Tools and technologies for equitable access[1]

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[1] This paper is part of a series on equitable access to ICT infrastructure commissioned by APC for an event on equitable access which took place in Rio de Janeiro in November 2007. The papers and commentaries on these papers can be found at: www.apc.org/en/pubs/research

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Executive summary

Equitable access to infrastructure requires the combination of policies, technology and human capacity building. This issue paper is one of a series of four on aspects of equitable access to infrastructure commissioned by the Association for Progressive Communications (APC). It focuses on technologies and tools for developing regions to improve internet access. The technologies are presented in five major areas:

- *Wireless access*
- *Low-cost and low-power computing*
- *Open standards, hardware and software*
- *Local services and content*
- *Open access and open networks.*

The paper provides background for each of these technology areas and refers to practical strategies to ensure equitable access. After reviewing the various issues and strategies, it makes a set of recommendations related to each of the technology areas. The suggested interventions cover a range of issues, including: public access to radio spectrum, open networks, capacity building, the promotion of local services, the use of open standards, and quality control in information and communications technologies (ICTs).

The paper concludes that no matter which time in history we look at, the equitable use of ICTs results from making technology accessible, adequate and relevant to local realities.

1. Issues at stake

Five major issues affect the roll-out of tools and technologies for equitable access in developing regions:

- *The lack of high-capacity national fibre networks*
- *Unfavourable regulatory frameworks*
- *Unreliable or non-existent power grids*
- *A low level of ICT skills*
- *Limited access to hardware supply chains.*

Within this context, five "technological areas" are felt to be strategic in the deployment of internet access, especially in developing regions. These are:

- *Wireless access: Refers to licensed and unlicensed wireless technologies that bring last-mile connectivity to areas that lack fixed infrastructure.*
- *Low-cost and low-power computing: Refers to affordable yet hardy end-user technology (e.g., PCs, laptops, mobile devices) that can operate in developing*

country conditions. These conditions include poor power supply or the absence of a power grid and extreme environments with excessive heat, dust or humidity.

- *Open standards, hardware and software: Refers to technical standards in hardware and software that facilitate interoperability, avoid vendor lock-in and promote technology ownership for the user.*
- *Local services and content: Refers to tools and technologies that promote the creation and use of local content and services that meet local needs (including being produced in local languages). It can also refer to the technological means for accessing safe (private and secure) international bandwidth, including developing internet exchanges.*
- *Open access and open networks: Refers to networks that are not monopolies. They can be accessed fairly by a range of stakeholders, including government, civil society and the private sector. Typically it is envisaged that they are run independently of any service or content offering and are structured, financed and owned so as to serve the common good.*

It is important to note that in order to achieve equitable access, tools and technologies require a favourable regulatory and policy framework, as well as economic and social incentives for their deployment. Although last-mile technology on its own has helped to provide universal access in a few areas around the world, it is not the only key factor. Equitable access in most "connected" countries of the world is the result of a history of substantial public and private investment in fixed and wireless infrastructure, including dark fibre and power distribution networks. Equitable access needs a combination of large investment in backbone infrastructure, the deployment of open networks, business incentives and subsidised access.

2. Practical strategies

Wireless access

Wireless has been touted as an important way of achieving equitable access in developing regions. WiFi has dramatically increased access to ICTs by extending existing infrastructure to areas where traditional operators have little interest. The technology has enabled revolutionary ways to hook new communities to the network, and encouraged the creation of new internet service providers (ISPs) independent of large national operators. WiFi-based solutions are also offered by major internet service providers in developed and developing regions. The numerous successful networks based on WiFi show that wireless connectivity requires three conditions to be successful: spectrum availability, technology accessibility and the possibility of new business opportunities.

There are hundreds of good examples of how WiFi is being used to achieve equitable access. In Peru, WiFi is used to provide internet health and agricultural services in Amazonia and

Huaral.[3] In Nigeria, the Fantsuam Foundation has linked local partners in the Kafanchan area to the internet.[4] Guifi.net in Spain has connected over 4,000 nodes, including municipalities in Catalunya.[5] Inveneo and Battery Operated Systems for Community Outreach (BOSCO) provide access to displaced persons in refugee camps in Gulu, Uganda.[6]

WiFi is a good example of how technology can empower communities and how adequate policy and access to technology can make connectivity happen. In order to understand the relevance of wireless access and how accessible technology can promote equitable access, it is interesting to understand its background and history. Although we learn from history that humans never learn anything from history,[7] understanding historical technological revolutions is key to achieving success when initiating new ones.

