International Journal of Advanced Science and Technology
Vol.118 (2018), pp.47-56
http://dx.doi.org/10.14257/ijast.2018.118.05

Strategies for Applying Open Source Software to Defense Sector - Focused on Developing Countries -

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Abstract

Open source software is developed by various members of the community instead of a limited number of people, and promotes accumulation of knowledge, both of which factor into national growth. The advantages of open source software, such as its economic efficiency, security benefits, the overcoming of vendor dependencies, innovation of technology, and market competition, are reasons for governments around the world to support open source software. Therefore, in developing countries where the underlying technology of software are weaker, actively utilizing open source software in defense industry is a necessity, and related policies need to be applied in an efficient manner. In this paper, we inspected policies that encourage the use of open source software around the world and the examples of successful adoption and use of open source software in defense sector. And we proposed the policy direction for promoting the introduction of applying open source software technology into national defense sector in developing countries.

Keywords: *Open Source Software, Defense Sector, Developing Country, Strategy, Policy, Network-Centric Warfare*

1. Introduction

Software industry has a strong network effect, so if commercial software occupies most of the market, a proprietary market structure can be formed by a specific vendor. If the industry is completely locked-in to a set of specific commercial software, it may hinder the development of the software industry across the country. Developed countries such as the United States of America have been aware of the pitfalls of strong dependency on dominant technology of commercial software since the 1990s. In order to prevent technological lock-in, these developed nations are actively promoting open source software both to reduce the cost of software use and to further develop the technology. Endorsement and utilization of open source software has catalyzed the growth of the industry, but developing countries have not enjoyed similar level of growth, and now lack competitiveness in the industry.

Open source software, by design, is developed by various members of the community instead of a limited number of people, and promotes accumulation of knowledge, both of which factor into national growth. In particular, the advantages of open source software, such as its economic efficiency, security benefits, the overcoming of vendor dependencies, innovation of technology, and market competition, are reasons for governments around the world to support open source software.

Received (January 4, 2018), Review Result (March 11, 2018), Accepted (March 20, 2018)
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ISSN: 2005-4238 IJAST

On the other hand, the direction of defense informatization is headed towards Network-Centric Warfare (NCW) globally, which greatly enhances the effect of combat power, since many combat systems are organized as a network, effectively sharing information simultaneously. The integration of defense IT and the deepening of defense informatization have greatly increased the importance of software, including C4I and others, and software is now mentioned as a key factor in controlling military power.

In developing countries where the underlying technology of software are weaker, actively utilizing open source software in defense industry is a necessity, and related policies need to be applied in an efficient manner.

In this paper, we propose a policy direction for promoting the introduction of applying open source software technology into national defense sector in developing countries. To do this, we will inspect policies that encourage the use of open source software around the world through related literature. We will also look at examples of successful adoption and use of open source software in defense. These examples will provide many implications for policies to expand the use of open source in the defense sector of developing countries.

2. Software Technological Capability

The growth of the software industry depends on securing the technological capabilities that enable software development. Grundey & Heeks [1] presents the levels in software technology capabilities as shown in Table 1.

Table 1. Scale of Software Technological Capability

Label		Capabilities
Level 1	Non-production operational capabilities	• Using a system of menus • Using a conventional package (e.g. word processor) • Choosing a software package • Training others to use software
Level 2	Non-production technical capabilities	• Filling a package with situation-specific data (e.g. spreadsheet) • Filling a package with situation-specific data (e.g. database) • Installing and troubleshooting software
Level 3	Basic production	• Making copies of an existing software product
Level 4	Adaptation without production	• Creating a situation-specific application from a package (e.g. creating menus and queries with simple programming; using macros; developing Web pages)
Level 5	Simple software production	• Creating a new set of interfaces for users • Creating a program to move data between applications • Creating a small utility program • Modifying an existing program to meet user needs
Level 6	Software redesign	• Redesigning a program to meet local user needs • Redesigning a program to meet regional/global user needs • Minor process change: modifying the software production process
Level 7	Skilled software production	• Local product innovation: developing a new program to meet local user needs • International product innovation: developing a new program to meet regional/global user needs • Major process change: redesigning the software production process • Process innovation: designing a completely new software production process

