

# Bridging Digital Divide in the Developing Countries with Linux

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## Abstract

The phenomenal growth of the Internet has opened great opportunities for knowledge sharing. The knowledge sharing ability leads to knowledge economy by superior technical competency. This in turns will bring greater quality of life to the people. However, most people living in the developing countries have been left untouched and unimpressed by this 'revolution', since it has failed to improve their lives. Within the boundaries of these countries, the ability of having access to Internet resources has been mostly to the ones who have the means. What has been considered a technical tool for technical people are now considered necessary resource. With all the information stored on the Internet, access to these resources must be provided at all community levels at a lower cost. GNU/Linux operating system provides the much cheaper alternative for the Internet community by its 'freedom' philosophy embodied in the GNU Public License.

## 1 Overture

Digital divide definition [1]:

*“Digital divide means that between countries and between different groups of people within countries there is a wide division between those who have real access to information and communications technology and are using it effectively, and those who do not.”*

Digital divide challenges [2]:

*“For developing economies, the challenges are substantial. The possibility that the gap already existing between the front-runners of the networking revolution (mostly high-income economies) and those lagging behind (mostly low-income countries) may still grow larger, raises the specter of a “digital divide.” The concern here is not restricted to the issue of connectivity per se; it also includes the implications of connectivity (or lack of it) for economic growth and the broader agenda of sustainable development. The danger faced by all is that the digital divide may reinforce patterns of divergence both internationally and within countries.”*

## 2 Introduction

Information technology has been accepted as a necessary technology in today education, economy, social and political sectors. It is, therefore, no more a luxury enjoyed by certain classes of technical savvy people. Digital divide phenomenon, however, is depriving people in the developing countries from the benefit of the information technology.

The digital divide is not only attributed to the ones who ‘have’ and ‘have not’ the information camps. It is also now covers effective and ineffective use of information camps. Effective use means that by using the technology, they can improve the quality of their lives. Only by understanding this reality, the gap of digital divide can be reduced.

We started the paper by the definition of digital divide and the introduction to the paper content. Then we describe the comprehensive bridging obstacles that obstructing the digital divide. Later on we present the obstacle categories in which Linux can effectively contribute the narrow the gap of digital divide. We the explain in brief how Linux can help in each category and what are the opportunities that can be exploited for the benefit of the people. At the end we present two case studies that already use Linux to solve their problems. The final case study is built from the experiences gained from the previous two case studies. It is open for discussion and contribution.

## 3 Bridging Obstacles

According to Professor Davis Foulger [3], there are at least seven fundamental obstacles to overcome in order to bridge the digital divide as illustrated by figure 1. The obstacles that must be bridged can be described as follows:

- Social and Legal Constraints
- Economic Priorities
- Basic Infrastructure
- Network Infrastructure and connectivity
- Computer Resources
- Literacy and Language
- Choice

Linux cannot bridge all the obstacles but it is suitable for bridging:

- Network Infrastructure and connectivity
- Computer Resources
- Literacy and Language

The network infrastructure and connectivity must be cost effective so that people can really benefit. The computing resource should be affordable and rugged to meet the rural environment. Literacy and language problem should be handle by localised user interface. The summary of the requirements is shown in figure 2 and table 1.

