Networked Micro-Services: Empowering Local Micro-Enterprises in a South African Township through Community Wireless Networks

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Abstract. Internet and cloud resources are a growing resource for micro-enterprises. However, small businesses in low-income communities struggle to use these resources due to the cost of access and the perceived cost of producing digital applications. In this paper, we draw on interviews with residents and small business owners from a South African township, towards the design of services to support micro-services through locally-hosted infrastructure. We present design implications for the architecture of these services, discussing the merits of internet-based versus community-based architectures, and present four prototypes to demonstrate possible designs of local centered e-commerce applications. This paper extends insights about local micro-enterprises' feature requirements and no-code local content creation services in remote communities. It also illustrates some factors that hinder the success of e-commerce in remote areas and how CWNs mitigate that. This work aims to contribute to both Sustainable Development Goals (SDG) goal 8, which focuses on promoting economic growth, and goal 11, which aims to build sustainable communities.

Keywords: Human Computer Interaction(HCI) · Community Wireless Networks · User-Centered Design

1 Introduction

The high cost of mobile data and monthly WiFi packages has limited the ability of underserved communities and those at the fringes of networks to harness the

potential of the internet in supporting their local businesses. However, framing this issue solely around "Internet access" assumes that local businesses require global internet connectivity for their success. Conversely, many local businesses seek stronger connections within their own communities. Community wireless networks (CWNs) serve as a means to facilitate local connections and community development. CWNs are community-owned mesh wireless networks that allow communities to pool their demand for internet access and share network resources locally [37, 11, 9]. Community development involves collaborating with individuals within a community to establish sustainable approaches that uplift the community by addressing existing imbalances [1]. In this research, we collaborate with a community to gain a better understanding of how Information Communication Technologies (ICTs) can be leveraged to achieve their goals [26].

Our focus includes empowering individuals within this community by promoting local services and enhancing local business activities [36], an objective shared by our community partners. Local services refer to products and services produced and sold within the community, often considered more affordable and accessible to community members. These services play a pivotal role in empowering communities and contributing to community development. While the creation of platforms that can host and support local services for communities is desirable, it presents a challenge. The design of such platforms needs to account for community constraints and environmental factors [44]. In this research, we delve into the design of a platform suitable for hosting local services, tailored to community users. Unlike non-local platforms such as Takealot (a popular South African e-commerce site), LinkedIn (a professional social networking site), and Spotify (a music-streaming service), which are often inaccessible due to data costs and prerequisites like access to email and credit cards, our community members lack access to the required infrastructure. As such, the question of appropriate architectures for locally hosted alternatives remains unanswered, as does the inquiry into effectively integrating and innovating new platforms designed specifically for CWNs and the operating communities.

This paper presents four case studies of applications developed by the authors to support local services in Ocean View, a low-income community in Cape Town, South Africa, facilitated by the iNethi community wireless network. These case studies focus on designing applications to facilitate the buying and selling of face masks, music sharing, the creation of a business directory, and the establishment of an employment-seeking platform for domestic workers within the Ocean View community. Through the provision of platforms that support and empower local community businesses, this work aims to make a meaningful contribution toward achieving Sustainable Development Goals (SDG), particularly Goal 8, which focuses on promoting economic growth, and Goal 11, which centers on building sustainable communities.

The research and development processes for these case studies involved conducting interviews with various stakeholders, including directors of OVCOMM Dynamic (the cooperative responsible for managing the network), local business owners, domestic workers, community members, CWN users, and musicians in

Ocean View. Based on these interviews, the authors created prototypes and evaluated services to meet the participants' needs. This study presents design implications for the architecture of these "local" services, discusses the merits of internet-based versus community-based architectures, and showcases four prototypes to demonstrate potential designs.

This paper is structured as follows: "Background and Related Works" offers a brief overview of the Community Wireless Network (CWN) in Ocean View and the services it provides. The "Methods" section outlines the authors' approach to gathering insights from community members to inform the design of CWNServer services. "Case Study Findings" presents the four case studies, each with its overarching architecture and design rationale, drawn from interviews with directors of OVCOMM Dynamic, local business owners, domestic workers, community members, CWN users, and musicians in Ocean View. The "Discussion" section analyzes the needs identified through the case studies, deliberates on the trade-offs between CWNServer-hosted and cloud-hosted services, and concludes by outlining requirements for services that support micro-enterprises.

2   Background and Related Work

2.1   Ocean View

Ocean View is a small coloured township (peri-urban) community located forty-five kilometers from Cape Town, South Africa. The establishment of Ocean View in the late 1960s to 1970s was a consequence of the Group Areas Act, which granted the apartheid government in South Africa the authority to forcibly relocate people of colour (including mixed-race, Khoi, San, Indian, Chinese, and specifically in Cape Town, descendants of Malay slaves, excluding black Africans) from what were designated as 'white-only communities' [32]. The township was named Ocean View due to its residents' connection to the sea. The majority of Ocean View's residents face bandwidth constraints due to unequal coverage and the high data costs prevailing in South Africa [23] [18].