Level 1 and 2 represent simple operational capabilities to utilize software without production capacity and simple technology capabilities to resolve simple software issues. Level 3 and 4 represent the basic production capability and adaptation capability, which are the rudimentary forms of producing and applying existing software products. At level 5, Simple software production capability is finally achieved. Only at level 6, is Software re-design with program redesign capabilities achieved, and meet user demands. Finally, when you reach Level 7, you acquire the skilled software production capabilities [1]. The technology capabilities required to develop software range from simple operational capability and ability to resolve simple issues on the lowest end to basic production level through imitation and ability to re-design and modify existing products to produce new products, and finally inventing a new product through innovative process on the highest end. Range of software development skills vary widely, thus, improving software development skills mean that the industry will be able to perform at a higher level and improve the skill further.

Carmel [2] categorizes software exporting countries into four tiers based on three criteria: software industry maturity, clustering, and export revenues.

Table 2. The 4-tier Taxonomy of the World's Software Exporting Nations

Label		Nations
Tier 1	Major software exporting nations	• Mostly OECD nations such as: USA, Canada, UK, Germany, France, Belgium, Netherlands, Sweden, Finland, Japan, Switzerland, Australia • Includes entrants from the 1990s: Ireland, Israel and India
Tier 2	Transition software exporting nations	• Only Russia and China
Tier 3	Emerging software exporting nations	• Brazil, Costa Rica, Mexico, Philippines, Malaysia, Sri Lanka, Korea, Pakistan, Romania, Bulgaria, Ukraine, Poland, Czech Republic, Hungary, Estonia, Latvia, Lithuania, Slovenia, Chile, Argentina, Thailand, South Africa
Tier 4	Infant stage software exporting nations	• Cuba, El Salvador, Jordan, Egypt, Bangladesh, Vietnam, Indonesia, Bangladesh, Iran, others (Another 10-20 nations are likely to be in this tier though data are not available)
Non-Competing	Non-Competing	• Most of the (smaller, least developed) countries of the world (e.g., Gambia, Nigeria, Mozambique, Bolivia, Paraguay, Syria, Afghanistan, Laos)

Tier 1 nations are the Major Software Exporting Nations. These nations have a tradition of exporting high tech and software products and services. The traditional software exporting nations have been the advanced industrialized economies. Tier 2 nations are the Transition Software Exporting Nations which include two particular cases – China and Russia. The missing factors for these industries are maturity and size. Embedded in the notion of maturity are the weaknesses in these nations firms relative to those in Tier 1 nations: in software management, quality management, and marketing. Tier 3 nations are the Emerging Software Exporting Nations. These nations already have significant software export industries. They also have one or more small geographic clusters of successful enterprises SMEs (small and medium-sized enterprises), with a few large enterprises in a limited number of Tier 3 nations. These enterprises of various sizes may be software subsidiaries of multinational enterprises, or home-grown, independent

software firms. Many Tier 3 nations are unlikely to move to Tier 2 because of their small size (which restricts their ability to grow large industries) and other unfavorable conditions (political instability, stage of economic development, *etc.*). Tier 4 nations are Infant Stage Software Exporting Nations. These nations have little impact on the global market in software. While there is some foreign investment in a number of these nations' firms, it is rare. Much of the software industry in these nations is still a cottage industry: firms are small, managerial processes are informal, and marketing is immature. Most Tier 4 nations are unlikely to move to Tier 3 because of their small size (which restricts their ability to grow large industries) and other unfavorable conditions (political instability, stage of economic development, *etc.*). However, many Tier 4 national industries have benefited from some recent governmental attention focused, specifically, on the software exporting sector. Finally, most of the 200 nations of the world are Non-competing nations. These nations have few to no software exporting firms to speak of [2].

3. Open Source Software

Seungkwon Jang *etc.*, [3] analyzes that the most important problem for developing countries is securing their software development capabilities. In particular, the ability for these countries to advance technological capabilities based on private software will meet the structural limitations of proprietary nature of private software and competitiveness of the existing market. It will be difficult to develop technological skills necessary to move beyond level 5 to level 6 and 7.

On the other hand, it's much easier to access the source code of open source software, which allows open technological development and technical manpower development. This will lead to improving the development skills such that redesigning software using open source software can be achieved.

