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Innovative telecommunications strategies for bridging digital inequities: A framework for empowering underserved communities

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Abstract

This paper explores innovative telecommunications strategies to bridge digital inequities and empower underserved communities. It highlights the transformative potential of emerging technologies such as 5G, satellite internet, and mesh networks in providing high-speed connectivity to remote and underserved regions. The study underscores the critical importance of affordability and accessibility in promoting digital inclusion, advocating for subsidies, financial assistance, and innovative pricing models to reduce the financial burden on low-income households. Public-private partnerships (PPPs) are identified as pivotal in pooling resources, expertise, and infrastructure to drive digital inclusion efforts. Furthermore, the paper emphasizes the significance of community engagement and capacity-building initiatives to ensure sustainable digital inclusion, advocating for tailored digital literacy programs and technical training. Policy recommendations focus on creating supportive regulatory environments, streamlining approval processes, and protecting data privacy and security. The paper concludes by outlining practical recommendations for policymakers, industry stakeholders, and community leaders, aiming to foster a more inclusive digital landscape and unlock socio-economic benefits for all.

Keywords: Digital Inclusion; Telecommunications Strategies; 5G Technology; Satellite Internet; Public-Private Partnerships; Community Engagement

1. Introduction

1.1. Overview of Digital Inequities and Their Impact on Underserved Communities

Digital inequities refer to the disparities in access to, use of, or knowledge about information and communication technologies (ICTs) between different populations. These inequities are starkly evident in underserved communities, which include rural areas, low-income households, and marginalized groups (Helsper, 2021). The digital divide manifests in various ways: limited or no internet access, insufficient digital literacy, and lack of affordable digital devices. The consequences of digital inequities are profound, affecting education, employment, healthcare, and social inclusion (Robinson et al., 2020). For instance, students in underserved communities often struggle with remote learning due to inadequate internet access and insufficient digital tools. This gap exacerbates educational disparities, leading to lower academic performance and reduced future opportunities (Hsieh, Rai, & Keil, 2011).

In the job market, individuals without reliable internet or digital skills are disadvantaged, facing job search difficulties, skill development, and remote work opportunities. Healthcare access is also compromised, as telemedicine services, which became crucial during the COVID-19 pandemic, remain inaccessible to many in digitally underserved areas. Socially, the lack of connectivity isolates individuals from digital social networks and vital information, hindering community engagement and support systems (Vasilescu, Serban, Dimian, Aceleanu, & Picatoste, 2020).

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1.2. Importance of Innovative Telecommunications Strategies

Addressing digital inequities requires innovative telecommunications strategies that extend beyond traditional infrastructure solutions. These strategies encompass a range of technologies and approaches designed to make internet access more affordable, reliable, and widespread. Innovations in telecommunications can bridge the digital divide by bringing connectivity to the most remote and underserved areas, thereby fostering greater social and economic inclusion.

One key innovation is the deployment of 5G networks, which offer higher speeds, lower latency, and the capacity to connect a multitude of devices simultaneously. 5G can revolutionize internet access in underserved areas, providing the bandwidth needed for educational resources, telehealth services, and remote work capabilities (Akyildiz, Nie, Lin, & Chandrasekaran, 2016). Satellite internet is another transformative technology, capable of delivering high-speed internet to rural and remote regions where traditional broadband infrastructure is lacking. Companies like SpaceX's Starlink are pioneering low Earth orbit (LEO) satellite constellations to provide global internet coverage (Minoli, 2015).

Community-based solutions such as mesh networks and public Wi-Fi initiatives are also vital. Mesh networks, which consist of interconnected nodes that share internet access, can be deployed in communities to create localized, resilient internet networks. Public Wi-Fi projects, supported by governments and private entities, can provide free or low-cost internet access in public spaces, enhancing digital inclusion (Greig, 2018).

1.3. Objectives and Scope of the Paper

This paper aims to explore and propose innovative telecommunications strategies that can bridge digital inequities and empower underserved communities. By examining current digital inequities and their impacts, identifying emerging telecommunications technologies, and developing a comprehensive framework, this paper seeks to provide practical recommendations for policymakers, industry stakeholders, and community leaders.

The scope of the paper includes a detailed analysis of the current state of digital inequities, focusing on the factors that contribute to the digital divide and the specific challenges faced by underserved communities. It will review a range of innovative telecommunications technologies and strategies, evaluating their potential to enhance digital access and inclusion. The paper will then propose a framework for implementing these strategies, considering policy, regulatory, and community engagement aspects.

