The Power to Change: Adopting Free and Open Source Software in Papua New Guinea

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Abstract

Free and Open Source Software has a huge potential to contribute to the development of a sustainable ICT infrastructure for developing countries. Lower initial and recurrent costs, less dependence on foreign software vendors, increased local capacity development and growth potential for a local ICT industry are the main advantages. Papua New Guinea has not embraced these advantages. This article explains the nature and characteristics of Free and Open Source Software and outlines some measures to increase the adoption of Free and Open Source Software in Papua New Guinea.

Key words: Free and Open Source Software, sustainable ICT, digital divide, ICT policy, ICT for Development (ICT4D), IT Information Technology

Introduction

Information and Communication Technologies (ICT) are relatively recent instruments in the fight to eliminate hunger and poverty and increase the quality of life of the people living in the developing countries (Blommestein et al., 2006). The World Bank in its 2002 strategy paper on ICT states that:

> Information and Communication Technologies are a key input for economic development and growth. They offer opportunities for global integration while retaining the identity of the traditional societies. ICT can increase the economic and social well-being of poor people, and can empower individuals and communities. Finally ICT can enhance the effectiveness, efficiency and transparency of the public sector, including the delivery of social services.
>
> (World Bank, 2002)

Information and Communication Technology projects have been implemented in several sectors in the developing countries and gradually it becomes clear that successes are possible, but that the programs need to be designed and implemented with great care. Early enthusiasm and claims that ICT would prove a silver bullet for development problems lead to a number of false starts. Many of the problems in the early period are to be blamed on the lack of experience of the project managers from both the donor countries as well as on the recipient's side and the fact that solutions that worked in developed countries were unthinkingly copied to projects in developing countries. Over time the program managers have matured and the uniqueness of ICT solutions

for developing countries is gradually recognised. The last process is still underway and this article tries to contribute to this domain of knowledge. Regardless of how we measure it, there is an immense information and communication technology gap, a 'digital divide', between developed and developing countries. Statistics published by the ITU illustrate the magnitude of the digital divide. (See: http://www.itu.int/wsis/tunis/newsroom/stats/).

In 2004:

- the developing world had four times fewer mobile subscribers per 100 people than the developed world
- the developed world still had eight times (was 73 in 1994) the Internet user penetration rate of the developing world
- less than three out of every 100 Africans use the Internet, compared with an average of one out of every two inhabitants of the G8 countries (Canada, France, Germany, Italy, Japan, Russia, the UK and the US)
- there are roughly around the same total number of Internet users in the G8 countries as in the whole rest of the world combined: 429 million Internet users in G8 and 444 million Internet users in non-G8
- the G8 countries are home to just 15% of the world's population – but almost 50% of the world's total Internet users
- the top 20 countries in terms of Internet bandwidth are home to roughly 80% of all Internet users worldwide.

Relative to income, the cost of Internet access in low-income countries is 150 times the cost of a comparable service in a high-income country. There are similar divides within individual countries. ICT is often non-existent in poor and rural areas of developing countries (United Nations, 2006). This is partly due to the lack of infrastructure but another reason is the relatively high costs: Even when the costs are the same in both urban and rural areas, income disparities between rural and urban communities make communication services more expensive for rural dwellers. Among the countries in the regions there are also significant differences. Table 1 provides a detailed breakdown of the computer and internet usage in different areas in the world.

Table 1: Computer and internet use in different regions (UNDP, 2006)

Region	Computer Use (per 100 people)	Internet Use (per 100 people)
Developing Countries	2.5	2.6
Least Developed Countries	0.3	0.2
Arab States	2.1	1.6
East Asia and the Pacific	3.3	4.1
Latin America and the Caribbean	5.9	4.9
South Asia	0.8	0.6
Sub-Saharan Africa	1.2	0.8
Central & Eastern Europe & CIS	5.5	4.3
OECD	36.3	33.2
High-income OECD	43.7	40

The situation of Papua New Guinea is comparable with the average of the least developed countries as listed in Table 1. The ICT diffusion in Papua New Guinea ranks among the lowest 45 countries in the world. Thirty four of the lowest ranking 45 nations are in sub-Saharan Africa. India and its neighbours Nepal, Bhutan and Pakistan also fall into this group. The other low ranking countries tend to be scattered around the world — for example, Haiti, Cambodia, Lao People's Democratic Republic, Solomon Islands and Yemen. (United Nations, 2006). In the table below the index for ICT diffusion for some countries in the region are listed for reasons of comparison.

Table 2: Index for ICT diffusion in the Asia-Pacific region

Rank	Country	Access index	Connectivity index	ICT diffusion index
175	Solomon Islands	0.341	0.016	0.115
151	Papua New Guinea	0.393	0.021	0.207
135	Vanuatu	0.444	0.023	0.233
103	Fiji	0.521	0.078	0.299
15	New Zealand	0.832	0.478	0.655
9	Australia	0.807	0.589	0.698

The figures of the World Bank show that Papua New Guinea is faced with the enormous challenge to provide affordable access to ICT to its urban, but most importantly its rural population (World Bank, 2007). With substantial financial donor support some limited progress has been made in the last years, but the development is mostly felt by the high-income group in the rural centres.

As a result of its colonial past, Papua New Guinea tends to rely strongly on Australia for financial and capacity support. This also holds for the ICT sector. The market is strongly influenced by the Australian way of thinking and solutions are mostly based on proven technology and best practices in Australia. Many of these solutions fail because they are not geared to the specific needs of Papua New Guinea. Where many solutions are based on proprietary (software) tools, concerns are raised about the (financial) sustainability of the projects and achievements.