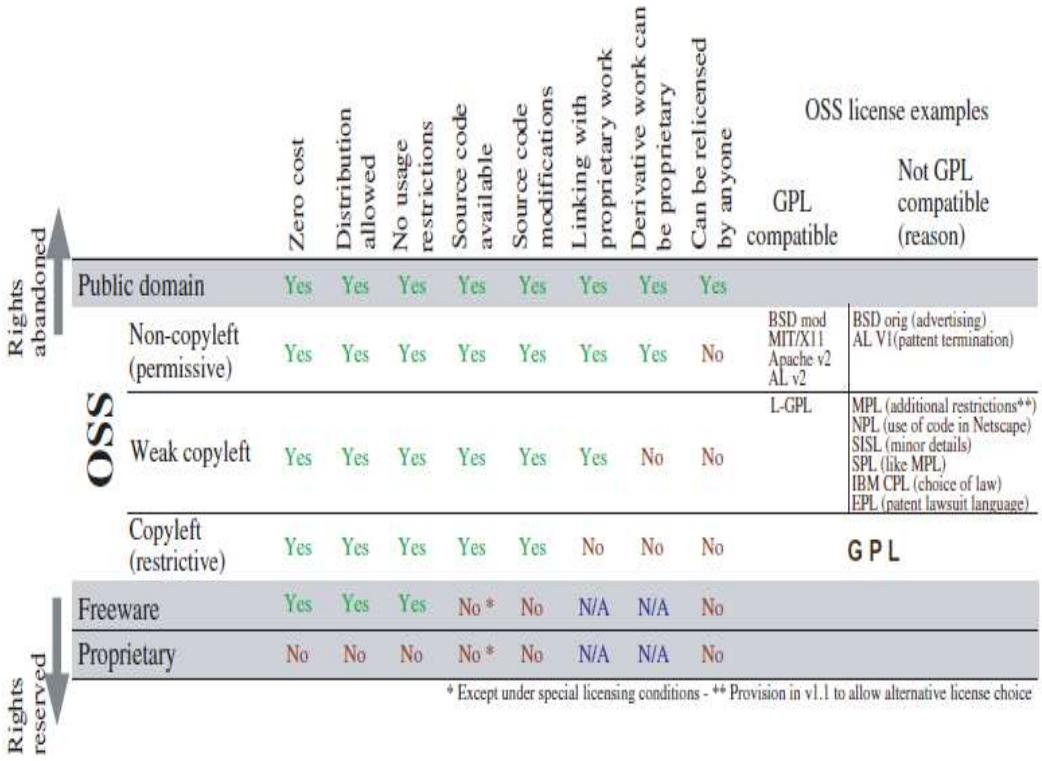

Figure 1. A Categorization of Open Source Software License Types

As shown in Figure 1[12], open source software (OSS) is software distributed with a license allowing access to its source code, free redistribution, the creation of derived works, and unrestricted use.

Open source applications cover most areas of consumer and business software. Prominent application areas include systems infrastructures like operating systems and databases, software development, personal productivity, desktop, entertainment, graphics, publishing, education, scientific, engineering, content management, and business software [9].

Open source software can be reused as a (low cost) product, as an adaptable component, or as code and other elements that are morphed into another system. Increasingly, open source systems form complete stacks used as infrastructure for other applications. In specific categories, such as web applications, the adoption level of open source software is near or even higher than that of proprietary offerings. The impacts and effects from open source adoption affect an organization's bottom line, its management, the software's quality, and the software development process[10][11].

A number of operating systems and a multitude of open source software applications emerged over the last three decades, including systems applications and infrastructure software, desktop applications, software for publishing, graphics and entertainment, scientific and business applications, and of course a whole range of tools for software development including compilers, interpreters, editors, ides, and version control systems. In terms of user base many open source software systems occupy the first or second place in their respective category.

Developing countries have a great percentage of the world's brain power, yet only enjoy a very small share of the world's technological innovation [6]. Open source software is considered to be a solution for bridging the digital divide between the most advanced countries and developing countries that still face massive economic, social and infrastructural challenges. Being generally free and easily accessible, open source software is attractive for all types of users, ranging from home users and schools to businesses and governments, especially in challenged environments where funds and resources are particularly scarce. As an added bonus many open source software offerings require fewer computing resources than their proprietary alternatives, and can therefore run on older or cheaper hardware.

