Fachhochschule Brandenburg
Technology and Innovation Management

Master's Thesis

Free Open Source as a Technology Transfer tool in the Arab World

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30. October 2006
Germany

Zusammenfassung

Free Open Source als Technologietransfer Tool in der arabischen Welt

Die arabische Welt hat bis jetzt minimalen Teilnahme zum gegenwärtigen globalen Innovation System. Technologietransfer ist ein Hauptfaktor hinter solcher Schwäche. In der arabischen Welt, könnte der Free-Open-Source-Prozeß (FOS) als preiswertes und schnelles alternatives Tool für Technologietransfer angenommen werden.

Diese Studie konzentriert auf die Wirksamkeit des FOS Prozesses auf dem Technologietransfer und wie sie die gemeinsame Arbeit zwischen der Forschung und industriellen Instituten verbessert, die im ICT Sektor in der arabischen Welt arbeiten.

Abstract

The Arab world has so far minimum contribution to the current global innovation system. Technology transfer is a major factor behind such weakness. Within the context of the Arab world, the Free Open Source (FOS) process could be adopted as a cheap and fast alternative tool for technology transfer.

This study will focus on the effectiveness of FOS process on the Technology Transfer and how it will improve the cooperation between research and industrial institutes working in the ICT sector in the Arab world.

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Chapter 1

Introduction

> "Diffusion of technical know-how does not simply depend on ability to pay. It owes a great deal to personal contacts and discussion, or to the movement of people" (Freeman and Soete, 2004, p.179)

1.1 The Arab world

The Arab World term usually refers to the Arab League states that are listed in (Appendix B.1). This report will focus on the 13 ESCWA countries (Appendix B.2) and the North Africa countries which are known as the MENA region.

Although the Arab world is diversified with different subcultures and economical progress, this report will consider the whole Arab world as a single entity due to lot of similarities that led some international organizations deal with this region as a single entity. The term Arab world is used in this report instead of Arab States or Arab region because the MENA

geographical area does not represent the whole Arab states nor its inhabitants are only Arabs.

1.2 Status of Innovation in the Arab World

According to (Freeman and Soete, 2004, p.291) the National Innovation system can be defined as the "interactions between various institutions dealing with science and technology as well as with higher education, innovation and technology diffusion (...) whether public or private" institutes. So in order to discuss the innovation in any region it would be important to explore the education, research and technology commercialization.

In the following sections, the status of the national innovation system in the Arab world will be summarized through the analysis of education, research and technology in both private and public sectors.

1.2.1 The general picture of public Research & Education

The universities in the Arab world between 1980 and 1999 have witnessed great increase in the number of registered students. In spite of that, the percentage of the tertiary students in science math and engineering to all tertiary students have decreased and the focus was on humanitarian studies (Qasem, 2003, p.26);(Bennani et al., 2003, p.71). This is possibly because the governments -the major universities supporters- can not afford the increasing demand on the S&T related studies (Qasem, 2003, p.24). What worsens the situation is the low expenditure on education in the Arab world. For example the expenditure in countries like Saudi Arabia is 5.8% of the GDP in 1990, Kuwait 4.8% and Qatar 3.5% while in countries like

Israel it is 6.3% and in Malaysia is 5.1% for the same period (Watkins et al., 2005, pp.284–287).

On the other hand, the expenditure on R&D activities as percentage of GDP has increased from about 0.15% in 1996 to 0.22% in 1999 (Qasem, 1998, p.2). In spite of this increase, the average is very low when it is compared to the global average expenditure in 2003 which was 2.4% or to Israel (5.1%) or even to Malaysia (0.7%) (Watkins et al., 2005, pp.262–265).

This expenditure in the Arab world goes mainly to fund public research institutes/units where most of the funds come from central funding mechanism controlled by the governments and the public sector(Qasem, 1998, p.2). This lead to the increase in the number of research units in the Arab world from only 322 units in 1998 to more than 500 in 2003 (Qasem, 2003, p.43). But this has not affected the accomplishments of Arab R&D institutes which remain incomplete, because they do not reach the stage of investment (Bennani et al., 2003, p.100).

1.2.2 Innovation and research in the Industry

The research activities almost do not exist in the industry. For example 67% of the Saudi firms do not have any budget for R&D. Moreover the production firms depend on imported technologies and partnering with foreign institutes for the development of the products without considering the local researchers and engineers (Elhmood, 2003, p.201). This trend in the Arab world industries worsens the educational researches and provides no incentives to the researchers to develop new technologies.

Another indication is that most of the researchers in the Arab world are concentrated in governmental institutes and universities, while the private sector share is only 2% (Qasem, 1998, p.3). Deeper analysis on the research

fields , shows that in 1996, 72.7% of engineering research activities were curried on by universities (Qasem, 1998, p.27).

High-technology exports is one of the output indicators for research in the industry and private sector. In 2003 the average High-technology exports was 2% of the total manufactured exports in the Arab world. This figure in the developing countries reached 21%, OECD countries 18% and in east Asia and pacific states was 29% in the same period according to (Watkins et al., 2005, pp.274–277). In general, the exports and trade in the Arab world is still highly dependent on the energy and agricultural related products.

1.2.3 ICT industry and its infrastructure

Computers, Internet and communication are the basis for the ICT industry and its infrastructure. This industry has progressed in the last 50 years and lead to major changes in the human life nowadays. Although the Arab world has progressed in the ICT infrastructure implementation, but still the average number of telephone lines, cellular subscribers, personal computers and Internet users are far below the global average (Watkins et al., 2005, pp.262–265). For example, "there are less than 18 computers per 1,000 persons in the (Arab) region, compared to the global average of 78.3" (Bennani et al., 2003, p.63).

Moreover, the ICT industry in the Arab world is based on using the technologies and they do not develop the technologies for their own use. This case is indicated by (Coury and Dutta, 2003, p.123) as all Arab states are net importers of technology .

1.2.4 Innovation system problems highlight

The weak input factors discussed before, lead to weak outputs in the Arab world innovation system. For example the average number of scientists and engineers in R&D (per million people) in the Arab world is about 275 according to (Bennani et al., 2003, pp.201–206), which is very low when it is compared with countries like Israel (1570), Korea (2139) or even china (459). The number of scientific publications originated in the Arab world does not exceed 1.1% of world production (UNESCO, 2005, p.161). The number of registered patents in the united states patent office between 1980–2004 was 543 while in the same period 12348 patents were registered from Israel and 35673 from South Korea (USPTO, 2006).

(Coury and Dutta, 2003, p.123) referred the poor performance in Technology in the Arab world to

- The absence of serious national ICT R&D funding commitments and strategies
- Brain drain
- The reliance on foreign expertise

Besides that, (Ishak and Ghnayem, 2003, p.360) show that the academic teaching represents 85% of the universities activities while 6% goes to research and development and 3% to planning. Moreover the "higher education systems respond weakly to labor market needs related to science and technology" (Bennani et al., 2003, p.71).

1.3 Study core questions and Hypotheses

The previous section showed that the innovation system in the Arab world suffers from low and weak performance not only in the outputs but also in

the inputs. Besides that, it seems that both public (mainly universities) and private institutes do not have strong cooperation in research and product development.

This study suggests the use of Free Open Source process to improve the cooperation between the research and industrial institutes.

Objectives (Hypotheses):

The study will discuss the Effectiveness of processes related to Free Open Source to improve the cooperation cooperation between the industry and research institutes in the Arab world to develop high technology products.

It will try to answer the following questions: What can be learned from FOS for technology transfer in the Arab world? and how can it be used to improve the Technology transfer in the Arab world in the ICT fields?

These questions will be analyzed with the focus on the Arab world which represents the Middle East and North Africa (MENA) region and on the Information & Communication Technologies (ICT) field.

1.4 Study structure

After the brief view of the status of technology and innovation system in the Arab world, the report will clarify both the Technology Transfer concepts and the free open source model in chapters 2, 3 and 4. After that, the incentives for the actors in the free open source will be discussed in chapter 5 and the final part will show how the free open source could be used as technology transfer model and its adoption and effectiveness in the Arab world.

Chapter 2

Technology Transfer

> "Technological catching up will only be achieved through acquiring the capacity for creating and improving as opposed to the simple 'use' of technology. This means being able at some stage to enter either as imitators or as innovators of new products or processes." (Freeman and Soete, 2004, p.352)

(UNIDO, 1996, p.15) supported this concept since machines acquisition can be simply purchased by competitors, as a result knowledge is the most important component in achieving competitiveness.

2.1 Definition and characteristics

(Hodgson, 2002, p.2) refers to technology as all processes and activities including social and organizational that transfers inputs into outputs. This definition conforms with the technology definition in (UNIDO, 1996, p.21) which is "the system of knowledge, skills, experience and organization used to produce and utilize goods and services to satisfy human demand".

(Dodgson, 2000, p.1) indicates that technology is not only the tangable results but also as the knowledge that enables the replication of the functionality, which is defined by (Hering, 1991, p.631) & (Zhao and Reisman, 1992, p.15) as the know-how.

"The conventional conception of technology transfer is that it is a processes through which the results of basic and applied research are put into use by receptors" (Rogers, 2003, p.150). In general the Transfer Indicates the movement of knowledge, capabilities and Technology from where they are generated to where they are to be used (Boulter and Bendell, 2002, pp.643–644);(Spann et al., 1995, pp.19–20);(Dodgson, 2000, p.203);(Hering, 1991, p.631), this is not only to transfer the knowledge from research institutes and universities to the industry but also the transfer from outside the state to the local use (Dodgson, 2000, p.203); (UNIDO, 1996, p.16,145). (Zhao and Reisman, 1992, p.15) added to this definition the diffusion of technology & knowledge through human activities, while (Rogers, 2003, p.150) argued that the technology transfer (TT) is not a one direction of information flow, instead it is a two way communication process based on feedback and information exchange between the producers and the receptors.

Since the technology transfer deals with knowledge, both knowledge transfer and technology transfer are used interchangeably in the literature, the same will be followed in this study.

2.2 Needs & incentives

On the national level the advantages of Technology transfer can be summarized in the following points:

- Job creation (Hering, 1991, p.632)

- Improve the national industrial and trade competitiveness (UNIDO, 1996, p.4)
- Building up domestic technological capabilities (UNIDO, 1996, p.4)
- Accelerate the growth of some industries (UNIDO, 1996, p.11)
- The return on the governmental research investment through the taxpayers (Hering, 1991, p.631)

From the industry point of view, the involvement in Industry Science relation (ISR) is important because:

- The market has expanded and the technology has progressed due to innovations based on pure science like Bio and information technologies (OECD, 2000, p.161)
- Current innovations require multidisciplinary knowledge (OECD, 2000, p.161) and technology accumulation (Hering, 1991, p.631)
- Cooperation between different players are needed to reduce the R&D cost and acquire needed knowledge and access expertise beyond industry boundaries (Santoro and Saparito, 2006, p.335);(OECD, 2000, p.161);(Dalziel, 1994, p.744)
- The industry can increase the control on the researches according to their goals when they cooperate with research institutes (Dalziel, 1994, p.744)

(Dalziel, 1994, p.744) showed that the academic interest in the ISR was rated higher than industry interest. The reasons for this interest can be to:

- increase the limited fund to researchers and their institutes (OECD, 2000, p.161)
- see their research results in real-life implementation (Dalziel, 1994, p.744) since high percentage of patents are not commercialized (Hering, 1991, p.631)
- get involved in interesting problems and create projects for students (Dalziel, 1994, p.744)
- create jobs for the students and graduates (Dalziel, 1994, p.744)

- build technical, cultural and social skills and life long learning for the students (BIAC, 2003, pp.9–10)

2.3 Tools and Approaches

"innovation and transfer are recognized to be complex social activities with communication processes at the core of them"(Hodgson, 2002, p.1). Figure 2.1 shows the complexity of a technology transfer model.