Finding appropriate solutions to bridge the digital divide for Papua New Guinea needs to be guided by a range of methodologies and hardware/software tools focusing on long-term sustainability (Reijswoud & Jager, 2008). The choice for software is an important parameter. This article considers the role Free and Open Source Software can play in the development of the country. We start to look at the challenges for organisations and government before going into detail on the characteristics of Free and Open Source Software. To understand the political side of Free and Open Source Software a brief stakeholder analysis is presented and the main hindrances for the introduction of Free and Open Source Software explained. We conclude with recommendations for Papua New Guinea. The article argues from the position that Free and Open Source Software provides one of the solutions that may

help Papua New Guinea to leap into the information age and provide affordable and sustainable ICT solutions to improve the well-being of all citizens in the country.

Challenges for organisations and governments

Although ICT is an important tool to bridge the digital divide, the technology also brings along huge challenges for organisations in developing countries. These challenges are divided into two main categories: capacity challenges and financial challenges. Both challenges are addressed below.

Capacity challenges

ICT brings new and powerful technology for all developing countries. Where developed countries have already a long history in which ICT has gradually been developed and integrated in the daily and organisational reality, developing countries were only confronted with it in the last 10-15 years, depending on the countries.

The consequence of this late introduction is that there is no or very limited knowledge infrastructure to support the creative development and use of ICT. Primary and secondary education is not providing basic computer literacy programs, universities have no appropriate programs in computer science or information systems (or outdated and theoretical ones), decision-makers are not aware of the possibilities that the new technology is to offer, there is no trained local business support and so on. In other words, the powerful technology lands in a knowledge and capacity vacuum. Expensive foreign experts are more than happy to fill in this vacuum, the ICT market in Papua New Guinea is a illustrative example of this reality.

In order to bring down the costs of development, implementation and maintenance of the ICT infrastructure, local capacity needs to be build rapidly and with the appropriate knowledge and skills. 'Old school' university curricula have to be replaced with programs that provide practical skills to students in order to be able to play an active role in the ICT infrastructure development in the country. In many countries this process is underway. Universities are gradually changing the programs and vocational training is offered for sub-university level students. Programs like the CISCO academy program for developing countries are important initiatives to improve the knowledge and skills levels to the required level.

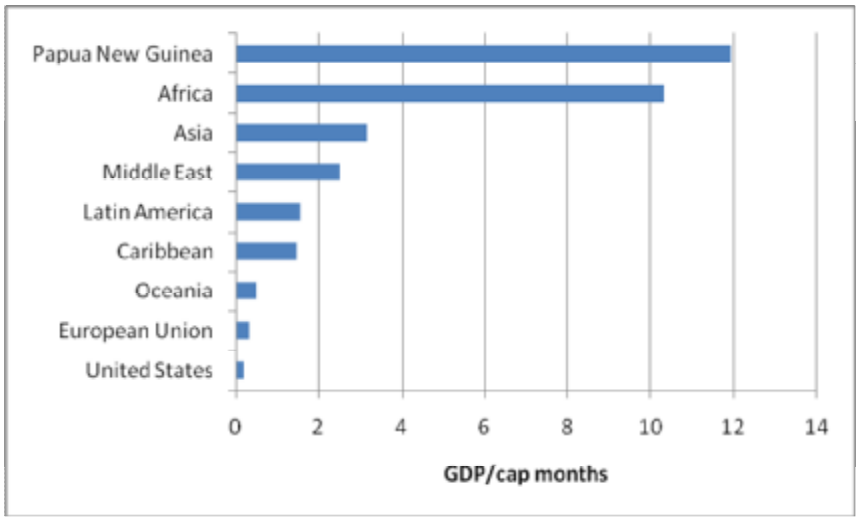
Financial challenges

The introduction of ICT also brings along financial challenges to those organisations eager to adopt the new technology. Next to the costs of training and educating people, as we have seen in previous section, acquiring hardware, ICT governance and software also poses challenges.

Computer hardware is often a large expense for organisations in the developing world, when compared to available financial resources. The costs of a simple computer (with internet connection and the necessary surge protection) are often comparable to the annual salary of the person using it. (Two figures on salaries of individual computer users are not at hand, but this remark is certainly justified for the situation at the government offices in Papua New Guinea.)

The introduction of ICT, for example in a ministry in a developing country, is accountable for a huge investment, which is, in a lot of cases, not available. Computer software is an often forgotten and underestimated cost. Ghosh (2003) shows that, what the developed world considers minor costs for productivity software like Microsoft Windows and Microsoft Office, become an exorbitant cost when it is related to the Gross Domestic Product of the developing countries. In figure 1 the price of Windows XP is expressed in the Gross Domestic Product months for several countries and regions in the world.

Figure 1. Price of WinXP expressed in GDP/cap months



Prices of commercial software like databases, learning management systems, document management systems, software development environments etc. extend the costs of the ICT far beyond the investment costs of the hardware. It clearly shows the relative expensiveness of WinXP for the users in Papua New Guinea, in relation to the Gross Domestic Product per capita; the average Papua New Guinean would have to sacrifice almost 12 months of income.

Increased personnel costs are the last financial challenge that needs to be highlight. The introduction of ICT in an organisation is always accompanied by new internal or external staff members (an often advisors/consultants) providing ICT maintenance and user support. Users needs to be trained, day-to-day problems will have to be addressed and solved, server and other systems

will have to be maintained and updated and important information will have to be stored and protected. Soon after the first computers are introduced an ICT department is established. At national levels, the introduction of ICT may lead to new governing and regulating bodies, and increasing to the establishment of ICT ministries. These should be all considered ICT related costs.