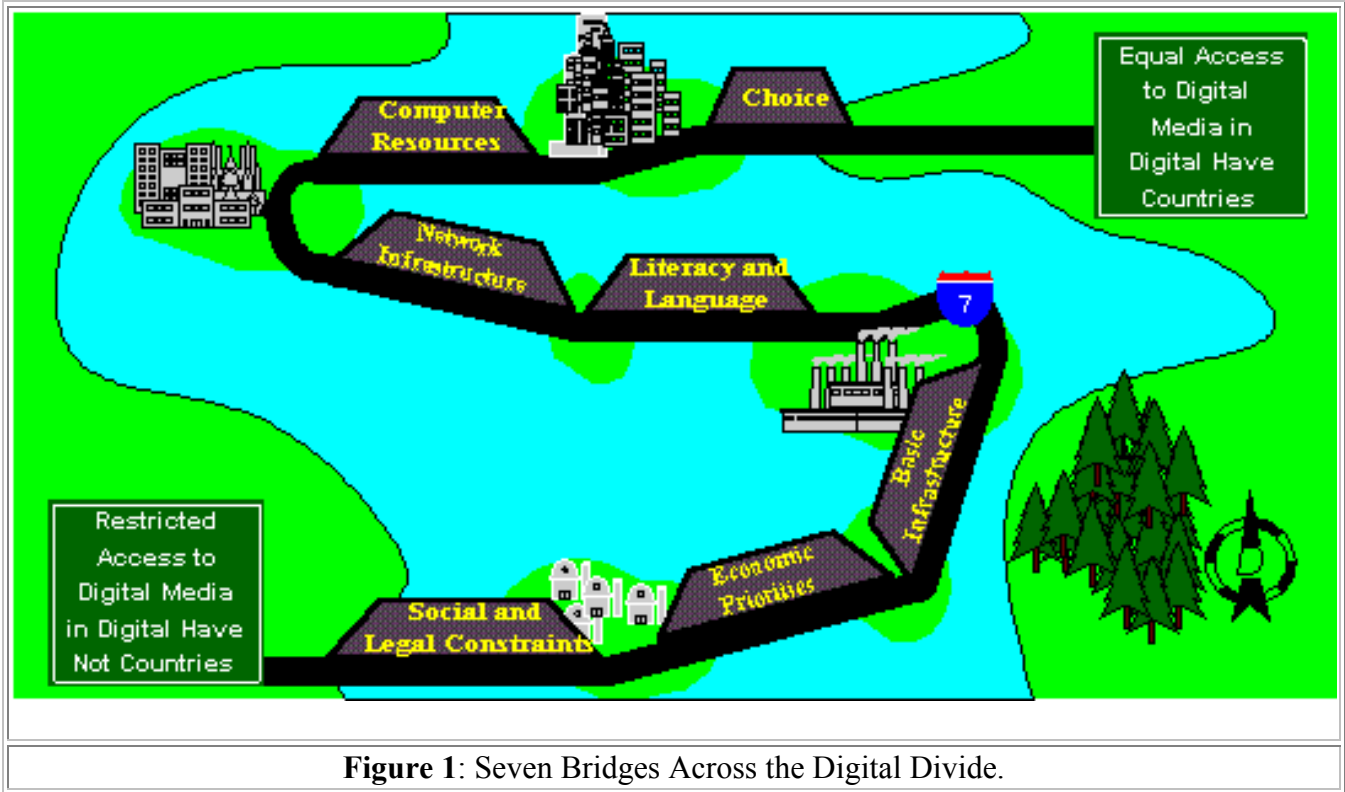


Figure 1: Seven Bridges Across the Digital Divide.