Ocean View Community Wireless Network The Ocean View community wireless network (OVCWN) is a community-owned mesh wireless network in South Africa. Using the CWN, residents can share access to locally-hosted resources and access the internet at a low cost, leveraging a shared connection[44],. Inethi Network[8] is an edge-hosted cloud platform that supports sharing of content and services within a community. The Inethi Network network deployment in Ocean View demonstrates and presents the benefits of CWNs in low-income/under-served communities. Inethi Network acts as an open-source quasi Internet Service Provider (ISP) that comprises a voucher system, locally-hosted services, and monitoring services that allow the community to set up a micro-ISP and deliver lower-cost Internet access. These services include platforms to

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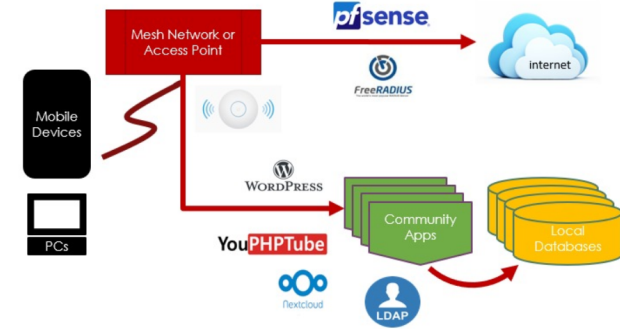[8] Project names changed/obfuscated for anonymity.

Fig. 1. The Inethi Network Design master plan.

deliver educational content, content related to local businesses, local music sharing, and social media platforms such as WhatsApp and Facebook. The OVCWN hosts an instance of Inethi Network and presently entails 20 hot spots [14]. The OVCWN network can be accessed by anybody that is within range of any of the WiFi hot spots. Hence, Inethi Network provides an interface that empowers the Ocean View community to leverage wireless communications to increase community digital participation, increase the value of local resources, and bring communities together. [33, 40]. The network design presented in the Figure 4 shows that this network provides the Ocean View community with access to the Internet, access to local content, and services via a WiFi mesh network across the community. The Inethi Network provides data backup and remote access by synchronising with a paired instance hosted by Amazon Web Services [21, 32]. Members of the community can purchase vouchers that are priced at R20/GB, which makes them at least five times discounted than the lowest cost bulk 1GB voucher available from mobile operators within South Africa [47].

2.2   Services in Community Wireless Networks

Currently the primary role of Community wireless Networks (CWNs) is to provide access to the internet by providing a framework for distributing broadband services to under-resourced areas. However, various CWNs, especially wireless user groups (WUGs) have also explored shared access to local resources and services [46]. CWNs can benefit developing communities by minimizing the cost of internet access and improving socio-economic development in these communities through skills and job generation [15, 24, 22, 20, 39, 36].

Some CWNs offer business services, often specifically adapted for low-income communities, and usually based on open-source software. Furthermore, CWNs assume mobile-first interaction, better catering to typical CWN users [10]. Community members can share files and use these internet services via the CWNs to access information that is available globally; such as access to education and

health resources/opportunities. In addition, CWNs also support under-served communities by giving them access to online resources such as educational materials, e-commerce support, marketing, and finding jobs online [7, 6].

2.3   Micro-services for Small Businesses in Developing Regions

Micro-services are an approach to software development that structures an application as a collection of small, independent, and loosely coupled services. In a micro-services architecture, each service is responsible for performing a specific business capability and communicates with other services through a well-defined interface[45]. This approach promotes modularity, scalability, and fault tolerance, as each service can be developed, deployed, and maintained independently[27]. Micro-services are often implemented using containerization and orchestration technologies, such as Docker and Kubernetes, which provide a lightweight and flexible way to package, deploy, and manage individual services. While, a micro-enterprise is a small business that employs fewer than 10 people, has an annual turnover of less than ZAR 1 million, and has assets worth less than ZAR 1 million. Micro-enterprises are often sole proprietorships or family-owned businesses that operate informally in the informal economy[2]. The South African government recognizes the importance of micro-enterprises in driving economic growth, reducing poverty, and creating jobs, particularly in disadvantaged communities. As such, it has implemented various policies and initiatives to support the development and growth of micro-enterprises[2, ?,26]. Local small businesses have the potential to grow bigger and faster if they use ICTs, internet resources and platform services to become more profitable[35].

3   Methods

For this research, we partnered with a cooperative running a community wireless network for a coloured[9] township. In this study, the authors identified various areas for the development of community-based networked services, based on previous community engagements. Four student co-authors selected an application area each and conducted interviews with community members interested in their respective areas, as identified by the cooperative directors. Subsequently, we developed a prototype based on community engagement and solicited feedback from the same community members regarding the prototypes. The engagements took place between July and August 2020.

   The authors acknowledged that the traditional ethnographic method was not ideal for this study due to the Covid-19 Pandemic at the time. As a result, we opted to apply remote ethnography by utilizing digital tools to share low-fidelity prototypes and developed applications with participants before conducting remote interviews via video-conference calls and WhatsApp. Remote ethnography

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[9] In South Africa, the term 'coloured' specifically refers to a multiracial ethnic group native to Southern Africa that was officially defined by the South African government from 1950 to 1991.

Table of Participants

	Business Directory	Facemask	Music Sharing	Employment
Requirement Interviews	4 entrepreneurs 2 community **6 total**	3 seamstresses 2 NGO managers 7 community **12 total**	3 musicians 3 researchers **6 total**	7 community **7 total**
Prototype & App feedback	Same participants as above	3 seamstresses 7 community **10 total**	Same participants as above	Same participants as above
Total	6	12	6	7

Fig. 2. The table above presents the number of participants that took part in interviews, prototype feedback, and application testing for each case study.

is a research methodology used to study how people interact with technology and how technology impacts their daily lives without physically being present with them[34]. With remote ethnography, researchers can collect data without being physically present by using digital tools and communication technologies. We modified and extended remote ethnography by screen sharing: To observe how participants interact with the applications, that allowed us to view their screen as they complete tasks, Conducted follow-up interviews: After participants complete the usability test, we followed up with them to ask additional questions about their experience. This provided valuable insights into how participants felt about the applications and identified areas for improvement. By modifying the remote ethnographic methodology to include these approaches, we conducted effective usability testing remotely during COVID-19.