Free and Open Source Software

> Briefly, Free and Open Source Software programs are programs whose licenses give users the freedom to run the program for any purpose, to study and modify the program, and to redistribute copies of either the original or modified program (without having to pay royalties to previous developers).
>
> (Wheeler, 2003)

Finding an agreement on one definition of Free and Open Source Software has proved to be difficult, but the definition of David Wheeler provides a good description of the essence of what Free and Open Source Software is. It is software that is produced and issued by a community that likes to have their products open and likes them to be shared freely with the others in the community. It argues from the idea of a community that likes to learn and share without leaving people out. The Free and Open Source Software community promotes the growth of knowledge by allowing other members to stand on the shoulders of the giants in this same community.

At the philosophical level we find two major schools or paradigms in the Free and Open Source Software world: the oldest is the philosophy of the Free Software Foundation philosophy founded by Richard Stallman. On the other end is the more business-like approach expressed in the Open Source Initiative philosophy.

The Free Software Foundation has a long history rooted in the academic principles of knowledge sharing. The Free Software Foundation emerged in the early days of computer science and computer industry when sharing software code became a problem and software gradually became 'closed'. Before this period software was treated as most academic products. People were sharing computer code, algorithms or whole programs with their peers. This sharing was done on the basis that you could use it, but had to acknowledge the origin of the information, the same way most of the academic world is still functioning.

The rise of industry and the commercialisation of the computing industry changed this attitude. Sharing was gradually replaced by protection and academics that promoted openness had to make way for entrepreneurs that build 'closed'/proprietary software. By many, William (Bill) H. Gates' now-famous pamphlet: *An Open Letter to Hobbyists* dated 3rd February 1976, is considered a landmark in this change. In this letter Bill Gates rails against the prevailing culture of software sharing:

> *Why is this? As the majority of hobbyists must be aware, most of you steal your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid?*

The gradual destruction of the software sharing culture Gates refers to was reason for Richard Stallman, researcher at MIT Artificial Intelligence Lab to stand up and promote the Free and Open Source Software development and licensing. He founded the Free Software Foundation.

According to the Free Software Foundation, free software is about protecting four user freedoms:

- The freedom to run a program, for any purpose.
- The freedom to study how a program works and adapt it to a person's needs; Access to the source code is a precondition for this.
- The freedom to redistribute copies so that you can help your neighbour.
- The freedom to improve a program and release your improvements to the public, so that the whole community benefits. Access to the source code is a precondition for this.

At the heart of the Free Software Foundation is the freedom to co-operate and collaborate. Because non-free (free as in freedom, not price) software restricts the freedom to co-operate, Free Software Foundation considers proprietary software unethical. Free Software Foundation is also opposed to software patents and additional restrictions to existing copyright laws. All of these restrict the four basic user freedoms listed above. (For a more detailed explanation of why software needs to be free see: *Why Software Should Be Free*, http://www.fsf.org/philosophy/shouldbefree.html)

At the same time the world and the Free and Open Source Software community is changing. Free and Open Source Software has become an international phenomenon, moving away from relative obscurity to being the basis of a full blown industry. Within the context of the approach of the Free Software Foundation, business initiatives do not always feel comfortable. The approach of the Open Source Initiative likes to accommodate this. In the nineties, this group associated with Free Software Foundation introduced the term 'open source' to emphasise a break with the pro-hacker, anti-business past associated with GNU and other free software projects and to place a new emphasis in the community on the possibilities of extending the free software model to the commercial world. The new 'open source' projects exist in the mainstream of the commercial software market and include operating systems, such as Linux, the Apache web server, and the Mozilla browser.

The Open Source Initiative philosophy is therefore somewhat different from the Free Software Foundation philosophy:

> The basic idea behind open source is very simple: When programmers can read, redistribute, and modify the source code for a piece of software, the software evolves. People improve it, people adapt it,

> people fix bugs. And this can happen at a speed that, if one is used to the slow pace of conventional software development, seems astonishing
>
> (Wong & Sayo, 2003)

The Open Source Initiative is focused on the technical values of making powerful, reliable software, and is therefore more business friendly than the Free Software Foundation. It is less focused on the moral issues of free software and more on the practical advantages of the Free and Open Source Software distributed development method. 998, a group associated with free software introduced the term 'open source' to emphasise a break with the pro-hacker, anti-business past associated with GNU and other free software projects and to place a new emphasis in the community on the possibilities of extending the free software model to the commercial world. These new 'open source' projects would exist in the mainstream of the commercial software market and include operating systems, such as Linux, the Apache web server, and the Mozilla.

Open Source Initiative defines Open Source as software providing the following rights and obligations:

- No royalty or other fee imposed upon redistribution
- Availability of the source code
- Right to create modifications and derivative works
- May require modified versions to be distributed as the original version plus patches
- No discrimination against persons or groups
- No discrimination against fields of endeavour
- All rights granted must flow through to/with redistributed versions
- The license applies to the program as a whole and each of its components
- The license must not restrict other software, thus permitting the distribution of open source and closed source software together.

This definition clearly leaves room for a wide variety of licenses. While the fundamental philosophy of the two movements are different, both Free Software Foundation and Open Source Initiative share the same space and co-operate on practical grounds like software development, efforts against proprietary software, software patents, and the like. As Richard Stallman says, the Free Software Movement and the Open Source Movement are two political parties in the same community.

