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The Selection Criteria of Open Source Software Adoption in Malaysia

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Abstract

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 OSS potential users may have their own selection criteria on adopting any product which may comply with the requirements specified. The criteria of selection may differ between the stakeholders within the organizations. Yet, 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 projects, little documentation and user manuals, and immature products. Therefore, there is a tendency that the user's biased perception on OSS characteristic or capability on solving problems. The contribution of this paper is to identify the selection criteria of OSS adoption based on four dimensions: system quality, information quality, service quality, and other dimension which includes the potential internal constraints such as internal technical competencies and knowledge. In this paper, the background research in OSS adoption and criteria of selection are discussed and explored which then moves to the selection issues and identified selection criteria of OSS adoption. Identifying the selection criteria will help to build confidence among users and better understanding of their perception of OSS.

Keywords*: Open Source Software Adoption, Selection Criteria*

1. Introduction

The terms "Open Source Software" (OSS), "free Software", "Free Open Source Software" (FOSS), and "Free/Libre Open Source Software" (FLOSS) are often used interchangeably [1][2]. The difference was at the license agreements which free software generally licensed with GNU General Public License (GPL) while OSS may use some other license or GPL [3].

In this paper, we use term of OSS and its generally defined as software which the source codes freely distributed and the users have the right to modify the code, and on the condition that redistribution is not restricted, and is obtainable for no more than the reasonable cost of production [4]. The OSS widely used by government, businesses, and non-profits organization because of the financial benefits [5]. In this study we are focusing on what services does user's expected from OSS community to ensure that users can evaluate the services given by community rather than to understand development/maturity of OSS community. The contribution of this work is for the OSS users to identify their priority on selecting an appropriate selection solution.

The remainder of the paper is organized as follows. In Section 2, the related work of the study and OSS adoption issue are presented and reviewed. Section 3 discusses on the proposed selection criteria. The methodology of this study is presented in Section 4. Then, in Section 5 the data and results are presented. Discussion of the results is presented in Section 6. Finally, Section 7 summarizes our insight of the study and directions for future research.

2. Research background

Open Source Software initiative was launched on 16th July 2004 under The Malaysia Public Sector Open Source Software Master Plan Phase II. It has entering self-reliance phase, phase III from 2010 and onwards. The ultimate goal is the agencies are competence to develop and implement OSS solution independently. However, until end of 2010 [6], statistic shows that only two OSS solution area which are desktop and infrastructure solutions contribute the biggest number of OSS adoption in Malaysia public sector agencies. Another four OSS solution areas which are application, workload consolidation, high performance computing and distributed enterprise are still at low number of adoption.

The adoption of OSS among potential users in public sector agencies still low and needs to increase as formulated under The Malaysian Public Sector Open Source Software Master Plan. In pursuing Public Sector adopting OSS, Malaysian Administrative Modernization and Management Planning Unit (MAMPU) has lead many OSS initiative such as produced frameworks, policies and guidelines of OSS implementation [7],[8]. This implementation guideline was proposed by Public Sector agencies to use Open Source Maturity Model (OSMM) model by Navica and CapGemini or any other quality assessment model in order to evaluate OSS product. However the evaluation exercise proposed by this document is not supported by any assessment toolkit to assist public sector in making decision on choosing the right OSS product [8]. It's quite tedious work where assessment activity is done manually by agencies especially to assess quality of code programming. Using an assessment toolkit may assist and finally increase number of OSS adoption among public sectors agencies as well as to achieve OSS objectives [4].

There are many ways to built confidence among OSS potential users. Based on The Malaysian Public Sector Open Source Software Master Plan, there are eight (8) initiatives has been established. The initiatives are: promotion and awareness, certification body, communication and collaboration, policies/guidelines, training, knowledge bank, research and development and technical support [4]. However there are still lack of evaluation methodologies and tools to support potential users on selecting the right OSS products which meet user's need and comply with the "information quality", "system quality" and "service quality".