Ultimately, this paper aims to highlight the critical role of telecommunications in fostering digital equity and provide actionable insights that can guide efforts to bridge the digital divide. By empowering underserved communities through improved digital access, we can unlock opportunities for education, employment, healthcare, and social participation, contributing to overall societal development and economic growth. The findings and recommendations presented in this paper are intended to inform and inspire initiatives to reduce digital inequities and promote inclusive connectivity. As the world becomes increasingly digital, ensuring that all communities have equal access to the benefits of the internet is not just a technological imperative but a moral and economic one. Through innovative telecommunications strategies, we can create a more equitable digital landscape, where everyone has the opportunity to thrive in the digital age.

2. Current State of Digital Inequities

2.1. Analysis of the Digital Divide in Various Regions and Demographics

The digital divide, the gap between those with access to modern information and communication technology and those without, remains a significant challenge globally. This divide manifests across various regions and demographics, often leaving rural areas, low-income households, and marginalized communities at a severe disadvantage (James, 2003). For instance, internet penetration rates remain alarmingly low in many developing countries. According to the International Telecommunication Union (ITU), as of 2022, nearly 3 billion people worldwide still do not have access to the internet, with the majority residing in Asia-Pacific and Sub-Saharan Africa (Casetti, 2022). Even within developed countries, rural and remote areas often experience lower connectivity compared to urban centers. In the United States, the Federal Communications Commission (FCC) reports that nearly 30 million Americans lack high-speed broadband access, primarily in rural regions (Crawford, 2011).

Demographically, the digital divide affects various groups differently. Older adults, individuals with disabilities, and minority communities often face greater barriers to digital inclusion (Newman, Browne-Yung, Raghavendra, Wood, & Grace, 2017). For example, elderly populations may lack the digital literacy required to navigate the internet effectively, while persons with disabilities might encounter inaccessible digital content and platforms. Socioeconomic factors also

play a significant role, making low-income households less likely to afford internet services or digital devices. This disparity in access and usage further entrenches existing social and economic inequalities, perpetuating a cycle of disadvantage for those on the wrong side of the digital divide (Yardi & Bruckman, 2012).

2.2. Factors Contributing to Digital Inequities

Several interrelated factors contribute to digital inequities, encompassing economic, social, and geographical dimensions. Economically, the cost of internet access and digital devices is a primary barrier. In many low-income households, the expense of maintaining a broadband connection or purchasing computers and smartphones competes with other essential needs such as food, housing, and healthcare. This financial strain limits the ability of these households to participate fully in the digital world (Reddick, Enriquez, Harris, & Sharma, 2020).

Social factors, including education and digital literacy, also contribute significantly to digital inequities. Individuals with lower educational attainment are less likely to possess the skills necessary to use digital technologies effectively. This lack of digital literacy impedes their ability to engage with online resources for education, employment, and social interaction. Furthermore, cultural and linguistic differences can hinder access to digital content, which is often predominantly in English and not tailored to diverse cultural contexts (Hargittai, Piper, & Morris, 2019).

Geographically, rural and remote areas face unique challenges in achieving digital equity. The sparse population density in these regions makes the deployment of telecommunications infrastructure less economically viable for service providers. As a result, rural communities often suffer from slower internet speeds, limited service options, and higher costs compared to urban areas. Physical terrain and environmental conditions can further complicate the infrastructure deployment, exacerbating the digital divide (Chaoub et al., 2021).

While extensive in many parts of the world, the existing telecommunications infrastructure has notable limitations that hinder efforts to bridge digital inequities. Traditional wired broadband, including Digital Subscriber Line (DSL) and cable internet, remains the primary connectivity in many regions. However, the deployment of these networks is expensive and time-consuming, particularly in rural and remote areas where the return on investment is low. Consequently, these areas often rely on outdated infrastructure that cannot support modern broadband speeds, leaving residents with subpar internet access (Gorshe, Raghavan, Starr, & Galli, 2014).

Wireless technologies, including 4G and emerging 5G networks, offer potential solutions to these limitations but are not without their challenges. While 4G networks have significantly expanded mobile internet access, they are often concentrated in urban and suburban areas, with rural coverage remaining sparse and inconsistent (Akpakwu, Silva, Hancke, & Abu-Mahfouz, 2017). 5G technology promises faster speeds and lower latency, but its rollout is still in the early stages and primarily focused on urban centers. The high-frequency spectrum used by 5G requires a dense network of base stations, which is challenging to implement in less populated areas (Khanh, Hoai, Manh, Le, & Jeon, 2022).

Satellite internet presents an alternative, particularly for remote regions with impractical terrestrial infrastructure. Companies like SpaceX's Starlink and OneWeb are developing low Earth orbit (LEO) satellite constellations to provide global internet coverage. While these systems show promise, they currently face challenges related to latency, cost, and the need for ground-based receiving equipment. Moreover, satellite internet services' scalability and long-term sustainability remain areas of ongoing research and development (Kodheli et al., 2020).