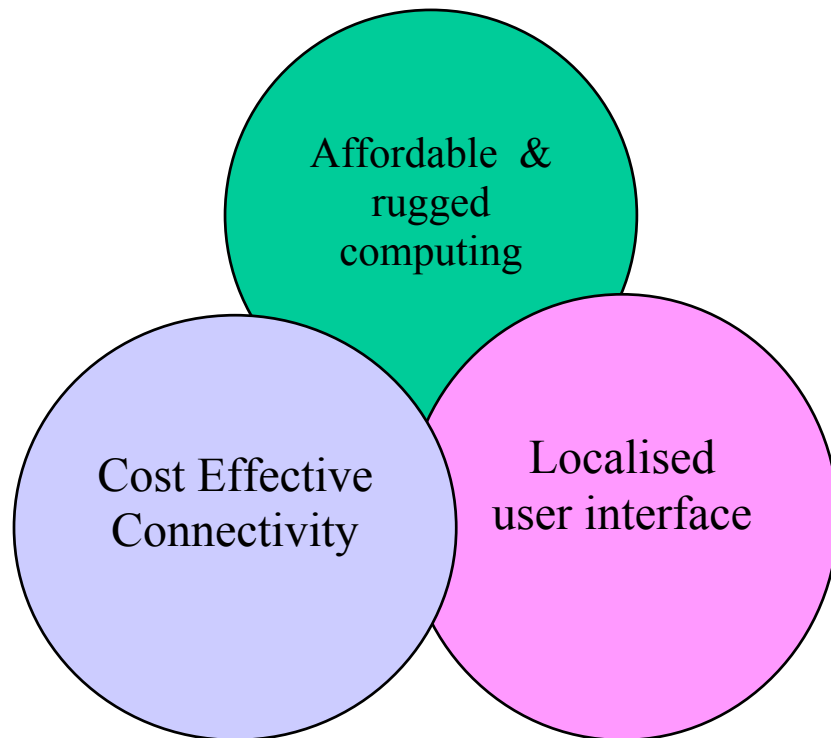


Figure 2: Objectives of bridging obstacles with Linux.

OBSTACLES	OBJECTIVES
Network Infrastructure and connectivity	Cost Effective Connectivity
Computer Resources	Affordable and rugged computing
Literacy and Language	Localised user interface

Table 1: Bridging obstacles and corresponding solution objectives

### 3.1 Network Infrastructures and Connectivity

Providing the network infrastructure and connectivity can be very expensive in terms of the hardware and software. Most of the networking vendors would probably bundle together their software and hardware for the reason of optimised networking solution. While this statement has some truth but the fact that bundling together means greater profit margin, thus more expensive solutions.

Fortunately, Linux has most of the critical network infrastructure software components needed for connectivity such as bridge, router, firewall and Domain Name Server (DNS). These are the default software that can be found in most Linux distributions. It is not an exaggeration to conclude that Linux has all the utilities required to set up an Internet Service Provider (ISP). The good news is that all of the networking software can be operated using off-the-shelf hardware and PC. For example, a bridge might require a Network Interface Card (NIC) with multiple ports in order to avoid the PC from running out of PCI bus slots.

Internet connectivity is expensive in urban area. For connectivity in the rural area the price is more expensive since longer cable is needed for connectivity. Some geographical landscape cannot even support cable wiring hence wireless connection is mandatory. The 802.11 wireless Local Area Network (LAN) can also be used to create a cheaper LAN with no wiring necessary. The Internet Wide Area Network (WAN) Internet backbone connection can be provided by the satellite link or long distance terrestrial radio link. Where it is affordable, normal fibre optic backbone can be used for extra reliability.

Regardless of the connection medium, Linux has a lot to offer. For examples, there are dedicated Linux distributions such as *Peewee Linux* [4] and *OpenAP* [5] for building satellite router and 802.11 wireless LAN access point, respectively.

The good thing about 802.11 is that multi-hops and ad hoc routing are now possible as opposed to conventional cellular based wireless communication where only single hop routing can be performed using the base stations. Multi-hops means nodes at proximity with each other can route Internet packet to directly unreachable destinations through their neighbours. Ad hoc means no existing fixed infrastructure is necessary. This robust configuration is suitable in rural environment where fixed infrastructure is scarce.

### 3.2 Computer Resources

Computers cost money, and countries in which monthly average earnings are far less than the cost of a new computer usually have very few of them. Linux can contribute by providing a low cost PC operating system and the ability of running on the legacy hardware. The legacy PC hardware such as based on Intel 80386 or 80486 Central Processing Unit (CPU) can still be used to run Linux over the network (thin client) or by providing only basic applications and running resource hungry applications from the application servers.

The legacy PCs can be used a cheap terminal for thin client (diskless) solution running Linux Terminal Server Project (LTSP). For easier and cheaper maintenance, PCs with hard disk connected to central application servers such as word processing server can be utilised to speed up the running application. This can work natively under Linux since the default windowing system, Xfree86, used by Linux was designed originally as network windowing system [6].

The latest computing trend is to use Personal Digital Assistant (PDA) since it is small and easy to carry around. It is also much cheaper than the normal PC price. Fortunately, Linux is the most portable operating system, thus theoretically it can be ported to any CPU used by the PDA. Thus PDA can be sold cheaper by running Linux.

