White Paper

OPTIONS AND CHALLENGES IN PROVIDING UNIVERSAL ACCESS

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EXECUTIVE SUMMARY

Global efforts towards achieving universal Internet access are encouraging, however many obstacles and challenges to providing this commodity for all global citizens still exist. The authors of the following white paper have identified five challenges in providing universal Internet access, positing potential solutions for each. The first challenge is infrastructure, with solutions focused on providing electricity and access in rural areas, options for infrastructure, and choosing types of infrastructure, including wired and wireless networks. The second challenge posited is cost, where solutions seek regulatory authorities to help shape markets to promote competition and ease of connectivity, which should lead to lower cost. The third challenge is digital literacy, where solutions look to localizing language online as a basis to providing digital skills. The fourth challenge is location and availability, where solutions include the use of innovative technologies and trending business models to reach the most remote locations. The final challenge is disinterest, where relevance and personal context are suggested as means to providing personal connections to the value of Internet access.

INTRODUCTION

Universal access to the Internet surpasses geographical and political borders, gender, age, cultures and economies. The Internet's open, interoperable standards reduce barriers to interaction among people, giving rise to flexible options for connecting the human population, both technically and socially. Internet access evolves as the Internet itself evolves. From its humble beginnings as a closed communication network of the U.S. Department of Defense and a number of Universities, to the hub of global communications everywhere from banking to entertainment to commerce, the Internet has grown from a small project to a massive communication network that encompasses so much more than a mere repository of information and communication between nodes. The Internet has opened up new spaces for interaction that transcend traditional borders of citizenship, making way for the advent of the global netizen (i.e. "Internet citizen" or "net citizen"), and allowing new interfaces for interacting with the world around us. Although the Internet's very openness creates several undesirable issues, ranging from political manipulation to cyberhacking, the great societal benefits of the Internet make it imperative to provide access to as many people as possible. Yet, large portions of the world's population still do not have Internet access. This paper examines the challenges and proposes solutions to achieve the goal of universal Internet access and use.

BACKGROUND

The early Internet played a limited role and did not drive real-time, massive flows of information as it does today. It was restricted by limited penetration, a narrow set of applications, low bandwidth, heavy and fixed terminals, the demand for advanced computer skills, and high costs of entry. With the advent of email messaging, the value of the Internet as a communication tool grew, and with the creation of the World Wide Web it grew even more.

The Internet now supports a dazzling array of applications. Many users now take for granted the process of accessing and using the Internet in their daily and routine tasks and are dependent on its functionality, from making phone calls to watching videos to chatting with friends and colleagues on social media to using it for work purposes. These users need not comprehend the underlying infrastructure of such communications or software design, and many users are oblivious to the nature and complexity of the processes involved. Because of easy-to-use interfaces and more and better applications, adoption has increased exponentially.

Rapid population growth is creating global pressures for economic and social development that Information and Communication Technologies (ICTs) can help resolve. Specifically, Internet access is of primary importance to:

1. *Citizens*: The UN Human Rights Council unanimously proclaimed that the basic human rights that people enjoy offline extend to the online realm as well. To fully embrace these rights, people need reliable Internet connections [1].

2. *Education*: Internet use is very important to all levels of education (pre-school through post-doctoral). Students can have access to online learning even if they are far away from their schools. While research via print-based resources is time-consuming and limited by physical access, Internet-based resources are both faster and more varied. Learning how to verify and validate Internet-based information should be part of the training for Internet use.

3. *Government Information and Services*: Internet access plays a significant role in politics and government functions by facilitating discourse, information, and access to services. The UN defines e-government as "the utilization of the Internet and the world-wide-web for delivering government information and services to the citizens [1]." E-government increases the government functions' transparency and allows citizens to interact with legislators to make timely contributions to the decisions that affect them.

4. *Healthcare*: The Internet is a useful communication tool between patients and their health providers, especially in emergency cases [2]. Also, Internet access potentially allows health care providers to monitor their patients' activities. Internet access could also be used to provide health care in hard to reach areas that currently lack this very valuable necessity.