The four applications areas include: 1) a business directory to support advertising of local businesses within the community, 2) a music-sharing service to enable local artists to track interest in their recordings and sell music, 3) cloth face mask production, meeting a new demand in the early days of the pandemic, and 4) an employment resource to help address high rates of unemployment in South Africa.

In the following section we present each of these areas as case studies depicting the community need, the design of a system intended to address that need, and feedback from the participants on these prototypes. Based on these case studies we discuss local networked micro-services, highlighting the key concerns that emerged from our experiences in an initial co-design of the applications for the community wireless network.

3.1   Participants

The participants of this study were residents of the Ocean View community and other stakeholders: directors of OVComm Dynamic, the Ocean View-based cooperative running a local community wireless network (CWN); and researchers and software developers building Inethi Network, a software and hardware solution used to manage the network services. The participants were selected on criteria

that they belong to the Ocean View Community or they use the CWN for internet connection and access to local services. The OVComm directors helped with recruiting participants by providing us with the contact details of some CWN users. Using the snowballing method, we were able to find more participants that were directed to us by our first initial participants. Each case study had specific requirements for participants to be selected for interviews. For the face-mask application, the participants were required to specifically have interest in cloth face masks, or be individuals that make face masks from home and those that benefit from any face mask donations to the community. While for the music-sharing application the participants were required to be musicians/artists within OV, prospective music consumers, and included one of the directors and a researcher who was also a musician. The business directory required participants that were local business owners and local domestic workers that were seeking jobs for the employment-seeking application.

3.2   Initial Community Interviews

We constructed interview questions that were based on current challenges related to buying and selling face-masks, music sharing, the business directory, and employment seeking for domestic workers. We discussed possible solutions and had insightful discussions on the problems with the participants before we started identifying the features of the potential systems/platforms/applications or websites that would best fit as the solution. Through these interviews, we sought to better situate each of the applications in the context of the target users, and to co-ideate approaches to addressing their needs.

3.3   Prototype Development

Based on the key requirements emerging from the community interviews, each student developed a prototype application. These applications were to be viewed not necessarily as a definitive architecture emerging from the engagement, but rather as technical probes to help elucidate specific community needs and other issues surrounding the deployment of services within the community [16] [5] [42]. Molapo [25] problematizes attempts to co-design ideas when participants do not have experience with the design artefact [25]. Hence, the mutual development of the prototype also serves as a step towards making participants more co-design ready by giving them concrete "sketches" of systems to engage with [13].Which is essential for developing community ownership and ease sustainability for co-designed services.

3.4   Prototype Feedback

Each student conducted a second set of interviews to present application prototypes to participants for feedback. Application requirements were assessed again after development, and participants were consulted for testing and to identify

problems for correction. New participants were recruited if necessary. During the prototype feedback interviews, students presented paper prototypes via online video conference tools like Zoom and Microsoft Teams. Participants provided feedback on the design and functionality of the applications remotely by listening to students demonstrate the prototype drawings online. After explaining the user interface design, participants were asked about their views on application pages, page navigation flow, login methods, electronic payments, and card payments. Feedback was used to improve the user interface designs for the final application prototype.

3.5   Analysis

After the interviews, we analyzed each case study separately using thematic analysis. Students went through each interview transcript looking for themes. Based on the research questions, similar themes regarding changes on the user interface were selected and considered to be implemented on the final applications development. The following themes emerged: the preference of using cell phone numbers for authentication purposes, using cash on delivery over electronic bank card payments, and using a WhatsApp chat bot over mobile applications for domestic employment seeking were selected by participants, each student then developed an application that would use cellphone numbers for that specific case study.

We consolidated prototype feedback in the form of further updates to the applications, the final version of which is presented in this paper. For this paper, the co-authors then shared findings across the case studies, discussing where design decisions converged and diverged. The results in this paper are based on our collective analysis of the four cases.

4   Findings

Together with the community we identified four potential services of interest and worked with community members to receive feedback on prototypes and evaluate how these might be implemented. In this section we present the case study for each application area. Each case study first outlines the need as identified in our initial interviews with key stakeholders. Then we present a proposed architecture for a community-based service designed to meet this need, together with our design rationale. Finally we present community feedback on the proposed systems.

4.1   Case 1: Mask Making

For this case study we engaged three local seamstresses (people interested in income generation through making masks), two managers of organisations seeking to distribute masks within OV, and seven other OV community members as potential buyers of masks.
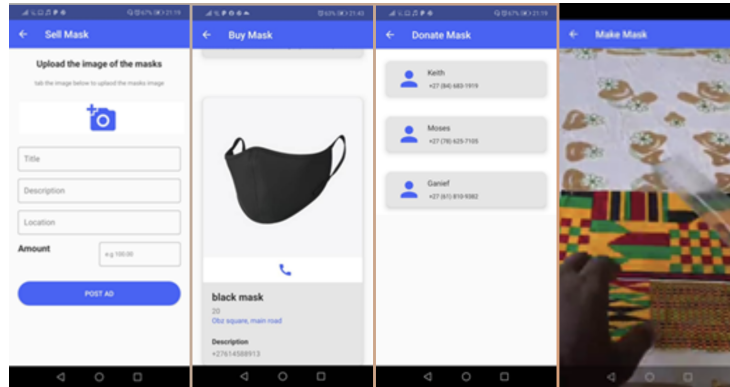
Fig. 3. This figure displays the Face Mask application for selling, buying, donating and learning how to make face masks.