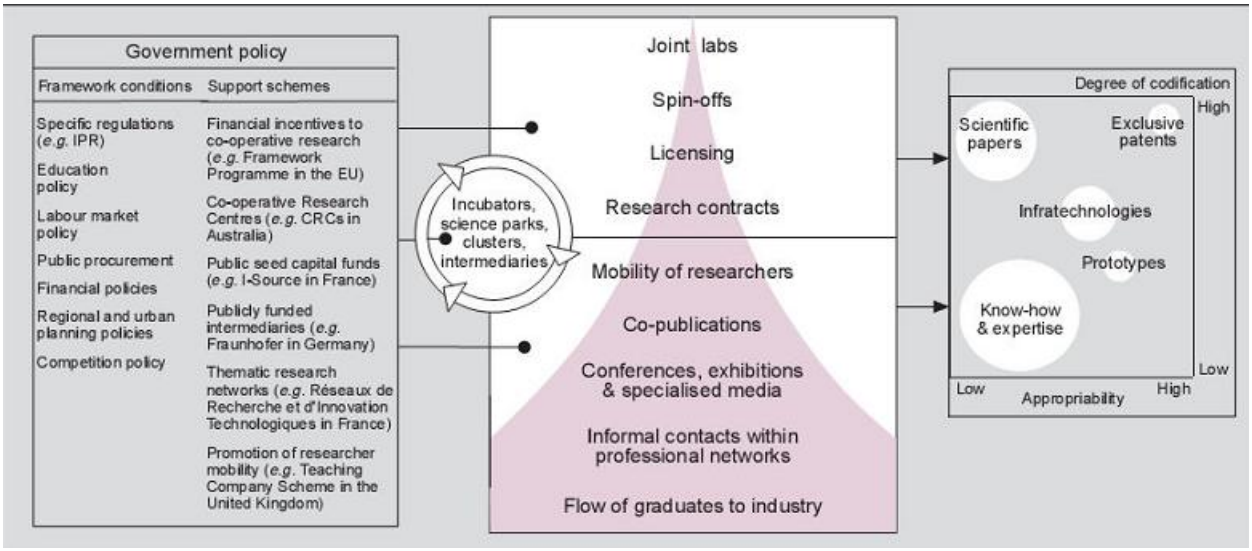

Figure 2.1: Technology Transfer Model
Source: (OECD, 2000, p.165)

The common Technology Transfer approaches can be summarized from (OECD, 2000, pp.165–171); (UNIDO, 1996, p.16);(Scotchmer, 2004, p.241) & (Dodgson, 2000, p.203) as joint ventures and labs, licensing, imitation, subcontracting, foreign buyers, OEM, Company acquisitions, strategic partnerships and spin-offs.

Both (Dodgson, 2000, p.204) and (OECD, 2000, pp.165–171) focus on the

importance of the personnel transfer in technology transfer because they hold the knowledge. Figure 2.1 on the preceding page shows some personal interaction schemes that supports the technology transfer such as co-publications, mobility of researchers and employee, professors exchange and training.

According to (Dalziel, 1994, p.745) from the industry point of view the least effective technology transfer approaches are University Research Chairs, licensing, seminars and workshops while the most effective tools are collaborative and contract researches, consulting, industry visit to universities and students participation in work teams in the industry.

On the other, hand the literature did not discuss in details the most effective ways from the research side, but (BIAC, 2003, p.5) pointed the need to improve the management and marketing skills at universities to improve the technology transfer, for examples, the licensing office at MIT is a good approach to support the technology transfer at universities (Hering, 1991, p.633).

On the governmental side, they try to improve the technology transfer through the implementation of technology incubators , Technology parks, Innovation centers and High-technology industrial clusters (OECD, 1997, p.14); (ESCWA, 2001, pp.4–6).

2.4 Indicators & measures

"Knowledge transfer and knowledge sharing between the public and private research sectors is (...) impaired by the lack of agreed methodologies for measuring performance" (OECD, 2000, p.162). This lack of measurement is due to the different goals and point of views of the actors

(UNIDO, 1996, p.65) and the infrequent use of the measures (Spann et al., 1995, p.19,26).

Some measures to the technology transfer can be identified by:

- Shared patents licenses between universities and industry and income from royalties (OECD, 2000, pp.161–181); (Dalziel, 1994, p.745); (Spann et al., 1995, p.20)
- Research publication (Dalziel, 1994, p.745)
- Number of spin offs from public research institutes (OECD, 2000, p.171)
- Number of contracted researches and labor mobility and sharing (OECD, 2000, p.174)
- Creating novel technologies and their industrial use (Dalziel, 1994, p.745)

All kind of measures are needed to quantify the effectiveness and prove the efficiency the process (Spann et al., 1995, p.19). The effectiveness of transfer is the result of strategies adopted in both the business-unit and individual levels (Spann et al., 1995, p.27). Some Strategies for increasing the effectiveness of technology transfer include involving industry in applied research, increase their R&D investment and preparing the university environment to facilitate, evaluate and reward the interaction with industry (Dalziel, 1994, p.743). (Spann et al., 1995, p.26) emphasized on the importance of having clear reward system for individuals, since they are involved in accessing the knowledge source directly rather than acquiring research results through licensing (Dalziel, 1994, p.743).

To summarize, (Pau, 1988, p.34) emphasized that the technology transfer process would be meaningless "if the local technical workforce cannot digest the new technology, absorb the essence of materials, and finally come up with products suitable for local applications", which means the results of technology transfer should be reflected on the local users otherwise im-

porting technical products would be more efficient.

2.5 Conclusions

The technology transfer is based on three main factors, the knowledge, its movement and the communication and feedback among the players. There are several approaches to support the technology transfer and co-operation between research institutes and industry, but the most effective approaches that focus on the sources of knowledge through individual interactions and those approaches that will lead to the adoption of the knowledge in direct and local use.

Chapter 3

The Free Open Source concept

> "Free and Open Source Software (FOSS) has become an international phenomenon, moving from relative obscurity to being the latest buzzword in a few short years."(Wong and Sayo, 2004, p.6)

3.1 Definition & philosophy

Generally the term Free Open Source (FOS) is referred to software programs that are available for free on the Internet and are developed in voluntarily basis. According to (Wheeler, 2005) the Free 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)".

The Open Source Initiative (OSI) has 10 criteria in its Open Source Definition (OSD) (Perens, 2006) that a program has to comply with to be certified

as open source, the main factors are: The availability of source code, the ability to distribute the software freely, the right to create derived works through modification, and no discrimination to join the development.

The free software foundation (FSF) philosophy (GNU, 2006) calls the same concept as the free software where "Free as in speech" and not "Free as in beer". The free software should provide the freedom to:

1. run the program
2. study the program and adopt it
3. redistribute it
4. improve the program and release the improvements to the public

In the literature the term Free Open Source software is widely used to cover both OSI & FSF point of views. This software gives everyone the rights of use, redistribute and modify the software free of charge (Hars and Ou, 2001, p.1), while Goldman and Gabriel (2005, p.29) focused on the definition of FOS on the ability to customize and modify the design to suite user's need.

In short words table 3.1 shows the position of FOS software to other types of known software.

	Open Source	Closed Source
Free	FOS	shareware
Non-free	Commercial OS	Proprietary/Commercial

Table 3.1: Types of software
Source: Adopted from (Ghosh et al., 2002a, p.11)

3.2 History of FOS movement

The free open source software can be considered as the continuation of the traditional software (Goldman and Gabriel, 2005, p.3). In the early stages of the software industry, the software was distributed as part of the hardware and were not sold as separate products (Hars and Ou, 2001, p.1). On the other hand, the software was considered as pure university researches, research tools or results so the software community used on sharing the software between them as part of their scientific publications.

In the early 70's, the commercial software start to be the trend. For that reason, Stallman started the Free Software Foundation (FSF) in 1985 to promote computer users' rights to use, study, copy, modify, and redistribute computer programs for free to get back to the original traditions of the software development (Stallman, 2001). This culture has supported the development of the Internet which in turns supported the diffusion of the FOS concepts because it provides a simple communication platform for software distribution.

In 1991, Linus Torvalds, at the time a graduate student at Helsinki University in Finland, wrote a Unix-compatible operating system (Williams, 2002). This step is considered one of the major steps in the FOS software movement till today since it provided a free common platform to the FOS developers.

Table C.2 summarizes the most important events in the advancement of FOS software.

3.3 FOS models

By 2003-2005 open source software will win its goal in software and "at that point it will become more appropriate to try to leverage open-source insights in wider domains" (Raymond, 2001, p.194).

The term Free Open Source is commonly linked to the software programs but there are many other fields that can adopt this concept. In spite of that, this report will focus on the Free Open Source Software because the other models are relatively new and there is not much information discussed in the literature about them.

3.3.1 Software

The software field is the most widely known Free Open Source model, and in fact the term was originated in this field and started to diffuse to other fields. For example the embedded systems market start to address Linux based solutions for set-top-boxes, video recorders, cameras, phones and other applications (Dravis, 2003, p.26). The FOS software model will be discussed in details in this report.

3.3.2 Hardware

Open source hardware is simply defined as “computer, or electronics, hardware that is designed in the same fashion as open source software” (Wikipedia the free encyclopedia, 2006a). The concept of open source hardware is relatively new, the term start to appear in the late 90’s with some articles and papers such as (Benjegerdes, 2006);(Lamberts,

2006);(Seaman, 2006). For that reason there are still no common definition for open source hardware.

Most of the attempts (Khatib and Salem, 2004);(Lamberts, 2006);(Seaman, 2006);(Wikipedia the free encyclopedia, 2006a) in defining the open source hardware, focus on the free disclosure of:

- The information and documentation needed for using the hardware
- The design and documentation on the hardware operation
- The information needed to implement the design
- The Software for running the hardware

(Khatib and Salem, 2004) add that software used in the design and the infrastructure should also be free open source to allow the community to reuse and improve the designs.

The major problem facing open hardware is the cost associated with development, manufacturing and testing the design (Lamberts, 2006);(Wikipedia the free encyclopedia, 2006a). The software development has not this associated cost because it does not incur physical output. As a result the hardware developed in these techniques are known as open source hardware or free open source hardware design, since the hardware itself can not be made for free but the design can.

3.3.3 Contents

The Free contents or free information is another model of FOS. It is defined as "any kind of functional work, artwork, or other creative content having no legal restriction relative to people's freedom to use, redistribute, improve, and share the content" (Wikipedia the free encyclopedia, 2006c). Besides that, the contents should be freely modified, expanded, updated

and redistributed to be considered as free content (Wikipedia the free encyclopedia, 2006c).

This FOS model has started with the introduction of FOS software manuals that was distributed with the FOS software. The model has been adopted by many developers and scientists to produce free contents and books mainly related to software. The most widely known example of the free contents is Wikipedia `http://www.wikipedia.org` the Web-based free-content encyclopedia project which allows visitors to edit its content and the contents to be written collaboratively by volunteers.

Some universities and institutes start adopting the Free content model to publish some of their contents. Massachusetts Institute of Technology (MIT) is the leader in this field with its OpenCourseWare project `http://ocw.mit.edu/` where MIT courses and study materials are published on-line for free. Besides MIT, the Harvard University Library Open Collections program `http://ocp.hul.harvard.edu/` has followed this approach in its library.

3.4 Characteristics of FOS products

The low cost (even free) of the FOS products is the most commonly known feature of FOS products cost because they are based on voluntary work (Scacchi, 2002, p.2). Dravis (2003, p20) considers the FOS software as public goods that are created and used by the public which increase the access to the information and transparency.

The FOS software sometimes is considered better and faster than the closed (Traditional) software since it is continuously tested by many participants (including users) and it is developed by decentralized community that provides different point of views (Scacchi, 2002, p.3); (Gold-

man and Gabriel, 2005, pp.47–48). Besides that, the developers participate based on their own interest which increases the productivity and quality (Potdar and Chang, 2004, p.107). A large number of FOS software programs are developed by professional and experts to fulfill their needs (Goldman and Gabriel, 2005, pp.46–47)

On the other hand, the main problem with FOS is having no contractual deadlines, which can reduce the dependency on the FOS products (Gacek and Arief, 2004, p.39). Besides that, (Hars and Ou, 2001, p.3) argued that the disadvantage of FOS is no incorporation of user needs because it is based on developers needs. This point could be only valid if the users are not the same developers as it will be discussed later on in chapter 4.

