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Evaluating Open Source Software Using The Selection Criteria And Analytical Hierarchy Process

[1]Yusmadi Yah Jusoh, [2]Khadijah Chamili, [3]Jamaiah Hj. Yahaya and [1]Noraini Che Pa

[1]Department of Software Engineering and Information Systems Faculty of Computer Science and Information Technology Universiti Putra Malaysia (UPM) 43400 Serdang, Selangor, Malaysia
[2]Centre of Information Technology Universiti Sains Islam Malaysia (USIM) 71800, Putra Nilai, Nilai Negeri Sembilan, Malaysia
[3]School of Computer Science Faculty of Information Science and Technology Universiti Kebangsaan Malaysia (UKM) 43650 Bangi, Selangor, Malaysia

Abstract: There are many potential and good open source software (OSS) products available in the market with free license. However, with various choices, the adoption rate is still low among OSS potential users because there is not an agreed acceptable set of criteria to evaluate and decide varieties of OSS products, with little documentation and user manuals, and immature products. Therefore, the users need to consider on how to improve decision making on selecting the most suitable OSS products. In this paper, the background research on the proposed OSS adoption and criteria of selection are discussed and explored which then moves to the implementation of the My Open Source Software Toolkit (MyOSST) v1.0. The analytical hierarchy process (AHP) was applied for selecting the most suitable OSS products and assisting the potential user for deciding the OSS products based on their preferred selection criteria. The toolkit will support the OSS adoption process with proposed criteria selection and pair wise comparison. The toolkit was tested and validated by IT professionals capable to assist the decision making on selecting an appropriate OSS product.

Key words: open source software selection, selection criteria, analytical hierarchy process

INTRODUCTION

The adoptions of open source software (OSS) are still continuously growing all over the world including at businesses, non-profits and public sector agencies because of the financial benefits. The criteria of selection may differ between the stakeholders within the organizations. Therefore, there is a tendency that the user's biased perception on OSS characteristic or capability on solving problems on selecting OSS products.

In the previous study we have identified all possible OSS characteristics which referred to ISO standard for comparison, better understanding and future enhancement purposes. We also proposed an additional quality characteristic which is the internal constraint to be included for agency's decision making in OSS adoption. With these hierarchical characteristic of OSS selection criteria might benefit to build users' confidence in OSS product adoption in future.

OSS adoption rate in Malaysian public sector agencies is still low until end of 2010 (MyGIFOSS, 2011) (MAMPU, 2011) (Tan and Jacob, 2011). Therefore, the next step is to apply the suggested selection criteria to understand what is the most quality dimension contributes to Malaysian public sector agencies in order to encourage adoption and implementation of OSS products in their agencies. In other words, the proposed selection criteria may help to identify characteristics considered by the users on adopting the OSS product. Hence, a survey will be conducted to identify the main characteristics for the proposed OSS adoption model.

Recently there are many potential and good OSS products in the market with free license but yet still not popular among Malaysian public sector agencies (MAMPU, 2010). What are the constraints or limitation in not adopting these good OSS products? What drive them to rely on proprietary software which cost them hundred thousands of dollars? To understand this scenario, a survey will be conducted among technical and IT managerial personnel at selected public sector agencies.

The survey on the open source software products is composed of three main components: its adoption/implementation in the agency, their awareness and the evaluation criteria. The objective is to identify the most and relevant dimension (system quality, information quality or service quality) which derive or motivate IT decision maker in choosing their products. The data analyses help to understand all possible selection criteria or quality characteristic used by these potential users in evaluating OSS product for adoption purposes. The surveyed data and analysis will rank the sub-characteristics identified in this study.

The contribution of this paper is to explain the adoption of AHP on selecting OSS product based on four dimensions: system quality, information quality, service quality, and others which includes the potential internal

Corresponding Author: Yusmadi Yah Jusoh, Department of Software Engineering and Information Systems Faculty of Computer Science and Information Technology Universiti Putra Malaysia (UPM) 43400 Serdang, Selangor, Malaysia

constraints such as internal technical competencies and knowledge. Identifying the selection criteria will help to build confidence among users and better understanding of their perception of OSS.