Lack of confidence and user's perception on OSS product contribute to this situation. To build confidence among users and to understand user's perception of open source, a study need to be conducted before any decision making on adopting OSS product is made. The study on OSS evaluation model may help the decision makers to better identify an appropriate OSS solution. Although the propose evaluation criteria may not be applicable in all cases since different project may have different requirements it may useful to indicate their priorities on the OSS selection.

2.1. The OSS evaluation models

There are four OSS evaluation model quoted by Norita Ahmad [1] and Confino and Laplante [5] from their studied which are the Open Source Maturity Model (OSMM) created by Capgemini in 2003, Open Source Maturity Model (OSMM) created by Navica in 2004, the Qualification and Selection of Open Source software method (QSOS) was created in 2004 by the consulting company Atos Origin and The Business Readiness Rating (BRR) created by Carnegie Mellon West, SpikeSource, O'Reilly and Intel in 2005.

In addition to the recent years, other studies also have been done such as for evaluating the OSS communities performance or service and product assessment are QualOSS Open Source Assessment Model (QualOSS) and SQO-OSS quality model (SQO-OSS) [9],[10]. QualOSS more focus on development communities with respect to community sustainability, process maturity and maintenance capacity. Understanding the users' expectation from OSS will allow the community improves their services. In addition, this is the best way community should learn to develop and grow. Although OSS

community is loose community, OSS project cannot be started at early stage without essential team member. Next, the team member (community) should understand what users expected from them once software is launch, then they start acknowledge and used their products. This is the starting point that 'contract' has been made between this team and users and people build trust and confidence among each other. Organizational adoption of OSS studied by Glynn et al. [11] by examining factors and behaviors through data gathered from the US Fortune-1000 companies and the result shows that adoption of OSS in large US companies is significant and is increasing over time through a low-churn transition, advancing from applications to platforms.

The studies conducted by Norita Ahmad [1] and Confino and Laplante [5] have proposed a set of criteria and a methodology for assessing OSS for fitness of purpose using functional and non-functional factors. The nine evaluation criteria suggested are functionality, product evaluation, licensing, longevity/ pedigree, community, market penetration, documentation, support and code quality.

The empirical study on OSS adoption by Spinellis and Giannikas [12] divided into five factors, which are: phenomenology (adoption level, adoption dynamics); technological context (driving software, network effects); organizational context (organization size, information technology usage intensity, cost savings, operational stability, policy); individual factors (knowledge intensity, personal productivity); and external environment.

2.2. OSS success dimensions

In OSS context, the 'power of creation' is more derived this team at early stage when they decide to create any software to assist and contribute to society. So, the most important thing in this so called 'contract' between users and community is how this 'contract' can be sustainable without understand what should be supplied and received.

In order to build the OSS success dimensions, we applied D&M IS Success Model [15] which known by IS researchers as a useful framework to organize IS success measurement in any IS context. This model is flexible enough which allow any success dimension to be selected in order to identify metrics to be measured. Thus, in OSS context, we choose system quality, information quality and service quality as our main OSS success dimension. Furthermore, another dimension called 'other dimension' is introduced to consider internal constraint. Beside D&M as a framework, we proposed that OSS success dimension should comply with any international standard such as ISO/IEC 25010 [19]. Using this standard would guide us where all metrics defined from previous works were matched into this standard model. ISO/IEC 25010 is also used to ensure that all metrics terminology used in our selection criteria is standard and understandable to all readers.

Both information quality and system quality was grouped as product quality under ISO/IEC 25010: SQuaRE (Software product Quality Requirements and Evaluation). For service quality, few researchers used SERVQUAL model to analyze gap between user's need (expected service) and perceived service. SERVQUAL proposed 5 dimensions, which are: (1) Tangibles - appearance of physical facilities, equipment, personnel and communication materials; (2) Reliability - ability to perform the promised service dependably and accurately; (3) Responsiveness - willingness to help customers and provide prompt service; (4) Assurance - knowledge and courtesy of employees and their ability to convey trust and confidence; and (5) Empathy - the firm provides care and individualized attention to its customers.