Arguably, the most popular PDA today is *iPaq* and it is using StrongARM CPU from Intel. There is an equivalent open source PDA project based on StrongARM CPU called *Simpuser* that uses Linux as the operating system. This PDA is specifically proposed in India to bridge the digital divide.

### 3.3 Literacy and Language

It is easier to explain in the context of illiteracy rather than literacy since we are in the problem domain. There are two kinds of illiteracy in the context of information technology, computer and language illiteracy. Linux can effectively help in solving computer illiteracy problem. The pre-requisite for computer literacy, however, is the language itself since we cannot operate if we cannot read and understand the computing menu or manual. Generally, language literacy can be further divided further into no-English or no-language illiteracy. The no-English illiteracy refers to the people who cannot read English but their own native language. The no-language literacy refers to the people that cannot even read their own native language. Figure 3 exhibits 'Illiteracy Tree' in the context of information technology.

Productive software such as database, office suite, programming utilities, multimedia players and browsers are the 'bread and butters' for computers. It is not over-stated to say that without them we will lose the reason to use the computer. These productive software require a certain level of skill, so called 'literacy', to operate them. Literacy is achieved by accessibility and operability of the software.

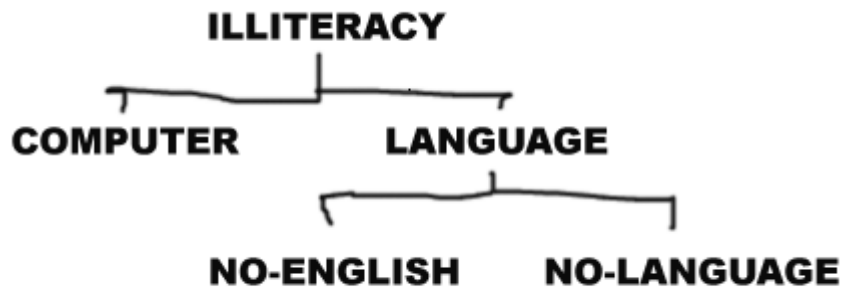


Figure 3: ‘Illiteracy Tree’ in the context of information technology

Since most of the productive software comes default with any Linux Distribution, thus accessibility is no longer an issue. The next problem is the operability of the software. Professional training can cost a fortune in the developing countries and a self learning is usually hard since most of the software menu and manual are not in the user native language. Learning can be made easier by the existence of Linux User Group (LUG) where volunteers teach each other about Linux usually in the form of mentoring. Online Usenet and mailing lists can be helpful but the default language is English, therefore, it is quite prohibitive for the average persons.

The language problem is hard to solve in proprietary world since only a large user base can justify any inclusion of a particular language. Linux and open source environment make easy for native speakers to convert any existing productive software to be converted to their language. For example, there is a Malay language version of Mozilla browsers called Meksom [7].

Linux can also help people with no-language illiteracy to use the information technology. They can utilise text-to-speech synthesis system for a particular language. For instance, there is a Konqueror (Linux based browser) *Speaker* plugin that can perform text-to-speech synthesis developed by Edinburgh University. Since it is open sourced, any person can convert the software into his own native language. Thus, we can solve the no-English and no-language illiteracy obstacles with Linux at one time!

#### 4 Case studies

Case study is where the theory meets practice. It shows how the problems of digital divide can be solved in the real world. There are two case studies and an open case study. The first case study is the Simputer where the problem of computer resources and literacy/language are tackled. The next one is the wireless community where the network and connection infrastructure can be built using off-the-shelf hardware and Linux. The open case study is the foreseeable strategy in solving digital divide problem in the fishermen community.

## 4.1 Simputer

The Simputer project was conceived during the Global Village, an international Seminar of Information technology for developing countries in 1998. Simputer stands for Simple, Inexpensive and Multilingual computer [8]. While resembling a Personal Digital Assistant (PDA), the device is more powerful running an Intel StrongARM CPU, a Linux operating system and 32MB RAM. The Information Markup Language (IML) was created to suit the unique needs and purpose of the Simputer. Referred to as 'Illiterate' Markup Language, it was designed to provide the following features:

- Uniformity across diverse applications
- Ease of use
- Support for multi-lingual text and speech output
- Support for smart card usage
- Transparent access to remote/local resources
- Ease of application development
- Use of Internet standards
- Platform independence

Application development for the Simputer can be done on any platform: Linux, Windows, Solaris, MacOS. The Simputer application can be viewed as a black box that reads in IML and outputs IML. It can be run from AAA battery or from the main power supply.