Methodology:

In this section, we will describe our proposed OSS selection dimensions; elaborate the AHP technique applied for the decision making and development environment of MyOSST v1.0.

2.1 OSS Selection:

The first step of our methodology is identifying the existing research on the selection criteria of the OSS product. Many researchers have suggested model and frameworks on their preferred list of important selection criteria for OSS selection (MAMPU, 2012) (Confino and Laplante, 2010) (Soto and Ciolkowski, 2009) (Ioannis *et al*, 2008) (Glynn *et al*., 2005) (Spinellis and Giannikas, 2012) (Open BRR, 2005) (Ahmad, 2011) (del Bianco *et al*., 2010) (Delone and McLean, 2003) (Uzma and Tretter, 2012) (ISO/IEC, 2011) (Pitt *et al*., 1995). The details on related study was reported in previous publication (Yusmadi *et al*.,2012a) (Yusmadi *et al*, 2012b).

The proposed dimensions, criteria's and characteristics for selecting the OSS product are as shown in Table 1. The product selection in this model are organized in a hierarchy of two levels that we indicate as criteria and characteristic which are interconnected with four (4) main dimensions: system quality, information quality, service quality and others. The others dimension possibly can be added as preferred by the organization to contribute in the selection criteria. Both criteria and characteristic are considered to contribute in some way or another to each of these dimensions it belongs to. To ensure these quality characteristics are ranked accordingly, we also put measurement for each of the characteristic.

Table 1: The dimension, criteria and characteristics for OSS product Selection

Dimension	Criteria	Characteristic
System quality	Reliability *(C01)*	Maturity
		Popularity
		Availability
	Usability*(C02)*	Learn ability
		Operability
		Accessibility
		User interface aesthetics
	Performance efficiency *(C03)*	Time behavior
		Resource utilization
	Functionality *(C04)*	Functional completeness
		Functional correctness
		Functional appropriateness
Information quality	Maintainability *(C05)*	Modularity
		Modifiability
		Reusability
		Testability
	Security*(C06)*	Confidentiality
		Integrity
		Authenticity
Service quality	Tangible*(C07)*	Support
		Documentation
	Reliability *(C08)*	Version
	Responsiveness *(C09)*	Community
	Assurance *(C10)*	Competence
		Credibility
	Empathy *(C11)*	Communication
Others	Competence *(C12)*	Skill

2.2 Analytical Hierarchy Process (AHP):

The AHP was developed in the 1970s by Thomas L. Saaty. It is a systematic decision making method which includes both qualitative and quantitative techniques. It is being widely used in many fields for a long time. The Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions based on mathematics and psychology (Saaty, 1980) (Saaty, 1986) (Azadeh and Shirkouhi, 2009).

Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. The main advantage of the AHP is its ability to rank choices in the order of their effectiveness in meeting conflicting objectives. It is quite hard – but not impossible – to 'fiddle' the judgements to get some predetermined result as well as to detect inconsistent judgements.

The AHP also can be used by individuals working on uncomplicated decisions; it is most useful where teams of people are working on complex problems, especially those with high stakes, involving human

perceptions and judgments, whose resolutions have long-term repercussions. It has unique advantages when important elements of the decision are difficult to quantify or compare, or where communication among team members is impeded by their different specializations, terminologies, or perspectives.

Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well- or poorly-understood—anything at all that applies to the decision at hand.

Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to one another two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons (the pair wise comparison), the decision makers can use concrete data about the elements, but they typically use their judgments about the elements' relative meaning and importance. Each of this judgement is assigned a number on a scale as shown in Table 2.

Table 2: AHP Scale

Importance Level	Definitions	Explanations
1	Equal	Two factors contribute equally to the objective
3	Moderate	Experience and judgement slightly favour one over the other.
5	Strong	Experience and judgement strongly favour one over the other.
7	Very Strong	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice.
9	Extreme	The evidence favouring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed

These pair wise comparisons are carried out for all elements to be considered, until matrix is completed. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations. The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques.