Community Needs Amid the breakdown of Covid19 in March 2020, wearing face masks became mandatory in public spaces [19]. People started sewing cloth masks as they were reusable as they could be washed many times. While in lockdown, some OV community members started sewing cloth face masks for their families and later saw it as an opportunity to generate income. These community members started selling face masks within the community. Due to the restrictions of the lockdown, it was difficult for community members to both sell and buy face-masks. Hence, the goal of the face mask app was to link potential local face mask producers with buyers, link locals to face mask donors, and share a face mask making video tutorial.

Proposed Architecture This is a basic client-server service, with a mobile app connecting to a cloud-based server hosted by Firebase. The server is used to store the mask listings.

Users would log in to the mobile app using their cell number and a one-time password (OTP) sent via SMS to verify the number. Upon log in they can view a list of masks for sale or create a sale listing. The app also includes contact information for prospective mask donors and a short video tutorial on how to make a mask.The option for facemask donations was useful because most residents could not buy facemasks and they got their facemasks from church and NGO donations in the OV community. The app does not support direct financial transactions. Instead, listings include the contact information of the seller, allowing potential buyers to contact the sellers directly.

Design Rationale

- **Website vs Mobile App:** The mobile application was designed targeted at the Users (Ocean View Community members and OVCWN users). We
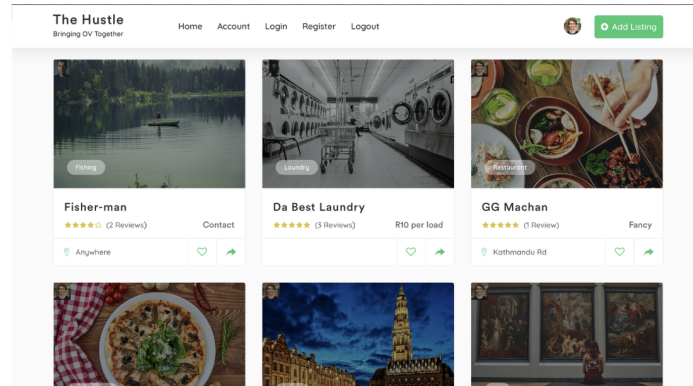
Fig. 4. The figure above presents the business directory platform.

considered developing a website but it was not fit for the users as they did not have access to laptops or tablets to get the best experience from a website. Most users had android smartphones and a mobile application was the ideal platform as they wanted an application to use on their phones.

– **Cloud vs Local Services** The mobile application is connected to a cloud server hosted by Firebase. The app APK(Android Package) was to be placed on the Inethi Network application folders in an executable form for an Android phone. The app traffic would be white-listed to the Internet through the network to be data-free. This way the users could access the app at no cost, although it still required an active internet connection.

– **Login mechanism:** To verify the users we opted to use phone numbers because most of our participants did not make use of email addresses or have access to emails. To ensure that the users entered the correct phone number, they had to verify with the OTP from the Firebase database to complete a user login and registration.

– **Payments:** During the interviews, most users outlined that they are not comfortable with using bank cards to purchase goods online, while others indicated that they hardly ever use cards to purchase local goods/services. They mostly use cash, especially around the community. The mobile application was to cater for online payments but tailors or face mask sellers that participated preferred to receive cash on delivery/pick up.

– **Video Tutorial:** During the interviews, some community members outlined that they can make their face masks if given guidelines because they can reuse old clothes as materials to make their masks at home. One participant said, "I prefer to make my face mask because the ones being sold are too small and uncomfortable because they start getting wet after some minutes". We found several video tutorials and selected one that was simple because it presented making your face mask using tools that one is likely to find in their home (thread, cloth material and scissors). With permission from the video owner,

the video tutorial was incorporated directly in the app to make it readily available offline.

User Evaluation The face mask app was evaluated by potential users from the Ocean View community and OVCWN users. We shared with the users the app apk via Whats app chat and they installed it on their cellphone. This was because all users were on whats app and they preferred to download it from there. Each participant was then given a task to download the app and register/login to the app then make a post as a seller, make a purchase as a buyer, and view the video tutorial. Participants responded positively to the tasks by posting pictures of the face masks that they are selling. Participants were also able to contact sellers using the sellers contact details displayed alongside the face mask image. They could all open the video tutorial and expressed that they would have preferred if the app presented more videos.

4.2   Case 2: Music Sharing

For this case, we interviewed three musicians that make hip-hop music from OV and three researchers from the university that are involved in Community Wireless Networks.

Community Needs Ocean View has a thriving community of artists, including the presence of a Rastafarian settlement at the edge of the community [21] [38]. Sharing music files without unlimited internet access can be costly especially when uploading music files on YouTube and Sound Cloud. Cloud services such as YouTube and Sound Cloud have a global audience but limited access for community members.Therefore, community members shared music files among each other via Bluetooth and Whats-app. Hence, the goal of the music-sharing application was to create a music sharing platform that allows local musicians to share their music with residents of OV community and people residing outside of OV at low or free internet access.

Proposed Architecture From the prototype evaluation, the musicians needed to increase their audience beyond OV community, we created two instances of the music sharing website. The first version was for users that would access the website using a wireless access point within the community location. While the second version was hosted on an Amazon Web Services (AWS) server that can be accessed globally by anyone.