But Free and Open Source Software is more than a philosophy, it is also a software development approach that has resulted in the new and powerful software, of which some dominate the current software spectrum. The changing concept and work approach that is used in open source software development was well described and analysed by Erik Raymond in his book *The Cathedral and the Bazaar* (Raymond, 1998). The cathedral and bazaar analogies are used to contrast the Free and Open Source Software development model with traditional software development methods.

Commercial software development is similar to the way cathedrals were built in ancient times. Small groups of skilled artisans carefully planned out the design in isolation and everything was built in a single effort. Once built, the cathedrals were complete and little further modification was made. Software was traditionally built in a similar fashion. Groups of programmers worked in isolation, with careful planning and management, until their work was completed and the program released to the world. Once released, the program was considered finished and limited work was subsequently done on it.

In contrast, Free and Open Source Software development is more akin to a bazaar, which grows organically. Initial traders come, establish their structures, and begin business. Later traders come and establish their own structures, and the bazaar grows in what appears to be a very chaotic fashion. Traders are concerned primarily with building a minimally functional structure so that they can begin trading. Later additions are added as circumstances dictate. Likewise, Free and Open Source Software development starts off highly unstructured. Developers release early minimally functional code to the general public and then modify their programs based on feedback. Other developers may come along and modify or build upon the existing code. Overtime, an entire operating system and suite of applications develops and evolves continuously.

The model of the bazaar is an interesting model for users and software industry in the developing countries. Since they have not been involved in the development of the 'software cathedrals' of modern times, their needs have not been addressed. Requests like translating e.g. Microsoft Office in local languages (even the large ones like Pidgin) land on deaf ears. In the bazaar model it becomes more easy to get the needs of the developing countries' integrated, through collaborating in the development of new applications or forking4 of existing applications. (4 Forking in software development is like branching: Programmers take a copy of a program and start to develop a new program.)

Advantages and disadvantages of Free and Open Source Software

The discussion about the advantages and disadvantages of Free and Open Source Software is a difficult discussion since there little objective information available. The counts for both proprietary as well as for Free and Open Source Software. We will therefore list some of the advantages and disadvantages mentioned by others.

In 2004 the Australian Computer Society produced a positive recommendation (ACS, 2004) for a stronger emphasis of the IT community on Free and Open Source Software. They summarised the following advantages for the ICT-industry, software users, and corporate, government and individual consumers.

- Total Cost of Ownership for open source software can be much less expensive than proprietary alternatives. For large consumers such as corporations and government, this can translate to significant cost savings.

- Additionally, base level technical support for many open source applications is provided free of charge by the program authors and user community that has grown up around the program.

- Major IT vendors such as IBM, Sun, Novell, Oracle, Computer Associates as well as specialist open source firms such as Red Hat and MySQL, offer 'fee for service' commercial support for open source applications.

- Of major interest to the ACS, is that open source applications encourage innovation within the Australian ICT industry. Because open source applications rely on open standards, such as common data, document formats and protocols, for interoperability, any software using open standards (whether open source or proprietary) prevents vendor lock in, and allows consumers to compare and switch vendors and negotiate on price.

- Open source software allows programmers to readily share and capitalise on each others ideas. Fixes and enhancements are not limited by vendor resources and other constraints and evolve at a more rapid pace than for proprietary products. The ability for programmers to base new systems on pre existing open source architecture reduces time, risks and costs associated with software development.

The Australian Computer Society concludes that:

> ... open source software has the potential to increase competition, innovation and stimulate the Australian software development industry. It can represent a cost effective alternative to proprietary software and private and public sector procurement and evaluation processes should include assessment of both proprietary and open source alternatives.

At the same time there are also limitations and drawbacks to the use of Free and Open Source Software. The UK Office of Government Commerce identifies the following factors that may limit successful implementation:

- Available support for Free and Open Source Software. In the past years support has been lacking a professional approach. In recent years this has improved now that large software companies like IBM, SUN and HP have started to join the Free and Open Source Software movement.

- Finding the appropriate software: Since Free and Open Source Software is not 'advertised' it can be very difficult to select the appropriate applications for the task it has to support. A more active approach is needed from the users.

- Documentation: The documentation that accompanies Free and Open Source Software application is often idiosyncratic and sometimes non-

existent. Free and Open Source Software developers are motivated towards the technical aspects of the application than towards the usability.

- Limited best practices: There are very little known and documented cases of large-scale migration from commercial software to Free and Open Source Software.

- Hardware – software fit: Free and Open Source Software often lags behind concerning new hardware. This is caused by the fact the hardware manufacturers fail to release hardware specifications in time to the Free and Open Source Software community.

It has to be noted that the resistance against Free and Open Source Software is getting less world-wide. The bazaar method of software development has been proven over time to have several advantages:

Reduced duplication of effort: By releasing programs early and granting users the right to modify and redistribute the source code, Free and Open Source Software developers reuse the work produced by compatriots. The economies of scale can be enormous. Instead of five software developers in 10 companies writing a single networking application, there is the potential for the combined efforts of 50 developers. The reduced duplication of effort allows Free and Open Source Software development to scale to massive, unheard of levels involving thousands of developers around the world.

Building upon the work of others: With the availability of existing source code to build on, development times are reduced. Many Free and Open Source Software projects rely on software built by other projects to supply the functionality needed. For example, instead of writing their own cryptographic code, the Apache web server project uses the Open SSL project's implementation, thereby saving thousands of hours of coding and testing. Even in cases where source code cannot be directly integrated, the availability of existing source code allows developers to learn how another project has solved a similar problem.

