how to fix it isn't always straightforward [5,6]. On top of that, disagreements can come up over who gets to use certain devices, leading to arguments. All these issues show the range of problems families face in trying to keep their home internet running smoothly, pointing out a clear need for simpler network management solutions that fit everyone's level of tech know-how.

3. Review of Current Network Management Tools

Network management tools available today are primarily tailored for professional use in organizational settings, requiring a high level of technical expertise. Examples such as HP OpenView offer comprehensive solutions aimed at technical support teams rather than the average, non-technical user [5,6]. This focus overlooks the needs of community-owned networks, where users often come from less privileged backgrounds and may not have formal education, let alone specialized technical training.

Furthermore, most existing tools are designed to handle the visualization of expansive network

topologies, not the comparatively diminutive networks seen in community settings or households. The scale of home networks, being significantly smaller, means that tools prioritizing scalability might not suit these environments. Their visual representations may not effectively convey the simpler structures and needs of smaller networks.

Tools like Ethereal, along with command-line utilities such as ping, netstat, and traceroute, tend to offer detailed technical data on network performance indicators like latency, traffic, and bandwidth usage. However, they place the burden of data interpretation on the user. For home and community owned networks, where users may lack the experience or inclination for technical diagnostics, there is a clear need for tools that offer straightforward, actionable advice for troubleshooting [5]. Such tools would better meet the requirements of non-technical users, making network management more accessible to a broader audience.

4. Understanding User Perspectives in Community Networks

4.1 Challenges in Network Comprehension and Security.

In exploring how individuals interact with and comprehend their community networks, it became evident that several issues frequently surfaced. First, there was a common uncertainty among users regarding the physical boundaries of their wireless networks, as well as concerns about unauthorized access by others [9]. Additionally, the components of a home network are often spread across different locations within the home, some even concealed for aesthetic reasons, complicating efforts to achieve a cohesive understanding of the network's structure and setup [9]. This led to people creating their own diagrams or mental maps to keep track of the various devices connected and their configurations.

Moreover, the interaction with many home network devices is limited to interpreting a set of blinking lights, which seldom offer clear insights, especially during technical difficulties. For example, merely looking at a router provides no immediate information about which devices are currently connected or whether the network's security has been breached [9].

Lastly, tools that do allow for a peek into the network's activities, like those visualizing network traffic, tend to be usable only by those with a high degree of technical knowledge. This lack of accessible information about the network's operations often complicates the maintenance of the home network, hampers effective communication regarding network issues, and obscures the understanding of how network resources, such as bandwidth, are utilized [5,6,9].

5. Designing for Usability and Accessibility

Designing user-friendly applications for community networks requires attention to how users interact with and understand these systems. The concept of usability emphasizes creating technology that's easy to use and fits well into the specific activities and settings of its users [10]. Early efforts in computing didn't always focus on how everyday people would interact with technology [8]. When user perspectives aren't considered, technology that's supposed to make life easier can end up making it more complicated [7].Users today want technology that fits smoothly into their lives, enhancing communication, entertainment, and accessibility [7]. They value the ability to personalize their tech and get clear feedback, like knowing whether they're connected to a network [7,9]. An effective community network app should inform users about their

connection status clearly and allow them to adjust settings easily, giving them a sense of control and independence [9].

Simplifying how people interact with community network apps involves several strategies. The app should display network information in a way that reflects the real network setup, avoiding confusion for the user. Personalization features can make the app more relatable and easier to navigate [9]. Using straightforward language to explain network functions can demystify technology for those without a technical background. Showing users the tangible effects of their actions within the app can increase their engagement and trust in its usefulness. Moreover, providing detailed insights about network speed and performance equips users with the necessary information to address concerns with their service providers [9]. Centralizing network monitoring in a non-intrusive manner ensures users receive accurate updates on network performance without disruption.

Past research indicates that systems designed to clarify the reasons behind their behaviors can enhance their intelligibility, meaning they help users comprehend how the system achieves its objectives and the rationale for its actions. Additionally, these systems can boost accountability by making transparent what information the system has collected about the users, especially in contexts where this data may be shared with others. Such transparency and understanding also contribute to the system's overall usability, making it easier for users to interact with [11,12,13].
By implementing these strategies, community network applications can significantly improve usability, transforming network management into an integrated and user-friendly aspect of everyday life.

Network Visibility and Accessibility: A User-Centric Perspective

Several studies highlight the importance of network visibility and accessibility for effective network management [9,15, 16].

6.1 Network Visibility: Seeing is Believing

Network visibility allows administrators to monitor network traffic, identifying performance bottlenecks, potential security threats, and overall network health [15]. However, the literature suggests a gap between this technical visibility and user experience. While the inner workings of a network may be obscure, user understanding of basic network functions can be empowering.

