Towards bridging the digital divide using innovative and community-based interventions

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Abstract: Access to high-speed broadband infrastructure and services plays a vital role towards achieving the United Nations' Sustainable Development Goals (SDG). However, the International Telecommunication Union (ITU) revealed that only 63% of the global population has access to the internet. The gap between those who can and those who cannot access and use broadband services (known as the digital divide) is wider mostly in developing countries. Therefore, closing the digital divide will require some innovative and cost-effective interventions. This paper discusses the two types of the digital divide and explores technical interventions for bridging the digital divide. More specifically, four technical interventions for rolling affordable broadband to rural areas are discussed. The realisation of these interventions will require concerted efforts by policymakers and regulators in developing regions, as well as partnerships between the private and public sectors, and the involvement of affected communities. Furthermore, the sustainability of community owned broadband networks requires the development and implementation of bankable business models. The implementation of the proposed technical interventions would contribute toward closing the digital divide gap between the rural and urban areas.

Keywords: access divide, broadband, digital divide, information and communication technology, usage divide.

1. Introduction

The information and communication technology (ICT) and telecommunications sectors provide key enabling tools for addressing developmental outcomes such as education, health, business, media and entertainment, and poverty reduction. This point is fully supported by the South African National Development Plan 2030 [1] which reads: *"efficient information infrastructure that promotes economic growth and greater inclusion requires a stronger broadband and telecommunications network, and lower prices*". Thus, access to high-speed broadband infrastructure and services plays a vital role towards achieving the United Nations' Sustainable Development Goals (SDG), more specifically SDG 9 [2],[3] which aims at building quality resilient infrastructure for the promotion of inclusive and sustainable industrialization. Despite its importance in improving the quality of lives of the people, universal access to broadband internet remains a challenge, especially in developing countries and rural areas.

It is a well-known fact that basic mobile network infrastructure (such as the second generation or 2G technology) covers most of the population. For instance, a report by ICASA showed that 2G provides coverage to 100% population of the South African population [4]. However, the deployment of broadband mobile technologies such as 4G and

5G is concentrated in urban and densely populated areas which are characterised by high average revenue per user (ARPU), leaving out the rural and sparsely populated areas.

The 2021 statistics by the International Telecommunications Union (ITU) show that only 63% of the global population uses the internet, and in Africa, the total population of internet users was 33% [5]. Moreover, the number of internet users in urban areas was reported to be twice as high as in rural areas. Such broadband disparities between developed and developing countries, as well as between urban and rural areas, contribute to what is generally referred to as the "digital divide".

Efforts to bridge the digital divide formed part of the ITU Development Bureau's 2022 World Telecommunication Development Conference (WTDC-22) under Resolution 37 (which is titled: "Bridging the digital divide") [6]. This resolution recognised the following, among others, as the major factors in the growing digital divide gap:

(a) The unaffordability of broadband services and devices,
(b) lack of digital skills and,
(c) inequality "in the technical and economic availability of telecommunication/ICT facilities and services", or lack of access to broadband infrastructure.

We argue that finding sustainable solutions to the above three factors promises to significantly contribute toward narrowing the digital divide gap, which persists to grow in developing countries.

The purpose of this paper is to highlight the importance of bridging the digital divide in developing countries by considering locally based solutions and innovative business models. The main objective of the paper is to propose innovative solutions to address the digital divide, mainly focusing on the access divide. We argue that the advancements in technology, such as the software-defined radio, open radio access networks (RAN), and network slicing techniques should be leveraged to accelerate the process of bridging the digital divide. We describe the two types of the digital divide (access and usage divide) and propose technical interventions to address the access divide (i.e. solutions to bringing broadband infrastructure to those who are not connected). Interventions on how to address the usage divide (i.e. digital illiteracy and unaffordability issues) are beyond the scope of this paper.

The remainder of this paper is presented as follows. Section 2 discusses the digital divide, mainly the two types of the digital divide. Section 3 presents the related work. The technical interventions for bridging the digital divide are discussed in Section 4. Section 5 concludes the paper with some proposed further work.

2. Understanding the digital divide

The digital divide is defined as "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities" [7]. To address the digital divide problem, it is therefore important to understand the barriers or factors that contribute to the existing or even growing digital divide gap between rural and urban areas. Figure 1 provides an illustration of the digital divide gap.