Better quality control: 'Given enough eyeballs, all bugs are shallow' is an oft-cited quotation in the Free and Open Source Software world. It means with enough qualified developers using the application and examining the source code, errors are spotted and fixed faster. Proprietary applications may accept error reports but because their users are denied access to the source code, users are limited to reporting symptoms. Free and Open Source Software developers often find that users with access to the source code not only report problems but also pinpoint the exact cause and, in some cases, supply the fixes. This greatly reduces development and quality control time.

Reduced maintenance costs: Maintenance of any software package can often equal or exceed the cost of initial software development. When a single organisation has to maintain software, this can be an extremely expensive task. However, with the Free and Open Source Software development model,

maintenance costs can be shared among the thousands of potential users of a software application, reducing per organisation costs. Likewise, enhancements can be made by the organisation/individual with the best expertise in the matter, which results in a more efficient use of resources.

The advantages are alike for the developed and developing countries, but some have more weight in the developing countries. The most obvious aspect is the cost aspect, for Free and Open Source Software users (individuals and organisations) pay no licensing fee. Cost reduction, especially recurrent costs, is increasingly important in for all developing countries in order to become less dependent on donor grants. The total cost of ownership is often mentioned to be higher for Free and Open Source Software since more development time (with expensive developer salaries) is needed. In the developing countries where salaries are significantly lower, this may tip the scales to the other side.

However, the 'openness' and flexibility of Free and Open Source Software is more important when considering the situation at hand in countries like Papua New Guinea. Free and Open Source Software can be customised and constantly revised to develop and change with the needs of the user. It is only now when ICT is implemented in the developing countries that the needs and requirements for the software is gradually discovered. Moreover, where propriety software is very hardware intensive, Free and Open Source Software can be modified to run on computers that are 'obsolete'. This will limit the need to replace hardware frequently.

Of all the advantages and disadvantages the open software development communities may prove the biggest advantage of Free and Open Source Software in for the developing countries. Lecturers and trainers that are conversant with modern software technologies and tools are often hard to find. This has a negative impact on the development of the technical capacity needed. Through the participation in bazaar like software development projects, implicit training in software development becomes available though other participants, that would otherwise not be accessible.

Stakeholders in the Free and Open Source Software arena

In order to understand the Free and Open Source Software movement better we provide an overview of the different players that participate in the community and the stakes that they have (World Bank, no date). The main stakeholders are identified:

Software industry: The key players in the Free and Open Source Software arena are the software manufacturers, both producing and distributing proprietary software and Free and Open Source Software. In recent years, the proprietary software industry has shown an increasing interest in the developing countries as a new sales frontier. Decision-makers and responsible government officials are approached in order to standardise on propriety software. Interesting 'free software' deals are offered. Unfortunately, the Free

and Open Source Software vendors have shown relatively little interest in the developing countries' market, with the exception of Ubuntu.

Governments: Governments are the central players in the arena. The other stakeholders fight for their attention in order to make them create the 'right' rules, regulations and laws. The governments in the developing nation are often corrupt and therefore the outcomes of the decision making processes are unpredictable and not transparent (Laffont, 2005).

Donors: With the term donor we denote all foreign agencies that providing or support in terms of knowledge or skills in developing countries. So this includes both funding agencies as well as implementing agencies. The power of the donor is mainly determined by the amount of funds they make available for development of the key issues in the country. Almost all donors invest in ICT as part of their approach, but there are only few donors that are specialised in explicitly devising ICT solutions for development. In general donors have good relations with decision-makers and government officials. Few donors have relations within the (local) ICT or software industry.

Local ICT industry: The local ICT industry is often young, immature and with a low level of organisation. Individual businesses and entrepreneurs are fighting their way into a new market. In most developing countries these businesses are run by young people who have recently graduated from local universities. In the case of Papua New Guinea the market is dominated expatriates that try to capitalise on the skill and knowledge gap. The level of internal organisation of the ICT industry is generally low, and when organised in a professional organisation, like computer societies, they are unable to put sufficient pressure on the government and decision-makers.

Local business community: The local business communities increasingly depend on the ICT climate in a country. ICT is getting more and more important for their survival in the global economy and a good ICT infrastructure is a precondition for their international success. The local business community does have influence on the direction of the government policies, but only to a limited extent.

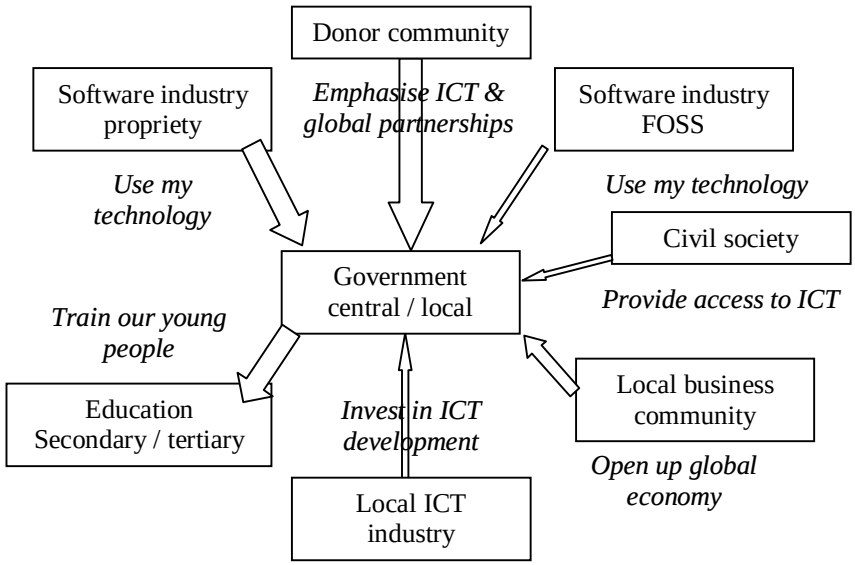
Civil society: Like the local business community, civil society is increasingly aware that access to ICT and information plays a crucial role in the country's development. They will try to influence government and decision-makers to improve regulations that promote access information and communication possibilities for all citizens. However, their influencing powers are limited.