Design Rationale
– **Wordpress** We elected to leverage an existing content management platform, Wordpress, because it does not require any coding experience to edit pages and configure plugins. This would make it easier for a resident in OV with no programming knowledge to edit and adapt the website front-end and its features as they see fit.

- **Cloud vs Local Services** Our participants sought a platform that would enable music sharing within the OV community and also aimed at reaching music lovers beyond Ocean View. This was achieved by hosting the website on the local server in OV and synchronising it with an instance of the website on an AWS instance for global access.
- **Login mechanism:** Logins were done by a wordpress plugin. To sign up and login, users need to enter their user name and password that they used to register.
- **Payments:** For both users, the seller and music buyers have to upload their banking details on the web application. The banking details were tested with Postman manually. The Postman tests involved entering incorrect bank details, bank details missing fields and then correct bank details. These were all sent to the API using get requests and the responses for all tests displayed the correct output. This was done to ensure that users enter the correct banking details.
- **The song downloads indicator:** For the users to download the songs, we needed to use the song indicator to query the downloads for a newly uploaded songs, querying the downloads for a song multiple times within a thirty-minute period and querying a song that had been downloaded a known amount of times to allow users to flexibly be able to get the songs.
- **Song Upload and Coupon Generation:** Another purpose of the music sharing website was to promote local content and assist with stimulating the community economy by helping local musicians generate income from producing music. To do this we included an essential e-commerce feature, coupon generation that allows music fans to buy coupons to download music.
- **Social media profiles:** To assist musicians with making money we also included a social media profile feature that allows musicians to market themselves online. The social media platforms also accepted donations to musicians and allowed them to share their contact details for possible collaborations with other musicians. This profiles were very useful for OV based musicians as they played an important role with increasing the music audience.

User Evaluation The web application technical ability of users was tested by the OVCOMM directors and they managed to upload and download songs. They indicated that the a website feature (help page) pre-populated with detailed explanations of the core functionality of the website would be great and how to make use of these services. One participant brought forward that this was necessary as the average users have not made use of technology beyond WhatsApp messaging.This meant that features of the website could not be assumed to be intuitive. This was corroborated by the other participants.All the artists, outlined that they liked the genre tagging system, the profile page because they can share their details. They also engaged and interpreted the analytics page well as they could track user engagement and a way for users to preview their music. This was really amazing because they presented how enthusiastic they are about the music sharing application.

4.3   Case 3: Business Directory

For this case study we enquired with four local entrepreneurs during the requirement interviews and we were joined by two community members from Ocean View during feedback engagements.

Community Need While many NGOs in Ocean View have websites, these are primarily outward-facing, aimed towards donors or other people outside the community rather than serving as a resource within the community [31]. Moreover, Ocean View business owners have no access to a local website for their products and services. Hence, the goal of the business directory was to help members of the Ocean View community to connect, to seek services within the community and not just from outside.

Proposed Architecture This is a Word Press website application connecting to the Inethi Network local Server and AWS Inethi Network cloud server. The base components were built using the following dependencies (Docker→Nginx, MariaDB →Word Press). The web application has a business listing Page and a business portfolio page. The user(OV business owners or NGO) can register and create a business page for their business that will be displayed on the directory. On the business portfolio, each business owner can enter their business name and register under the right category(clothes,food, services etc).The owner will provide the pricing model of the business, upload pictures of their business, add a phone number, email address, and a location. The name, featured photo, categories, pricing and location are displayed prominently in a tile in the directory User Interface (UI).

- **Website vs Mobile App:** Just like the music sharing web application, a business directory Word Press application was more suitable for Ocean View business owners and prospective customers from the community. This is because the OV business owners have windows laptops and Android cell phones like most community members. A Word Press web application is also more suitable as a community software because local network operators can make changes to the front-end without any programming skills.
- **Cloud vs Local Services:** The business directory web application used both local Inethi Network and cloud AWS servers for the business directory to be accessed by Ocean View community members and people out of Ocean View. This way the users within Ocean View community will access the business directory at no cost through the local server or cloud server because the business directory traffic is white-listed for community members.
- **Login mechanism:** The business owners have to register and sign up with their cellphone number. The users cellphone number was used for verification by receiving an OTP pin to ensure the number is correct and the owner can be contacted to verify the business page.

- **Payments:** Simplicity is favoured by the community in a number of ways, including the opinion that online sales were not favourable for the majority of business owners in OV. Cash was and still is king; the accessibility of cash to all (alongside the physical transaction meaning that business owners are able to build a relationship with their customers) trumps the efficiency of online payments in OV.
- **Business Owner Persona:** The design behind the business owner persona is that the business owner wants the business to be discovered by potential customer who are searching for their product/service, they want space to adequately convey the brand values, and to accurately display relevant information to those viewing the business listing (such as pricing, operational hours, location, etc.)on this space. The business owners also outlined that they have no way of building a rapport amongst the community, and this makes it more difficult to convince new customers of the business'reliability and standard. The business directory solves these problems with its design and features. A user can create a business listing that will be displayed on the directory. This listing contains the following features that can be set by the user at the listing creation and edited at any point thereafter.The business is required to have a name. The business listing can then be categorised in multiple of the available categories. The owner can set the pricing model of the business, upload pictures of the business, add a phone number and email address, and a location. The name, featured photo, categories, pricing and location are displayed prominently in a tile in the directory user interface. Within the listing, a dynamic, large text field can be used to display price lists, the business mission and vision, contact instructions and links to the internet and device apps (e.g. to Facebook pages, the default phone or mail application, or WhatsApp chat).
- **(Potential) Customer Persona:** This second persona of the business directory was designed for the costumers, it aimed to provide solutions for Ocean View residents that are looking for specific products or services within the community. Users (potential customers) without creating an account, can do a simple, multi-variable search across all businesses listed on the business directory. This provides the users with relevant businesses based on location, category, name and any other information added by the business (e.g. slogan). In the search results,they can view the star rating of the business, pricing and structure. After performing a search,the user can select to be notified of new listings within that category using an RSS Feed. Upon tapping a listing, they are then presented with the full details of the listing, options to contact the business full reviews of the business by other users of the business.After transacting with the business, the customer can then leave a review for others to immediately see.The website, using a cookie, can remember your details for future reviews without creating an account if the optional checkbox is selected.