The price for the Simputer is about USD\$200 or Rp10,000. This value is about two months salary for the working class people. The Indian came out with a working product but they fail in bridging the digital divide since the cost is prohibitive for the target group. This is largely due the cost of the hardware itself. StrongARM is a product of Intel licensed from ARM Company, thus the price is expectedly prohibitive. This price can be made significantly lower by using local made CPU processor. In Malaysian context, we can use PESONA processor since it is a much cheaper than the StrongARM [9,10].

## 4.2 Wireless Community

Network Address Translation (NAT) is a technique that enables multiples PC to share an Internet address. This technique can be applied to multiple sharing a single Internet connection. For example, a T1 line with 2Mb/s connection can be shared amongst 50 houses and each house get to use 40kb/s connection if all of the houses connected at the same time. Internet connection can become even cheaper by using wireless since no prior cable wiring is necessary. The added advantage is that a connection is available everywhere within the range since it is wireless. This new arrangement is called wireless community.

In the wireless community, at least a volunteered house with 24x7 fast Internet connection becomes a neighbourhood ISP. The participated houses must have a rooftop antenna that connected to in-houses Wireless Access Point (WAP). The rooftop antenna is an omni directional antenna. It is basically a transceiver that acts as a router and a node at the same time. This practice becomes popular overnight with communities in major cities around the world such as Geneva, Vancouver, Sydney and London. There is a website [11] dedicated to track such communities all over the world.

The majority of the wireless communities are using 802.11 wireless LAN protocol because of its many advantages. Off-the-shelf hardware is used and mostly running Linux and open source platform. It did not, however, come as a surprise that many of the implementation used Linux as the network infrastructure software platform as described in [12]. What came as a surprised that most of the people involved are from cities of the developed countries since this opportunity should be fully utilised by the people in the developing countries to their benefit. It is, however, a good example of solving digital divide problem within the already developed countries.

### **4.3 Open case study: The intelligent fishermen radio**

In this open case study section we will try to build a solution based upon the experiences gained from both previous case studies in order to solve a particular digital divide problem.

Suppose we want to provide cost effective information technology for the fishermen. The facts are fishermen live near to the sea and working in their boats. Fishermen have to face many problems such as uncertain weather condition and illegal fishermen from the neighbouring countries. Thus they need reliable and affordable device for information and communication plus the network connection infrastructure to solve their daily problems. We proposed the Intelligent Fishermen Radio (IFR) with multi-hops and ad hoc wireless connection to solve the problems as illustrated in figure 4 [13].

The IFR can be just a customised PDA with localised content. It should be robust, affordable and easy to use. The PDA can be off-the-shelf or local made to significantly reduce the price. The software and the user interface should be user friendly even to the illiterate fishermen similar to the Information Markup Language (IML) used by the Simputer.

The cost network connection is minimal since the cost to build the infrastructure can be put to the minimum by using Linux and open source platform. The idea can be directly borrowed from the wireless community project. It is possible to local made the antenna for the terrestrial radio link to the ISP for cheaper set up cost. These solutions would fulfill the objectives listed in table 1.

Figure 4 shows a scenario of the deployment of the intelligent fishermen radio. The idea may be new but the necessary technologies are already existed and can be provided cost effectively by Linux.