These five dimensions will be mapped according to OSS context. For example, tangibles dimension will be replaced with documentation since we are not dealing with any kind of physical facilities and equipment. The personnel were changed into community and support. The changes make the dimensions more meaningful for OSS context. The details of the selection criteria are listed and discussed in section three.

It is difficult to make comparison with one model to another such as QSOS and OpenBRR. In this paper, we try to list all possible OSS characteristic which leads to ISO standard for comparison, better understanding and future enhancement purposes by other researchers. Through the literature review previous models still lack of considering the users constraint while evaluating and selecting OSS product. Issues related to budget constraint and internal staff skills – operating system, language and tools, also should take into account. Although OSS is somehow free license, but in larger scale project, budget and staff skill constraints may influence the organization in selecting the OSS. Therefore, users' constraint should be included.

2.3. OSS adoption issues

Selecting appropriate OSS with a given problems or requirements is crucial so that the users can fully utilized it usage and solving particular problem. However, it is difficult due to the fact that: (1) there is not an agreed acceptable set of criteria to evaluate and deciding the selection [1], (2) there are many available OSS products and it is reported that there are over 100,000 ongoing OSS project based on SourceForge repositories alone and many more others such as CodeHaus, Java.net, Tigris and Open Symphony [13], (3) OSS projects often have minimum documentation and user manuals; therefore it is difficult to identify its feature set [1], [5], and (4) longevity where the availability of future releases depends on community efforts and low quality code for immature products [13]. Thus, an OSS community includes virtual communities and virtual organizations. The communities mostly made up members with technical backgrounds and technology play an important role to the OSS community. Due to the selection difficulties, many potential users still not adopting OSS in their working environment because of biased perception on OSS characteristic [14].

3. The selection criteria

The selection criteria suggested are divided into four (4) dimensions: system quality, information quality, service quality and the additional dimension named as other dimension. The characteristics of the dimension can be added as preferred by the organization as their own evaluation criteria. It is important to note that in generating the selection criteria, we referred mainly from four main sources which are the D&M IS Success Model [15], related work on OSS quality model such as [1],[5],[11],[12],[16], [17], [18] and other general standards for software quality, such as ISO 25010 [19] and Malaysian Public Sector Open Source Software Initiative, the OSS Implementation Guidelines [8].

Some of works done on OSS quality model previously are not presented in a structural way and standardize to the readers. For easy understanding, standardization and comparison, OSS quality model or OSS selection criteria should comply with some quality standard like ISO 25010. This will help researcher works forward on enhancing the existing model and could be used to build the confidence of OSS potential users. The metrics captured were rank according to the metric severity and has been match to ISO 25010 standard and then group them into three main dimensions (system quality, information quality and service quality).

Table 1 lists the dimension, criteria and characteristic used in this study. There are 12 criteria which incorporated in four dimensions. Each criterion may have one or more characteristics identified. There are 27 characteristics listed in this study for the user to indicate their importance on selecting the OSS products.

System quality is referred to software product characteristics. There are four criteria included: reliability, usability, performance efficiency and functionality. There are 12 characteristic involved in the system quality dimension: maturity, popularity, availability, learnability, operability, accessibility, user interface aesthetics, time behavior, resource utilization, and functionality (completeness, correctness and appropriateness).

The information quality includes the code quality and the desirable characteristic of source code of the OSS. Two criteria and seven characteristics were included, which are maintainability (modularity, modifiability, reusability, testability) and security (confidentiality, integrity and authenticity) on selecting OSS products for adoption.

Service quality implies to expected support from OSS community provider. The suggested dimension of service quality based on SERVQUAL measurement instrument which adapted from the field of marketing and has been recognized as an important component of IS success [15], [20]. In this study the SERVQUAL measurement is adopted to define expected services received by the users and their expectations from community of OSS. The expected services possibly based on their previous experience from other software products. By identifying and understanding user requirements might help to list all possible expectation and at the end will develop users' confidence to OSS community as providers. The service quality includes the five criteria (and seven characteristics) related to tangible of

support and documentation, reliability of the version, community responsiveness, assurance (competence and credibility) and empathy of communication.