User Evaluation During the user evaluation phase, participants (local business owners and local customers) tested the web application by completing the following tasks: Registering an account, adding a business listing, searching for their listings by tag, text or location, rating other businesses and viewing or changing one's profile. Participants managed to navigate through the website to complete those tasks. They also stated their own desire to introduce others to the business directory and show them how to use it. They said that having the ability to point their customers towards their listing on the site was a good thing and that being able to be discovered by those searching and browsing on the directory is really exciting because it can boost their business.

4.4 Case 4: Domestic workers Employment Seeking channel

For this case study we interviewed and received feed back from seven community members from Ocean View with interests and experience in domestic jobs around Cape Town.

Community Need The high unemployment rate in South Africa affects the townships and rural areas more especially when it comes to domestic workers due to the lack of online platforms [43]. Most domestic workers from townships do not have emails, Linked-In platforms to submit and seek job applications. Locals miss out on opportunities due to a lack of online platforms and services to interact with potential employers. Amid Covid-19 locals from townships struggled more to find jobs due to the restrictions as communication migrated to online channels [41]. Our goal was to link domestic job seekers with potential employers through a free-data platform that allows job seekers to interact with potential employers.

Proposed Architecture This is a Whats app chat bot designed using Land bot with an emulated wizard-of-z back end. The features of the WhatsApp bot came from the user requirement interviews with participants(Job seekers from Ocean View Community). Users need to save the what app chat bot number and start interacting with the welcome menu.

The initial start up menu on the whats app bot welcomes the user to the platform and gives the users an option to choose the language they prefer to use and gives the users options on what service they want to use: apply for a job or post a job opportunity, ask frequently asked questions and join domestic workers union. The User data collection feature collects personal information from the user,such as their Name, contact details, address, education background ,skills and experience. This information is stored in the whats app bot domain. The data collected is then used to generate a simple CV and cover letter for the users. The CV and cover letter can be viewed by potential employers and community members can use them do apply and seek for jobs.

– **A chatbot vs Mobile app:** A whats app chat bot was designed targeted at the Users (Ocean View Community job seekers or OVCWN users). We

were looking at developing a mobile application but participants preferred a Whats app chat bot because most community members with smartphones use whats app and a mobile application will take up extra storage capacity on their devices. We used a Whats app bot because participants expressed that WhatsApp is cheaper for them because they can purchase a WhatsApp ticket (data bundles for WhatsApp) for 7 days. The whats app bot is easily accessible via whats-app app, the users will only need to set is up by saving the Whats app bot number.

– **Cloud vs Local Services** The whats app chat bot is to be assessed via both the Inethi Network server and AWS cloud server so that users can access it via the Inethi Network network.

– **Option for different Language:** Most participants from Ocean View that are interested in finding domestic work opportunities were not good in reading and writing in English. Therefore, they suggested the use of other language options such as Afrikaans and isiXhosa to make it easy for our participants to be a part of the application process sidelined.

– **Features to improve your employ-ability:** While job seekers outlined that they cannot receive individual feedback when their applications are not successful, information on how they can improve their CVs. Features to improve and determine their employ-ability includes how to refine your short description since this is what can attract the employers as well as their skills.

– **Creation of Curriculum Vitae:** Potential domestic work seekers from the community that participated in this research were 45 years old and above, with many having obtained grade 11 which was then known as Standard 9 in the BEE syllabus, they outlined that CV formats were not taught during their days and they still cannot understand how they work and they mostly have to ask their children or grandchildren to help them with the writing of CV. It is for this reason that we had to fill in the need by having an auto-generated CV on the WhatsApp bot platform.

– **Creation of the cover letter:** For the same reason why the creation of the CV had to be filled in, our participants did not know how a cover letter is formatted, they outlined that most of the time if they were to find a job application requesting for a cover letter, they would immediately leave the application and focus on other ones.

– **Frequently asked questions (FAQs):** Frequently asked questions (FAQs) are provided in many sites to help customers, especially if a site does not support a help desk. To answer some of the questions that applicants and employers will post, an FAQ section on the WhatsApp bot was included to help users answer some questions.

– **Terms and conditions:** Before posting a job, a user had to agree to the terms and conditions that were published in the labor laws of domestic workers act of the Republic of South Africa, that way if a scam is reported, a case can be reported to the South African Police Service (SAPS).