In such economies and conditions, locking institutions into proprietary software that charges, or may in the future start charging license fees is not feasible. With open source software it is possible to train professionals to use, modify and maintain the software they need to perform their professional, educational or everyday tasks, due to its openness and availability of the source code [7].

The distributed development model of open source software also allows people in developing countries to participate in and learn from such projects, without the need to relocate to other parts of the world, as would be typically required in order to work in a large software firm (an effect labelled the "brain drain," whereby educated people are forced to abandon their home countries in search of employment and career opportunities elsewhere in the world) [8].

For developing countries to evolve and benefit from current technological advances, a community of trained local professionals must be formed and supported. Outsourcing opportunities offer considerable employment currently, but this is not enough [8]. The open source software approach is well suited for empowering the software development and research communities of developing countries.

4. Developing Countries' Open Source Software Policies

Some of the developing countries' open source software policies are as follows. First of all, South American countries have a low development rate compared to North American

counterparts, and there are many more developing countries, while Brazil is much more interested in developing policies to enable much friendlier environment for open source software development, relatively speaking [13].

Table 3. Brazil's Open Source Software Policies

Policy	Execution Year	Executing Organization
Replacing 300,000 MS Windows computers for government with Linux	Jan./June 2005	Executive
Legislation stating that Software used by federal government and the public is open source Software	Oct.2003	Legislative
Make laws about using free/open source software	2003	Rio Grande do Sul

In Peru, along with Brazil, a variety of government-wide policies, radical and innovative, for the introduction of open source software have been applied to the industry and observed to measurable effect.

Table 4. Peru's Open Source Software Policies

Policy	Execution Year	Executing Organization
The Technology Neutral Act has been passed in using open source software	Dec. 2002	Legislative

The open source software movement in Thailand is very active as well. In June 2003, Thailand's Ministry of Information and Communication and the Ministry of Science and Technology showed their willingness to collaborate on open software development, and the National Electronic Computer Technology Center (NECTEC), the government R&D branch of Thailand, has developed an Open Office based on Thai version of Linux, also known as Office for TLE(Thai Language Extension). This along with low-price policies have led to spread of PC. Vietnam, Myanmar, Laos and neighboring countries, which have been dealing with low PC adoption rate and low incomes, are studying the policy model in Thailand very closely.

Table 5. Thailand's Open Source Software Policies

Policy	Execution Year	Executing Organization
Recommend use of open source software include the Pladoa	Dec. 2002	Information and Communications Ministry
Recommend use of open source software, a percentage of approximately 50 %	May. 2005	National Electronic and Computer Technology Centre

In 2005, Malaysian Cabinet Secretary Osman established the master plan to introduce open source software in the public sector, and released an expansion guide, MyGIFOSS (Open Government Software Interoperability Framework for Open Source Software).

This guide discusses a variety of essential information needed to introduce open source software, such as licenses, ecosystems, and frameworks.

Table 6. Malaysia's Open Source Software Policies

Policy	Execution Year	Executing Organization
Establish the open source software capability center	2003	Ministerial
Government-led $ 36 million fund to start open source software development	2003	Executive /Ministerial
Recommend use of open source software in public sector	2007	Legislative

Tanzania Free Open Source Software Association (TFOSSA) held a seminar for the government to increase the support for open source software development and to encourage communities and educational institutions to develop open software for their respective organizations. It is also encouraging governments to adopt FOSS and promote open source software technology skills for young people and women.

Table 7. Tanzania's Open Source Software Policies

Policy	Execution Year	Executing Organization
TFOSSA conducts a campaign for hosting the seminar against the government, encourage development of open source, recommend communities and educational institutions develop open source software for development projects, encourage governments to adopt FOSS, and promote open source software technologies for young people and women.	2004	Tanzania Free Open Source Software Association(www.tafossa.or.tz)

Kenya has been pushing policies to support migration to Linux and open source software, centered on LPA-Kenya (http://www.lpakenya.org/home/). In November 2009, Kenya National Education Network (KENET) announced 'Open Source Software Policy for Schools' policy. The main purpose of this policy is to reduce the cost incurred in adopting the information system and to encourage the use of open software to standardize the system.