Making spectrum available was a fundamental decision that affected the future of wireless deployment. To ensure reliable communication in the presence of a noisy environment, it was necessary to "spread" the radio signal over a wide frequency range – a range several magnitudes higher than the minimum requirement. This technique, known as "spread spectrum", has been fundamental for the deployment of modern wireless communications including code-division multiple access (CDMA), very small aperture terminal (VSAT) satellite systems, Bluetooth and WiFi.

In 1990, a standardisation body known as the Institute of Electrical and Electronics Engineers (IEEE) formed a new working group, 802.11, with a focus on indoor wireless operating in existing unlicensed bands. But in order to see personal wireless broadband taking off, a communication standard and interoperability guarantees were needed. Pre-standard devices were manufactured in the mid-1990s, and finally in 1999 the IEEE 802.11b standard was born. Efforts to guarantee interoperability between different implementations led to the creation of a new organisation called Wireless Fidelity (WiFi, known as WFA today). Although the IEEE 802.11b standard was designed to operate in indoor environments and was initially conceived as short range, it did not take long to see several products implementing point-to-point and point-to-multipoint outdoor solutions in metropolitan area networks and rural areas. The technology was soon adopted by ISPs in developing regions and modified by different vendors to overcome the limitations of a wireless indoor standard. The basic idea behind hundreds of small ISPs was to distribute a VSAT connection among several customers by means of a low-cost wireless local loop. In other regions with fixed infrastructure like fibre, asymmetric digital subscriber line (ADSL) or integrated services digital network (ISDN), connections are distributed by similar means.

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[3] Enlace Hispano Americano de Salud: www.ehas.org; Huaral Irrigation Users' Wireless Network: news.bbc.co.uk/2/hi/technology/4071645.stm

[4] Zittnet: www.fantsuam.org; fantsuam.it46.se

[5] Guifi.net : www.guifi.net

[6] Wireless in IDP Camps: www.bosco-uganda.org

[7] Paraphrased from George Bernard Shaw.

The way that WiFi-based solutions are spreading is similar to the revolution in open standards or the proliferation of personal computers some twenty years ago. There was a need, the technology was available, and a standard aiming for interoperability and mass production was created.

During the last five years, a new effort in the wireless arena has taken place known as IEEE 802.16 (WiMAX). In 2004, the original standard, IEEE 802.16 (2001), was extended to operate in a larger range of frequencies (2-11GHz). WiMAX aims to provide the ultimate solution for broadband outdoor wireless, but the history of WiMAX is very different from WiFi, and existing solutions are far from low cost. Although the technology can operate in a wide range of frequencies, it is also still subject to regulatory restrictions.

The focus of WiMAX has always been to play a role in the third generation (3G) mobile market, as is shown in the decision by the International Telecommunication Union (ITU) Radiocommunication Assembly to include WiMAX-derived technology in the framework of the International Mobile Telecommunications-2000 (IMT-2000) set of standards (August 2007).[8] IMT-2000 is the global standard for 3G wireless communications.

WiFi was never intended to be the best radio technology for long-distance point-to-multipoint radio links. Amongst other things, its worldwide success is due to:

- *The low cost of the radio equipment due to mass production.*
- *The possibility of easy integration with personal computers and operating systems.*
- *The existence of certified interoperability between vendors.*
- *The possibility of developing very favourable regulatory frameworks in comparison to other radio technologies and related services.*

Mobile devices and IP convergence

In recent years there has been a trend towards internet protocol (IP) convergence in the mobile telephony industry. Mobile operators are looking into technologies that can provide efficient voice and data services over one single network. This all-in-one network is known as the Next Generation Intelligent Network (NGIN) – the convergence of data infrastructure for cellular, fixed and IP networks.

[8] "International Telecommunication Union Approves WiMAX Technology as New IMT-2000 Standard", *WiMax Forum* [online] 17 August 2007. www.wimaxforum.org/news/pr/view?item_key=993a9f3e2bf2b5b6822364fd90738185f17f2de0

Several technology standards are providing data services in mobile devices, including GPRS/EDGE[9] and CDMA2000. The latest developments in the 3G arena include the use of WCDMA, and the Chinese alternative TD-SCDMA. Although many projects are using portable devices to access the internet via cellular networks, the networks are often congested and not able to fulfil users' expectations. In developing countries, voice services are often still a priority for operators, and the provision of international bandwidth for internet use is insufficient. In rural regions, accessibility through cellular networks is also highly dependent on the price of international bandwidth provided through satellite connectivity.

IP connectivity in developing regions has not changed much in the last years and fibre deployment and markets are still small. Analysts have pointed to the need for addressing simultaneously the lack of infrastructure, unfavourable regulatory environments, high pricing, and uncompetitive market structures.[10]

Low-cost and low-power computing

One of the main challenges in developing regions is access to power. The challenge of providing low-cost and low-power computing goes in hand with the implementation of alternative sources of energy such as solar or wind power. One of the first known efforts to build a low-power and inexpensive computer was the Simputer. The Simputer was designed by a non-profit organisation funded in 1999. The project did not take off and in 2005 only a few thousand units were sold. The project was licensed under SGPL.[11] There are a number of factors that can explain the lack of adoption of the Simputer, including: licence costs; the high cost of the hardware in comparison to handhelds; the lack of support from NGOs and governments; and a decrease in the price of general-purpose laptops.

