Tools and technologies for equitable access

1st November 2007

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ASSOCIATION FOR PROGRESSIVE COMMUNICATIONS (APC)

APC-200711-CIPP-I-EN-PDF-xxx

ISBN TO BE ASSIGNED

THIS PAPER WAS COMMISSIONED BY THE APC FOR PRESENTATION AT PASSWORD: EQUITABLE ACCESS, NOVEMBER 10 2007, RIO DE JANEIRO, BRAZIL.

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Executive summary

Equitable access to infrastructure requires the combination of policies, technology and human capacity building. This paper focuses on adequate 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**

This paper provides the necessary background for each of these technology areas and refers to practical strategies including existing initiatives. After reviewing the various issues and practical strategies the paper makes a set of recommendations related to each of the technology areas identified. 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 ICTs.

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

1. The issues at stake

This paper focuses on technologies and tools for developing regions and has identified five major issues which affect the rolling out of tools and technologies for equitable access:

- lack of high capacity national wide area fibre networks
- unfavourable regulatory frameworks
- unreliable or non-existent power grid
- low level of ICTs skills
- limited access to hardware supply chains.

This paper looks at five broad technological areas since it would be impractical to look at specific applications or tools in detail in this short summary of analysis. It examines some strategies taken in each of the areas in the context of the issues mentioned above. These are areas which are felt to be strategic in the deployment of Internet access, especially in developing regions.

These five areas are:

- **Wireless access**: licensed and unlicensed technologies to bring last mile and backbone infrastructure to areas with lack of fixed infrastructure. Internet access by means of cellular networks and mobile devices.
- **Low cost and low power computing:** computing platforms that can operate in developing countries conditions: poor or no power grid, dust/tropical environment, limited or no ICT skills, multi-lingual environments, limited or no bandwidth, etc.
- **Open standards, hardware and software:** technical standards, hardware and software that facilitate interoperability, avoid vendor lock-in and promote technology ownership by recipients.
- **Local services and content:** tools and technologies that promote the creation and use of local content and services in local languages. Technological means to safe international bandwidth including Internet exchanges.
- **Open access and open networks:** networks that run independently of any service or content and are structured, financed and owned so as to serve the common good.

It is important to mention that equitable access can not be achieved only by means of technology. Tools and technologies require a favourable regulatory and policy framework and both economical and social incentives for their deployment. Equitable access in the most "connected" countries of the world is the result of a history of large public and private investments in fixed and wireless infrastructures including dark fibre and power distribution networks. It is a fact that although technology has helped to provide universal access in a few and small areas in the world, it is not the only key factor. Equitable access is the result of the combination of large investments in backbone infrastructure including the deployment of open networks and business incentives as subsidized access.

2. Practical strategies

Wireless access

Wireless has been presented as a viable alternative to implement equitable access in developing regions. The numerous successful networks based on WiFi show that wireless connectivity requires three conditions to take off: spectrum availability, technology accessibility and the possibility of new business opportunities. **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 the creation of new ISPs independent of the large national operators. WiFi based solutions are part of major internet and content Providers in developed and developing regions.

There are hundreds of good examples of how WiFi is being used. In Peru, WiFi is used to provide Internet health and agricultural services in Amazonia and Huaral[2],[3]. In Nigeria, Fantsuam Foundation has deployed an integrated rural ISP linking local partners in the Kafanchan area to the Internet[4]. Guifi.net in Spain has connected over 4000 nodes including municipalities in Catalunya[5]. Inveneo and Battery Operated Systems for Community Outreach (BOSCO) provide access to Internally Displaced Persons (IDP) 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 man can never learn anything from history[7], understanding technological revolutions is key to success in initiating new ones.

To make the spectrum available was a fundamental decision for the future of wireless deployment. To ensure a reliable communication in the presence of a noisy environment, it was needed to "spread" the radio signal over a wide frequency range, a range several magnitudes higher than 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 Engineer (IEEE), formed a new working group, 802.11 with focus on indoor wireless to operate in the

[2] Enlace Hispano Americano de Salud http://www.ehas.org
[3] Huaral Irrigation Users' Wireless Network http://news.bbc.co.uk/2/hi/technology/4071645.stm
[4] Zittnet http://www.fantsuam.org, http://fantsuam.it46.se
[5] Guifi.net http://www.guifi.net
[6] Wireless in IDP Camps http://www.bosco-uganda.org
[7] Famous quote of the novel price of literature George Bernard Shaw after reading to Hegel

existing unlicensed bands. Having the spectrum available (unlicensed ISM) and a technology accessible (spread spectrum) was not enough to see personal wireless broadband taking off. A **communication standard and interoperability guarantees were needed**. Pre-standard devices were manufactured in the middle 90s, and finally in 1999 the "IEEE 802.11b" was born. Efforts to guarantee interoperability between different implementations led to the creation of a new organization called Wireless Fidelity (WiFi, known as WFA today).