Network accessibility ensures authorized users and devices can connect and utilize network resources. This involves factors like user authentication, network permissions, and device compatibility [16]. However, current user experience may be hampered by the invisibility of network infrastructure.

6.2 The Invisibility Paradox and its Consequences

There seems to be a paradox – the very infrastructure facilitating network access remains largely invisible to users. This invisibility can lead to several user frustrations. Studies suggest limited network visibility makes it difficult to distinguish between an internet service provider (ISP) outage and a router malfunction, hindering troubleshooting efforts [9]. Additionally, users may struggle to identify the source of network problems within their homes or recognize approaching bandwidth limitations [9].

Interestingly, the information users lack is often captured within their digital footprint, as defined in Chapter 1 [9]. This footprint includes data on network usage patterns, resource consumption (bandwidth and electricity), and user behavior. However, even technically knowledgeable users face challenges due to the inaccessibility of this information. Managing multiple devices and maintaining awareness of their status within the network becomes difficult [9]. Furthermore, the aesthetic placement of devices can exacerbate the invisibility problem, with users forgetting

about hidden devices connected to the network [9].

6.3 The Need for User Awareness

The ongoing debate around broadband caps and speed variations underscores the need for better user awareness. However, limited research exists on user knowledge of broadband limitations, connection speeds, and factors impacting their internet experience.

By bridging the gap between network invisibility and user awareness, we can empower users to manage their home networks more effectively. Further research can inform strategies to improve network transparency and user understanding.

6. Measurement Of Quality of Experience

Quality of Experience (QoE) is how happy or frustrated a person feels when using a program or service. In the past, experts have tried to figure out QoE by either looking at data or asking users directly. [24]. In the past, experts have tried to figure out QoE by either looking at data or asking users directly. [22,23].

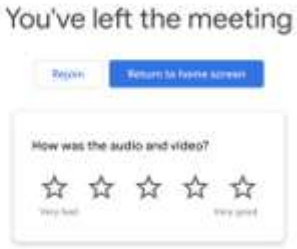
Studies have shown that just because a service works well technically doesn't mean people will like using it. This problem often happens because there's a disconnect between evaluating the service's performance and understanding what users really value. Researchers argue that it's important to consider all aspects of a user's interaction with a service to truly gauge Quality Of experience [26,27,28].

Martinez and Segall mentioned that one of the main challenges in understanding user experience is recognizing the outside factors that affect how users feel about a service, and pinpointing what makes an experience good or bad [27].

Quality Of Experience is usually rated on a scale from 1 to 5, with 1 being the worst quality and 5 being the best [28,29,30]. This scale helps to give a straightforward number, known as the Mean Opinion Score (MOS), which indicates how users perceive the quality. Anything above a 3.5 is considered acceptable.

Quality	Mos Score
Excellent	5
Good	4
Fair	3
Poor	2
Bad	1

Figure 1: QoE five-point MOS quality scale



Although MOS is widely used to measure quality, it's crucial to remember its limitations. Hoßfeld and others have pointed out that relying solely on MOS can be misleading because it doesn't capture everything about a user's experience. [31]

7. Discussion

8.1 Beyond MOS: Advancing QoE Assessment through Human-Centric Approaches

In exploring the multifaceted dimensions of usability, quality, and accessibility, a shift towards human-centric methodologies offers profound insights into Quality of Experience (QoE) determinants, transcending traditional technical

metrics [33]. This discussion illuminates the shortcomings of relying solely on the Mean Opinion Score (MOS) for evaluating user experiences. Despite its simplicity and directness, MOS inadequately captures the full spectrum of factors impacting QoE and user satisfaction. Our analysis reveals that exclusive reliance on MOS prevents the acquisition of critical insights into the elements influencing QoE [32]. The integration of the QoE framework proposed by Wu et al. significantly enriches the evaluative landscape, allowing for a comprehensive exploration of the human factors influencing QoE perceptions [32]. Such progress prompts researchers in Human-Computer Interaction (HCI) and networking to explore deeper into human-centric influences on QoE.

The literature review's focal discussion on assessment methodologies for usability, quality, and accessibility highlights the cruciality of adopting a holistic, user-centered approach to QoE understanding. This approach effectively moves beyond the constraints of MOS as the sole QoE metric, which, despite its operational simplicity, fails to encapsulate the complex dimensions of user experience [32]. Incorporating Wu et al.'s framework into the evaluation procedures represents an essential stride towards an enriched comprehension of QoE, underscoring the necessity of frameworks that can thoroughly address the intricacies of user experience. This refined approach facilitates a deeper appreciation of user interactions and the perceived quality of community networks, accentuating the pivotal roles of usability and accessibility in fostering a well-rounded user experience [32].

8.2 The Critical Role of Usability and Visibility

Evaluating usability in community networks is crucial to ensure that digital services align with user needs and expectations. Modern users demand technology that seamlessly integrates into their daily lives, boosting communication, entertainment, and accessibility [7].