In addition to these technological limitations, policy and regulatory challenges also impact the effectiveness of telecommunications infrastructure. In many countries, regulatory frameworks have not kept pace with technological advancements, resulting in outdated policies that hinder innovation and investment in new infrastructure. There is also a need for greater collaboration between public and private sectors to address the financial and logistical challenges of expanding digital connectivity to underserved areas.

3. Innovative Telecommunications Strategies

3.1. Exploration of New and Emerging Telecommunications Technologies

Innovative telecommunications technologies hold the key to bridging digital inequities and bringing the benefits of the internet to underserved communities. Among these technologies, 5G, satellite internet, and mesh networks are transformative solutions. 5G technology represents the next generation of mobile internet connectivity, offering significantly faster speeds, lower latency, and the ability to connect a vast number of devices simultaneously (Chaoub et al., 2021). This leap in performance is crucial for enabling advanced applications such as remote healthcare, online

education, and smart agriculture, which can significantly benefit underserved communities. The widespread deployment of 5G can enhance connectivity in urban areas and extend high-speed internet to rural and remote regions where traditional broadband infrastructure is impractical. However, the rollout of 5G faces challenges, including the high cost of infrastructure development and the need for a dense network of base stations, particularly in sparsely populated areas (Hambly & Rajabiun, 2021).

Satellite internet is another promising technology, particularly for remote and rural regions. Traditional satellite internet has been limited by high latency and variable speeds, but advancements in low Earth orbit (LEO) satellite constellations are changing the landscape. Companies like SpaceX's Starlink and Amazon's Project Kuiper are deploying thousands of small satellites to provide global internet coverage (Logue & Pelton, 2019). LEO satellites orbit closer to Earth than traditional satellites, reducing latency and improving internet speeds. These systems can deliver high-speed internet to areas that are difficult to reach with terrestrial infrastructure, offering a viable solution for connecting the unconnected (Kua, Loke, Arora, Fernando, & Ranaweera, 2021).

Mesh networks are another innovative approach to expanding internet access. Unlike traditional networks that rely on a central hub, mesh networks consist of multiple nodes communicating with each other to share an internet connection. This decentralized structure makes mesh networks resilient and scalable, ideal for community-based solutions. Mesh networks can be set up in urban slums, refugee camps, and rural villages, providing reliable internet access without the need for extensive infrastructure. They can also support local content and services, empowering communities to create and share information relevant to their needs (Cilfone, Davoli, Belli, & Ferrari, 2019).

3.2. Strategies for Affordable and Accessible Internet Connectivity

While new technologies are essential, strategies to make internet connectivity affordable and accessible are equally crucial. Cost remains a significant barrier for many underserved communities, necessitating innovative approaches to reduce expenses and enhance accessibility.

Subsidies and financial assistance programs are effective strategies to make internet access more affordable. Governments can subsidize low-income households to help cover the cost of internet subscriptions and digital devices. These programs can be funded through universal service funds, which collect fees from telecommunications providers to support the expansion of connectivity in underserved areas. Additionally, targeted subsidies for educational institutions, healthcare facilities, and small businesses can enhance digital inclusion by ensuring these critical services have reliable internet access (Hamilton & Morgan, 2018).

Community networks, often established and maintained by local residents, offer a grassroots solution to digital inequities. These networks leverage local knowledge and resources to build and operate internet infrastructure tailored to the community's specific needs. Community networks can reduce costs through shared infrastructure and volunteer labor, making internet access more affordable. They also promote digital literacy and community engagement, fostering a sense of ownership and empowerment among users (Tim, Cui, & Sheng, 2021).

Innovative business models can also drive affordability and accessibility. For example, zero-rating initiatives allow users to access certain websites and applications without consuming their data allowance. This model can be particularly beneficial for accessing essential services like education, healthcare, and government information. Additionally, prepaid internet plans and pay-as-you-go models provide flexible and cost-effective options for users with limited financial resources, enabling them to manage their internet usage according to their budget (Romanosky & Chetty, 2018).

3.3. Role of Public-Private Partnerships in Implementing These Strategies

Public-private partnerships (PPPs) are critical in addressing digital inequities, leveraging the strengths of both sectors to expand internet access and enhance digital inclusion. These partnerships can pool resources, expertise, and infrastructure to implement innovative telecommunications strategies effectively. Governments play a pivotal role in creating an enabling environment for PPPs. This includes developing supportive policies and regulations, providing financial incentives, and facilitating stakeholder collaboration. For example, governments can offer tax breaks or grants to private companies that invest in expanding internet infrastructure in underserved areas. They can also streamline regulatory processes to reduce the time and cost of deploying new technologies.