A number of hardware vendors have jumped into the race of bridging the digital divide by providing low-cost and low-power solutions. In 2005, VIA launched its pc-1 initiative based on its C3 and C7 processors. During the 2004 World Economic Forum, AMD launched the 50x15 initiative based on AMD Geode processors. Intel did not want to be left out of the race and launched the Classmate PC (formerly Eduwise). China has its own effort, the Longmeng computer. It is based on a locally made processor and the result of a joint effort between the Jiangsu Menglan Group and China's Institute of Computing Technology (ICT).

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[9] Telecentre connected to internet via EDGE network, Bangladesh: community.telecentre.org/en-tc/node/44315

[10] See, for example, Sarrocco, C. (2002) *Improving IP Connectivity in the Least Developed Countries*. Geneva: International Telecommunication Union (ITU).

[11] The Simputer General Public Licence, or SGPL, is an open source hardware distribution licence drafted specifically for the purpose of distributing Simputers.

One of the latest initiatives in this field is the One Laptop per Child (OLPC) project. The laptop involved is now known as the XO-1. However, the effort has been criticised in several forums as being centralised and top-down in design and distribution.

While there is agreement on the need for low-cost and low-power computing solutions, there is no consensus on the best way to empower poor communities using these solutions. The costs of maintenance, training and internet access are very seldom discussed as part of existing projects. Most of the initiatives seem to be driven by vendors without a solid understanding of community needs, and no real field experience. A critical review of this leg of the race to bridge the digital divide is needed.

Open standards, hardware and software

When looking at equitable access it is important to consider the role of open standards, open hardware and open source software. Open standards allow everyone to implement interoperable communication systems. With interoperability, it is possible to avoid vendor lock-in and ensure fair market competition. Open hardware allows small and medium enterprises, community projects and entrepreneurs to manufacture and assemble hardware locally. With free software, projects can learn from existing experiences, integrate solutions and ultimately share their results with others.

It is difficult to imagine sustainable development without knowledge transfer and technology ownership. Unfortunately, many governments and other institutions have failed to demand openness in their technological investments, and in many cases have played a questionable role in locking their citizens and consumers into a certain technology or product. Notable examples of vendors' interest in consumer lock-in can be found in Microsoft's success in lobbying for their OOXML[12] document format during the ISO/IEC evaluation, or technologies like Active Directory. Similar closed solutions can be found in popular software such as Skype and binary-only releases of hardware drivers.

Although many telecommunication standards are publicly available, telephony has always been under the control of a few vendors capable of negotiating contracts at regional or national levels. This fact might explain why it is common to see the same type of equipment in different towns and cities across a particular country. Although the rules (or standards) that govern telephony have been relatively open, the rules that govern the hardware have always been kept secret. This reality is changing slowly as open source software moves into the telephony space with initiatives such as Asterisk,[13] OpenSER[14] or the Gizmo Project.[15]

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[12] For a critique of the OOXML document format see: en.wikipedia.org/wiki/Office_Open_XML

[13] Asterisk project: www.asterisk.org

[14] Open SIP Server: www.openser.org

[15] Open and standards-based telephony project: www.gizmoproject.com

Many low-cost computing solutions use open source software for their operating systems. These include the XO-1 and Inveneo's low-power computing station, which are both based on AMD Geode processors. In the wireless arena, innovative wireless solutions come from open source developments, notably OpenWrt and DD-WRT.[16] Open source firmware based on the original Linksys router firmware has been extended and rewritten to include new functionalities.

Open standards, open hardware and open source software must be considered in any equitable access strategy, to avoid vendor lock-in and encourage knowledge transfer.

Local services and content

Although the internet has been designed to provide public and private services to any user connected to the network, a trend towards the concentration of critical services controlled by very few companies is limiting the full potential of a multicultural internet environment. Local initiatives have a difficult time competing with free services such as Gmail, Flickr, YouTube, Hotmail and Skype. Moreover, a handful of languages are responsible for most of the existing content on the internet, while many prominent languages in regions across the world do not feature online.

The long-term impact of this trend is a lack of deployment of physical and service infrastructure in the South, and the concentration and control of information in small parts of the North. In the majority of cases free services involve the trade of personal data and the acceptance of user profiling and content monitoring. Most users are not aware of the long-term implications to their online security and privacy when giving away personal information.