3.5 Protection & intellectual property rights

Intellectual property rights are important to motivate the creativity and innovation. In general, the software can be protected either by patents, copyrights or trade secrets. This depends on the level of information or knowledge the creator wants to disclose (Scotchmer, 2004, p.83).

The GNU project is the pioneer in discussing the FOS software protection. It has introduced the copyleft concept which uses the copyright law, but differently. Instead of privatizing software, the GNU public license (GPL), (copyleft rather than copyright as it is called by GNU), keeps it free and protect users freedom (Stallman, 2001);(Wu and Lin, 2001, p.33).

Similar to the GNU project, the Open source initiatives tries to certify licenses that regulates the ownership and control of FOS software based on the definition of open source software discussed in section 3.1. All certified licenses are based on copyright laws such as Mozilla Public License

(MPL), General Public License and Berkeley Software Distribution (BSD)[1]

The patents have not found their way to FOS software licenses because the knowledge resulted from the software is already disclosed. On the other hand, limited open source case law exists that violates such FOS licenses (Dravis, 2003, p.31).

The FOS hardware model differs from the software one since it contains physical product not only knowledge. For that reason, so far this issue has not been discussed in the literature and even the FOS hardware community did not reach agreement on a protection method. In general, currently most FOS hardware products are protected by copyright laws and use the GPL.

In contrast to the FOS hardware model, the contents are easier to protect by copyrights since they contain information (Wikipedia the free encyclopedia, 2006c) and even several licenses exists to protect them like the GNU Free Documentation License (FDL) `http://www.gnu.org/copyleft/fdl.html`.

3.6 Advantages to developing countries

The adoption of FOS concepts in developing countries would promote the local research and development efforts because they rely on external suppliers to import technological products. FOS can also leverage the locally developed skills, increase local talents participation, minimize investment risks and increase costs saving (Dravis, 2003, pp.20–22).

The FOS contents like courseware can improve the knowledge accessibility and education. It would improve the teaching and learning approaches

[1]Complete list can be found under `http://www.opensource.org/licenses/`

and the curriculum through peer review which in turn can lower the cost of course development (Materu, 2004, p.12-13).

3.7 Conclusions

In order for products to be defined as FOS, "anyone should be able to use them, modify them and circulate such modifications without having to pay anything"(Wang et al., 2005, p.309). The FOS concepts are not exclusive to software as it is commonly known, they are adopted on wide range of intellectual products. The FOS development have several advantages to the developing countries that can help the improvement of the national knowledge and technology.

Chapter 4

FOS process & development

> "Linus Torvalds's style of development – release early and often, delegate everything you can, be open to the point of promiscuity – came as a surprise." (Raymond, 2001, p.21)

4.1 Sources of ideas

The most cited statement in the literature about the sources of ideas in FOS projects is:

> "Every good work of software starts by scratching a developer's personal itch" (Raymond, 2001, p.23).

This indicates that the developer is the main source of the ideas in FOS projects which are based on personal solutions to specific problems. After that these solutions spread because they could be typical ones to large number of users (Raymond, 2001, p.49).

(Massey, 2002, pp.1–3) discussed the sources of FOS projects requirements which can be summarized in the following points:

1. Personal developers needs are the main source of projects' requirements. This source is almost negligible in the commercial projects.
2. Users are important source of requirements and they share the ideas directly with the developers.
3. Emulation and imitation of existing products and standards.
4. Personal needs to learn and understand specific technologies or to build some prototypes of researches.

4.2 FOS Community

"While FLOSS code is easy to access, understanding the communities that build and support the software can be difficult" (Crowston and Howison, 2006, p.89). The FOS community is typically defined as "an Internet-based community of programmers" (Hars and Ou, 2001, p.1). (Gacek and Arief, 2004, p.36) has specified this community as all those "with common interests that's involved either in continuously evolving (FOS) related products or in using its results". On the other hand, the FOS community can be considered more as social activity and interaction between developers and users rather than pure development or use of products (Goldman and Gabriel, 2005, p.8). However, there is no clear FOS community structure in reality because there are many projects involve just single developer (Gacek and Arief, 2004, p.36).

In fact, everyone capable of writing code can join the open source community (Wu and Lin, 2001, p.33). Besides that, Joining, contribution and even leaving the project at anytime is free for anyone. This makes it almost impossible to know how many developers or users of the project (Bonaccorsi

and Rossi, 2004, p.18). In spite of the simplicity of joining the FOS community and since each group has its flavor, (Goldman and Gabriel, 2005, p.178) focus on the the importance of the social sides like getting familiar with the culture, finding roles and acknowledging the achievements within the community.

The FOS community is onion-shaped where projects leaders are in the core, followed by the code developers and finally the active users (Goldman and Gabriel, 2005, p.53);(Crowston and Howison, 2006, pp.89–90). The users are important to the FOS community because the "developers are always users" (Gacek and Arief, 2004, p.35) and they should be treated as co-developers (Raymond, 2001, p.24);(Dravis, 2003, p.34). The active users can contribute by testing new releases, posting bug reports, writing documentation and most important they can insulate core developers and form a natural buffer between developers and (passive/non-active) users to protect the developers from burnout or frustration of new users support (Crowston and Howison, 2006, pp.89–90).

Some FOS communities have some structured hierarchy of developers others are too loose (Gacek and Arief, 2004, p.36). In general managing and coordinating the FOS community is based on lightweight decentralized informal mechanism (Scacchi, 2002, pp.50–51). The technical competences (Goldman and Gabriel, 2005, p.160) and communication skills (Raymond, 2001, p.49) make the good FOS community leader and decision maker.

According to (Ghosh et al., 2002b, pp.9–20) the age concentration of FOS community is 21–27 years and about 70% of the developers have university degrees. Although 41.4 % of the participants were singles but about 39.9% are either married or live with a partner and the majority of the developers are employed 65% and 26% of them spend about 2–5 hours per week on open source development.

4.3 Product Development process

The main characteristics of FOS product development process can be summarized in the following points:

- "Release often and early" (Raymond, 2001, pp.28–33) so the products can be quickly used, evaluated and improved according to users' needs
- "Doing open-source requires transparency and openness" (Goldman and Gabriel, 2005, p.183) to build trust within the community
- The FOS development process is recognized as pendulum process that changes between implementation and testing on one side and validations and specification request on the other side (Potdar and Chang, 2004, p.108). This means that the product development and its life time can be longer than other products besides the testing efficiency improvement
- The availability of the information and source code makes it easier for testers and developers to share products and communicate effectively (Raymond, 2001, p.33)
- Figure 4.1 on the next page, shows the FOS product development cycle and the ability of joining existing projects and the coordination

4.4 Needs for FOS development

The FOS software projects and community have grown only with the advancement of ICT and Internet infrastructure. Not only the infrastructure is needed, but also free development platform should be available for the community (Dravis, 2003, p.34).

On the technical side FOS software projects need public achieve, project documentation, bug database, public mailing list, website (Goldman and Gabriel, 2005, pp.138–147), release management and source code mainte-

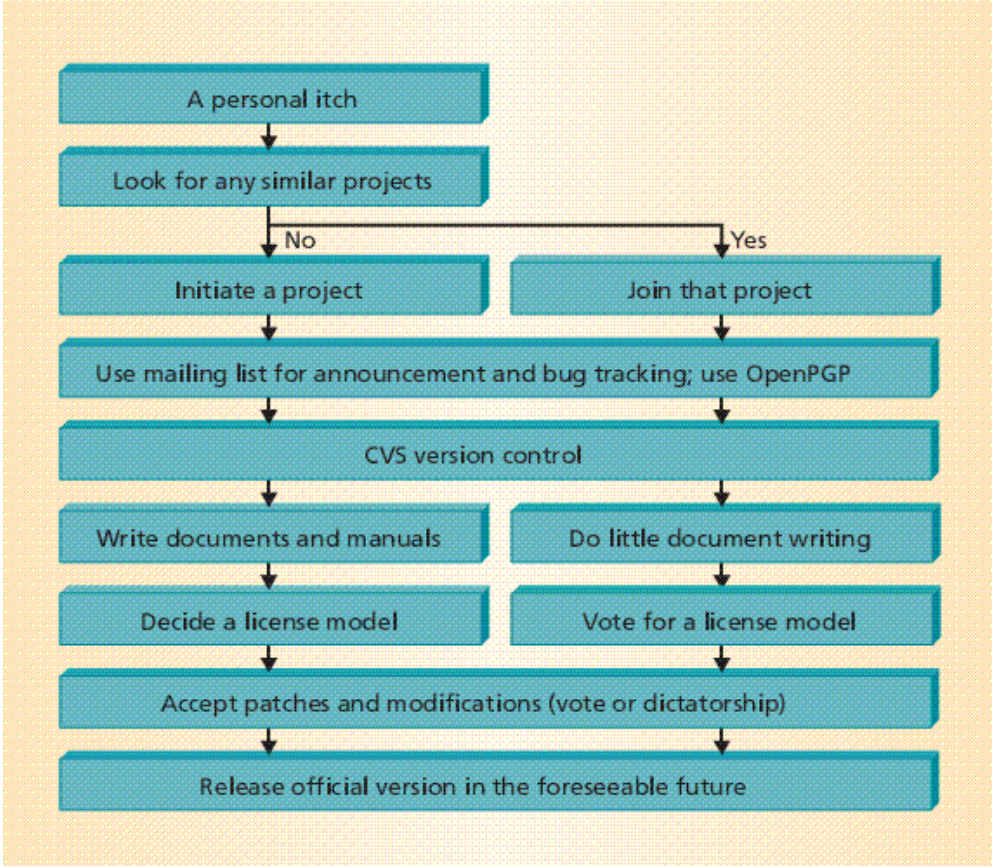

Figure 4.1: Open source system development cycle
Source: (Wu and Lin, 2001, p.34)

nance repositories (Crowston and Howison, 2006, p.91). (Raymond, 2001, p.113) added the needs of funds for FOS projects to support them, either as non-profit or for-profit fund models.

There are several Web-hosting companies offer free hosting services to support the development of open source projects such as SourceForge `http://SourceForge.net` that offers a platform for sharing and managing project development besides the communication between the developers and allow them to copy, modify and distribute the source code (Wu

and Lin, 2001, p.34).

4.5 Evaluation and success indicators

Commercial software projects define evaluation and success indicators for economical and financial reasons (e.g. being on time or on budget) (Stewart, 2004, p.92), but for FOS evaluation it is important for projects' managers to asses their projects and to the sponsors to understand the return on their investment in such FOS models (Crowston et al., 2003, p.2);(Crowston et al., 2004, p.29). Moreover, there are several researches trying to learn from the FOS activities but in order to learn, we have to define how the outputs of this process are working well (Crowston et al., 2003, p.2).

The observability is an important difference between FOS software and commercial one that affects the evaluation. While it is easy to observe the use environment (e.g. users) for the commercial software, since it is well defined through selling or licensing, it is not easy for the FOSS. On the other hand, the development process is visible in the FOSS while it is not accessable in the commercial one (Crowston et al., 2003, p.2). For these reasons, the evaluation should depend on the software characteristics with the consideration of the FOS process characteristics.

(Crowston et al., 2003, p.4) suggested some success measures of the FOSS projects that can be summarized (Details are discussed in Appendix C.1) into some groups like system quality, user satisfaction, project's outputs, outcomes for project members and the development process.

Although the completion of an FOSS project can be an indication to the success of the project, but since it is not clear how to measure the completion due to the lack of clear specifications in FOS projects (refer to section

4.1). (Crowston et al., 2004, pp.31–32) pointed some clear measures considering the FOS nature which are summarized in (table 4.1) with rough success indicators.

View	Measure	Indication
Input	Development team size	More developers, more participation
Process	Bug reporting & fixing time	Fast report & fix, high interaction among developers and users
Process	Project Activity	Fast project releases, high interest
Output	Number of downloads	More downloads, more usage

Table 4.1: Free Open Source measures of success
Adopted from (Crowston et al., 2004, pp.31–32)

(Stewart, 2004, p.93) discussed the success factors with the focus on the social side where trust building in the team, social communication and the alignment of the project factors with developers motivation factors would all increase the commitment to the project and its success. Moreover, (Crowston and Howison, 2006, p.89);(Goldman and Gabriel, 2005, p.101) indicated that the community health can be observed from its shape and size. Such social factors (specially trust (Santoro and Saparito, 2006, p.335)) are important to the technology transfer because they improve the human capital and their skills through FOSS development.