Private sector companies bring innovation, technical expertise, and investment capacity to PPPs. Telecommunications providers, technology companies, and internet service providers (ISPs) can collaborate with governments to design and implement projects that extend connectivity to underserved communities. These companies can also contribute by developing affordable and scalable solutions tailored to the needs of low-income users. For instance, partnerships

between ISPs and tech companies can result in low-cost devices bundled with internet services, making it easier for underserved populations to get online (Delmon, 2021).

Non-governmental organizations (NGOs) and community groups are essential partners in PPPs, providing on-the-ground knowledge and ensuring that projects align with the needs and priorities of their communities. NGOs can facilitate community engagement, provide digital literacy training, and support the maintenance and operation of community networks. They can also advocate for the needs of underserved communities, ensuring that their voices are heard in policy discussions and project planning (Marx, 2019).

4. Framework for Empowering Underserved Communities

4.1. Development of a Comprehensive Framework Integrating Innovative Telecommunications Strategies

Empowering underserved communities through digital inclusion requires a holistic and strategic framework integrating innovative telecommunications technologies. This framework should encompass the deployment of advanced infrastructure, the promotion of affordable and accessible internet services, and the creation of supportive environments for digital literacy and engagement.

The first component of the framework is the deployment of advanced telecommunications infrastructure. This includes leveraging 5G networks to provide high-speed internet access in urban and rural areas alike. The high bandwidth and low latency of 5G can support various applications critical to community development, such as telemedicine, online education, and smart agriculture. Satellite internet, particularly through low Earth orbit (LEO) constellations, can extend connectivity to remote and hard-to-reach areas where traditional infrastructure is not feasible. Mesh networks, with their decentralized nature, can provide resilient and scalable internet access, especially in community settings.

The second component involves strategies to ensure that internet access is affordable and inclusive. Governments and private sector stakeholders must collaborate to offer subsidies and financial assistance to low-income households. Innovative pricing models, such as pay-as-you-go and zero-rating for essential services, can also make internet access more financially accessible. Community networks, operated and maintained by residents, can provide cost-effective and locally tailored connectivity solutions.

4.2. Policy Recommendations and Regulatory Considerations

Effective policy and regulatory frameworks are essential to support the deployment and sustainability of innovative telecommunications strategies. Governments should prioritize digital inclusion in their national agendas, recognizing it as a critical component of socio-economic development.

Regulatory bodies must create an enabling environment for rapidly deploying new technologies. This includes streamlining the approval processes for 5G and satellite infrastructure, ensuring that spectrum allocation is efficient and fair, and providing incentives for private sector investment in underserved areas. Policies should also address the affordability of internet services by regulating pricing practices and promoting competition among service providers to drive down costs.

Data privacy and security are also crucial considerations. As more communities come online, protecting users' data and ensuring secure internet access become paramount. Regulations must enforce stringent data protection standards and promote cybersecurity awareness among new internet users.

4.3. Community Engagement and Capacity-Building Initiatives

Community engagement is a cornerstone of any successful digital inclusion strategy. Empowering underserved communities requires providing access to technology and ensuring that individuals have the skills and knowledge to use it effectively. Capacity-building initiatives should focus on digital literacy, technical training, and ongoing support.

Digital literacy programs should be tailored to the needs of different demographics within the community, including children, adults, and the elderly. These programs can be delivered through schools, community centers, and online platforms. Partnerships with local organizations and NGOs can help to design and implement training that is culturally relevant and accessible.

Technical training initiatives should build local expertise in maintaining and operating telecommunications infrastructure. This ensures the projects' sustainability, creates job opportunities, and fosters local economic development. Community members trained in ICT (information and communication technology) can serve as digital champions, helping to troubleshoot issues and promote digital inclusion within their communities. Ongoing support mechanisms, such as help desks and online forums, are essential to address any challenges that arise as new users navigate the digital world. Peer support networks can also be effective, where more experienced users assist others in the community.

4.4. Potential Socio-Economic Benefits and Expected Outcomes

The socio-economic benefits of bridging digital inequities are substantial and multifaceted. Improved internet access can transform underserved communities' education, healthcare, economic opportunities, and social engagement. In education, digital inclusion enables access to many online resources and learning platforms. Students in remote areas can participate in virtual classrooms, access digital libraries, and benefit from online tutoring. This can significantly enhance educational outcomes and open up new opportunities for higher education and skills development.