Although the IEEE Standard 802.11b was designed to operate in indoor environments and it was initially conceived as a short range, it did not take long to see several products implementing point-to-point (PtP) and point-to-multipoint (PtMP) outdoor solutions in metropolitan area networks (MAN) 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, ADSL or ISDN, connections are distributed by similar means.

Image 1: Zittnet. Extending satellite connectivity using WiFi. Fantsuam Foundation, Kafanchan (Nigeria)

The way that WiFi-based solutions are spreading is similar to "the revolution of the open standards and the 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 is taken place known as IEEE 802.16 (WiMAX). In 2004, the original standard, IEEE 802.16 (2001), was extended to operate in a large range of frequencies (2 to 11 GHz) range even coexisting with WiFi. WiMAX aims to provide the ultimate solution for broadband outdoor wireless but **the history of WiMAX is very different from WiFi and existing solutions, targeted to large operators in rural and semi-urban setups, are far from low cost.** Although the technology can operate in a wide range of frequencies, it is still subject to regulatory restrictions. The focus of WiMAX has always been to play a role in the 3G market as is shown in the decision of the International Telecommunication Unit (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 third generation (3G) wireless communications.

WiFi was never intended to be the best radio technology for long distance point-to-multipoint radio links but has shown similar wide acceptance to the open architectures or personal computers in the past. Reasons for its worldwide success in the data infrastructure can be found in the:

- low cost of the radio equipment due to its mass production
- possibility of easy integration with personal computers and operative systems
- existence of a certified interoperability between vendors (WiFi)
- possibility of finding a very favourable regulatory framework in comparison with other radio technologies and related services.

These aspects of the "WiFi revolution" should be considered in any new initiatives with independence of the technology used.

Mobile devices and IP convergence

In recent years there has been a trend towards IP convergence within the industry of mobile telephony. 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 converge of data infrastructure for cellular, fixed and IP networks.

Several technologies 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 by cellular networks, the networks are often congested and not able to fulfil users' expectations. In rural regions, accessibility through cellular networks is also highly dependent on the price of international bandwidth provided through satellite connectivity.

A major use of cellular networks for data communications comes with the Short Message Service (SMS), often called text messaging. One remarkable trend is the use of SMS as means of political campaigning. In 2001, SMS messages about political corruption in Philippines led to street protests and political change[10].

An example of how international bandwidth is still a major hurdle can be found in existing cellular networks in East Africa. For example CDMA2000 networks have been deployed by MTN and UTL in Uganda and Zanzibar Telecom in Tanzania. Although telephones are available under 100 USD and Internet access is available for a flat rate of 60 USD/month, connectivity is still very limited in terms of quality of service. Although connectivity by means of cellular networks might seem a promising solution, the reality is that most networks are highly congested as voice services are still the major priority for operators and the provision of Internet international bandwidth is insufficient.

The situation of IP connectivity in developing regions has not changed much in the last years and fibre deployment and markets are still small. An excellent description of this "vicious circle": **no-infrastructure, no-markets; no-markets, no-infrastructure** was presented by ITU in 2002[11]. The report presents the need of addressing simultaneously the lack of infrastructure, unfavourable regulatory environments, high pricing, and uncompetitive market structures.

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[8] Press release announcement: WiMAX is a IMT-2000 standard (17th August 2007) http://www.wimaxforum.org/news/pr/view?item_key=993a9f3e2bf2b5b6822364fd90738185f17f2de0

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

[10] Mobile Active, http://mobileactive.org/mobile-phones-and-social-activism-ethan-zuckerman-white-paper

[11] Claudia Sarrocco, Improving IP connectivity in the last developed countries, 2002

Low power computing and energy

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.** Providing a suitable computing solution is still a challenge and there are many lessons to learn from several attempts. A few of these attempts are described below.