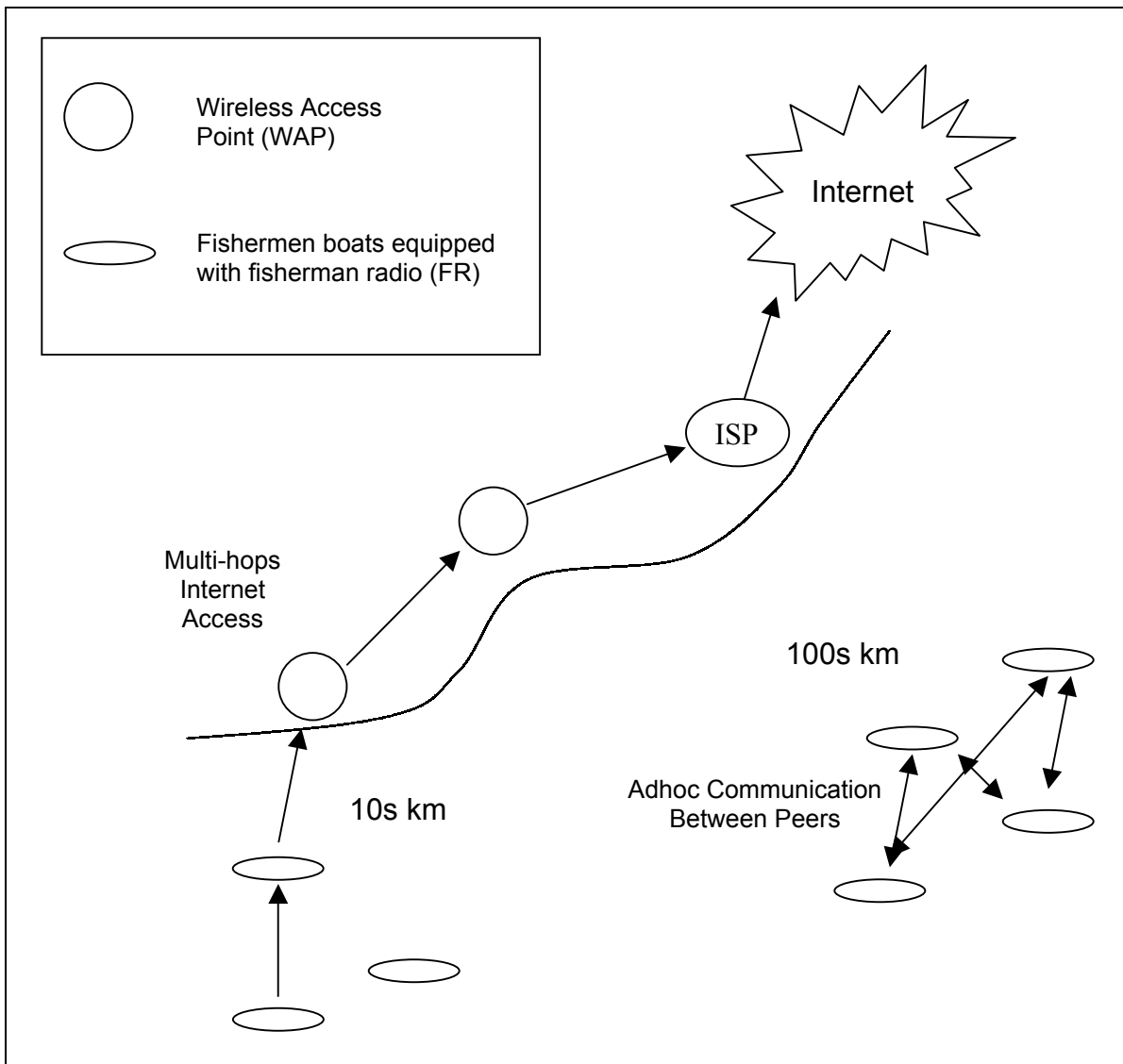


Figure 4: A deployment scenario of the Intelligent Fisherman Radio

## 5.0 Conclusion

In this paper we have presented the challenges and obstacles that are obstructing the objectives of bridging the digital divide in the developing countries such as Malaysia. In conclusion, Linux is the operating system of choice in bridging the digital divide in the developing countries. This is due to the fact that Linux provides cost effective platform and environment for spanning the gap of *Network Infrastructure/Connectivity*, *Computer Resource* and *Literacy/Language* elements of digital divide.

The new paradigm of software freedom introduced by GNU/Linux and open source can really improve the people quality of lives in the developing countries. This is very important since it is not merely the technology the ultimate focus but the people themselves.

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