Knowledge creation has been briefly discussed in (Crowston et al., 2003, p.7) which fits in the technology transfer context. Knowledge creation could be measured according to (Crowston et al., 2003, p.7) through observing and analyzing the changes in the rules and procedures over time that may be transferred through the FOS project development .

The success factors of FOS models other than software have not been discussed in the literature, but the previously mentioned factors can be ap-

plied for them. Some specific factors could be investigated. For example major success indicator for the FOS hardware model could be the implementation or the verification of the project in real physical system. While for the FOS contents, the size, the quality and the accessibility of the contents could indicate the success of the project.

4.6 FOS and networks of innovations

"Industrial innovation is becoming more open, requiring changes in how firms manage innovation. External sources of knowledge become more prominent, while external channels to market also offer greater promise" (Chesbrough, 2004, p.23).

This section will discuss the similarity of FOS networks with some innovation networks and the cooperation with external partners.

4.6.1 Open Innovation

Internal R&D is considered one of the major competitive advantages and barrier to market entry. Such expensive R&D activities can be afford only by large firms, but in mid 90's, companies like Sun, Intel and Cisco began to compete even with their small R&D resources at that time. They managed that through the investigation of external innovations and cooperation with other institutes to undergo the R&D activities (Barfield et al., 2003, p.25) (Chesbrough, 2004, p.23). Hence, the open innovation concept start to grow, which indicates more use of both internal and external sources of innovation, intellectual property capital sharing and marketing the ideas through external channels (Chesbrough, 2004, p.24);(Barfield et al., 2003, p.28). This concept sometimes is identified as out sourcing of

projects to other firms to cut costs, improve efficiency, get access to external experts and discover innovations (Barfield et al., 2003, pp.26–27).

Many of Open Innovation concepts can be seen in FOS model. For example, looking for external sources of innovations and getting access to smart people can be seen in the FOS model since it enables the direct communication with experts and smart people from the whole world besides the free exploration of new ideas (Barfield et al., 2003, pp.30–31).

4.6.2 Research Development Innovation Networks

Research Development Innovation (RDI) "networks are defined as cooperative arrangements adopted by a variety of actors, including individual researchers, research centers, academic research groups and firms. These actors share more or less common objectives and tasks, sometimes use common resources, and work on mutually agreed research agenda with well-defined goals"(ESCWA, 2005, p.17). Such cooperative networks enable the implementation of large multi-disciplinary projects through both resource and expertise sharing.

The FOS community members have common objectives of using and developing the products which is the same as in the RDI networks members. Besides that, the development activities in both FOS and RDI models are done in cooperation between all their members whether they are individuals or institutes.

4.7 Conclusions

This chapter discussed the FOS and its development model. The projects are usually initiated by users and developers and then a community is formed around it. The members of such community are free to join and leave it at any time and they should have good communication skills because the projects are developed through the interaction and direct communication between developers and users. The FOS community can be characterized by lightweight informal management and its qualified developers with different backgrounds.

Good ICT, freedom to access the Internet and the know-how on using shared development environment are important to develop FOS projects and improve the communication among members.

At the end of this chapter, two innovation networks models show that some of FOS concepts are already used and adopted in reality.

Chapter 5

FOS Motivations and incentives

> "Is the image correct that open source developers are highly altruistic people who want to advance the good cause or are there other explanations?"(Hars and Ou, 2001, p.1)
>
> "*Free software* is a matter of liberty, not price. It is like *free* as in *free speech*, not as in *free beer*"(GNU, 2006)

5.1 Internal factors

The motivation structure is the most discussed topic in the FOS literature, some have divided the motivations into internal (intrinsic) and economic (extrinsic) (Wang et al., 2005, p.309);(Hann et al., 2002, p.1) while others divided them into social, economic and technology factors (Bonaccorsi and Rossi, 2003a, p.2);(Wang et al., 2005, p.311). In this study the first classification will be used for simplicity where social factors will be considered under the internal ones and the technology will be discussed with the economic factors.

The internal motivation factors can be explained by the third level of Maslow's hierarchy of needs -belonging and love- (Wikipedia the free encyclopedia, 2006b). Community identification, self satisfaction and fulfillment that arises from writing programs are considered the main factors that motivates the FOS developers since they write them to fulfill their personal needs as it is the case in both PERL & Apache projects (Hars and Ou, 2001, pp.3–4).

The literature (Wang et al., 2005, p.311);(Bonaccorsi and Rossi, 2003a, p.1);(Hars and Ou, 2001, p.3) refer to writing programs that have open source codes at the developers own costs (time and energy) as altruism which is the most important internal motivation factor. Moreover, according to (Barfield et al., 2003, pp.18–19);(Wang et al., 2005, p.311);(Hann et al., 2002, p.1);(Bonaccorsi and Rossi, 2003a, p.1);(Hars and Ou, 2001, p.3) the internal motivation factors can be summarized in the following points:

- Knowledge sharing
- Satisfaction of achieving something valuable
- Professional reputation and recognition among peers
- Learning and improving Personal skills
- Group problem solving
- Fight against proprietary software
- Having the sense of belonging to the community
- Having fun while developing projects

From the empirical side, the FLOSS survey (Ghosh et al., 2002b, pp.44–48) shows that the major reasons of developers participation in FOS software development are:

- To learn and develop new skills
- To share knowledge

- To improve products
- To have freedom in developing software

It is noticeable that both the literature and the survey results show that knowledge sharing among participants is a key motivators that can be used in the technology transfer.

5.2 Economic factors

Although the low price of the FOS products is the major factor for using these products, this section will show some other economic perspectives not only in using FOS but also in developing the products.

The FOS actors can be divided into three groups, the governmental institutes, the FOS developers both individuals and firms and finally for profit institutes.

5.2.1 Governments and Individuals

Governments

(Dravis, 2003, p.7) has identified four main economic incentives for the adoption of FOS software and support its development by governments:

1. Controlling costs of software licensing and upgrades
2. Control and increase the access to intellectual properties
3. Reducing the reliance on proprietary software
4. Promoting software use in the public sectors

Individual developers

Although most of surveyed FOS developers (46%) do not earn money from FOS development according to (Ghosh et al., 2002b, p.65) and "greater open source participation per se, (...) does not lead to wage increases (...) (, but) from an economic perspective, a programmer will choose to contribute to an open source project if the benefits outweigh the costs of participation" (Hann et al., 2002, p.1).

The developers expect future direct or indirect monetary rewards. The major direct rewards for individuals can be identified as the revenues from related products and services such as commercial consulting, training, distribution, support and implementation services (Hars and Ou, 2001, p.3) or rewards from current or future employers to have higher wages or attractive job positions or career benefits (Hann et al., 2002, p.1);(Bonaccorsi and Rossi, 2003b, p.5);(Wang et al., 2005, p.311).

Indirect economic rewards can be summarized in the following two points:

- Increase personal use-value of the FOS product by adding more functions and validation through cooperation with others (Hann et al., 2002, p.1)
- FOS can be good channel for self marketing and advertising of personal skills and capabilities (Hars and Ou, 2001, p.4)

5.2.2 Business models and commercial advantages

IBM, the top patent holder in the US, has let the open source community to use 500 patents of its own in 2005, because this "will allow them (IBM) to expand on the technologies in ways that the company might never do on its own" (Paulson, 2005, pp.23–24). This is one of many examples of

commercial and industrial interest in FOS. The firms can be involvement in the FOS by direct development, support the development or even in making direct business out of the FOS products.

Incentives for using FOS

While the low price is the most obvious factor for the adoption of FOS products, the transaction costs of licensing and acquisitions negotiation can be reduced since whole information are available and licensing is simple (Demil and Lecocq, 2003, pp.10–16).

Goldman and Gabriel (2005, p.107–109) has discussed some reasons behind the use of such products in the firms that can be summarized as the following:

- The ability to have direct involvement in defining FOS features or adding missing features to increase the usability of the product
- Getting direct technical support from the developers
- Training and deployment costs reduction by using the on line forums, mailing lists or documentation

Incentives for developing FOS products

Lower R&D costs (Bonaccorsi and Rossi, 2003a, p.1) and hiring skilled employees working on project field (Hann et al., 2002, p.2) are considered widely in the literature as major incentives for supporting the FOS development. (Goldman and Gabriel, 2005, pp.76–96) discussed more reasons on why companies develop FOS projects such as:

- Establishing new communication channels with both developers and customers

- Product improvement due to direct customers feedback and extensive debugging and testing
- Skills improvement through cooperation and learning from the community
- Access to extra resources and skilled developers
- Get support and help from community in both product development and customers support
- Speed up the time to market by early and continuous releases

Business Models of FOS

"Collections of free software sold on CD-ROMs are important for the community, and selling them is an important way to raise funds for free software development" (Stallman, 2001). Packaging and distributing software is also the most adopted business model (such as Linux distribution companies) and the most discussed in the literature (Ghosh et al., 2002a, p.41); (Barfield et al., 2003, pp.42–43); (Hecker, 1999, p.49); (Gacek and Arief, 2004, p.36).

The second major business model is services around FOS products like support, consulting and training (Ghosh et al., 2002a, p.41); (Barfield et al., 2003, pp.42–43); (Hecker, 1999, p.49).

(Hecker, 1999, p.49) discussed some other FOS business models such as:

- selling hardware that uses the FOS software or drivers
- selling accessories such as books, manuals, or other physical items associated with the FOS software
- creating applications or derivative or customized products for specific users' needs
- if the product start to be out production life cycle as traditional commercial products, then the company can extend its life by releasing

it as FOS product

5.3 Conclusions

This chapter discussed the major incentives and motivation factors behind the FOS development and use. Knowledge sharing and free access to information are important factors for Technology Transfer and among the major motivators for FOS developers . Besides that, community belonging and skills improvement motivate the FOS developers and on the same time, they improve the Technology transfer.

On the economical side, there are several FOS business models that can be adopted. These models are based on improved communication channels between technology developers and users/customers which will lead to better product commercialization.

Chapter 6

FOS as a Technology Transfer tool

> "A substantial part of technology transfer occurs outside the technology transfer market itself. That is technical knowledge spreads internationally by noncommercial forms means, and it may even be transmitted free of charge."(UNIDO, 1996, p.21)

6.1 Model and concepts

This section will discuss the characteristics of FOS that can help in the technology transfer. The FOS is not only helpful for the free transfer of knowledge but also for the communication and the development processes.

The FOS model model can be characterized by its direct communication between technology developers and users, community members with common interests are free to join and leave and the free access to all information (Refer to chapters 3 & 4). Moreover, the technology transfer is based on three main factors, the knowledge and its movement, the com-

munication and feedback among the players (chapter 2). In this section the term FOS model will refer to the adoption of FOS in the Technology Transfer process.

Since the knowledge transfer is the basis for any technology transfer tool, the FOS model can support the knowledge transfer because the developers in this model are motivated by sharing knowledge to achieve recognition among peers. Besides that, the information in the FOS model can be accessed freely by any one, which increases the diffusion of the knowledge and technology to wider range of users and adopters.

Chapter 2 showed that the most effective Technology Transfer approaches that focus on the direct interactions with knowledge holders. Furthermore, according to (Dalziel, 1994, p.743) direct access to knowledge source is better for the technology progress rather than acquiring the research results made available through licensing. FOS model enables the direct contact with the technology developers and knowledge holders over the Internet and the access not only to the documentation but also -sometimes- to all discussion achieves.

Furthermore, the FOS development process support the multi-directional communication needed for the Technology Transfer tools (Section 2.1). The FOS product development progresses by the exchange of test results, developments and features requests between developers and users (Section 4.3).

Trust is needed in such communication and relationship between knowledge holders and adopters. According to (Santoro and Saparito, 2006, p.344) the success of technology transfer and relation between university and industry is based on trust. The FOS community on the other hand can not survive without trust among its members. Even more, anyone doing business with FOS project should fit with this community culture.