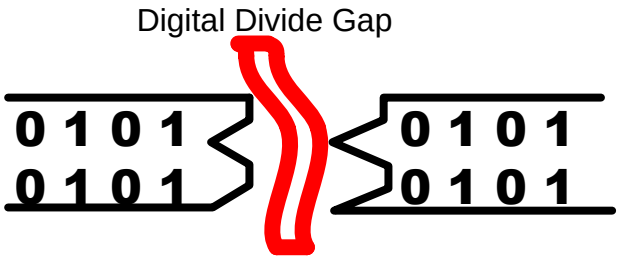

Figure 1: Illustration of the digital divide gap. The size of the gap depends on the geographical location and a number of factors such as the types of the digital divide (source: drawn by the author)

2.1 Types of Digital Divide

We broadly classify the three major factors fuelling the growing digital divide gap (discussed in Section 1) into two types of digital divide:

a) **The access divide**: refers to inequality "in the technical and economic availability of telecommunication/ICT facilities and services", or lack of access to broadband infrastructure. The access divide refers to the gap between those who can access and those who cannot access broadband services. It is driven by a lack of broadband infrastructure in areas where people are living. It can be viewed as the primary digital divide between urban and rural areas in South Africa.
b) T**he usage divide**: it is due to the lack of digital skills (also known as digital illiteracy) and the unaffordability of broadband services and devices. The usage divide refers to a gap between those who use and do not use broadband services and applications. Other than a lack of digital skills to use broadband or digital services, some studies found other factors such as unwillingness to use broadband services. This gap can be viewed as the secondary digital divide because the population already has broadband coverage (infrastructure). Therefore, addressing this gap may require policy and regulatory interventions and other interventions (such as skills development and digital literacy).

2.1.1 Unaffordability Issues

The unaffordability of broadband services is one of the usage divides that affects communities in both rural and township areas. However, rural communities turn to suffer the most in both the access and usage divide. For instance, unlike most townships, many rural areas fall outside the mobile broadband coverage [4].

The first affordability challenge relates to the digital **end-user devices** used to access the internet. Most of the townships in South Africa (especially the bigger townships within the metros) have access to high-speed or broadband mobile coverage such as 4G and 5G. Furthermore, most households in these townships are located within hundreds of meters from the nearest fibre point of presence (PoP). However, the high cost of having smartphones capable of accessing recent mobile network technologies such as 5G becomes the main challenge. This means users from these areas do not experience an access divide, but a usage divide.

The second affordability challenge relates to the high **cost of data**. In this case, users may have the correct device, but the cost of data bundles or post-paid contracts is high and unaffordable. In this case, users may afford limited mobile data bundles per month (e.g. 1 GB bundle that expires after 30 days). As a result, they would preserve the data bundle and

only use it for what they deem to be crucial services, which limits their broadband usage unless they move to areas where there is a public and free Wi-Fi hotspot.

2.1.2 Summary of Digital Divide

A holistic approach to addressing the digital divide is to understand that the **digital divide = access divide + usage divide.** Thus, the digital divide consists of the number of people living in areas where there is broadband infrastructure and services *plus* the number of people who do not subscribe (or use) broadband services. From the business development perspective, the access divide represents the supply gap (i.e. the market to be supplied with broadband infrastructure), while the usage divide represents the market demand gap.

3. Related Work

Work focusing on bridging the digital divide is not new. It has been reported in [8] that the term "digital divide" was first introduced in 1995. A significant amount of research work aimed at closing the digital divide in developed countries dominated the literature from the late 1990s to early 2002. While some developed countries may have managed to reduce the access gap, more efforts are still required to bridge the digital divide, especially in developing and least-developed countries. In their study on the digital divide challenges in the United States of America and Europe (specifically in the Netherlands), van Dijk and Hacker [9] found that there are four types of barriers to access:

(a) No possession of computers and network connections,
(b) Lack of elementary digital experience caused by lack of interest, computer anxiety, and unattractiveness of the new technology,
(c) Lack of digital skills caused by insufficient user-friendliness and inadequate education or social support, and
(d) Lack of significant usage opportunities.

For over a decade now, the digital divide in terms of access to broadband connectivity and end-user devices has been narrowed and sort of negligible in developed countries [9]. However, the same cannot be said for developing countries, where the gap seems to be growing instead of narrowing [6]. Lembani et al [10] explored the negative impact of the access divide on students in accessing higher education and distance learning. It was found that "students with poor ICT access" in rural areas are experiencing a "significantly different educational experience" when compared to those from urban areas.

Olwal et al [11] argued that an all-inclusive ICT penetration, especially in Southern African countries will require the development and implementation of liberal ICT policies. For example, regulators should explore a paradigm shift from static spectrum regulation to more dynamic spectrum management, which promotes sharing of the radio frequency spectrum among different operators.

In their study on the digital divide in South Africa, Bornman [12] found that cultural and social dynamics could also contribute towards the digital divide. Therefore, it is important to consider such dynamics when deploying and providing broadband infrastructure and services to some communities. Such may be achieved through community engagements and awareness campaigns about benefits of the ICT and how can it improve the lives of community members (e.g. through job creation and digital entrepreneurial opportunities).