In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action.

2.4 Development Environment:

In developing the OSS selection criteria toolkit, few things were put into consideration, which are the system should be a web based application to allow users to access via internet and the development are based on the OSS environment using MySQL 4.1.14 , PHP 5.0.5, and Apache HTTP Server.

MySQL is the world's most used open source relational database management system (RDBMS) that runs as a server providing multi-user access to a number of databases. MySQL is primarily RDBMS and ships with no GUI tools to administer MySQL databases or manage data contained within the databases. Users may use the included command line or download MySQL front-ends from various parties that have developed desktop software and web applications to manage MySQL databases, build database structures, and work with data records. The data in MySQL is stored in database objects called tables. A table is a collection of related data entries and it consists of columns and rows.

PHP is a general-purpose server-side scripting language originally designed for Web development to produce dynamic Web pages. It is one of the first developed server-side scripting languages to be embedded into an HTML source document rather than calling an external file to process data. The code is interpreted by a Web server with a PHP processor module which generates the resulting Web page. It also has evolved to include a command-line interface capability and can be used in standalone graphical applications. PHP can be deployed on most Web servers and also as a standalone shell on almost every operating system and platform free of charge.

The Apache HTTP Server, commonly referred to as Apache, is web server software notable for playing a key role in the initial growth of the World Wide Web. In 2009 it became the first web server software to surpass the 100 million website milestone. Apache was the first viable alternative to the Netscape Communications Corporation web server (currently named Oracle iPlanet Web Server), and since has evolved to dominate other web servers in terms of functionality and performance. Typically Apache is run on a Unix-like operating system.

3. MyOSST v1.0:

MyOSST has been developed to implement all selection criteria in Table 1 in order to assist potential users while making decision on choosing OSS products in their agencies. Below are the list of scope and features of the system:

i. Web based application which allows users to access via internet.

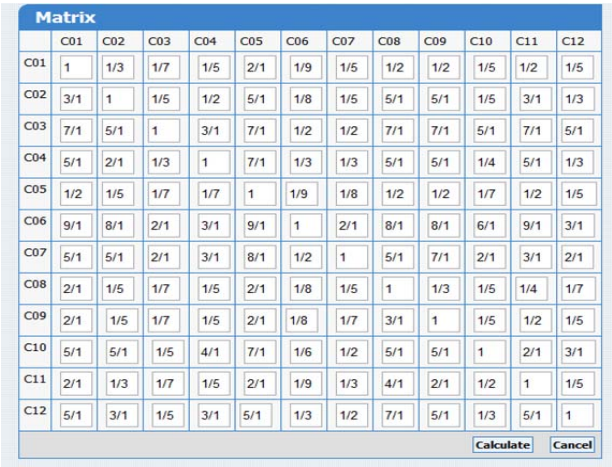
ii. Adopting the main OSS dimension-criteria which are system-reliability, system-usability, system-performance efficiency, system-functionality, information-maintainability, information-security, service-tangible, service-reliability, service-responsiveness, service-assurance, and service-empathy.

iii. Allow single input (one person) for each project based. However, small group discussions are encouraged to determine the criteria weightage.

There are several processes involves by MyOSST v1.0 user as follows:

i. Add a project and/ or define the project goal in the MyOSST v1.0.
ii. Add the product alternatives or options user needs to evaluate.
iii. Select the selection criteria need to be choosen in order to build the comparison matrix.
iv. System will display a matrix table and the user need to fill-in the cell in the matrix using fraction value which denoted each of pair wise comparison activities done in the group discussion. The alternatives matrix – such as for criteria C01- System Reliability. Fill in the available cell with fraction numbers for the pair wise comparison on alternatives.

Figure 1 shows an example of users input for the pair wise matrix and generated reciprocal value based on fraction values.