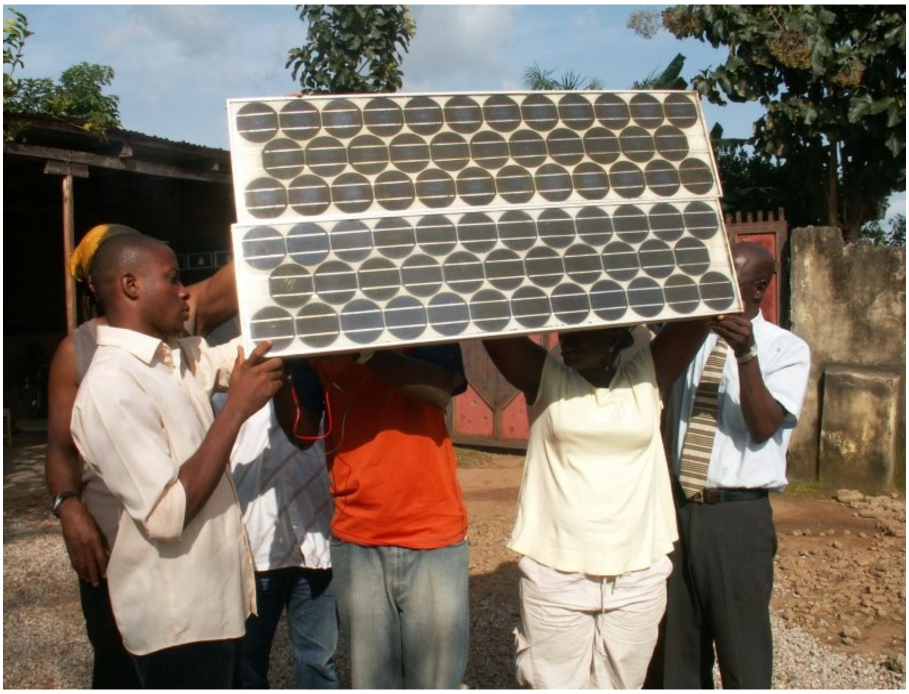

Image 2: Equitable access requires alternative sources of energy and computing solutions adapted to local needs

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 organization 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[12] with a license fee of around 25000 USD to commercially exploit the Simputer design. There are a number of factors that can explain the lack of adoption of the project including: the license costs; the high cost in hardware in comparison to handhelds; the lack of support from NGOs and governments; and the decrease of the price of general purpose laptops.

One of the latest and most known initiatives is the "one-laptop-per-child" (OLDP) effort. The laptop is now known as the XO-1. The effort has been criticized in several forums as being centralized and top-down in design and distribution.

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

[12] The Simputer General Public License, or the SGPL is an open source hardware distribution license drafted specifically for the purpose of distributing Simputers

While there is an agreement on the need for low cost and low power computing solutions, there is not a consensus on the best way to empower poor communities by means of low power computing. The costs of maintenance, training and Internet access are very seldom discussed as part of the existing projects. **Most of the initiatives seem to be driven by vendors without a solid understanding of the community needs and real field experiences.** A critical review of this "race" is needed.

Open standards, hardware and software

When looking at equitable access it is important to mention 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-locking solutions 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.

Most of the low cost computing solutions are using free and open software as one possible operating system. This includes 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 DDwrt[13]. Open source firmware based on the original Linksys router firmware has been extended and rewritten to include new functionalities.

It is difficult to imagine sustainable development without knowledge transfer and technology ownership. A solution based on open standards and free and open hardware and software does not only provide a technically sound solution but also enables the possibility of adapting it to anyone's requirements.

Public and "free" technical standards ensure that computers and services can communicate with each other and that telephone exchanges around the globe can interoperate. Without standards a computer network or telephone system of one region might not interoperate with another system a few kilometres away. Furthermore, users are free to implement solutions based on multiple vendor's options instead of locking themselves with one single alternative.

The role of standards in telephone services is particularly important. 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 extremely common to see the same type of equipment 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 is also moving into the telephony space with initiatives as Asterisk[14], OpenSER[15] or the Gizmo Project[16].

With the proliferation of new open standards and the reduction of costs in computer power, we are heading towards software based solutions rather than expensive dedicated hardware. Unfortunately, many governments and other institutions have failed to demand openness in their technological investments and in many cases played a "questionable" role in locking their citizens and consumers to a certain technology or product. Notable examples of vendors interest in consumer locking can be found in Microsoft's success in lobbying for their OOXML[17]

[13] DD-WRT and OpenWRT projects http://www.dd-wrt.com http://www.openwrt.org
[14] http://www.asterisk.org Asterisk Project
[15] http://www.openser.org Open SIP Server
[16] http://www.gizmoproject.com Open and standards based telephony project
[17] http://en.wikipedia.org/wiki/Office_Open_XML Includes critics to the OOXML document format

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.

Avoiding vendor locking and guaranteeing knowledge transfer by means of free (libre) hardware and software are elements to be consider in a strategy for equitable access.

Local services and content

One area that remains unsolved is the asymmetric distribution of services in the Internet. Although the Internet has been designed to provide public and private services to any user connected to the network, the current distribution of services is highly asymmetric. A handful of languages are responsible for most of the existing content on the Internet while many large languages have not even made it to computers.