4. Technical Interventions to bridge the access divide

This section discusses the proposed or available interventions towards addressing the broadband access divide challenges. The realisation of these interventions will require political will, especially from the policymakers and regulators, if the current status quo is to be challenged.

4.1 Reusing 2G and 3G infrastructure

One good success story by mobile operators across many developing countries is that they were able to deploy a second-generation (2G) cellular network that covers almost 100% of the population. Unfortunately, the 2G and 3G cellular networks are not capable of providing meaningful and reliable broadband access (i.e. they were meant for voice telephony and basic text services such as short message service – SMS and Multi-Media services - MMS). As a result, there are efforts from both the policymakers and some mobile network operators (MNOs) to switch off 2G and 3G networks to re-use the spectrum for advanced mobile generations such as 4G, 5G and beyond.

The 2G and 3G networks switch-off create an opportunity for MNOs to fast-track the deployment of 5G networks making use of the existing infrastructure. With the availability of sub-1 GHz spectrum (700 and 800 MHz band), MNOs are expected to contribute significantly towards bridging the digital divide in rural areas [13].

4.2 Open Radio Access Network

Open radio access network (RAN) refers to the disaggregation, virtualisation and softwarisation of interconnected components through open and standardized interfaces which are interoperable across different vendors [14]. We believe that by embracing the Open RAN concept, new and cost-effective business models to connect the unconnected using mobile networks can be explored. Benefits of Open RAN include:

- Support migration from integrated single-vendor systems to more modular and open platforms.
- Lowering the barrier cost for new entrants into the telecommunications sector.
- Enable the development of cost-efficient solutions to provide wireless broadband to rural & marginalised communities.
- Promoting vendor diversity and ecosystem.
- Support the competitiveness of locally based enterprises.

The use of Open RAN is also promoted at the ITU level through Resolution 139 (Bucharest, 2022) [1]which invites all member states & sector members "*to foster an enabling environment for disaggregated, open and interoperable network technologies, such as* ***Open RAN*** *and others, and to promote reliable and interoperable broadband access at affordable cost*". The ITU WTDC-22 Resolution 37 [6] also encouraged member states to host workshops and capacity-building activities on Open RAN. While Open RAN may still be in its infancy, we would like to encourage the ITU member states to actively participate in regional and international initiatives towards promoting the use of Open RAN. Indeed, Open RAN promises to bring about reliable, interoperable meaningful broadband access to all in the most cost-effective way.

[1] ITU Plenipotentiary 2022 Final Acts, https://www.itu.int/dms_ties/itu-s/md/22/pp/c/S22-PP-C-0202!!PDF-E.pdf

4.3 Community Networks

Community networks refer to the establishment, installation, operation and maintenance of the telecommunication infrastructure by some of the community to meet their own communication needs [15]. In most cases, the community's needs for ICT services are identified by one of the community members, who then plants such seed in a small group of community members who will work on the initiative as volunteers. Then external funding and expertise are brought in to work with the community volunteers to realise the establishment and deployment of the community networks [16].

For many years, community networks have played an important role in bridging the digital divide, especially in rural and remote areas [15][16]. However, one of the weaknesses of most community networks is that they are unstructured and lack financial support to scale and remain sustainable. With sufficient support and sustainable structures, community networks can address both the access divide and the usage divide. For example, communities may have localised skills development, encourage and motivate community members to use the ICT as a result of local content, and keep the cost of accessing broadband extremely low or in some cases, free of charge. Innovative business models should be developed to ensure the sustainability of the community networks. At the end of the day, skilled community members involved in the operationalisation and maintenance of the community networks should be able to put food on the table.

4.4 Television White Space Networks

The television white space (TVWS) refers to the portions of unused radio frequency spectrum on the ultra-high frequency (UHF) band, more specifically frequencies between 470 and 690 MHz. Due to their favourable propagation characteristics, TVWS networks have been explored and successfully used to provide wireless broadband connectivity in rural and underserved areas [17]. New regulations authorising the use of TVWS technology for broadband access already exist in many African countries such as Malawi, Ghana, Kenya and South Africa[2]. While the TVWS technology may be considered new, we are already seeing new and improved TVWS devices coming into the market with better throughput performance.

Figure 2 illustrates how a TVWS network can be deployed to connect rural areas in the most cost-effective way. The fact that TVWS utilises the sub-1GHz bands means that signals can propagate longer, and as such, many nearby villages can be connected using one (macro) base station compared to several base stations required when using frequencies above 2 GHz. A spectrum database is mandated by some regulatory authorities as a tool to manage interference by assigning available channels (white spaces) for use by TVWS networks.