User Evaluation The Whats app chat bot was evaluated by potential users from Ocean View Community and OVCWN network users. We shared with the participants the whats app chat bot number that they should save and text on the whats app application. Most participants could navigate through the chat bot, only one participant said that she had to get her daughter to help her and this was due to the language barrier. She then suggested that language options should be provided on the startup menu in which she mentions Afrikaans is the language she would prefer. Other participants outlined that they will refer fellow community members to the chat bot as they believe that this could help more people. One employee also preferred if they could be any way to verify if the job posted is for real and not some scam wherein people will contact you and tell you to send money for your application to be processed. She further expressed how an agreement on terms and conditions should be included before posting or applying for a job. An employer stated that he would like to know his domestic workers in detail, not just the things written out in the CV but things like the criminal record for safety purposes. After the walk through, participants had questions about when they should get the feedback on their applications, how can they update their CV, and if they want some type of help where they should ask. This was reasonable and important feedback from participants because it touches on having frequently asked questions in our WhatsApp bot.

5   Discussion

5.1   Local vs Cloud-based Services

In contrast to the general trajectory of the internet towards cloud-based services [32], the Inethi Network platform specifically advocates for "local" services, for which clients can leverage community-hosted resources instead of paying for internet to connect with people outside their community. In this research, we look at networked services, with an eye towards understanding to what extent can we support the OV community business market using cloud-based services that will not require them to pay premiums. In this project, two cases opted to develop WordPress-based services hosted on the Inethi Network, one developed a WhatsApp chatbot, and another developed a dedicated mobile app. Here we discuss the trade-offs between each of these approaches for the communities.

In the case of WordPress-based sites, the service sacrifices availability for ease of updating content. End users are effectively connecting to a local "cloudlet" to access the services, but they can only do so when they are actively connected to the OVCWN network. In the case of the mask app, the designer prioritized availability of content, which was not expected to change frequently. Updates could occur when connected, but users would retain access to that content even when not connected to the CWN. Likewise, by using a WhatsApp chatbot, the employment service compromised on cost of participation in favor of universal access, recognizing that 'social bundles' offering a discounted rate for WhatsApp data can help ameliorate data costs if the service is of sufficient utility. However this comes at the cost of hosting; while the cost of hosting a WordPress site on

Inethi Network is an existing sunk cost on the Inethi Network, the cost of running a publicly-hosted chatbot using Landbot is likely to be unaffordable for the community. Thus while no one architecture is necessarily appropriate for every audience or service, the choice of platform and hosting entails tradeoffs in terms of hosting costs, ease of content updates, user data costs, and offline access to resources.

Data costs vs Availability If the local people were to sell/promote their local businesses on highly established platforms such as Takealot.com, BidorBuy and Superbalist (all popular South African e-commerce sites), the cost involved will be unsustainable, they have to pay subscription fees to host their products on the platforms, they will need data to monitor their products on the platform and local community members (potential customers) will also need data to access the products on those platforms which is expensive. Moreover, promoting music through traditional media such as radio and television will also require local people to spend airtime while if they need to use modern online platforms like iTunes, and Spotify they have to pay subscription fees to promote their music there. On the other hand, local job seekers cannot use most platforms like LinkedIn, email based applications, and website applications to seek/apply for jobs, as these platforms require the use of data and they are complicated for locals to submit application documents. Africa has already the minimum rates of internet dispersion when compared to other continents and many people cannot afford internet access especially here in South Africa [31, 12]. The monthly WiFi packages in South Africa cost around 300 Rands a month for limited WiFi, while mobile data is also not affordable because of high rates as indicated here: R59 for 500MB, R113 for 1GB, R226 for 2GB, R452 for 4GB, R903 for 8GB. People from townships cannot afford monthly packages or mobile data as most of them, their monthly income is around R 1600 [31]. This means that most people especially those from townships will not be able to access available services as they do not have connectivity means to use these services. This also contributes to township businesses low performance.

The neo-colonial enterprise (or who pays and who earns) The use of international/ foreign owned applications that facilitate local businesses does not uplift the community much as the communities do not gain full profits from them. Due to the newness of the Inethi Network service platform, three of the case studies depend on external, internet-based services to support their functioning. In the case of the WhatsApp chat-bot - service fees for hosting as currently architect-ed would be unsustainable without donor support. This issue has also been observed with other USSD/SMS and WhatsApp services, where the cost per user is extremely high. Fire-base, as used with the mask-making service, is relatively low cost - but also depends on the user having data, and the number of transactions being hosted. This is feasible, assuming users are within

the coverage area of the wireless network. However - this also necessitates paying outside entities (i.e. Fire base/Google and mobile service providers) for services that are essentially local only to the community. The payments mechanism integrated with the music service is also from outside the community - these services typically charge 6-20 percent of the transaction costs. Thus in order to be truly local, to keep these costs within the community, the Inethi Network platform will need to integrate its own payment mechanisms, have more reliable database services, and to increase coverage so that those in the community can access the services without relying on internet access, using the local network.

Platform familiarity and critical mass WhatsApp is one of the most used smartphone message platforms in the world and more especially here in South Africa [17, 29]. The use of mobile applications especially for business purposes are the next easiest, most used, and common platforms for online shopping and service rendering. Mobile apps guarantee and provides an excellent presentation of the products at any time on the application and bring flexibility for both the buyers and the sellers. They provide a common interface for a bespoke service, and if they are well-designed they do not require any training, they can help businesses reach critical mass. Web-based applications are not only best because they are cross platform, Web-based apps (e.g., word-press) are also familiar and easy to access.