Another advantage of the FOS community is the network effect, where the utility of using the product for each user increases with the increase of the number of total users (Scotchmer, 2004, p.289). The size of the FOS community indicates not only the health of the project, but also the adoption of the product and the diffusion of the technology, which are important for the technology transfer. Infrastructure technologies like computer operating systems and telecommunication (or ICT in general) are the most technologies that make advantage of this effect.

One of the most challenges for the technology transfer in the Internet era is the rate-of-change of technologies where new ideas and development occur in a matter of months (Colyer, 2000, p.571). Following the FOS concept of *release early, release often* can reduce this difficulty and improve the customer/user feedback on new technologies which in turn speed up the reaction to changes in both the market and technology.

The IP protection is considered one of the main draw backs in adopting the FOS model by both the research and industry. In spite of that, (Bessen and Maskin, 2004, p.3) indicated that the "traditional IP models fail to recognize the value brought by additional parties". So there is a need to have a protection method for IPs that developed through cooperation. FOS protection methods discussed in section 3.5 guarantees the rights of all developers including individual participation's. Besides that, the transaction costs and time needed for negotiating licensing technology is high in commercial licensing. Also the terms of such licensing are not simple and the termination can be costly (UNIDO, 1996, p.28). Furthermore, the FOS licensing is straight forward and can be acquired and terminated easily. All these factors could speed up the technology transfer between parties. To add more advantages, the patents have certain life time while FOS can remain as long as the product exists and developed.

6.2 FOS Adoption

(ESCWA, 2005, p.42) specified general steps and requirements for the adoption of FOS model in R&D which can be generalized for technology transfer. The following points summarize the main steps and requirements:

- Existence of a common research problem that interests a large number of stakeholders
- Existence of initiator research institute that is capable of establishing core of interested organizations and individuals
- Definition of Initial concepts and goals
- Developing an active Internet or physical based community. Promoting the collaboration, recognition, mutual trust in addition to motivation and personal satisfaction schemes are needed to support
- Establishing rules, roles, licensing and measurements

Besides these factors, there should be a common communication infrastructure for community members.

The FOS model can be used for technology transfer by forming a community from both the research and industrial institutes with open membership even to low level researchers, students and engineers. The results (both final and intermediate) and information should be released always and as early as they are available and they should be made accessable to the community to improve the quality of the research through the exchange of comments and feedback. Within the frame of FOS development, members' roles in the development should be defined according to the available resources and skills of the each member to motivate each of them (even individuals).

All parties interested in joining existing FOS technology Transfer community should accommodate to the community culture (Goldman and

Gabriel, 2005, p.35) and be familiar with the communication schemes (Crowston and Howison, 2006, p.91) the same as in FOS projects.

6.3 FOS Technology Transfer incentives

Incentives for the governments (national economy)

Adopting the FOS model makes more information available to startups and existing business to enable them to develop commercial products which in turns increases the national innovations. Furthermore, (Demil and Lecocq, 2003, p.24) claims that the diffusion of the FOS concepts to an industry will increase the number of new adopters and entrants since they will need less development resources.

Incentives for researchers and research institutes

The academics and researchers are generally intrinsically motivated mainly to find interesting challenges to work on for reward (Dalziel, 1994, p.744). The FOS model provide them with wide range of new discoveries and research topics which they can participate to. Besides that, they can have access to expertise beyond the university and get informed about real life problems with direct information from technology users.

(Scotchmer, 2004, pp.252–253) discussed the concept of open science where scientists are motivated with publishing the results quickly opposed to the closed science where they should wait until intellectual property rights are registered. The FOS model provide the scientists with the flexibility of publishing the results while their rights are reserved. (Scotchmer, 2004, pp.252–253) elaborated on open science where sharing ideas

between researchers enables them to build on the ideas of each other to speed up the aggregate research progress. The FOS model will enable the researchers to share the ideas not only within their community but also with the industry and the end users and get wider range of ideas beyond their field.

Incentives for businesses

One of the main reasons to close the sources (information) is to make profit out of them, but the FOS model has its own business models and even it does not prevent the businesses from adopting mixed models (ESCWA, 2005, pp.40–43).

Further more, with the FOS the average size of the firms in the specified field will decrease due to the cooperation with several partners (Demil and Lecocq, 2003, p.25). Moreover within the frame of FOS technology transfer model, the industry (business) can take more control of research goals (Dalziel, 1994, p.744) without demotivating the researchers since they are free to join the community, have all information and even can develop parts of the projects

6.4 Indicators & measures

Although both measurement tools for Technology Transfer (section 2.4) and FOS (section 4.5) can be used to measure the success of the FOS technology transfer adoption, but the following list is customized to fit in the context of the suggest FOS Technology Transfer model.

- The community size and diversity of participants (i.e. not all from research or industry)

- Number of exchanged information, comments and feedback between members (degree of interaction and discussions
- Number of individuals and institutes interested to join the community
- The degree of the social trust and mutual cooperation among the parties within the community
- The size and quality of information and knowledge created and made available specially through publications and products
- The degree of interest from the industry and research (both outside and inside the FOS community) to access the available information
- The reflection on the local industry and education system (in the specified field) by the number of startups, products, students and researchers in the field

6.5 Conclusions

This chapter discussed the adoption of FOS model to technology transfer approaches. It is noticeable that the characteristics of FOS development model can fit with the technology transfer context due to the similarity of objectives and to the motivation schemes that work for both the industry and research fields.

In order for the industry and research institutes to adopt the FOS technology transfer model, they must get used to the FOS cultures and values.

Chapter 7

FOS and TT in Arab World

> "The Arab world, which is obliged to purchase new production capabilities whenever the technologies it owns become obsolete, is currently – and expensively – stuck at the wrong end of the technology ladder, a situation which drastically reduces Arab investment returns." (Bennani et al., 2003, p.99)

7.1 FOS in the Arab world

The Free Open Source in the Arab world is still in its infancy stages, the community is rather small and organizations' awareness of its importance needs a great boost.

7.1.1 Needs and Difficulties

Besides the advantages of adopting FOS model discussed in chapter 5, the FOS can support the Arab world to have control over adopting and customizing the software to both Arabic language and culture (such as

the Arabic calender) (Tawileh, 2005, p.3). The FOS increases the freedom of choice and reduce the dependence on the offered commercial software. Besides that, the FOS can support the IP rights and reduce the software piracy by providing low cost and legal alternative software in the Arab world (Alkanhal, 2005, p.2);(Alwarghey, 2005, p.2).

The status of the FOS in the Arab world is inclined with the status of ICT and IT level that are still far beyond the international levels (Chapter 1). The ICT infrastructure needed for shared development over the Internet in the Arab world is still weak and slow compared to other countries like in Latin America or the far east.

(Tawileh, 2005, pp.3–4) referred not only to the lack of advertisement in the Arab world to the use of FOS software that affects the diffusion of such products, but also to the huge support programs and projects (such as trainings, low cost software, etc.) offered by large international companies to the Arab world to increase the use of their software. Moreover, the specialties of the Arabic language in software is one of the main technical reasons affecting the adoption of FOS software.

7.1.2 Status

Surveys and statistics

There is not enough information neither about FOS development nor its use in the Arab world. For that reason the Arab League Educational, Cultural and Scientific Organization (ALECSO) started in 2005 a project to study the status of FOS in the Arab world and the possibilities to promote its concepts. To reach this objective, a bilingual (Arabic-English) survey and *Free/Open Source Software Meeting* for the Arab world in Tunisia 2005 have been carried.

The survey was distributed in 2005 through formal channels (the National Educational Cultural and Scientific Committees) to establishments and groups involved in FOS in all Arab countries (ALECSO, 2005, pp.1–2). It targeted two groups, the developers and the adopters from governmental, research and private institutes. The unpublished results indicate only 38 reply from the 22 Arab states, few of the replies came from developers. After almost a year, the same survey was posted on Handasa Arabia `www.handasarabia.org` web site (a virtual organization deals with FOS in the Arab world) in the time between August to October 2006. Besides the availability of the survey on the web, it was distributed to 8 FOS communities in the Arab world (listed in appendix C.4 on page 78). According to the unpublished results only 12 replies were collected 67% of them from FOS developers which means almost one developer participated per FOS community.

The detailed results of both surveys are not published by the time of writing this report, but the number of replies indicates the weak interest or understanding of FOS concepts. Moreover, these results could indicate that the FOS community in the Arab world is still small or not easy reachable. Likewise, the on-line FLOSS survey carried by the University of Maastricht and Berlecon Research showed that the participation of Arabs in the international FOS software movement is low. According to the country of residence and nationalities of the participated developers, non of the Arab countries were in the list of the top twenty countries, while both India and Turkey were in the list (Ghosh et al., 2002b, pp.16–17).

Strategies

The Arab Free/Open Source Software Meeting final report (ALECSO, 2005, pp.1–2) made some recommendations to be implemented in the na-

tional strategies to minimize the lack of knowledge and interest in FOS. These recommendations include introducing the FOS concepts to the universities, encourage the investments in FOS products and support commercializing FOS projects. The most important recommendation is to support the translation of existing FOS software to Arabic to encourage using such software.

Recently most of the Arab states (like Tunisia and KSA) have included some plans to support FOS in the national IT or ICT strategies, others like Sudan are planning to include such strategies in the future (Alkanhal, 2005, pp.2-3);(Alwarghey, 2005, p.3). These plans follow the already established strategies in many countries like Brazil, India, European Union, Malaysia, Pakistan and others (Dravis, 2003, pp.7–11).

FOS Communities

A quick search in the Internet for Arab FOS communities gave 18 main FOS communities from all Arab states. The communities in this context are referred to websites or on-line forums that deal with either Linux or general FOS projects. Out of these 18 communities only 11 are active. They updated their websites or made discussions in 2006. Although this number is relatively not bad, but most of their activities (according to the websites and discussions) deal with providing technical support to FOS software adopters or announcing latest national and international progress in FOS development. Few of these communities are developing or translating FOS software. This indicates that the Arab communities are still consumers rather than producers while most of the development activities focus on translating the software.

7.2 TT in the Arab world

> "With few exceptions, the experience of individual Arab countries in technology transfer management and adaptation has not met initial expectations, although technology transfer has always been a top national priority. Arab countries recognised, at an early stage, that their socio-economic development required moving towards industrial (...) and export-based economies. This perception (...) was correct, yet it was not translated into effective policies." (Bennani et al., 2003, pp.97–98)

The technology transfer success in developing countries depends not only on the firms individual efforts but also on the characteristics of the national system of innovation (UNIDO, 1996, p.7). Section 1.2 discussed the status of the Arab national innovation system which is characterized by the weakness in both the input (e.g. fund, education, research, etc.) and output (e.g. Patents, publications, Technology products, etc.) factors. Besides that, the Arab world, similar to all developing countries, suffers from the lack of effective national R&D strategies and policies (Zaky and El-Faham, 1998, p.725).

One of the major difficulties facing the Arab world technology transfer is the lack of links between research and industry (Bennani et al., 2003, p.100). For example, the universities perform researches that do not meet the industry's needs or the industry is not aware of their existence (Zaky and El-Faham, 1998, p.725).

The reasons of this gap that fit in the context of Arab world can be summarized from (Zaky and El-Faham, 1998, pp.722–725) as:

- Education system is inherited from colonial system that do not fit the current local needs

- Universities curricula are modeled after international universities, for prestige recognition reasons without considering the needs of the local industry
- The lack of fund, equipment, laboratories and industrial experience
- The Universities are not good at marketing their researches to the industry
- The lack of lifelong learning process that supports the adoption to fast changing technologies
- Permanent jobs, bureaucracy and heavy teaching loads make it almost impossible to make communication with the industry

Moreover, some academics feel that interaction with industry has negative impact on getting tenure university (Dalziel, 1994, p.745), since the main objective for researches and publication in developing countries (which is the case in the Arab world) is obtaining promotion, while the choice of research is made almost exclusively by the supervisors according to their objectives (Zaky and El-Faham, 1998, p.725).