Educational institutions: The educational system provides the next generation computer users and ICT experts in a country. Nowadays most universities in the developing nations have a basic ICT infrastructure, train students to use computers and offer courses in Computer Science and sometimes in Information Systems. In an increasing number of secondary schools students have access to computer technology and some countries have made computer studies a compulsory subject for secondary school students. Governments set

the guidelines for curricula for schools and play an important role in types of systems and platforms that are used.

In the Figure 2 we have displayed the stakeholders relationships. The arrows display the direction of the relationships, and the thicker the arrows are, the stronger their influential relationship is.

Figure 2: Stakeholders and their stakes in the Free and Open Source Software Arena



Hindrances for the introduction of Free and Open Source Software

We identify three major factors that hinder the introduction of Free and Open Source Software in developing countries: 1. lack of information, 2.availability of software and 3. missing role models. We will consider these hindrances in more details below.

Information

Access to information about advantages/disadvantages Free and Open Source Software and alternatives to proprietary software is very limited. Most of this information is only available and distributed through the internet. The majority of the people in the developing countries, especially in the rural areas, still have limited access to this medium for information sharing. When people do have access they will only search for it when they are aware of the existence of Free and Open Source Software.

Unfortunately, universities and schools pay very little attention to Free and Open Source Software. The large majority of schools and universities use (often illegal) proprietary software for teaching and have little interest in

alternatives. At the level of the teachers and lecturers there is too little knowledge about the Free and Open Source Software in order to be a source of information for their students. In most countries in the developing world the issue of copyright receives too limited attention to provide a start for a search for alternative solutions. The discussion of copyright laws could be a stepping stone for elaborating on Free and Open Source Software and the creation of awareness among new users.

Some members of the ICT-oriented donor community are informed about Free and Open Source Software and will promote Free and Open Source Software based solutions, however, the majority promotes the use of ICT without addressing the Free and Open Source Software issue. With that, they fail to take their guiding role to the level that they should. Linux user groups (LUG) have emerged all over the developing world. They have become an important source of information for the Linux and Free and Open Source Software communities. Because of their local focus they are able to serve the direct needs in the community, which are often different in the developing countries than in the global newsgroups. At the same time, these groups are mostly technology oriented and this may form a barrier for newcomers to join and participate. In the Pacific region the Pacific Islands Chapter of the Internet Society maintains a Linux Users Group (PLUG) and some other technical forums.

Software availability

Like the information about Free and Open Source Software, the software is also made available through the internet. There are hardly no physical point of sale for Free and Open Source Software. Where proprietary software can be found on the shelves of the local IT vendors, packaged Free and Open Source Software tools are are to come by. It is even more difficult to buy a computer that has not Microsoft Windows installed. This creates a huge barrier for potential users of Free and Open Source Software, since in most of the internet connections in developing countries are slow, unstable and expensive. This makes the downloading of a complete distribution like SuSE or Fedora (1 Gb +) virtually impossible. In Papua New Guinea where Internet is paid per incoming megabyte the download of Ubuntu 7.04 (697.9 Mb) would cost around €200. This excludes the updates that are to be installed after the installation.

There are some solutions for the unavailability of the software. Organisations like the East African Center of Open Source Software (EACOSS, www.eacoss.org) in Uganda tried to overcome the problem by using normal mail to bring the software in the country, then storing it in a public repository on their website and re-distributing it to users. This 'last-mile' solution is facilitated through scooter-taxis (boda boda) that take the software to the users for the costs of the CD-rom/DVD's and the boda boda fare. This initiative has been replicated in several other countries in Africa. In Papua New Guinea such solutions are not offered to users.

The producers of the Ubuntu distribution also recognised the issue and has made, from the beginning, their distribution available through normal mail. Users can order, free of charge, one or more copies of their software from the Ubuntu website (https://shipit.ubuntu.com/). For other distributions there are no such services.

Missing role models

A third major hindrance to the growth of Free and Open Source Software in the developing countries is the lack of icons and iconic projects. In general the Free and Open Source Software movement has only a limited number of people that can serve as examples for young entrepreneurs to look up to, contrary to the proprietary software movement where people like Bill Gates and Larry Allison spark imaginations of wealth and influence and for many young IT professionals in the developing countries. Moreover, the leaders of the countries show little interest in Free and Open Source Software and there are hardly businessmen that have made a fortune with the application of Free and Open Source Software. Unfortunately, we see no leaders that make presentations that have been created in Open Office.

Similarly, there are very few large-scale projects that can serve as a model for young entrepreneurs. Large projects like in Extremadura Spain, where the Ministry of Education, Science and Technology successfully initiated projects to convert computer systems from proprietary systems to Free and Open Source Software have not been picked up in developing countries. The Extremadura project has been able to revive general prosperity and business activity in a poor region in Spain, and ultimately the quality of life in the region (APC, 2007, Nah Soo Hoe, 2006, Dravis, 2003).