The trend towards concentration of critical services controlled by very few companies is limiting the full potential of a multi-cultural Internet. Local initiatives have a difficult time competing with free services like Gmail, Flickr, Youtube, Hotmail, Skype, etc. The long term impact of this trend, is a lack of deployment of physical and service infrastructure in the South and the concentration of knowledge in small parts of the North.

In the majority of the cases free services involve the trade of personal data and the acceptance of user profiling and content monitoring. Most of the users are not aware of the long term implications of giving away personal identifiable information.

The high costs of connectivity and the omni-presence of private IP addresses are important hurdles in the effort of providing equitable access. International bandwidth requirements are growing steadily for the performance of the very basic operations such as receiving non-junk e-mail or keeping up with operative system updates.

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. Many countries lack basic infrastructure as well as Internet exchanges, support for local languages and an educational system with the wiliness of educating and generating local content. An Internet exchange point (IX or IXP) is a physical infrastructure that allows different Internet Service Providers (ISPs) to exchange Internet traffic between their networks locally. Although some efforts are under way to extend local infrastructure and several Internet exchanges has been implemented in developing regions, local content including services is a major area that requires attention.

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 seems the immediate answer to meet connectivity needs, fibre deployments do not necessary lead to low connectivity prices. Many fibres are used far under their capacity and prices are kept high where incumbents have full control over the physical infrastructure.

There is a myriad of tools and technologies that can enable the smooth coexistence of several Internet and content providers over a given physical infrastructure. Universal and equitable access requires the presence of new virtual operators that target areas with low or no profitability. Equitable access requires a model that allows new initiatives to use and deploy new infrastructure. It is recognized that communication technologies and local content is key for human development but it is often ignored that economical and social incentives have historically come from subsidised access. There is an expectation that private businesses address the lack of infrastructure and services in remote rural areas, ignoring that the very same remote communities in the "North" have gained access to infrastructure thanks to the support of public funding.

Image 3: The fibre divide: connectivity in Scandinavia is 1000 times cheaper than in rural Nigeria

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 OPLAN[18] "Open Public Local Access Networks" Foundation describes the distinctive defining characteristics of open networks as:

- they only serve a local geographic community or location, ranging from a street or business park through a rural community to an entire city
- they provide "open access" and are for use by any party located within the community - they serve both the public and private sectors, corporate and residential citizens, service 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 a PTO/ licensed telecommunications operator
- they deploy modern digital technology and offer true broadband (symmetrical) connectivity

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 worldwide.

[18] http://www.oplan.org OPLAN Foundation

A sign of the acceptance of the model is the International Network of e-communties (INEC) Declaration on Openworks of November 2006[19].

3. Support and interventions

Ten concrete recommendations related to the five technological areas presented in the previous section are summarized below. The recommendations are not listed in priority order.

(1) Governments and regulatory bodies should make radio spectrum available to support projects that aim to provide universal access. Policy should incentivize the implementation of wireless networks by allocating spectrum to initiatives that aim at reaching marginal populations.
(2) Tax exemptions for ICT equipment for universal and equitable access should be encouraged. Exemptions should include ICT related equipment including wireless antennas, energy backup systems batteries, deep cycle batteries, solar panels and regulators, low power computers, etc.
(3) Civil society organizations should emphasis the need for a critical review of low cost and low power computing initiatives including the OLPC, AMD 50x15, Intel Classmate and others. The review should address overall costs of technology ownership, including connectivity, energy, training and maintenance.
(4) Consumers should advocate for the demand of internationally accepted quality control standards in ICT hardware and software.
(5) Governments, Civil Society Organizations (CSOs) and consumers should avoid vendor lock-in and guarantee knowledge transfer by means of free (libre) hardware and software.
(6) Governments and private sector should Inactivate the deployment of local infrastructure including Internet exchanges.
(7) Local content should be promoted including the necessary tools and technologies related to software and content localization.
(8) Regulators including internet governance bodies should encourage open public access and networks.
(9) Investors must ensure that large investments in physical infrastructure are accompanied by training and the involvement of the local communities.
(10) CSOs must create awareness of the importance of technology ownership and knowledge transfer, including the risks present in the dependence of free Internet services.

4. Conclusion

Regardless of which time in history is analyzed, the equitable use of information and communication technologies results from making technology **accessible, adequate and relevant to local realities.**

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. Finally, solutions should not be technologically-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 of more capacity building. Capacity building should not just focus on providing skills to use technologies but to ensure a critical view of technology and its dependencies.

[19] INEC Declaration of open networks http://www.i-nec.com/activities/the_declaration