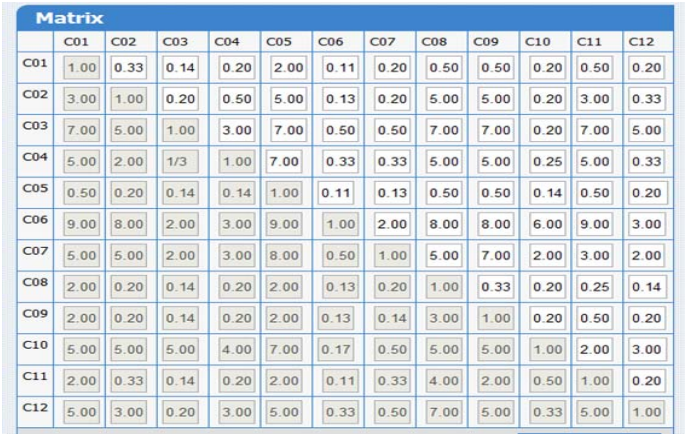
Matrix

	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12
C01	1	1/3	1/7	1/5	2/1	1/9	1/5	1/2	1/2	1/5	1/2	1/5
C02	3/1	1	1/5	1/2	5/1	1/8	1/5	5/1	5/1	1/5	3/1	1/3
C03	7/1	5/1	1	3/1	7/1	1/2	1/2	7/1	7/1	5/1	7/1	5/1
C04	5/1	2/1	1/3	1	7/1	1/3	1/3	5/1	5/1	1/4	5/1	1/3
C05	1/2	1/5	1/7	1/7	1	1/9	1/8	1/2	1/2	1/7	1/2	1/5
C06	9/1	8/1	2/1	3/1	9/1	1	2/1	8/1	8/1	6/1	9/1	3/1
C07	5/1	5/1	2/1	3/1	8/1	1/2	1	5/1	7/1	2/1	3/1	2/1
C08	2/1	1/5	1/7	1/5	2/1	1/8	1/5	1	1/3	1/5	1/4	1/7
C09	2/1	1/5	1/7	1/5	2/1	1/8	1/7	3/1	1	1/5	1/2	1/5
C10	5/1	5/1	1/5	4/1	7/1	1/6	1/2	5/1	5/1	1	2/1	3/1
C11	2/1	1/3	1/7	1/5	2/1	1/9	1/3	4/1	2/1	1/2	1	1/5
C12	5/1	3/1	1/5	3/1	5/1	1/3	1/2	7/1	5/1	1/3	5/1	1

Calculate Cancel

Fig. 1: The Pair Wise Matrix

v. After user complete fill-in the matrix for each criteria selected, system will then convert the fraction value to the decimal number as shown in Figure 2.



Matrix

	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12
C01	1.00	0.33	0.14	0.20	2.00	0.11	0.20	0.50	0.50	0.20	0.50	0.20
C02	3.00	1.00	0.20	0.50	5.00	0.13	0.20	5.00	5.00	0.20	3.00	0.33
C03	7.00	5.00	1.00	3.00	7.00	0.50	0.50	7.00	7.00	0.20	7.00	5.00
C04	5.00	2.00	1/3	1.00	7.00	0.33	0.33	5.00	5.00	0.25	5.00	0.33
C05	0.50	0.20	0.14	0.14	1.00	0.11	0.13	0.50	0.50	0.14	0.50	0.20
C06	9.00	8.00	2.00	3.00	9.00	1.00	2.00	8.00	8.00	6.00	9.00	3.00
C07	5.00	5.00	2.00	3.00	8.00	0.50	1.00	5.00	7.00	2.00	3.00	2.00
C08	2.00	0.20	0.14	0.20	2.00	0.13	0.20	1.00	0.33	0.20	0.25	0.14
C09	2.00	0.20	0.14	0.20	2.00	0.13	0.14	3.00	1.00	0.20	0.50	0.20
C10	5.00	5.00	5.00	4.00	7.00	0.17	0.50	5.00	5.00	1.00	2.00	3.00
C11	2.00	0.33	0.14	0.20	2.00	0.11	0.33	4.00	2.00	0.50	1.00	0.20
C12	5.00	3.00	0.20	3.00	5.00	0.33	0.50	7.00	5.00	0.33	5.00	1.00

Fig. 2: Convert to Decimal Numbers

vi. Next step is to get the ranking of priorities from the pair wise matrix by using Eigenvector solutions. To solve the eigenvector, system will run four steps as below:

a) Squaring the pair wise matrix where matrix is multiply with itself with some formulated calculations were imply.
b) Sum each rows of the matrix
c) Sum total rows of the matrix
d) Divide each sum rows with total rows

The values of the last step of the eigenvector value are representing the weight for each of the criteria.