This lack of interaction is not only limited within the Arab world, but also the networking among R&D institutes at the Arab states level is limited, temporary and not sustainable. The networking on the international level is also very weak specially in the ICT field. For example, only 8.4% of the cooperation projects with the European Union go to ICT and Bio-tech fields where the majority related to agriculture and natural resources (Bennani et al., 2003, pp.106–109).

7.3 FOS TT model adoption and advantages

Chapter 6 described both how FOS can be adopted as technology transfer model and the general advantages of this model. The Arab world has

its specialty in both FOS and TT which may increase the advantages of adopting FOS to TT.

In general, as for all developing countries, FOS can increase the access to information and leverage local skills and talents in the Arab world besides reducing the overall research costs and improve their quality (section 3.6). Adopting the FOS model can minimize the effects of brain drain by increasing the links with Arab experts living outside the area. Furthermore, although the international level indicate that high percentage of FOS developers have stable jobs, but on the Arab world the FOS can be used to reduce the effect of unemployment through participation in FOS projects to build new skills and experiences in real world projects which in turns could increase their chances.

Moreover, the Arab world, according to (Bennani et al., 2003, p.100), need for intermediate institutes to link between industry and research institutes. Using FOS will help in creating such link without the need for the establishment of an institute and its incurred costs, since the communications will be informal and direct with knowledge holders, in addition it will minimize the effects of bureaucracy.

The FOS can also support the establishment of project networks within the Arab states and with international projects (section 7.2) since the Arab institutes (research or industry) do not have to follow strict cooperation licensing (free to join and leave) or lengthy negotiations (one license for all). This will increase the cooperation within the Arab states and the expatriates and avoid the duplication of the activities.

Since high percentage of the Arab universities do not cooperate with the industry or gain commercial advantage from researches, through patents for example, they can adopt the FOS model in their students projects and researches besides the participation in international FOS projects. In this

way they can investigate possibilities of making use of such researches in real applications and getting feedback on the technical issues from wider range of experts and sources of ideas without being limited to their university boundaries.

In the university context, the successful participation and achievements with FOS projects can be a good reward system since it provides recognition for the researchers among the local and international peers even if they do not get direct reward from their institutes.

When universities open source their projects, publish the results of their researches for free, or even participate in international FOS projects, the local industry will be more encouraged to adopt such projects since they are already tested by the community and demonstrated some basic use in real world applications. This is in contrast to traditional research projects in the Arab universities that mostly do not demonstrate their use in real life applications and remain as basic researches according to researcher's interest and objectives or at the best wait for investment. Moreover such FOS projects will have better chances to be carried on outside the university either by international researchers or industry which will increase the interest in the project and extend its life time.

Most firms in the Arab world, as in developing countries, lack both financial and human resources to engage in research activities (UNIDO, 1996, p.10); (Bennani et al., 2003, p.105). The sharing nature of FOS projects can reduce the overall R&D and transaction costs. Not only through test equipment and facilities sharing within the same area, but with virtual networks that can increase the availability of equipment and facilities to the project. Moreover, the firms can engage with indirect investment or financial support to the FOS projects by using some of the FOS business models which in turn will improve the quality and trust of the projects.

With the industry participation in university FOS projects, they can deal indirectly with the curricula definition since they can push for their opinions and demonstrate their needs not only through the feedback on the project progress, but also with the direct involvement in the development.

The industry can adopt FOS business model because the related technological products and services do not require high investment nor intensive R&D activities which are weak in the Arab world. Moreover, since the Arab world lack both the experience and the proper investment in large R&D projects, specially in fields like ICT, adopting the open innovation and RDI networks models would be appropriate for large projects, since the experiences and funds can be gathered for single objective.

The local industry can learn from the FOS development and business models, the lightweight management and the empowerment of their engineers to establish informal communication channels with external researchers.

Finally, FOS culture can support better establishment of leadership which is required to motivate Arab societies to take responsibility for research and innovation according to (Bennani et al., 2003, p.73).

7.4 FOS TT model adoption difficulties

Although theoretically the FOS can be used in the Arab world as a technology transfer tool, but the there are several difficulties that may face the adoption of this model.

The ICT infrastructure and accessibility weakness in the Arab world do not support a reliable communication channel for FOS development. Besides that, there is in general, weak interest and understanding of the FOS concepts in the Arab world which are reflected on the small size of the

Arab FOS community.

One of the problems is the reward and motivation system for researchers who are used on fixed jobs and look for activities that lead for promotions and FOS achievements are not included in the universities culture.

The culture of low degree of general freedom in the Arab world (Bennani et al., 2003, p.28) makes it also not easy for individuals to adopt the FOS culture of development freedom and sharing. Not only the freedom, but also the bad economic situation reduces the chances of sharing and altruism culture and increases the individualism.

In short, the adoption of such new knowledge system need the dissemination of the available knowledge and the production of new forms of knowledge (Bennani et al., 2003, p.40), these processes are not easy within the frame of Arab national innovation system, since the effective policies need the availability of hardware and communication infrastructure, the know-how and skills and the integration between of them with the capital and skilled workforce (Ahmadi and Qassemzadeh, 1997, p.954).

On the other hand, since the Arab world is behind the world standard in both FOS and TT, it can learn from experiences of others and avoid the mistakes in national FOS strategies.

Chapter 8

Conclusions and Recommendations

The report showed that the links between industry and research institutes/universities in the Arab world are so weak which affect on the whole national innovation system. The FOS development process which is mainly based on direct communication, free knowledge sharing and trust, can be used to improve such links in the Arab world. These three factors, specially the direct communication, lead to most effective technology transfer methods.

The FOS concept is suitable for the Arab world technology transfer, since it provide cheap alternative model that does not require the establishment of expensive dedicated institutes. In addition, the transaction costs of communications, licensing and negotiations will be minimized and the funds will be reserved to the real development.

The efficiency of this FOS technology transfer model is not only related to cost, but also to the speed of implementation, which is important to the

Arab world to follow up with the international levels. The model can be implemented as fast as publishing the information and announcing the project, without the need to follow any bureaucratic procedures nor to wait the availability of investments since each party is free to join or leave according to its resources.

While the FOS could improve the communication, cooperation and the technology transfer, the Arab world still needs some time to support the adoption of such model. For this model to be used, careful planing and social values should be adopted within education and industry. On the social side, the culture of sharing, publishing results, valuing the individual achievements and participation (participate in external projects and allow others to participate in local projects) are needed.

The governments have to define policies and plans to support the introduction of FOS concepts to both the universities/research institutes and the industry. They can sponsorship the use and development of FOS products and show their advantages. As a good starting point, the universities could be the best platform to diffuse the FOS concepts in the Arab world.

Finally, further studies should focus on the policies and actions to support the adoption and diffusion of FOS concepts in the universities and industry in the Arab world.

Appendix A

Notations and Abbreviations

- **ALECSO**: The Arab League Educational, Cultural and Scientific Organization
- **ESCWA**: United Nations Economic & Social Commission for Western Asia
- **FOS**: Free Open Source
- **FOSS**: Free Open Source Software
- **GCC**: Gulf Cooperation Council (Saudi Arabia, Kuwait, Bahrain, Qatar, UAE, Oman)
- **GNU**: GNU Not Unix
- **GPL**: GNU public license
- **ICT**: Information and Communication Technologies
- **IP**: Intellectual Property
- **ISR**: Industry Science Relation
- **IT**: Information Technology
- **KSA**: Kingdom of Saudi Arabia
- **MENA**: Middle East North Africa

- **OEM**: Original Equipment Manufacture
- **OSD**: Open Source Definition
- **R&D**: Research and Development
- **RDI**: Research, development and innovation
- **S&T**: Science and Technology
- **TT**: Technology Transfer
- **UAE**: United Arab Emarits
- **UN**: United Nations
- **UNDP**: United Nations Development Program
- **UNECA**: United Nations Economic Commission for Africa
- **UNESCO**: United Nations Educational, Scientific and Cultural Organization

Appendix B

Arab States

B.1 Arab League states

1. The Hashemite Kingdom Of Jordan
2. United Arab Emirates
3. Kingdom Of Bahrain
4. Republic Of Tunisia
5. Democratic and Popular Republic Of Algeria
6. Republic Of Djibouti
7. Kingdom Of Saudi Arabia
8. Republic Of Sudan
9. Arab Republic Of Syria
10. Republic Of Somalia
11. Republic Of Iraq
12. Sultanate Of Oman

13. State Of Palestine
14. State Of Qatar
15. Federal Islamic Republic Of Comoros
16. State Of Kuwait
17. Republic Of Lebanon
18. Socialist People's Libyan Arab Jamahiriya
19. Arab Republic Of Egypt
20. Kingdom Of Morocco
21. Islamic Republic Of Mauritania
22. Republic Of Yemen

B.2 ESCWA states

1. The Hashemite Kingdom Of Jordan
2. United Arab Emirates
3. Kingdom Of Bahrain
4. Kingdom Of Saudi Arabia
5. Arab Republic Of Syria
6. Republic Of Iraq
7. Sultanate Of Oman
8. State Of Palestine
9. State Of Qatar
10. State Of Kuwait
11. Republic Of Lebanon
12. Arab Republic Of Egypt

13. Republic Of Yemen

B.3 UNECA states

1. Republic Of Tunisia
2. Democratic and Popular Republic Of Algeria
3. Republic Of Sudan
4. Socialist People's Libyan Arab Jamahiriya
5. Arab Republic Of Egypt
6. Kingdom Of Morocco
7. Islamic Republic Of Mauritania

Appendix C

Free Open Source

C.1 FOSS Success measures

Adopted from (Goldman and Gabriel, 2005, p.101) and (Crowston et al., 2003, pp.1–14)

- System quality based on code and documentation review
- User satisfaction of software use which is not easy to measure in FOS community due to its size
- Developer satisfaction that can be measured through surveying them
- Software use which is based on number of downloads
- Project completion which is not easy due to the lack of fixed specification
- Number of developers and size of the community
- Time between releases, bug reporting and fixing rate where frequent updates indicate the health of the project

C.2 Free Open Source Software History

Year	Event
1950s–1960s	Software source code is distributed without restrictions in IBM and DEC user groups, ACM's Algorithms section etc.
1969	Ken Thompson writes the first version of UNIX. Its source code is distributed freely throughout the seventies.
1978	Donald Knuth (Stanford) publishes TEX as free software.
1979	Following AT&T's announcement to commercialize UNIX, UC Berkeley begins with the creation of its own version of UNIX, BSD (Berkeley Software Distribution). Eric Allmann, a student at UC Berkely develops a program that routes messages between computers over ARPANET. It later evolves into Sendmail.
1983	Stallmann publishes GNU Manifesto calling for free software, and establishes Free Software Foundation.
1986	Larry Wall creates Perl (Practical Extraction and Report language), a versatile programming language used for writing CGI (Common Gateway Interface) scripts.
1987	Developer Andrew Tanenbaum releases Minix, a version of UNIX for the PC, Mac, Amiga, and Atari ST. It comes with complete source code.
1991	Linus Torvalds publishes version 0.02 of a new UNIX variant that that he calls Linux in a Minix newsgroup.
1993	FreeBSD 1.0 is released Based on BSD Unix, FreeBSD includes networking, virtual memory, task switching, and large file names. Ian Murdock creates a new Linux distribution called Debian Linux.
1994	Marc Ewing forms Red Hat Linux. It quickly becomes the Leading Linux distributor. Brayan Sparks founds Caldera with baking by former Novell CEO Ray Noorda.
1995	The Apache Group builds a new Web server, Apache, based on the National Center for Supercomputing Applications' (NCSA's) HTTPD 1.3 and a series of patch files. It has become the dominant HTTP server today.
1998	Netscape not only gives away Communicator 5.0 (Mozilla) but also releases its source code. Major software vendors, including computer Associates, Corel, IBM, Informix, Interbase,Oracle, and Sybase, announce plans to port their products to Linux. Sun announces plans to release the source code for Java 2 to developers.
1999	Number of Linux users estimated at 7.5 Million.
2000	More software companies such as Novell and Real release versions of their products which run on Linux.