Good examples of successful organisations that have succeeded with the use of Free and Open Source Software are needed to draw the attention of the leaders, the IT community, donors and users in the developing countries. Existing projects will have to be more closely monitored and deserve more attention by the donor community. New projects will have to be reported more broadly

The power to change Papua New Guinea

In order to leapfrog the digital divide and implement an ICT infrastructure that is sustainable in the long term, Papua New Guinea needs to put emphasis on the design of appropriate solutions and building local capacity. Free and Open Source Software will support the country with one of the important instruments to bring about this highly needed sustainable change. The current reliance on foreign experts and proprietary software will not bring about the needed change, and will most likely only broaden the information and technology gap between Papua New Guinea and the rest of the world.

In order enable sustainable change, measures will have to be taken at levels and by all stakeholders. A combined effort is needed to for the country out of the current downward spiral of strongly increasing software costs vendor lock-in

and dependence. In this conclusion we will consider the most important players: government, donor community and education.

Government

The government of PNG will have to start to recognise that an appropriate ICT infrastructure needs to be built that acknowledges the economic and social characteristics of the country. Recurrent costs as a result of software licenses and reliance on external (foreign) expertise therefore need to be minimised where possible. A growing number of governments around the world confirm this position explicitly in their ICT policies and some actively migrate to an ICT infrastructure based on Free and Open Source Software. As a developing nation, PNG should realise that the benefits can be huge, both in the short term as well as in the long term, and confirm that position in the ICT policy. The country needs to establish an Free and Open Source Software workgroup that investigates and reports on suitable software alternatives and procurement policies for the different sectors in the country. The workgroup will also provide guidelines in building the appropriate local capacity.

The government should also act as an agent of change. When the government, ministries and departments decide to use Free and Open Source Software, they will provide a positive example for the other stakeholders: opportunities are provided for a new group of local IT entrepreneurs, costs of software procurement will go down and the budget can be use to increase access, local innovative initiative is valued and overall they will show that things can be achieved in the 'PNG-way'.

Donor community

The members of the donor community that are involved in decisions on IT procurement and policy will have to be educated on the benefits of Free and Open Source Software to address the IT infrastructure challenges facing Papua New Guinea. They will have to be able to guide government and the other stakeholders towards a sustainable ICT infrastructure. The donor community should act as a role model by showing that their organisations and its individual members are able to fulfil their tasks with Free and Open Source Software tools and value open standards. For example, instead of standardising on proprietary office formats (.doc, .xls, .ppt, etc) they could use open standards (.odt, ods, odp, etc). A recent trend to send out documents in the new Microsoft Office 2007 format, forcing organisations in the developing world to upgrade, gives the wrong signal. The donor community should also set an example by running their IT infrastructure (databases, website and servers) on Free and Open Source Software and provide funds to train local capacity.

Education

The educational sector has to educate a new generation of users and IT experts that understand and know how to handle Free and Open Source Software. The new users must be aware of the costs of the software they are using and

alternatives that are available. The recent adoption of the Free and Open Source Software-based One-Laptop-Per-Child in PNG is an important step. But also initiatives by Divine Word University like the opening up of a computer laboratory that solely uses Free and Open Source Software, and the promotion of Free and Open Source Software in the server environment, needs to be acknowledged. A sectorial policy promoting the use of Free and Open Source Software would give a boost to its adoption and will put sustainable computing in reach of more secondary and tertiary institutions of education.

The country would benefit when the training of students in Computer Science and Information Systems is primarily on Free and Open Source Software tools. Not only do they get a deeper understanding of the technical aspects of computer technology, they will also have a broader view based on choice of alternatives. Free and Open Source Software holds the possibility for change in Papua New Guinea but it requires a new orientation of the stakeholders. Courage, persistence and a combined approach is needed to build capacity and an IT infrastructure that will lead the country into the 21st century.

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Appendix – Examples of Free and Open Source Software

Desktop

Software is an essential element in the operation of every computer, from PDA to notebook, from desktop to server. At a general level we identify two types of computer software: operating systems software and application software. We could introduce more complex classification of the different software layers, as the OSI model, but they are beyond the scope of this article.

Operating systems software is designed the make all the different hardware components in the computer, as well as all the peripherals, work together and to make it operate as an integrated machine. The operating system does interpret signals from keyboard and other input peripherals, allowing the user to input data, to process it in the central processing unit, store it temporarily or permanently on storage devices, and provide an output on output peripherals, as screen or printer.

Linux is considered the main operating systems software FOSS alternative. Linux is the runaway success of the Unix world. The term Linux is often used synonymous with the Linux distribution . The distribution is the Linux operating system software (kernel) bundled with application and/or server software. In some cases the distribution is a bundling of thousands of bigger and smaller applications. There is however only one Linux kernel and there are many Linux distributions. The best-know linux distributions are listed in the table below. (For a complete list of the all Free and Open Source Software and non- Free and Open Source Software Linux distributions see: www.distrowatch.com.) We have distinguished between fully Free and Open Source Software distributions and partial Free and Open Source Software, where Free and Open Source Software is combined with some proprietary applications.