5. *Social Impact*: Internet inclusion is the cornerstone of connecting people (professional and non-professional) using many social networks such as Facebook, Twitter, LinkedIn, and IEEE's Collabratec, reducing barriers to the transmission of information and the connections between people [3]. With that said, social media can be a two-edged sword where manipulation and disinformation via social media can negatively influence and shape culture.

6. *Economy*: Internet inclusion has made economic activities more efficient, faster growing, and less dependent on geographic constraints and limitations [4]. For example, market advertising, GPS-based products delivery, and Internet-based trading are boosting economies significantly.

Accessing the Internet has become a relatively simple technological task for the average individual in developed countries. Accessing the Internet in less-developed countries however is a challenge for many reasons, including lack of infrastructure, limited relevant content in local languages, lack of education and training, regulation and policy unfriendly to technology development and deployment, and high technology costs.

According to data released by the International Telecommunication Union (ITU) on July 22, 2016, around 3.9 billion people, or about half of the world's population have access to, but do not use, the resources available on the Internet. About one-third of the population is offline in the Americas and the Commonwealth of Independent States (CIS) regions. Almost 75% of people in Africa are non-users, and 21% of Europeans are offline. In Asia Pacific and the Arab States, the percentage of the population that is not using the Internet is very similar i.e. 58.1% and 58.4%, respectively [5] [6].

OVERVIEW OF CHALLENGES

The authors of this white paper have identified five significant challenges as barriers and/or obstacles to universal Internet access. These are:

Internet Network Infrastructure:

An appropriate infrastructure is critical to connecting the unconnected. Issues include capital scarcity, availability of electrical power, technology choices, and integration issues. Thus, the concerns addressed focus on providing electricity and access in both urban and rural areas, options for infrastructure, and choosing types of infrastructure.

Cost of Infrastructure and Service:

Cost is a major issue in three areas—infrastructure, Internet service, and user equipment. The capital expenditures associated with delivering infrastructure and services include installing, operating, and troubleshooting for the given infrastructure as well as the administrative costs of running an ISP such as monitoring traffic, and managing customer issues. Regulatory authorities can help shape markets to promote competition and ease of connectivity, thereby reducing costs to both companies and end users. Depending on market structure and regulatory regime, policies may not have the same effect on supply and demand sides. Regulators may also wish to support other values, such as privacy and security, which may increase costs but are important to society.

Universal Education, Digital Literacy, and Content:

Even if the entire global population were able to connect to the Internet, not all people have the expertise and knowledge needed to effectively and efficiently use it. We must ensure that everyone who desires access also possesses the skills needed to use these information and communication technologies. Furthermore, education must be provided to the local populations as to how they can find and produce relevant local content on the Internet. The content must be relevant to their daily lives for them to want to access the Internet. In many parts of the world, most of the Internet is not available in the local population's language and/or dialect, so both the content and the language must reflect local needs in order to be useful.

Location and Availability:

Some remote areas of the globe raise unique and difficult challenges for Internet access. A number of new, innovative communication technologies are emerging that may provide effective solutions. These include airborne technologies such as Low Earth Orbit (LEO) satellites, mobile airborne systems such as drones and balloons, and terrestrial solutions such as fixed-location wireless systems operating across a wide range of frequencies. Policymakers are wise to take into account the inventory of new technology tools when planning network buildouts.

Disinterest:

In light of the four challenges and obstacles listed above, as well as issues of privacy and security, a portion of the global population will still choose not to utilize the Internet. This raises issues of growing digital divides between and among nations, and is less of a technical issue than a policy one. While public policy issues are beyond the scope of this current study, policymakers may wish to survey the literature on adoption programs to learn about approaches that have been successful in similar societies.

The remainder of this paper addresses each challenge area and offers some proposed solutions.

CHALLENGE AND SOLUTION: INTERNET INFRASTRUCTURE

Internet infrastructure involves two distinct types of challenges. Internet access generally requires electricity, which presents a challenge in areas that have not been electrified. Additional factors relevant to specific deployments drive the choice of wired or wireless networks.