[2] https://www.icasa.org.za/legislation-and-regulations/regulations-on-the-use-of-television-white-spaces-2018

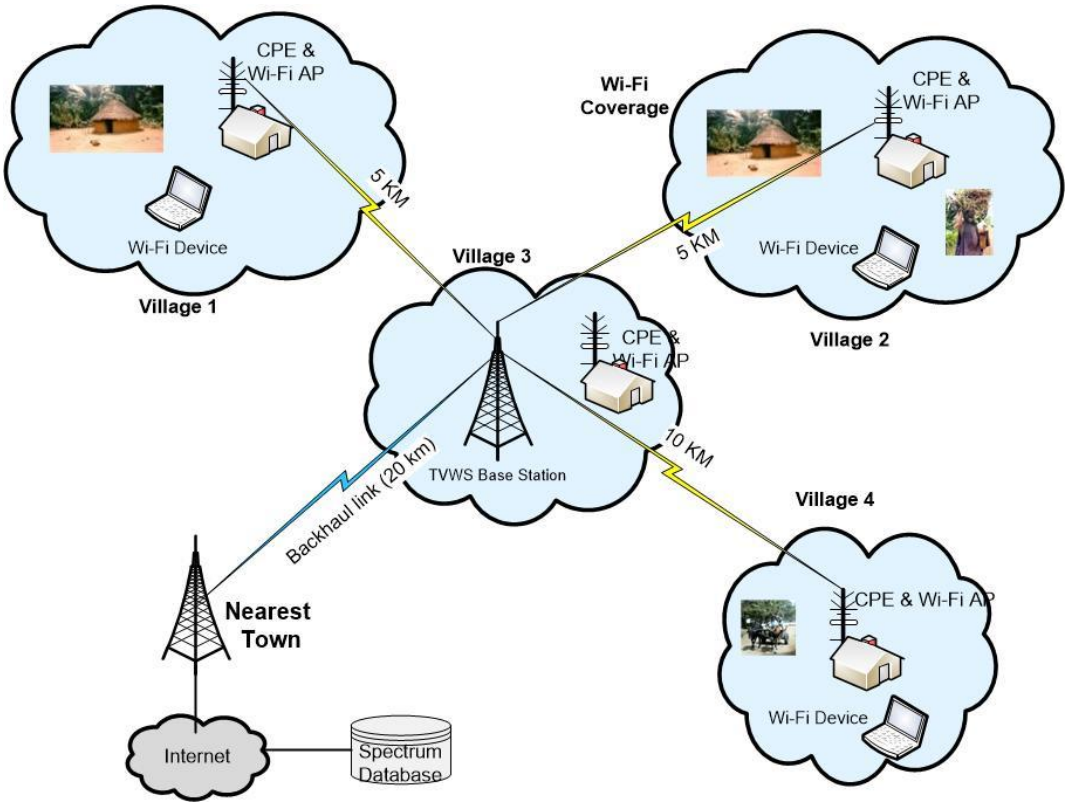

Figure 2: Illustration of a TVWS network. A centralised base station is used to provide point-to-multipoint links using the TVWS spectrum. Each village is then connected to the base station through the customer premises equipment (CPE). This diagram reflects one of the actual TVWS network deployment in the rural areas (Source: drawn by the author)

5. Conclusions and Recommendations

Access to meaningful and reliable broadband is crucial for inclusive participation in the digital economy as well as the realisation of the digital transformation. Despite this reality, more than a third of the global population is still excluded from participation in the digital economy due to the lack of access to broadband as well as the inability to use broadband services and applications.

In this paper, we highlighted the importance of bridging the digital divide in developing regions by discussing the two types of the digital divide and exploring several technical interventions that could be used to improve access to broadband infrastructure. These technical interventions include the reuse of 2G and 3G infrastructure, exploring Open RAN for 5G (and beyond) in rural areas, deployment of sustainable community networks and the use of TVWS technology. The realisation of these interventions will require some level of partnership between the public and private sectors, as well as the involvement of the affected communities. There are several initiatives happening or in planned in South Africa to test the interventions discussed in this paper. Some of the results will form part of our future work and disseminations.

It is recommended that policymakers and regulatory agencies in the ICT space should create an enabling environment for community owned networks to flourish, especially in rural areas. Issues of radio frequency spectrum should be looked at, for example – dedicating portions of the spectrum for community networks free from licensee fees. Moreover, partnerships among the business schools or business sector (e.g. large mobile network operators) and communities are encouraged for skills development as well as the new innovative business models.

Interventions on the usage divide (which include digital illiteracy and unaffordability) are outside the scope of this paper. Further work will include an analysis of solutions to address the usage divide in developing areas. A study on the early results of some of the already implemented interventions is also encouraged.

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