Table 8. Kenya's Open Source Software Policies

Policy	Execution Year	Executing Organization
Supporting to move public software, specialized software like as commercial Linux into the domestic market.	2007	LPA-Kenya (http://www.lpakenya.org/home/)
Kenya Linux Group's Procurement Policy announcement	2008	PPOA (Public Procurement Oversight Authority)
Open source policy for Schools, enhanced support for open source software distribution (teachers education)	2009	KENET (Kenya National Education Network)

Nigeria is working with the NITDA (The Nigeria Information Technology Development Agency) to use the Linux operating system and other open source software and tools such as MySQL and PHP.

5. Application and Implications of Open Source Software in Defense Sector

The US Department of Defense has been researching into application of open source software in defense and created open technology development application policy in 2006 to encourage the increased use of open source software in national defense sector. There's an effort to specify necessary policies to realize the effect of use of open source software. The US Department of Defense is actively utilizing open source software with the weapons system, and there are plans to increase the utilization rate. In order to do so, the United States Department of Defense is developing advanced technologies. This is similar in a non-weapons system environment as well. Open source software is used at a significant level in software development, security and research.

The US Department of Defense released a guide about open source software in 2009 and is using open source software in various defense operations. Especially, it is widely used in the system software, software development, security, etc. When constructing open source software-based cloud system, open source software, such as Linux, JBoss, Virtual SW, were used, and these even replaced a commercial Oracle server (a Linux based Red Hat server) [5]. In particular, due to the global economic crisis, the US Department of Defense has been actively considering introducing open source software since the US government began massive arms reduction in 2010. As a result of massive reductions in armaments, the US Department of Defense establishes guides for open standards technologies, and is actively engaged in the adoption of open source software, and continues to discover and disseminate best practices for software development in open source software.

Korea has provided opportunities to local software development companies through pilot programs promoted by the Ministry of Information and Communication, which allowed the information system of the public institutions to be converted to open source software, which led to changed perception of open source software. There are cases that contributed to the increased awareness of open source software of the person in charge of institutional informatization. In particular, this pilot project created precedence on how to build an information system based on open source software in the defense sector as shown in Table 9.

Table 9. Status of Pilot Projects Implementation by Open Source Software in the Korean Defense Sector

Year	Executing Organization	Project
2005	Air force Headquarter	Development of the open source software-based Defense Information System Integration Tools and Pilot System
2006	Ministry of National Defense	Establishing an education system dedicated to the open source software
2006	Battle Command Training Program Group	Development of Korean War Game System based on open source software
2006	Air force Headquarter	Development of the ACMI PC type DDS System ※ ACMI : Air Combat Maneuvering Instrumentation ※ DDS : Display & Debriefing Remote Simulation

Korea Open Source software Association conducted open source software education (course designed to increase open source software capabilities) to 2,100 defense IT personnel in 2015. In 2016, the defense IT personnel in charge of Gyeryongdae, Daegu, Wonju also received the education. Such education has led to the introduction of open source software for the defense cloud platform of the Ministry of National Defense and the application of open source DBMS to various operations. In addition, on February 16, 2015, the Ministry of Science and ICT and the Ministry of National Defense signed a Memorandum of Understanding (MoU) to promote technology development and utilization of open source software and Internet of Things (IoT) to lower dependency on foreign software companies.

Republic of Korea Ministry of National Defense issued a policy guideline on defense software management in December 2016. The guideline provides a direction on, writing systematic requirements, planning, acquisition, operation and maintenance of the defense software. In addition, the guideline provides factors to consider when introducing open source software to the military, and specify the application requirement to include the budget planning phase, the acquisition phase, and the maintenance phase [4].

Due to the closed culture and lack of awareness, combined with limitations of manpower and organization, and the use of open source software is much smaller compared to other public institutions. The slow rate of adoption of open source software in developing nations can be explained by barriers to the market, lack of success stories, and incompatibility among systems, as well as lack of technical support and lack of professional manpower. Some of these constraints are facts, but most of these difficulties are caused by misperception and prejudices of consumers. However, as the case studies have shown, open source software can be used in defense sector to secure development environment free of dependency on proprietary software, which will allow better interoperability and allow organizations to install better security system. Therefore, the use of open source software systems should be considered for weapons system, as well as non-weapons system.

Acknowledgments

“This paper is a revised and expanded version of a paper entitled [Strategies for Activating Open Source Software in the Defense Sector of Developing Countries] presented at [Ho Seok Jang and Jong Bae Kim, Ho Chi Minh, Vietnam, February 1, 2018].”

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