ELECTRICITY AND ACCESS IN RURAL AREAS

One of the identified challenges to providing universal access to all is the lack of a reliable and dependable source of electricity for those living in areas of energy poverty. According to the International Energy Agency in 2017 [7], approximately 1.2 billion of the world's population have no access to electricity. Approximately 80% of these live in rural areas. Internet access is difficult but not impossible for this group of the globe's population.

In Central America, Asia, Africa, and other regions and countries that have low electrification rates, one of the solutions to providing these residents with electricity is through the use of renewable energy sources in the form of off-grid or micro-grid electrification systems. The difference between off-grid and micro-grid is the possibility of being connected to the country's traditional infrastructure. A micro-grid system would be able to connect to the traditional electric grid; an off-grid system lacks this electrical connectivity component.

Using solar panels, wind turbines, or geothermal technologies, the off-grid system could provide a source of electricity limited in recurring energy costs for those living in rural and/or remote areas. These systems can be provided by both for-profit and non-profit private organizations as well as public sector agencies. But once the system is in place, connectivity to the network may remain a challenge. If the rural area is geographically located near mobile service coverage, then the residents could use their smartphones to connect to the Internet. Additional technologies, such as Satellites and High Altitude Platform Stations (HAPS) for wireless communications can extend coverage over difficult and expansive terrain.

In some cases, mobile phones were being used prior to the installation of the renewable energy off-grid systems. Where did the electricity come from to recharge the mobile phone batteries? One solution was for one village resident to collect all of the phones and take them to the nearest charging station. This could be several hours away. However, solar-powered keychains are arriving on the market that contain a handheld solar Photo-Voltaic (PV) array, and these

can be used to charge small batteries. With wireless data connections such as 4G LTE or 5G, these residents can be connected to the Internet.

But the best solution to the scarcity of electric power is expansion of the grid itself.

NETWORK TECHNOLOGY OPTIONS

Internet infrastructures can be divided into two main categories: wired and wireless. Wired infrastructures include Digital Subscriber Line (DSL), cable modem, and fiber optic. Wireless technologies include satellites at various altitudes, 3GPP cellular networks, aerial drones and balloons, and fixed wireless networks. Internet infrastructures cover three kinds of population zones, urban, semi-urban, and rural according to conventional demographic analysis [8].

In rural areas, providing basic infrastructure is a financial challenge. Improving efficiency of existing infrastructure is another challenge to incorporate a maximum number of users. User demands increase daily in terms of bandwidth, quality, and reliability needs as new and innovative services proliferate. Infrastructure, on the other hand, is not expanding at the same rate and is one of the challenges in providing universal access.

The existing Internet model consists of two layers: infrastructure platforms and service platforms. In this model, infrastructure is used to lay out the grounds for service providers to offer their services to customers. As the ICT industry has rapidly grown, existing infrastructures have been unable to keep up with increasing bandwidth demands [9]. Thus, they do not have the capacity to incorporate the additional traffic that will be generated by the increased number of users. At the same time, changing the entire infrastructure could prove to be too expensive.

To solve this problem, ICT researchers proposed the concepts of virtual networks, content delivery networks, and small switching centers [10]. Virtual networks lie on top of the existing infrastructure, providing greater opportunities for efficiency, improving security, and handling more diverse traffic requirements. In 5G networks, with the emergence of more stakeholders in the Internet, the service provider is subdivided further into: virtual network providers, virtual network operators, and service providers. Content delivery networks reduce transmission time and cost by staging information close to users. Switching centers – also known as carrier-neutral collation centers or Internet Exchange Points – further reduce time and distance by enabling networks to interconnect at more places.

CHALLENGE AND SOLUTION: COST

Internet access has become an essential utility and an integral part of our lives. However, as mentioned above, more than half of the world population is still offline, and cost is one of the primary reasons for this discrepancy.