Usability and visibility are essential components that significantly influence user experience and satisfaction within community networks. Usability focuses on how effortlessly users can interact with, comprehend, and navigate a digital service or network. It underscores the need for designs that are intuitive and functional, catering specifically to the activities and contexts of its users [10]. This involves crafting user interfaces that are straightforward, offering clear guidance and reducing technical terminology that might deter users without technical expertise. For example, Chetty et al. highlight the difficulties encountered by families in managing home networks and advocate for the development of tools that streamline this process, broadening accessibility to a larger audience [5]. Enhancing usability promotes deeper user engagement, maximizing the utility of community network services.

Visibility, conversely, relates to the user's ability to easily monitor, comprehend, and control the status and performance of their network connection, along with the accessibility and condition of network services. It enables network administrators to oversee network traffic, pinpoint performance issues, identify potential security risks, and assess the overall health of the network [15]. Key to visibility are clear indicators such as signal strength, connectivity status, and service access, which are fundamental for troubleshooting and enhancing user confidence and autonomy. Chetty’s research illustrates that providing users with insight into network performance and usage can markedly alleviate concerns and enhance their capability to address connectivity issues [9]. This aspect becomes increasingly relevant in community networks, where users often assume roles typically reserved for network professionals.

Usability and visibility are mutually reinforcing; advancements in one can augment the other. An intuitive user interface (UI) that vividly presents network status and performance data simplifies network management for users and aids in identifying and resolving issues, thereby enriching both usability and visibility [24]. Moreover, by equipping users with tools and functionalities that

facilitate straightforward monitoring and management of network resources, community networks can demystify technology, making it more approachable and less daunting for all users.

8.3 Usability Assessment Strategies in Community Networks: A Pathway to Digital Inclusivity

The importance of assessing usability within community networks cannot be overstated, as it ensures that digital services align with user needs and expectations. This discussion synthesizes various methodologies documented in the literature for evaluating usability, underlining their contribution to the development of intuitive and accessible digital interfaces.

Empirical Testing for Real-World Insights: Empirical testing, notably through user studies, stands out for its capacity to provide a window into actual user interactions with services and networks. Chetty et al.'s approach, involving in-home visits, exemplifies how such studies can reveal the complexities households face in managing their networks. This method not only uncovers specific usability challenges but also highlights the broader environmental and social contexts affecting user experience, advocating for the simplification of network management tools to accommodate a range of technical proficiencies [5].

Heuristic Evaluations for Expert Analysis: Heuristic evaluations offer a different vantage point, where experts apply established usability principles to identify interface issues. This approach, while less demanding in terms of resources and participant involvement, relies heavily on evaluator expertise. Nielsen's heuristics, for instance, have served as a crucial tool in identifying common usability shortcomings, such as poor system feedback and inconsistency, thereby pinpointing areas for immediate improvement [9].

Analytics and Logging for Quantitative Insights: Leveraging analytics and logging tools to track user interactions provides a quantitative lens through which designers can observe engagement patterns. This method illuminates user behaviors, including navigation preferences and common stumbling blocks, enabling targeted design interventions to enhance the usability of digital services [24].

The Intersection of Usability Testing and Community Network Evolution: Addressing usability challenges through these varied methods is pivotal for removing barriers to effective use. By identifying and mitigating issues related to complex interfaces and misaligned user expectations, community networks can become more accessible and engaging for a diverse user base. Importantly, usability evaluations foster an iterative design process, where user feedback informs continuous improvements, thereby elevating the overall user experience [5,9,24].

In essence, the strategic assessment of usability within community networks is foundational to crafting digital services that are both accessible and satisfying for all users. The combined use of empirical testing, heuristic evaluations, and analytics offers a comprehensive toolkit for designers and researchers to navigate usability challenges, steering community networks toward greater inclusivity and user-friendliness.

8. **Conclusion**

In synthesizing the exploration of design and implementation of inclusive experiences within community networks, particularly through the iNethi project in Ocean View, Cape Town, this paper underscores the transformative potential of community-owned wireless networks in diminishing the digital divide. By focusing on usability and accessibility, the research advocates for strategies that render community networks more intuitive and engaging, catering to users with varying technical skills. Despite the promising developments and insights offered, it is notable that there remains a paucity of Human-Computer Interaction (HCI) research specifically addressing the usability of community-owned networks. This gap highlights an urgent need for further investigation to understand fully and enhance the user experience in such critical infrastructures.

This lacuna in HCI research suggests a significant opportunity to deepen our understanding of how these networks can be designed and managed to meet the nuanced needs of their diverse user

bases more effectively. The evolution of community networks, such as iNethi, provides a compelling case study for the impact of targeted usability enhancements on user engagement and satisfaction. Therefore, advancing research in this area not only holds the promise of making technology more accessible and enjoyable for users but also plays a crucial role in empowering communities by ensuring equitable access to information and services.

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