Table 1. The dimension, criteria and characteristics for OSS product

Dimension	Criteria	Characteristic	Descriptions (Related question)
System quality	Reliability *(Q1)*	Maturity *(Q11)*	Used to indicate the software maturity in the market. (Does the software new in market?)
		Popularity *(Q12)*	Used to indicate the software popularity and available references in the market.(Does this software have numerous user? Any books/website/forum/blog written about this software available in market?
		Availability *(Q13)*	Used to measure the system quality of support available for the software.(Does this software frequently release new software version?)
	Usability *(Q2)*	Learnability*(Q21)*	Used to indicate the quality of the system learnability. (How easy to learn or understand the software without using user manual?)
		Operability *(Q22)*	Used to measure the system operability. (Is the software easy to operate?)
		Accessibility *(Q23)*	Is this software easy to accessed without other third party software or plug-in?
		User interface aesthetics *(Q24)*	Is the user interface is suitable with its software functionality?
	Performance efficiency *(Q3)*	Time behavior*(Q31)*	Is this software easy to install/configure and operate within short time?
		Resource utilization*(Q32)*	Is this software use minimal/ limited resources or can be used with existing resources (e.g : server, operating system)?
	Functionality *(Q4)*	Functional completeness *(Q41)*	Does the software meet user's expectation and requirement?
		Functional correctness (*Q42)*	Does the software provide correct output as user's expectation?
		Functional appropriateness *(Q43)*	Does the software function appropriately?
Information quality	Maintainability *(Q5)*	Modularity*(Q51)*	Used to indicate the quality of the source code. (Does the code structural and readable? How well is the software designed?)
		Modifiability *(Q52)*	How easy the system can be customized to meet user's requirement?
		Reusability*(Q53)*	How easy to reuse or extent the code for further extension or integration?
		Testability*(Q54)*	Is the software error-free?
	Security*(Q6)*	Confidentiality *(Q61)*	How secure is the data and the software? How confidence that software is free from vulnerabilities?
		Integrity*(Q62)*	Does the software have any control mechanism to ensure system integrity?
		Authenticity *(Q63)*	Does the software provide level of user's authentication?
Service quality	Tangible*(Q7)*	Support*(Q71)*	Is there any community or commercial support provided?
		Documentation *(Q72)*	Complete documentation provided? Both technical and user manual?
	Reliability *(Q8)*	Version*(Q81)*	Used to measure if the community has developed clear thoughts and plans about features will be added in the future. (Does software version release as targeted or

			expected time with mainly new functionality?
	Responsiveness *(Q9)*	Community *(Q91)*	Used to indicate the responsiveness of the community. How active is the community for the software?
	Assurance *(Q10)*	Competence *(Q101)*	Does the community posses of required skill and knowledge?
		Credibility *(Q102)*	Does the development team and community have perform good track record? How many bugs were fixed in last 6 month ?
	Empathy *(Q11)*	Communication *(Q111)*	Does the community acknowledge your problems and help in solving it?
Others	Competence *(Q12)*	Skill *(Q121)*	How many internal technical staff skilled with tools and language used by this software?

Others dimension based on the user or organization capability related to internal capability of skill competence. Compared to other quality models, the users' potential constraints are also included such as, what are the characteristic of the product quality and service quality should perceive and what are the internal constraints the users have in order to adopt any OSS products. The questions might be: "Do we have internal skill in regard of this language?" Or "Do we have expert/s to handle this operating system?"

4. Methodology

4.1. Sample

The sample of this study is the Malaysian government servant and their working nature is related to the area of information technology (IT). A set of questionnaire was designed and the selected respondents were notified through their official electronic mail address. They answer the questionnaires using the web address link to the online survey tools. There are 30 respondents who answered the questionnaires, which represent 11 Malaysian Government agencies. Table 2 shows the percentage of respondents based on their job position. The respondents comprise of IT director (3.3%), senior IT officer (10 %) and IT officers (86.7%).