BROADBAND PRICES COMPARED TO INCOME

By early 2016, international Internet bandwidth reached 185,000 gigabits per second, up from 30,000 gigabits per second in 2008. But bandwidth is unequally distributed globally. Absence of bandwidth remains a major impediment to improving Internet connectivity in developing and least developed countries. Subscriber entry-level broadband services across the world range from as low as $5 per month to a high of $1,700 per month. However, the range for most countries falls between $5 and $60 per month [11].

Low prices in Russia, Sri Lanka, and India can be at least partly attributed to low labor costs, a high level of competition between the suppliers, and government policies on infrastructure, finance, and licenses aimed at keeping prices low [12]. A total of 12 nations offer broadband prices of $10 or less per month. The least expensive broadband is just $5.5 per month in Sri Lanka. Cuba has by far the most expensive broadband services at around $1,753 per month. The second most expensive broadband is Swaziland, at $875 per month.

The cost of Internet seems to be falling in all parts of the world. Three years ago, the world's average price for fixed broadband was 115% of Gross National Income (GNI) per capita. This is now reduced to 40% of GNI per capita. In the majority of the world, the price of broadband is still very high relative to income, which hampers users from using the Internet. Prices are generally linked to the nation's income level, with the lowest relative prices often found in countries that have the highest incomes.

DIFFERENT BUSINESS MODELS TO LOWER THE COST OF INTERNET ACCESS

One possible solution to cost challenges is to create business models that lower the cost of Internet access. Two possible options are outlined below:

***Community Internet or Crowdsourcing*:** In this model, Wi-Fi signals are divided into two signals: one dedicated for private use and another for shared purposes for subscription holders. Users may share their home Wi-Fi in exchange for free Wi-Fi at other locations. Hotspots are free for users who contribute, offering the elimination of roaming charges. In addition, a growing number of municipalities, such as New York City, install free Wi-Fi or allow companies such as Google to provide advertising-supported Internet access.

***Alternatives to Full Internet*:** In certain parts of the world where it is expensive to provide end-to-end, always-on connectivity, other methods such as Information-Centric Networking or Delay Tolerant Networking may be explored. Information-Centric networking may help provide local services and content without being end-to-end connected. Internet-in-a-Box is a small and inexpensive device that provides essential Internet resources without any Internet connection. It provides a local copy of half a terabyte of the world's free information. However, such devices need to connect to the Internet periodically to refresh their content.

REDUCTION OF COSTS THROUGH INCREASED COMPETITION

Research by the Internet Society and Organization for Economic Co-operation and Development highlights the causation between improved competition and lower prices in the Internet market, linking lower prices with better developed Internet infrastructure. They outline a number of steps for promoting competition in the Internet market, including liberalization of telecommunication markets, dissemination of locally-produced content, and the reduction of complex licensing and investment restrictions that create barriers to entry into the telecommunications market [13].

Additional cost reductions from increased competition are created with increased spectrum allocations, where greater numbers of mobile operators result in lower prices. Policymakers can assist in the above liberalization of telecommunications markets by assuring fair distribution of assets, reducing and eliminating taxes on telecommunication markets, and through compulsory infrastructure sharing [13].

CHALLENGE AND SOLUTION: UNIVERSAL EDUCATION, DIGITAL LITERACY, AND CONTENT

The prerequisite of Internet literacy is general literacy. Previous literacy movements were aimed at assisting with reading and writing the spoken language. At the advent of the information age, the movement evolved to include computer literacy, focusing on efficient and effective use of traditional personal computers, a focus that was relevant until technologies changed and mobile devices began to proliferate.

Computer literacy thus became digital literacy, defined as "the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills." [14] One who is digitally literate can use a variety of hardware and software in his or her search for information. A person who possesses digital literacy can also search, retrieve, evaluate, and analyze information, its source, and its content. Communication and collaboration with colleagues and other peers via digital means is also a byproduct of digital literacy skills.

Thus, one of the main challenges of providing universal Internet access and inclusion is digital literacy. UNESCO Institute for Statistics [15] reveals the world adult literacy rate at 84.1%, and for youth, 89.1%. Only sub-Saharan Africa and South and West Africa have adult literacy rates lower than 50%. South-East Asia has a slightly higher adult literacy rate of 60%; however, the youth literacy is as high as 89%. Based on these rates, increasing digital literacy will prove the biggest challenge in some regions of Africa and South-East Asia. Without digital literacy, full social and economic benefits of universal access and inclusion cannot be achieved.