Once the eigenvector value is calculated, users need to repeat the pair wise comparison activities for the alternatives on each of OSS selected criteria. In this activity, users determine the preferences of each alternative over another. After completing the pair wise comparison on the alternatives, weight for each alternatives are generated by the system as depicted in Table 3. Finally, system will multiply alternative weight with the eigenvector value (the criteria weight) to get the winner between the alternatives. Column Result shows the winner of the selection.

Table 3: AHP Scale

	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	RESULT
Product A	0.2474	0.5239	0.2261	0.0993	0.6376	0.6804	0.1537	0.1714	0.11710	0.1090	0.5597	0.7079	0.3728
Product B	0.5981	0.3572	0.6746	0.2261	0.0739	0.2227	0.5564	0.6936	0.7274	0.5820	0.1208	0.2101	0.4211
Product C	0.1544	0.1189	0.0993	0.6746	0.2884	0.0969	0.2899	0.1350	0.1016	0.3091	0.3195	0.0820	0.2000

The Testing:

MyOSST v1.0 was tested in one of the public university in Malaysia. The testing exercise was conducted within a half day session at Data Center Unit, Information Technology Centre in June 2012.

4.1 The Procedure:

Testing session is started by explaining the objective of the testing session to small group of Data Center Unit which involves the Senior IT officer, IT officer and assistant IT officer. Coincidently the team currently is evaluating three products of business intelligent (BI) tools. They have studied products alternatives and already install, test and preview the selected products. However, the selected products are not 100% from open source product. They are mix between open source and proprietary products. Products/alternatives list for Business Intelligent (BI) tools are Qlikview, OracleBI and Pentaho (OSS). After some discussion, we decide to continue the testing session which we believe could give better result when using MyOSST v1.0 for decision making on choosing the precise tool.

They were given a briefing on how to use MyOSST v1.0 and how to prepare the pair wise matrix. The user also was informed the employment of AHP technique as a core function of OSS decision making tool. Users then are given half an hour to understand the criteria and prepare the pair wise matrix manually. Finally, they used MyOSST v1.0 by themselves with guidance by the instructor.

4.2 Results:

The group found that MyOSST v1.0 is very useful and really helps them on selecting product which based on pair wise comparison and selection criteria. However, they found it's quite difficult to prepare the pair wise comparison which needs them to understand and technically compare the criteria. But somehow agree that this technique would give more accurate result rather than traditional way which they need to choose based on one-one product features comparison which may lead to unfair judgments.

Another suggestion was that they need to have a detail discussion with other team member before creating the pair wise comparison again and get the consensus result for their proposal writing. In future it is suggested that the toolkit capable to generate pair wise comparison based on the multiple users for the group decision making.

Conclusion And Future Direction:

This paper describes on the selection criteria's, activities involve in prototype development phase, MyOSST v1.0 and technique used. Analytical Hierarchy Process (AHP) is one of the best decision making technique used over the world. This technique was adapted in MyOSST v1.0 in order to accomplish the objective of the prototype development mainly on assisting the decision making on the OSS selection. Through the user

acceptance testing conducted, the result shows that MyOSST v1.0 capable to assist the potential OSS users on selecting any selected products.

The study on methodology to improve the decision making on OSS selection may help to better identify an appropriate OSS selection solution. Therefore, using fuzzy theory may assist to identify the most appropriate options based on the selection criteria (Azadeh and Shirkouhi, 2009). Those dimensions, criteria and characteristics can possibly transform into hierarchical structure that represent the weight of importance by the users. Group decision making also should be considered in future since several number of decision makers involved.

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