Critical mass is the turn point for businesses' when they reach a point in which they no longer require further investments on cash to keep going. Critical mass especially for small start-ups can be reached depending on the number of users on the platform to determine the success of the platform and how valuable the product/service is. How can local businesses reach critical mass if they do not have cloud services to host their local products or if their customers cannot afford to get data to buy? The lack of data and local cloud services has made business exceedingly difficult for locals and has affected their chances of reaching critical mass. Business platforms count on direct and indirect network to charm, attract and maintain customers. Newly launched platforms deployed in communities have difficulties in picking up well as community members are already used to physical buying or selling [4][8]. It's easier to achieve critical mass when the platforms have a pre-existing network structure in case of Ocean View, the participants or users might have already used Inethi Network local content/services before.

However critical mass can be overrated, just because many people use WhatsApp does not mean many people will necessarily connect to a service on WhatsApp. They are willing to chat on WhatsApp or make calls but not join a chat bot. Additionally, websites and mobile applications are severely in use especially for business purposes but people might not be interested in downloading the mobile application and keeping it on their phones, they might just download

the app and use it to purchase whatever they want and some might delete it after using it / keep it in obsolete unless they need to keep using it more often depending on their interest in the products/service. The use of well-known applications/ websites interfaces does not guarantee a visit to your website/app. No particular architecture will necessarily solve the problem of gaining an audience. Our case studies improve the chances of local businesses to reach critical mass as they will not be required to make any payments on hosting their businesses on the cloud. Our applications and website on the Inethi Network server will also contribute to local businesses reaching critical mass as the customers will easy access the businesses without mobile data. This will increase the customers and decrease the expenses of the business owners. Our case study applications aimed to improve the identified challenges local business owners and community members go through which may have been exacerbated by the COVID-19 so we found different means which are cheap and accessible to help the community.

A hybrid approach Social network platforms may remove existing barriers and contribute to improving local business through network creation. Through, the social networks, people connect, keeping instant communication discussing real time news and information while having general fun and enjoyment. Social networks do not only connect people to people around them but connects people at national and global level. A cross tactic approach might improve the participation of community members interest local content and services and draw participants from neighbouring locations. This can work by using a social network platform that is linked to the Inethi Network content were people can cross post as a means of bootstrapping participation. Building a profitable and sustainable community owned connectivity network need a global and local reach to make the content visible and reachable to a great audience. MEs owners from marginalised communities lack advertising expertise, hindering growth to their businesses. MEs products/services can circulate on social platforms and not get attention. Besides that, the competition from foreign brands is so strong weakening the products of MEs in the marketplace.

Managing of Payments The use of cloud services to host websites/apps for local products /services may possibly lead to the methods of payment to migrate to online/electronic payments. When considering the use of e-commerce, payment systems are needed, we can either opt for payment service. Payment service includes the use of cash deposits, electronic payments such as direct debits/transfers, debit/credit card. These forms of payments can affect MEs negatively if customers are not familiar with them [28], which also depends on the market. For example, some customers will be comfortable buying music with their card but they will not be willing to do the same when buying face masks online. The use of card payments requires the business owner to have a secured online payment system or POS (point of sale) machine connected to

bank account which both come with extra charges. This might also be hard to manage because the business owners cannot afford to facilitate those and they require up time connection to work. The use of community payment service such as Person-to-person (P2P) can be more available as an option. Our applications do not manage to have electronic payment services as the buyer needs to collect or get the product from the seller. The business is transacted directly between the buyer and seller using our platforms/ applications an intermediary between the buyer and the seller.

Facilitating Connection There is a need to re-approach the use of internet in our communities. The availability and use of internet have a profound impact on promoting local products and services. But they are mostly used to encourage people to face outwards and purchase from external markets instead of purchasing local products. The use of internet in local communities has most interactions concentrated between members within the same geographical area which has the potential to boost and promote local products/services [18]. Our applications are hosted on the Inethi Network server which facilitates connection within the OV community which minimises the barrier of internet connection for community members to interact with each other.

No-code local content creation services Creating local content applications can be difficult for community members because software development skills are difficult to acquire [3]. Maintaining applications that require programming skills can be a problem for community members, with applications such as Word press and auto mobile application generators it is easier to edit and make changes to the application interfaces [30]. The business directory and music sharing website applications were developed using Word press to make sure we minimised complexity for community members when they need to make changes because with Word press you can do content management using the widgets and plugins which makes it easy to customize themes. Despite this, word press can be locally hosted on a web server or cloud which is the best option for community wireless networks.

6   Conclusion

The lack of affordable means of Internet access in low-income or bandwidth constrained communities in South Africa has minimised the impact of e-commerce in these areas. This paper identified some of the needs of local businesses in a local township and explored the development of platforms that can support local content in Ocean View community through community wireless networks. Communities at the edges of networks cannot capitalize on the Internet to support their local businesses.This paper uses four case studies of local micro-enterprise needs in a South African township to articulate some of the problems entailed

in rolling out services, to both motivate the need for community-based services, and to inform their design. Key to this is the issue of payments: local infrastructure reduces internet access and service hosting costs while enabling a local economy - but has limited applicability until critical mass enables network effects for service adoption. Our next steps are to further develop the OV CWN platform to better support these services, to create a toolkit that will enable community members to easily create their own services, access other community members, and to monetize their work within the community and more broadly.

Whats App bot for domestic employment seeking- One of the suggested future work on the Whats App bot is to extend the system to other languages such as Tshivenda and Xitsonga. Presently, the Whats App bot only has three languages: English, Afrikaans and isiXhosa. While there are 11 official languages in South Africa and should be taken into consideration for the future extension of the WhatsApp bot to other communities.

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