A range of skills, some more complex than others, are required to access the range of online facilities. As indicated by the results of the UK Children Go Online Project [16], digital skills are variedly and unequally spread across the population with age, gender, and social-economic status all associated with different literacy levels.

Younger people with home Internet access are likely to spend more time on the Internet and will thus have better Internet skills as compared to others [16]. Sufficient local expertise is required to create a local Internet ecosystem that can promote universal access. This expertise can be developed through training, which can be provided by a variety of stakeholder groups. A number of options exist for increasing Internet literacy, especially through engagement of non-governmental

organizations (NGOs), non-profit organizations (NPOs), Government Authorities, Schools and Education Institutes.

The European Union has more than a 90% adult literacy rate. However, according to Infographic [17], 22% of the EU population has no digital skills, and 40% have insufficient digital skills. One source [20] stated that "European campaigns such as e-Skills for Jobs 2015, and initiatives like the Grand Coalition for Digital Jobs, recognize that a digitally skilled workforce is a workforce that can meet the challenges of the not-too-distant future."

According to the National Digital Literacy Mission Program India [18], only 10% of India's population can be considered digitally literate. Ironically, 62.6% of GDP comes from the service sector [18], which relies on digital literacy, and therefore insufficient effort by India in promoting digital literacy can be economically damaging. In India, many non-profit organizations have developed dedicated programs for increasing Internet literacy among schools, rural women's groups, employed individuals, and retired groups.

Only 28.1% [19] of Africans have Internet access, and the majority of users are located in South Africa, Nigeria, Kenya, Morocco and Egypt. In Africa, there are also a number of initiatives taken by NGOs, NPOs, Government, Educational Institutes and Business organizations to increase digital literacy. SAP SE (German Software Firm) [19] has taken an initiative from October 2016 to educate 150,000 youth across 30 African countries to increase digital literacy. However, several African countries [20] are investing heavily in Internet infrastructure and efforts to improve quality of access.

Another dimension to increase digital literacy is the use of regional languages for Internet content. Originally, the most common language used on the Internet was English; however, the English language is currently used online by only 30% of the total users. A total of 10 languages are used online by 82% [21] of the users. Besides English, these languages are German, Spanish, Chinese, Russian, Arabic, Japanese, Portuguese, French, and Malaysian. There are a total of 6000 languages in use today, 130 of them available on the Internet. In regions of Africa, very few dialects are available online.

In many developing countries, the introduction of mobile phones has spurred interest in literacy as new users develop an interest in text messaging. NGOs offer rudimentary literacy training including abbreviations and emojis common in text messaging. Cell phones are therefore stepping stones to the development of full adult literacy. [22]

CHALLENGE AND SOLUTION: LOCATION AND AVAILABILITY

Generally, availability of the Internet is greater in urban areas than in rural areas. Additionally, Internet service providers have usually targeted urban areas as a better return on investment than rural areas. Rural areas are not given priority for services mainly due to higher capital investments and lower returns on investments (ROI) where lower ROI is due to fewer users compared to urban areas, and where rural users are spread over larger distances. Therefore, mobile broadband and satellite Internet access is increasingly a key part of Internet delivery in rural areas.

Statistics from the World Bank in 2014 indicated that a total of 47% of the world population is living in rural areas. In the United States, 39% of the rural population does not have Internet access. However, the situation is more serious in South East Asia, where only 10% of the rural population has Internet access. Asia, Europe and Pacific countries are in similar situations. A mix of satellite and wireless broadband can provide access in rural areas in both Canada and the United States [23]. The same mixed approach can be adopted for most of the world, since building a fiber optic network can be expensive and time consuming.

In 2016, both China and India have witnessed a surge in mobile Internet connections, and even with 4G services the reliability of connection may be insufficient to satisfy the demand. Whether the location is rural or urban, customers are demanding high-speed Internet connections.