Table 3: The major Linux distributions with their websites

Fully FOSS		Partial FOSS	
Ubuntu	www.ubuntu.com	SuSE	www.suse.de
Slackware	www.slackware.org	Red Hat	www.redhat.com
Debian	www.debian.org	Mandriva	www.mandriva.com

Application software is designed to support individual users or organizations in executing their tasks. Application software is used on top of the operation systems software. For most tasks that users perform on the desktop there are Free and Open Source Software alternatives available. In the table below we have listed major tasks of the user and the most important Free and Open Source Software alternatives that will support this task. Free and Open Source Software is often regarded as software that is designed for the Linux platform. However this is not necessarily the case. Many of the Free and Open Source Software applications work on the Linux operating system as well as on the

Microsoft Windows operating system. In the table below we have therefore indicated the operating system the software will work on. We have selected, where possible, software that works on both Windows (indicated with W in the table) and Linux (L). 10 We do not include Apple's OSX operating system, since we consider this a partial proprietary Unix variant and highly comparable with Linux.

Table 4: The main free and open source software alternatives for the user/desktop tasks

Task	Application	Website	Platform
Office productivity suite	Open Office	www.openoffice.org	W/L
Web browser	Firefox	www.mozilla.org	W/L
Email reader	Thunderbird	www.mozilla.org	W/L
Personal Information Management (calendars, tasks, addresses, emails etc)	Chandler Evolution Kontact	chandlerproject.org/ www.gnome.org www.kontact.org	W/L L L
Image Editing	GIMP	www.gimp.org	W/L
Desktop publishing	Scribus	www.scribus.net	L
Media player	VLC	www.videolan.org	W/L
Personal Database	Open Office Base	www.openoffice.org	W/L

Business software is often more expensive than user/desktop software and this poses a huge challenge for start up companies and small and medium enterprises (SME) in the developing countries. Although they are the driving force of many developing economies, the profits are small, financial institutions are reluctant to support investment for these organisations and therefore large investments in software are often not possible. However, in order to grow theirbusinesses and expand abroad, the SME's will have to automate. Free and Open Source Software provides a range of business applications that provide good alternatives for the expensive proprietary business software. Below we present a list of some of the most important Free and Open Source Software alternatives for common business tasks.

Table 5: A selection of Free and Open Source Software alternatives for (small) business tasks

Task	Application	Website	Platform
Customer Relationship Management	SugarCRM	www.sugarcrm.com	W/L
Document Management	Alfresco	www.alfresco.com	W/L
Financial Management	SQL Ledger GNU Cash	www.sql-ledger.org www.gnucash.org	W/L L
Project Management	Open Project Gantt Project	www.projity.com www.ganttproject.org	W/L W/L
Enterprise Resource Planning (including	CentricCRM Adempiere	www.centriccrm.com www.adempiere.com	W/L W/L

financial management)			
Knowledge management	pbwiki	www.pbwiki.com	W/L
Web Content Management	Joomla Drupal	www.joomla.com www.drupal.com	W/L W/L
Web Site Design	NVU Quanta Plus	www.nvu.com quanta.sourceforce.net	W/L L
Database	MySQL PostgreSQL	www.mysql.com www.postgresql.org	W/L W/L

Server

When using computers in a networked environment, the user is only confronted with a small proportion of all the software that is used. To connect and survive in a computer network the user is connected to one or more servers that contain information and software. For the user this software is mostly invisible and applications on the user side are used to navigate through the network without knowing the networking details. However, servers are recommended when more computers need to access the same data, and in many small and medium enterprises this is the case.

On the server-side, which is mostly operated by the network administrator or network operator, a lot of different applications and hardware are used to enable the major networking functions or services:

- *Email services*: In developing countries many small organisations use public email services like Yahoo! or Hotmail. When the organisation becomes more professional services need to be set up a mail server to send and receive mail.
- *Web services*: Many organisations acknowledge the importance of their presence on the World Wide Web (WWW) with a website with corporate information becomes more important. In order to do so, a web-server needs to be set up.
- *File Sharing services*: When working in a network with information and data on a central server, there is need for file sharing services.
- *Database services*: Getting information and storing information in the business is best done with databases.

When an organisation grows, central database systems will be introduced. Free and Open Source Software has a bigger impact on the server environment than it had in the user/desktop environment. Many system administrators find Free and Open Source Software interesting since it offers alternatives that require or little or no investments (Upadhaya, 2007). Presently, most of the Internet Service Providers and Telecommunication providers in the developing countries use Free and Open Source Software for their servers.

Table 6: A selection of Free and Open Source Software alternatives for the server environment

Task	Application	Website
Mail server	Postfix Sendmail	www.postfix.org www.sendmail.org
Web server	Apache	www.apache.org
Database server	MySQL PostGres	www.mysql.com/ www.postgresql.org/
File sharing server	Samba	us1.samba.org/samba/
Content filtering server	SquidGuard	www.squid-cache.org
Security server	NMap	www.insecure.org/nmap
Anti-virus	ClamAV Amavis	www.clamav.net www.amavis.org
Spam filtering	SpamAssassin	www.spamassassin.org

The server environment is often a major hurdle for organizations in developing countries since there are limited experts available that can setup and manage a complex server environment with all the components above. In the Free and Open Source Software world there are some excellent Linux distributions that offer all the applications that are needed to set up a server.

Currently one of the best examples is SME-Server. SME-Server provide a distribution that installs out-of-the-box a webserver, a mailserver, a network file server, a firewall, content filtering and more. A relatively new direction for organizations in developing countries is to use web-services like Google Apps (www.google.com/a). This service allows organizations to host their email, webserver, and most of the other services above for virtually no costs. The server management is done by Google in an secure environment in the USA. This not really a Free and Open Source Software solution, but very useful in an environment where limited qualified staff is available.