Table 2. Percentage of respondents by position

Position	No. of Respondent	Percent
IT Director	1	3.3
Senior IT Officer	3	10.0
IT Officer	26	86.7

4.2. Questionnaire design

The questionnaire comprise of four main sections: demographic information (3 items); the OSS product used by their agency (4 items); respondent awareness of OSS (5 items); and selection characteristics (27 items). The selection characteristics consist of the system quality dimension (12 items), information quality dimension (7 items), service quality dimension (7 items) and other dimension (one item). The questions related to selection characteristics require the respondent to indicate their score of importance on selecting the OSS products. In this survey, respondents were asked to evaluate the importance of each characteristic based on the following likert scale: 1= not important; 2= slightly important; 3= important; 4= very important; and 5= critical.

4.3. Procedure

The questionnaire was developed and generated into the online survey tool. The respondents were selected based on their job positions related to software development and information technology (IT) in the organization. Their experience in the OSS environment also important on justifying their

preferred criteria related to OSS product. The respondent was notified via their official electronic mail account that requesting them to click on the given link and answer the survey.

5. Data analysis and results

The data obtained was analyze to investigate the score of importance of each characteristics identified among IT practitioners at the government agencies in Malaysia. The score given by all the respondents for each characteristic were computed. The results in terms of averages are shown in the following tables.

5.1. System quality

The survey required respondents to indicate the level of importance on the system quality. Twelve items of characteristics have been included in this survey. Popularity characteristic (Q12) involves two different questions: "Does this software have numerous users?" and "Any reference books written about this software available in market?" The highest score given by the respondent was included for an average value in Table 3. The result shows that system functionality (Q4) is very important for their selection as it scores the highest average value. The average scores all the system quality characteristics are more than 3 which indicate that all characteristics are important for system selection.

Table 3. Results for System Quality

Criteria	Characteristic	Scale					Average
		1	**2**	**3**	**4**	**5**	
Reliability *(Q1)*	Maturity *(Q11)*	1	1	13	10	5	3.57
	Popularity *(Q12)*	-	-	16	13	1	3.25
	Availability *(Q13)*	1	3	12	11	3	3.40
Usability*(Q2)*	Learnability *(Q21)*	-	3	10	15	2	3.53
	Operability *(Q22)*	-	-	11	13	6	3.83
	Accessibility *(Q23)*	-	-	13	10	7	3.80
	User interface aesthetics *(Q24)*	-	1	17	10	2	3.43
Performance efficiency *(Q3)*	Time behavior*(Q31)*	-	-	9	15	6	3.90
	Resource utilization*(Q32)*	-	1	11	10	8	3.83
Functionality *(Q4)*	Functional completeness *(Q41)*	-	-	7	10	13	4.20
	Functional correctness *(Q42)*	-	-	7	10	13	4.20
	Functional appropriateness *(Q43)*	-	-	6	10	14	4.27

5.2. Information quality

There are four characteristics for maintainability (modularity, modifiability, reusability and testability) and three characteristics for security (confidentiality, integrity and authenticity) related to information quality. Two questions related to modularity and confidentiality characteristics. The modularity is related to the: (1) code structural and readable and (2) the software design. The confidentiality for the security associated to the user confidence of the: (1) data and software security and (2) software is free from intentional and unintentional vulnerabilities. The result shows that more than 50% of the respondents indicate that modularity and authenticity of the source code are very important. More than 40% of the respondents consider confidentiality is very critical (refer to Table 4).