Universal access in remote and rural areas requires a thorough analysis of demand, willingness, and ability to pay for services. If services are too expensive, then local governments may have to provide external sources of funding or subsidies. Planning for universal access in remote and rural areas may not look the same for all countries. For Europe, the Middle East and North America, the density of population in rural areas is much lower compared with the density in Asia, the Pacific, and South America [23]. As a result, providing universal access to people in rural areas of Europe, the Middle East and North America will be more challenging than in other countries.

Regulators and local governments can look toward availability of better ICTs for reducing infrastructure costs and improving quality of services to rural areas. Several Universal Access Funds are established by local governments to provide broadband services to rural and remote areas.

CHALLENGE AND SOLUTION: DISINTEREST AND LACK OF MOTIVATION

Even with universal connectivity, not everyone will use the Internet until and unless the factor of disinterest is addressed. The first and foremost factor leading to disinterest is a lack of skills or digital literacy, as discussed above, with digital literacy being an essential piece to embracing universal connectivity and universal access. Without the necessary skills to support digital exploration, interest remains limited, and the ability to discover the enormous potential of the Internet stays untapped. Without digital awareness, users remain ignorant of digital skills and their advantages and applicability. Lack of awareness can build a sense of fear among potential users.

Many other factors can cause disinterest. A fear of abusing or being abused by the technology (for example, privacy concerns) can hamper embracing Internet access, as well as a fear of the loss of personal online data. In addition, the lack of relevant cultural, commercial, or scientific content feeds disinterest. Age can also sometimes be a factor that contributes to disinterest. These factors, if they persist, will exclude a certain percentage of people from pursuing Internet access.

In some countries, ethical and political limitations bar users from using the Internet to its optimum potential. Individuals are often restricted from finding the information they are looking for. In other countries, unnecessary cost and taxation on Internet usage hinders affordability for most citizens.

It must also be acknowledged that disinterest in Internet use and literacy may not be an option much longer as critical life tasks become more exclusively reliant on Internet use. The application process for jobs and government benefits is increasingly delegated to an exclusive online application process where possessing the basic cyber skills needed to fill out online forms are non-negotiable.

In order to overcome disinterest, the advantages of Internet use can be made explicit to potential users. However, to do this, users must also be convinced that they can trust the technology. For example, users cannot control the security of their data held by government and commercial organizations, but they often end up paying the cost of having their data stolen and sold. Potential users may put more trust in the Internet and become more interested in using it if they felt safer online.

Both education and relevance are posited as means to overcoming disinterest,

where education empowers through choice, and relevance connects the use of the Internet to the user's daily functional needs. Active policy choices can help bridge Internet use advocacy, education, trust and technology towards a better leverage of Internet availability.

CONCLUSION

Although the goal of providing near-universal Internet access appears achievable, the necessary conditions do not yet exist that would support the worthwhile endeavor of global inclusion for all.

First and foremost, a reliable source of electricity is needed to support the required ICT infrastructure. Solutions include using renewable energy sources to provide electricity if the traditional infrastructure is not yet in place. From that foundation, several issues need to be addressed to provide the network infrastructure necessary to support global Internet connectivity. Some solutions include DSL, fixed wireless, cable modem, fiber optics, mobile technologies, and aerial technologies such as drones, balloons, and satellites in various orbits. Parallel to the infrastructure issue is the location and availability of connectivity providers. Developed countries typically have more choices, whereas undeveloped and less developed countries have fewer options.

Underlying the choices of network infrastructure and connectivity providers are the challenges of cost. This includes both cost of the infrastructure and cost of connectivity service. Business models will need to expand or be created to address these challenges. Even if all of these prerequisites are in place, universal access will occur only if there are supporting public policies in place. With the appropriate public policies, additional challenges include universal education, digital literacy, and content. In other words, making Internet content relevant for everyone must be addressed. And lastly, there will always be part of the population that is not interested in connectivity. The advantages of universal global Internet connectivity are many and varied, and the endeavor for achieving universal access for all will pose both new opportunities and continuing challenges.

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