Local services in local languages are key for equitable access. Unfortunately, investments in technology and infrastructure are negligible when it comes to local business models and local languages. At the same time, many countries lack institutional support for local languages and cultures.

Support for local content needs to go hand in hand with local infrastructure, such as internet exchange points (IXPs). An IXP is a physical infrastructure that allows different ISPs to exchange internet traffic between their networks locally. Although some efforts are underway to extend local infrastructure, and several internet exchanges have been implemented in developing regions, local content and services are major areas that require attention.

[16] DD-WRT and OpenWrt projects: www.dd-wrt.com; www.openwrt.org

Open networks

A common situation in most countries is the high cost of operating services using existing infrastructure. Copper and fibre networks are linked to monopolistic service providers that do not allow third parties to deploy services over a common infrastructure. Although fibre and high-capacity microwave backbone links seem the immediate answer to meet connectivity needs, fibre deployment does not necessary lead to low connectivity prices. The full capacity of many fibre cables is deliberately not exploited, and prices are kept high where incumbents have full control over the physical infrastructure.

While it is recognised that communication technologies and local content are key for human development, the fact that economic and social incentives have historically come from subsidised access is often ignored. There is an expectation that the private sector will address the lack of infrastructure and services in remote rural areas, ignoring the fact that remote communities in the "North" gained access to infrastructure through the support of public funding.

There are myriad tools and technologies that can enable the smooth coexistence of several internet and content providers over a given physical infrastructure. But equitable access requires a model that allows new initiatives to use and deploy new infrastructure. The role and responsibility of government is fundamental. Technology can enable efficient use of the infrastructure, but the ultimate challenge is to ensure that large investments in physical infrastructure are accompanied by training and the involvement of the local communities.

The Open Public Local Access Networks (OPLAN) Foundation[17] describes the defining characteristics of open networks as follows:

- *They only serve a local geographic community or location, ranging from a street or business park, to a rural community or even an entire city.*
- *They provide open access and are for use by any party located within the community – they serve the public and private sectors, corporate and residential citizens, service providers and content creators, as well as consumers.*
- *They are owned and controlled totally independently of any service or content that runs over them.*
- *They are structured, financed and owned so as to serve the common good – the value and benefit of the technology remains with the users.*
- *They are not owned by licensed telecommunications operators.*
- *They deploy modern digital technology and offer true broadband (symmetrical) connectivity.*

[17] OPLAN Foundation: www.oplan.org

Sweden has pioneered the deployment of open networks. Stockab, in Stockholm, was one of the first municipal open fibre networks in the world, and inspired many other initiatives across the globe. A sign of the acceptance of the open network model is the International Network of e-Communities (INEC) Declaration on Open Networks (November 2006).[18]

3. Support and interventions

Ten concrete recommendations relating to the five technological areas presented in the previous sections are summarised below. The recommendations are not listed in any order of priority.

Governments and regulatory bodies should make radio spectrum available to support projects that aim to provide universal access. Policy should provide an incentive for the implementation of wireless networks by allocating spectrum to initiatives that aim to reach marginalised populations.

Tax exemptions for ICT equipment for universal and equitable access should be encouraged. Exemptions should include ICT-related equipment such as wireless antennas, low-power computers, energy back-up systems, batteries, solar panels and regulators, etc.

Civil society organisations should emphasise the need for a critical review of low-cost and low-power computing initiatives including OLPC, AMD 50x15 and Intel Classmate. The review should address overall costs of technology ownership, including connectivity, energy, training and maintenance.

Consumers should advocate for internationally accepted quality control standards in ICT hardware and software.

Governments, civil society organisations and consumers should avoid vendor lock-in and guarantee knowledge transfer by means of free hardware and software.

Civil society must create an awareness of the importance of technology ownership and knowledge transfer.

Investors must ensure that large investments in physical infrastructure are accompanied by training and the involvement of the local communities.

Regulators, including internet governance bodies, should encourage open access networks.

Governments and the private sector should support the deployment of local infrastructure including internet exchanges.

Local content should be promoted, including the necessary tools and technologies related to software and content localisation.

4. Conclusion

Regardless which time in history is analysed, the equitable use of ICTs results from making technology accessible, adequate and relevant to local realities.

[18] INEC Declaration on Open Networks: www.i-nec.com/activities/the_declaration

Making the technology accessible might require policy changes such as liberating parts of the radio spectrum or deploying open networks. Adequate technologies should consider the environmental and social conditions of their users, including access to power and investment capacity. Solutions should not be techno-centric, and should seek what is relevant to local realities, including the promotion of local knowledge and local tools.

A way forward should always consider the need for capacity building. Capacity building should not just focus on providing skills to use technologies, but ensure a critical view of technology and its dependencies.