Table C.1: Open Source Time line
Source: (Hars and Ou, 2001)

C.3 Arab open source Survey questions

PART I: Companies/Institutes Survey

1. Do you use Open source programs in your company/ institute

oYes oNo

2. Do you plan to use (more) Open source products?

oYes oNo

3. Do you have confidence in software products developed by Arabs?

oYes oNo

o We are using now (please specify the products):

4. What are your concerns about using open source software on your servers?

o The lack of professionals to deal with the system

o Security issues

o The lack of country wide support for such open source systems

o Inability of the system to deal with my needs.

o The lack of knowledge of this system and its features

o Others.

5. What are your concerns about using open source software in your desktop software?

o The lack (in complete) of support of the Arabic language

o The lack of professionals to deal with the system

o The lack of country wide support for such open source systems

o Inability of the system to deal with my needs.

o The lack of knowledge of this system and its features

o The difficulties in dealing with open source programs

o Others.

Programs

6. Which operating systems do you use (or used) in your establishment

o Windows	o Unix-like (Solaris, HP-UX?.)
o Red Hat Linux	o Fedora Linux
o Suse Linux	o Debian Linux
o TurboLinux	o Hydar Linux
o Arabix Linux	o Resala Linux
o FreeBSD	o OpenBSD
o NetBSD	o Others

7. Which open source programs do you use?

o Apache Web Server	o Microsoft IIS Server
o OpenOffice	o Mozilla/fireFox
o Gnome	o KDE
o GIMP	o SAMBA
o Sendmail	o OpenSSH
o Others	

8. What are the Open Source programming Languages used in your Establishment (if any):

9. In your opinion the main advantages of using Open source products are

o The low Cost

o The Features it offers

o The support

o Ability to customize it to personal needs

o Free to copy and distribute it internally and externally

o Stability

o Many people and institutes are using it (recommendation to use it)

o Other advantages

o No advantages

10. In case you find bugs or deficiencies in the open source programs you are using, what will you do?

o Discard the programs and use commercial ones immediately

o Try to figure out the problem and solve it.

o Consult experts & have them develop customized software for our own needs

Open Source in the Business

11. Do you think that open source products can be used for developing profitable businesses?

oYes oNo oNot sure

12. Will you adopt open source business models in the future?

oYes oNo oNot sure

13. If you are using Open Source products; are they beneficial for your business?

oYes oNo oNot sure

14. Do you know of companies using Open source business model?

oYes oNo

Future perspective

15. Do you think Open source concept has a good future in business?

oYes oNo oNot sure

o It is suitable only for small businesses

16. Do you think Open source has a future in the academic field?

oYes oNo oNot sure

17. What type of Open Source projects would you like to see being developed in the future?

o Arabic Operating system	o Computer Hardware
o Home devices (TV, DVD player, phones...)	o Games
o Scientific programs	o Office programs
o Database	o Banking Software
o Inventory & accounting systems	o Others (please specify)

18. Do you like to have different Arabic Linux distributions?

oYes oNo oNot sure

19. Do you think that open source concept will promote knowledge and experience sharing among Arab countries?

oYes oNo oNot sure

20. Do you think that Open source concept will help in the improvement of Hi-Tech and IT industry in the Arab world

oYes oNo oNot sure

21. Do you think that there should be a national strategy to promote the use and development of Open source products? If yes, kindly sketch out some ideas to be included in such a strategy.

22. Do you know any Arabic open source groups? Kindly list them (with Emails), underlining the ones you cooperate with.

GENERAL INFORMATION ABOUT YOUR ESTABLISHMENT

23. Your establishment is a:

o Governmental Department/Institution o Private Company
o Non Governmental Organization o Educational Institution
o Other (Please Specify)

24. What is the size of your establishment:

o Tiny/home office: 1-2 persons o Small: 3-20
o Medium: 21-100 o Large: 101- and over

25. What best describes your organization in relation to Info. technology

o Use technology in most of our activities

o Develop new technologies/ technological products

o Resell info. technological products

o We only use Computer for Internet, writing documents, for accounting or inventory programs.

o Not related to information technology at all

PART II: Developers' Survey

Reasons and motivations

1. Why are you involved with open source projects?

o To gain reputation through my work

o To cooperate and share information with others

o To fight against proprietary products

o To promote the Open source concept in the Arab world

o To improve my skills to find a better job

o To solve technical problems that no one care about

o For fun

o For other reasons (please specify)

2. How do you describe your contribution to an Open source project you are involved with

o Project leader
o Project idea initiator but not a leader
o Develop parts of the project
o Translate an existing project into Arabic
o Advisor on certain aspects
o A learner
o Other (please specify)

3. What are your open source interest areas?

o Arabic Operating system	o Open source Computers/CPU
o Home devices (TV, DVD player, phones...)	o Games
o Scientific programs	o Office programs
o Database	o Banking Software
o Inventory & accounting systems	o Others (please specify)

4. In which area of open source are you working now ?

o Operating system	o Office application & publishing
o Scientific programs	o Games
o Translating/ porting	o Other (please specify)

5. I started the Open source development in year:

6. How many hours (on the average) do you spend on Open Source development per week:

7. What was the maximum number of hours per day you spent on Open Source development

8. How did your interest in open source begin ?

9. How do you like working in Open source environment?

o Fun	o Cooperation spirit
o Boring	o Endless discussions
o High quality and efficiency	o Innovative
o Other	

10. Have you been employed by an organization producing proprietary software?

o Never

o Yes (in the past)

o I am presently so

11. Have you developed proprietary software also?

oYes oNo

12. Please list all the software projects you have participated in (stating project title, project duration and your role in the project). Underline the projects that gained national or regional fame.

13. How long is your experience in Hi-Tech industry or IT

o 0-1 years o 2-5 years
o 6-10 years o More than 10 years

14. Age

o Under 18 years o 18-26 years
o 27-35 years o 36-45 years

o Over 45 years

15. Employment Status

o Employed with the government, the private sector, Self employed

o Unemployed o Retired
o Student o Other

16. Marital status:

o Single o Married without children
o Married with children o Other

17. Citizenship:

o Present nationality:

o Previous nationality:

18. Present Full Address

19. Knowledge of Languages

o Arabic o English
o French o German
o Urdu o Other Languages

C.4 Arab FOS communities

These are some of the main Arab FOS communities. The table indicates which communities have received the Arab FOS (not necessarily replied).

Community	Activity	Surveyed
Handasa Arabia http://www.handasarabia.org	Yes	Yes
Arab Eyes http://www.arabeyes.org	Yes	Yes
Arabic Open Office http://ar.openoffice.org	Yes	Yes
http://www.linux4arab.com	No	No
http://www.q8linux.net	Yes	No
http://www.linux-me.org	No	No
http://www.linux-maroc.org	Yes	Yes
http://www.iraqilinux.org	Yes	Yes
http://www.linuxarabia.com	Yes	Yes
http://www.linux-dubai.com	Yes	Yes
Egypt linux group http://www.eglug.org	Yes	Yes
Sudan Linux Group http://linux4sudan.org	Yes	No
http://www.leglug.org	No	No
http://www.linuxac.org	Yes	No
Palestine Linux Group http://www.plug.ps	Yes	Yes
Syrian linux group	No	No
Saudi linux group	No	No
Jordan linux group	No	No

Table C.2: FOS Arab Communities

The activities are measured based on the latest submission to the forum or site update, if the community has some activities in year 2006 it is marked as active.

Bibliography

H. Ahmadi and H. Qassemzadeh. Policy issues for technology transfer in developing countries, an analysis of alternatives. In *Innovation in Technology Management - The Key to Global Leadership. PICMET '97: Portland International Conference on Management and Technology*, pages 954–955, 27-31 July 1997.

The Arab League Educational, Cultural and Scientific Organization ALECSO. Final report. In *The Arab Free/Open Source Software Meeting*, Tunisia, 22–24 December 2005. URL `http://www.alecso.org.tn/index.php?option=com_content&task=view&id=523&Itemid=511`. Last accesed August 2006.

Mohammed Alkanhal. Status of free software in the kingdom of saudi arabia. In *The Arab Free/Open Source Software Meeting*, Tunisia, 22–24 December 2005. The Arab League Educational, Cultural and Scientific Organization (ALECSO). URL `http://www.alecso.org.tn/index.php?option=com_content&task=view&id=523&Itemid=511`. Last accessed August 2006.

Mohammed Alwarghey. National plan in free software: Tunisia. In *The Arab Free/Open Source Software Meeting*, Tunisia, 22–24 December 2005. The Arab League Educational, Cultural and Scientific Organiza-

tion (ALECSO). URL http://www.alecso.org.tn/index.php?option=com_content&task=view&id=523&Itemid=511. Last accessed August 2006.

Micah Barfield, Michelle Diego, Shea Tanabe-Hines, Mark Shaffner, and Gene Yelden. *Managing Innovation on the Internet: Analysis of Open-Source Networks*. Pacific Lutheran University, Tacoma Washington, USA, 2003. URL http://eplu.plu.edu/resource/mba_papers/open-source.pdf. Last accessed September 2006.

Troy Benjegerdes. Industry analysis paper, 2006. URL http://www.dodds.net/~hozer/opensource.html. Last accessed September 2006.

Farida Bennani, Hoda Elsadda, Nader Fergany, Fahmi Jadaane, and Atif Kubursi. *The Arab Human Development Report 2003: Building a knowledge society*. United Nations Development Programme (UNDP), New York, USA, 2003. URL http://hdr.undp.org/reports/detail_reports.cfm?view=712. Last accessed September 2006.

James Bessen and Eric Maskin. Intellectual Property on the Internet: What's Wrong with Conventional Wisdom?, 2004. URL http://www.researchoninnovation.org/iippap2.pdf. Last accessed July 2006.

Business and Industry Advisory Committee to the OECD BIAC. *Promoting Better Public-Private Partnerships Industry - University Relations*. September 2003.

Andrea Bonaccorsi and Cristina Rossi. Altrustic individuals, selfish firms? the structure of motivation in open source software, 8 2003a. URL http://opensource.mit.edu/. Last accessed September 2006.

Andrea Bonaccorsi and Cristina Rossi. Comparing motivations of individual programmers and firms to take part in the open source movement. from community to business, October 2003b. URL `http://opensource.mit.edu/`. Last accessed September 2006.

Andrea Bonaccorsi and Cristina Rossi. Contributing to os projects. a comparison between individual and firms. In Joseph Feller, Brian Fitzgerald, Scott Hissam, and Karim Lakhani, editors, *Proceedings of the 4th Workshop on Open Source Software Engineering*, pages 18–22, Edinburgh, Scotland, May 25 2004. URL `http://opensource.ucc.ie/icse2004`. Last accessed September 2006.

L. Boulter and T. Bendell. Managing the technology transfer process. In *Engineering Management Conference, 2002. IEMC '02. 2002 IEEE International*, volume 2, pages 643–648vol.2, 18-20 Aug. 2002.

Henry Chesbrough. Managing open innovation. *Research-Technology Management*, 47(1):23–26, January 2004.

A.M. Colyer. From research to reward: challenges in technology transfer. In *Software Engineering, 2000. Proceedings of the 2000 International Conference on*, pages 569–576, 4-11 June 2000.

Mazen E. Coury and Soumitra Dutta. *The Global Information Technology Report 2002-2003 : Readiness for the Networked World*, chapter ICT Challenges for the Arab World, pages 116–131. Oxford University Press, USA, February 2003.

K. Crowston and J. Howison. Assessing the health of open source communities. *Computer*, 39(5):89–91, May 2006.

Kevin Crowston, Hala Annabi, and James Howison. Defining open source software projects success. In *the 24th International Conference on*

Information Systems (ICIS 2003), Seattle, WA, 2003. School of Information Studies, Syracuse University,Syracuse, NY USA. URL http://opensource.mit.edu/papers/crowstonannabihowison.pdf. Last accessed September 2006.

Kevin Crowston, Hala Annabi, James Howison, and Chengetai Masango. Towards a portfolio of floss project success measures. In Joseph Feller, Brian Fitzgerald, Scott Hissam, and Karim Lakhani, editors, *Proceedings of the 4th Workshop on Open Source Software Engineering*, pages 29–33, Edinburgh, Scotland, May 25 2004. URL http://opensource.ucc.ie/icse2004. Last accessed September 2006.