Healthcare delivery can be revolutionized through telemedicine, allowing patients in remote locations to consult with specialists, receive diagnoses, and manage chronic conditions without traveling. This improves health outcomes and reduces the burden on often overstretched local healthcare facilities.

Economic opportunities expand as individuals and businesses access online markets, financial services, and digital tools. Small businesses can reach a broader customer base, utilize e-commerce platforms, and access digital marketing strategies. Employment opportunities in the digital economy, including remote work and gig economy jobs, become accessible to residents of underserved areas.

Social engagement and community cohesion are also enhanced through digital inclusion. Social media platforms, online forums, and community websites enable residents to connect, share information, and organize local initiatives. This can strengthen community bonds and foster a sense of collective identity and empowerment.

5. Conclusion

The exploration of innovative telecommunications strategies to bridge digital inequities has revealed significant opportunities and challenges. One of the key findings is the transformative potential of emerging technologies like 5G, satellite internet, and mesh networks in expanding internet access to underserved communities. These technologies offer robust solutions that can overcome geographical and infrastructural barriers, providing high-speed connectivity in areas where traditional broadband infrastructure is not feasible. The deployment of such advanced telecommunications infrastructure is essential for enabling critical services such as telemedicine, online education, and digital commerce, which can significantly enhance the quality of life in underserved areas.

Another critical insight is the importance of affordability and accessibility in promoting digital inclusion. While advanced technologies are crucial, their benefits cannot be fully realized without strategies to make internet access affordable. Subsidies, financial assistance programs, and innovative pricing models are necessary to reduce the financial burden on low-income households. Community networks also emerge as a viable solution, leveraging local knowledge and resources to provide cost-effective and tailored connectivity.

Public-private partnerships are highlighted as a pivotal element in implementing these strategies. Effective collaboration between governments, private companies, and non-governmental organizations can pool resources, expertise, and infrastructure, creating a supportive environment for digital inclusion. Such partnerships can drive investment, streamline regulatory processes, and ensure that the specific needs of underserved communities are addressed.

Lastly, the paper emphasizes the significance of community engagement and capacity-building initiatives. Empowering communities with digital literacy and technical skills is crucial for sustaining digital inclusion efforts. Training programs tailored to various demographics, technical training for local maintenance, and ongoing support mechanisms are essential components of a comprehensive digital inclusion strategy.

Recommendations

Practical recommendations are proposed for policymakers, industry stakeholders, and community leaders to translate these insights into actionable steps. Policymakers should prioritize digital inclusion as part of their national development agendas by developing comprehensive policies that support the deployment of advanced telecommunications infrastructure, promote affordability, and protect data privacy and security. Additionally, financial assistance programs are crucial for making internet access affordable. Governments should offer subsidies to low-income households and educational institutions to cover the cost of internet subscriptions and digital devices, utilizing universal service funds to minimize financial barriers. Simplifying regulatory approval processes for telecommunications infrastructure can accelerate the deployment of new technologies, reducing bureaucratic hurdles and providing clear guidelines for installing 5G base stations and satellite internet systems.

Industry stakeholders, including telecommunications companies and technology firms, should invest in developing and deploying advanced technologies such as 5G, LEO satellites, and mesh networks. These investments are essential for expanding connectivity to underserved areas and ensuring the latest innovations are accessible to all. Furthermore, public-private partnerships are vital for successful digital inclusion efforts. Industry stakeholders should collaborate with governments and NGOs to design and implement projects that extend internet access, leveraging the strengths of each partner to combine technological expertise, financial resources, and local knowledge. Adopting flexible pricing models, such as zero-rating for essential services and pay-as-you-go internet plans, can make internet access more affordable and cater to the financial constraints of underserved populations.

Community leaders are crucial in fostering digital literacy and technical skills within their communities. They should advocate for and facilitate digital literacy programs tailored to the needs of their communities, including basic digital skills, technical training for maintaining local networks, and ongoing support mechanisms. Encouraging establishing and operating community networks can provide cost-effective and locally tailored solutions to digital inequities. Community leaders should support these initiatives by mobilizing local resources, fostering community engagement, and advocating for necessary regulatory support. By actively participating in advocacy and stakeholder engagement, community leaders can ensure that their communities' specific needs and priorities are represented in policy discussions and project planning, shaping digital inclusion initiatives responsive to local contexts. In conclusion, bridging digital inequities requires a multifaceted approach that integrates advanced telecommunications technologies, affordability strategies, public-private partnerships, and community engagement. By implementing these recommendations, policymakers, industry stakeholders, and community leaders can work together to create a more inclusive digital landscape, ensuring that everyone has the opportunity to participate in and benefit from the digital economy.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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