Table 4. Results for Information Quality

Criteria	Characteristic	Scale					Average
		1	2	3	4	5	
Maintainability *(Q5)*	Modularity*(Q51)*	-	2	8	15	5	3.82
	Modifiability *(Q52)*	1	-	10	11	8	3.83
	Reusability*(Q53)*	1	-	9	14	6	3.80
	Testability*(Q54)*	-	1	8	11	10	4.00
Security*(Q6)*	Confidentiality *(Q61)*	-	-	7	10	13	4.17
	Integrity*(Q62)*	-	-	9	12	9	4.00
	Authenticity *(Q63)*	-	-	6	16	8	4.07

Most of the respondents agreed that security was very important on selecting the desirable characteristics of source code. Modularity and authenticity of the system was very important on selecting the product adoption by the respondent. The testability, confidentiality, integrity and authenticity characteristics score an average more than 4.0 (important). In general, all information quality characteristics score more than 3.5.

5.3. Service quality and other dimension

There are seven characteristics included for criteria of service quality dimension: tangible (support and documentation); reliability (version); responsiveness (community); assurance (competence and credibility) and empathy (communication). Table 5 shows that 50% of the respondents specify that the version released with new functionality is important. Communication (Q111) and community (Q91) characteristics are very important by more than 40% of the respondents. The results also indicate that 20% of the respondents consider community support (Q71) and documentation (Q72) are critical for the service quality expectation.

The average score on the service quality dimension shows that all characteristics are important. The highest average was on the documentation (Q72) of the product which is 3.67. As expected all the characteristics are considered important by the respondents.

The other dimension which is the competence skill scores the average of 3.77. Therefore, the users also consider the internal competencies on adoption the OSS products. The detail results on the competence skill in Table 5 shows that 20% consider it is critical, 37% indicates very important and 43% of the respondents believe it is important on selecting the OSS product. This indicates that the technical staff skilled with tools and languages is important on selecting the OSS products.

Table 5. Results for Service Quality and Other Dimension

Criteria	Characteristic	Scale					Average
		1	2	3	4	5	
Tangible*(Q7)*	Support*(Q71)*	-	3	12	8	7	3.63
	Documentation *(Q72)*	-	3	10	11	6	3.67
Reliability *(Q8)*	Version*(Q81)*	-	2	15	11	2	3.43
Responsiveness *(Q9)*	Community *(Q91)*	-	-	14	13	3	3.63
Assurance *(Q10)*	Competence *(Q101)*	-	3	12	11	4	3.53
	Credibility *(Q102)*	-	3	14	8	5	3.50
Empathy *(Q11)*	Communication *(Q111)*	1	2	11	14	2	3.47
Competence *(Q12)*	Skill *(Q121)*	-	-	13	11	6	3.77

6. Discussions

This study has shown that all dimensions are applicable for selecting the OSS products and all the characteristics are important on evaluating the OSS product selection. The results show that all characteristics are important. The selection criteria can be applied to justify the OSS user score of importance for each characteristic and the results can be used on justifying their decision. Government agencies may have their own requirements on the OSS products selection and criteria. It is recommended that the procedure is implemented carefully by going through the characteristics defined in this paper.

The proposed dimensions of the evaluation criteria provide some rigor and repeatability for general subjective process of OSS selection. The selection criteria are also can be used for comparing different OSS product with the criteria defined in this study. They are also applicable by customization with other additional criteria defined by users. The use of analytical hierarchy process for weighting factors by Norita Ahmad [1] and runtime scoring analysis by Confino and Laplante [5] can be applied to determine fitness of use and decision making.

7. Conclusion

In this paper, the results of the selection criteria based on four dimensions were presented. Based on the data and analysis results, we have identified the importance of the criteria and characteristics for the OSS selections by the respondents. Generally, the results show that each characteristic are important on adopting the OSS. However, this work is a preliminary study of OSS selection criteria in Malaysia. Further works need to be continued to understand the needs of potential users and to assist in achieving self-reliance culture (avoid vendor lock-in) in Malaysia government agencies as formulated under The Malaysia Public Sector Open Source Software Master Plan Phase II.

The most important to consider is how we can improve the decision making on selection the most suitable OSS products. The study on methodology to improve the decision making on OSS selection may help for better identifying appropriate OSS selection solution. Therefore using fuzzy theory for selecting OSS products can be used to reduce ambiguities and uncertainties of the selection criteria [1] [21]. 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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