M. Dalziel. Effective university-industry technology transfer. In *Electrical and Computer Engineering, 1994. Conference Proceedings. 1994 Canadian Conference on*, pages 743–746vol.2, 25-28 Sept. 1994.

Benoit Demil and Xavier Lecocq. Neither market or hierarchy or network: The emerging bazaar governance, September 2003. URL http://opensource.mit.edu/. Last accessed September 2006.

Mark Dodgson. *The Management of Technological Innovation: An International and Strategic Approach*. Oxford University Press, New Yourk, 2000.

Paul Dravis. Open Source Software: Perspectives for Development. Technical report, infoDev, Whashington DC, US, December 2003. URL http://www.infodev.org/files/837_file_Open_Source_Software.pdf. Last accessed July 2006.

O. Elhmood. *Missing links between education and the production and services activities and the economic role of science Arabization*, volume I, chapter 4, pages 161–234. The Arab League Educational, Cultural and Scientific Organization (ALECSO), Tunis, 2003.

United Nations Economic & Social Commission for Western Asia ESCWA. *Technology capacity-building initiatives for the twenty-first century in the ESCWA member countries*. United Nations Economic & Social Commission for Western Asia (ESCWA), New York, USA, 2001.

United Nations Economic & Social Commission for Western Asia ESCWA. *Networking research, development and innovation in Arab countries*. United Nations Economic & Social Commission for Western Asia (ESCWA), New Yourk, 2005. URL `http://www.escwa.org.lb/`. Last accessed September 2006.

C. Freeman and L. Soete. *The Economics of Industrial Innovation*. Thomson Learning, UK, third edition edition, 2004.

C. Gacek and B. Arief. The many meanings of open source. *Software, IEEE*, 21(1):34–40, Jan-Feb 2004.

Rishab Aiyer Ghosh, Bernhard Krieger, Ruediger Glott, Gregorio Robles, and Thorsten Wichmann. *FLOSS Final Report –Part 3: Free/Libre and Open Source Software: Survey and Study: Basics of Open Source Software Markets and Business Models*, volume Part 3. International Institute of Infonomics University of Maastricht, The Netherlands; Berlecon Research GmbH Berlin, Germany, June 2002a. URL `http://www.infonomics.nl/FLOSS/report/index.htm`. Last accessed September 2006.

Rishab Aiyer Ghosh, Bernhard Krieger, Ruediger Glott, Gregorio Robles, and Thorsten Wichmann. *FLOSS Final Report –Part 4: Free/Libre and Open Source Software: Survey and Study: Survey of Developers*, volume Part 4. International Institute of Infonomics University of Maastricht, The Netherlands; Berlecon Research GmbH Berlin, Germany, June 2002b. URL `http://www.infonomics.nl/FLOSS/report/index.htm`. Last accessed September 2006.

GNU. Philosophy of the gnu project, September 2006. URL `http://www.gnu.org/philosophy/philosophy.html`. Last accessed September 2006.

Ron Goldman and Richard P. Gabriel. *Innovation happens elsewhere: Open Source as business strategy*. Morgan kaufmann publishers, San Francisco, USA, 2005.

II-Horn Hann, Jeff Roberts, Sandra Slaughter, and Roy Fielding. Why do developers contribute to open source projects? first evidence of economic incentives. In *Proceedings of the 2nd Workshop on Open Source Software Engineering*, Orlando, FL, USA, May 25 2002. URL `http://opensource.ucc.ie/icse2002`. Last accessed September 2006.

A. Hars and Shaosong Ou. Working for free? motivations of participating in open source projects. In *System Sciences, 2001. Proceedings of the 34th Annual Hawaii International Conference on*, page 9 pp., Jan 3-6 2001.

Frank Hecker. Setting up shop: The business of open-source software. *IEEE software*, 16(1):45–51, January-February 1999.

D.H. Hering. Technology transfer: a designer's tool. In *Southeastcon '91., IEEE Proceedings of*, pages 631–635vol.2, 7-10 April 1991.

R.M. Hodgson. The development and transfer of advanced technology from universities to industry. In *Electronic Design, Test and Applications, 2002. Proceedings. The First IEEE International Workshop on*, pages 197–202, 29-31 Jan. 2002.

J. Ishak and M. Ghnayem. *Scientific and Technological gap in the Arab world from regional and global perspective*, volume I, chapter 8, pages 331–388. The Arab League Educational, Cultural and Scientific Organization (ALECSO), Tunis, 2003.

Jamil I. Khatib and Mohamed A. Salem. An introduction to open-source hardware development. *EETimes Online*, July 2004. URL `http://www.eetimes.com/news/design/features/showArticle.jhtml?articleID=22103383`. Last accessed September 2006.

Reinoud Lamberts. Open design circuits: Ultra low cost open chip development, 2006. URL `http://www.opencollector.org/history/OpenDesignCircuits/reinoud_index.html`. Last accessed September 2006.

Bart Massey. Where do open source requirements come from (and what should we do about it)? In *Proceedings of the 2nd Workshop on Open Source Software Engineering*, Orlando, FL, USA, May 25 2002. URL `http://opensource.ucc.ie/icse2002`. Last accessed September 2006.

Peter N. Materu. Open source courseware: A baseline study, November 2004. URL `http://www.worldbank.org/afr/teia/pubs_non_bank.htm`. Last accessed September 2006.

Organisation for Economic Co-operation and Development OECD. *OECD Science, Technology and Industry Outlook 2000*. France, 2000.

Organization for economic co-coperation and development OECD. *Technology Incubators: Nurturing small firms*. Organization for economic co-coperation and development (OECD), 1997.

A. Pau. Technology transfer of software engineering to developing countries. In *Computer Software and Applications Conference, 1988. COMPSAC 88. Proceedings., Twelfth International*, page 34, 5-7 Oct. 1988.

Linda Dailey Paulson. News briefs: Ibm lets open source developers use 500 patents. *Computer*, 38(3):23–24, March 2005. URL `http://`

csdl.computer.org/comp/mags/co/2005/03/r3022.pdf. Last accessed September 2006.

Bruce Perens. The Open Source Definition – Version 1.9. Published by the Open Source Initiative (OSI)., 2006. URL http://www.opensource.org/docs/definition.php. Last accessed September 2006.

Vidyasagar Potdar and Elizabeth Chang. Open source and closed source software development methodologies. In Joseph Feller, Brian Fitzgerald, Scott Hissam, and Karim Lakhani, editors, *Proceedings of the 4th Workshop on Open Source Software Engineering*, pages 105–109, Edinburgh, Scotland, May 25 2004. URL http://opensource.ucc.ie/icse2004. Last accessed September 2006.

S. Qasem. *Research and Development Systems in the Arab World States: Development of Science and Technology Indicators*. Economic and Social Commission for Western Asia (ESCWA) and United Nations Educational, Scientific and Cultural Organization Cairo Office (UNESCO), Cairo, 1998. URL http://unesdoc.unesco.org/ulis/. Last accessed September 2006.

S. Qasem. *Strategy for the development of science and Technology in the Arab world*, volume I, chapter 1, pages 11–94. The Arab League Educational, Cultural and Scientific Organization (ALECSO), Tunis, 2003.

Eric S. Raymond. *The Cathedral and the Bazaar:Musings on Linux and Open Source by an Accidental Revolutionary*. O'Reilly Media, Inc., USA, 2001.

Everett M. Rogers. *Diffusion of Innovations*. Free Press, New York, USA, fifth edition, 2003.

M.D. Santoro and P.A. Saparito. Self-interest assumption and relational trust in university-industry knowledge transfers. *Engineering Management, IEEE Transactions on*, 53(3):335–347, August 2006.

Walt Scacchi. Is Open Source Software Development Faster, Better, and Cheaper than Software Engineering? In *Proceedings of the 2nd Workshop on Open Source Software Engineering*, pages 49 – 51, 2002. URL `http://opensource.ucc.ie/icse2002`. Last accessed September 2006.

Suzanne Scotchmer. *Innovation and Incentives*. The MIT Press, London, England, 2004.

Graham Seaman. How can hardware be open? Available at:, 2006. URL `http://opencollector.org/Whyfree/open_hardware.html`. Last accessed September 2006.

M.S. Spann, M. Adams, and W.E. Souder. Measures of technology transfer effectiveness: key dimensions and differences in their use by sponsors, developers and adopters. *Engineering Management, IEEE Transactions on*, 42(1):19–29, February 1995.

Richard Stallman. The gnu project, 2001. URL `http://www.gnu.org/gnu/thegnuproject.html`. Last accessed September 2006.

Katherine J. Stewart. Oss project success: From internal dynamics to external impact. In Joseph Feller, Brian Fitzgerald, Scott Hissam, and Karim Lakhani, editors, *Proceedings of the 4th Workshop on Open Source Software Engineering*, pages 92–96, Edinburgh, Scotland, May 25 2004. URL `http://opensource.ucc.ie/icse2004`. Last accessed September 2006.

Anas Tawileh. Free open source software and arabic language. In *The Free/Open Source Software Meeting*, Tunisia, 22–24 December 2005. The Arab League Educational, Cultural and Scientific Organization (ALECSO). URL `http://www.alecso.org.tn/index.php?option=com_content&task=view&id=523&Itemid=511`. Last accessed August 2006.

United Nations Educational Scientific and Cultural Organization UNESCO. *UNESCO Science Report 2005*. UNESCO Publishing, Paris, France, 2005. URL http://www.unesco.org/science/psd/publications/science_report2005.shtml. Last accessed September 2006.

United Nations Industrial Development Organization UNIDO. *Manual on Technology Transfer Negotiation*. General Studies Series. Vienna, 1996.

United States Patents and Trademarks Office USPTO. United states patents & trademarks office (uspto), 2006. URL http://www.uspto.gov. Last accessed June 2006.

Fei-Rong Wang, Dan He, and Jin Chen. Motivations of individuals and firms participating in open source community. In *Machine Learning and Cybernetics, 2005. Proceedings of 2005 International Conference on*, volume 1, pages 309–314, 18-21 Aug. 2005.

Kevin Watkins, Haishan Fu, Ricardo Fuentes, Arunabha Ghosh, Chiara Giamberardini, Claes Johansson, Christopher Kuonqui, Andrés Montes, David Stewart, Cecilia Ugaz, and Shahin Yaqub. *Human Development Report 2005*. United Nations Development Programme (UNDP), New York, USA, 2005. URL http://hdr.undp.org/reports/global/2005/. Last accessed September 2006.

David A Wheeler. Why Open Source Software / Free Software? Look at the Numbers!, November 2005. URL http://www.dwheeler.com/oss_fs_why.html. Last accessed September 2006.

Wikipedia the free encyclopedia. Open source hardware, September 2006a. URL http://en.wikipedia.org/wiki/Open_source_hardware. Last accessed September 2006.

Wikipedia the free encyclopedia. Maslow's hierarchy of needs, October 2006b. URL `http://en.wikipedia.org/wiki/Maslow's_hierarchy_of_needs`. Last accessed September 2006.

Wikipedia the free encyclopedia. Free content, September 2006c. URL `http://en.wikipedia.org/wiki/Free-content`. Last accessed September 2006.

Sam Williams. *Free as in Freedom: Richard Stallman's Crusade for Free Software*. O'Reilly, Sebastapol, CA, 2002. URL `http://www.oreilly.com/openbook/freedom/`. Last accessed September 2006.

Kenneth Wong and Phet Sayo. *Free/Open Source software: A General Introduction*. United Nations Development Programme's Asia-Pacific Development Information Programme (UNDP-APDIP), Kuala Lumpur, Malaysia, 2004. URL `http://www.iosn.net/`. Last accessed: September 2006.

Ming-Wei Wu and Ying-Dar Lin. Open source software development: an overview. *Computer*, 34(6):33–38, June 2001.

A.A. Zaky and M.M. El-Faham. The university-industry gap and its effect on research and development in developing countries. In *Frontiers in Education Conference, 1998. FIE '98. 28th Annual*, volume 2, pages 722–726vol.2, November 4-7, 1998.

L. Zhao and A. Reisman. Toward meta research on technology transfer. *Engineering Management, IEEE Transactions on*, 39(1):13–21, February 1992.