ICIC Express Letters
Volume **13**, Number **5**, May **2019**

 ISSN 1881-803X
pp. **357–365**

AN EMPIRICAL STUDY FOR THE CURRENT PRACTICE OF COTS SOFTWARE SELECTION IN THE JORDAN ORGANIZATIONS

Feras Hamed Al-Tarawneh[1], Ali Mahmoud Al-Naimat[2]
Farhan Abdel-Fattah[1] and Boshra Mostafa Al-Tarawneh[3]

[1]Faculty of Sciences and Information Technology
Al-Zaytoonah University of Jordan
P.O. Box 130, Amman 11733, Jordan
{ f.altarawneh; farhan.A }@zuj.edu.jo

[2]Faculty of Information Technology
The World Islamic Sciences and Education University
Tabarbour, P.O. Box 1101, Amman 11947, Jordan
ali.naimat@wise.edu.jo

[3]Faculty of Engineering and Technology
The University of Jordan
The University of Jordan Street, Amman 11942, Jordan
Boshra_mt@yahoo.com

Received October 2018; accepted December 2018

Abstract. *The increased demands on the COTS software in the last decades have flooded the software market with a huge number of COTS software. Therefore, selecting the most suitable COTS software has become the main challenge to the organizations that intend to use such software. In other words, the wrong decisions will reflect negatively on the organization entirely by increasing the cost, time, and effort. In this paper, an empirical study is oriented towards discovering, describing, validating, and holistic understanding of processes, activities, characteristics of current practices, and problems of the COTS software evaluation and selection in Jordanian organizations. The findings of this survey that comprise the important processes, activities, techniques, problems, and approaches were delivered based on the developers' preferences. These also form the basis of knowledge from the practitioners' perspectives for researchers to develop and improve the existing theories, models, and techniques so that they would become more acceptable in real life. At the same time, these findings could also be used as feedbacks for organizations to not only improve the COTS software selection process but also encourage the use of a well-defined and systematic method.*

Keywords: COTS Based Systems (CBS), COTS software evaluation and selection, Empirical study

1. **Introduction.** Nowadays, most organizations have decided to change from in-house development towards COTS (*Commercial-Off-The-Shelf*) software integration in order to reduce the maintenance cost, development time, and operating, testing, and validating efforts [1,2]. Thus, COTS software has become strategic and economic way for building large and complex systems. This approach grants the opportunity to lower the development costs by sharing them with other customers, to provide rapid delivery to end users, and to reduce the development times and efforts [3-5]. Consequently, selecting the most suitable COTS software from the variety of COTS software in the market produced by different vendors with different capabilities and qualities has become the main challenge to the organizations [2,6,7]. As COTS software evaluation and selection provide the opportunity to select one or more of these software that can fulfill most users' requirements,

DOI: 10.24507/icicel.13.05.357

any wrong decision during this process will lead to catastrophic results. In other words, the wrong decisions will reflect negatively on the performance and quality of the final system [8,9]. Therefore, the evaluation and selection process is considered as a critical process because the success of the final system depends largely on it. Accordingly, several COTS selection methods have been proposed. Unfortunately, there is a gap between theory and practice on the COTS software evaluation and selection methods whereby many practitioners still rely on the ad-hoc manner in evaluating and selecting the COTS software. This gap exists because main issues and problems that have not been addressed in the previous methods need to be evaluated through empirical studies [6,10-12,19].

In this paper, the empirical study is performed to investigate the current practices and problems of the COTS software evaluation and selection in the Jordanian organizations. To do that, this study aims to: 1) verify the current practices of the CBS; 2) determine the benefits and risks of CBS; 3) identify the main problems related to the COTS software evaluation and selection; 4) identify the important processes, activities and techniques for selecting COTS software. Actually, the findings show that the "purchase and adapting" is the most frequently used approach for developing CBS. In addition, the cost and effort reductions are the main benefits of CBS, while the main risk is the lack of vendor's support. The findings also indicate that the main problem in most organizations is the lack of formal method for selecting the COTS software (see Section 4). The rest of the paper is organized as follows. Section 2 describes the empirical study methodology. Section 3 discusses the data analysis and findings. Section 4 presents the findings discussion. Finally, Section 5 includes conclusion and future work.

2. **Methodology.**

According to Saunders et al. [13], selecting the approach depends on the aims and objectives of study. As the aim if the study is to describe and document the current practices and potential benefits of CBS in the Jordanian organizations, a survey approach was adopted. Before implementing the actual survey, this study conducted a pilot survey that involved a number of pilot respondents. The pilot study was used to check the reliability and validity of the questionnaire and to rehearse the instruments and procedures which aim to fine-tune the design.

2.1. **Sample procedure.**

This study has selected the participating organizations through convenience sampling. This is considered as the most appropriate technique because it enables information to be collected from the population members who are conveniently available [14,15]. A sample of 200 participated organizations should be convincing enough for this study. This corresponds with [16] recommendation that the sample size of 100 is sufficient according to Roscoe's [17] rule of thumb, sufficient sample size is between 30 and 500. In this case, the 200 organizations that have been identified and selected randomly based on the list given by the Jordanian Ministry of Industry and Trade and the Jordanian business website directory.

2.2. **Instrument development.**

The questionnaire was designed according to the guideline proposed by Gay et al. [18]. It was developed based on adapting the questionnaires from reviewing the past empirical studies related to COTS evaluation and selection such as in [19,20]. The questionnaire consists of three sections: 1) demographic data; 2) current practices of CBS; 3) current practices of COTS evaluation and selection. Generally, five points likert scale was used for most questions. Also multi responses questions and yes/no questions were used.

2.3. **Survey execution.**

The questionnaire was delivered using the mail-back survey because it provides more opportunity to reach broader audience. The questionnaire was also hand-delivered because it presents opportunity for personal interaction with respondents

and to receive a greater response rate. Four weeks were given for each organization to answer the questionnaire so that the response rate can be maximized.

2.4. **Data analysis procedures.** In the data analysis activity, the findings were coded and analyzed using the Software Package for Social Sciences (SPSS). The description of the finding was based on the descriptive analysis. The descriptive statistics were used to depict the attributes of the collected data, verify any violation of the principle assumptions of the statistical methods, and address the particular research questions [21].

3. **Data Analysis and Findings.** The target respondent in the organization is the person who is responsible for evaluating and selecting the COTS software. The response rate for this study is 31.5%. This denotes that the completed questionnaires are ready to be analyzed since Saunders et al. [13] recommended that the reasonable average response rate is between the 30.0%-40.0%. The next sections discuss the results of survey.

3.1. **Demographic data.** Frequency distributions were used to categorize demographic data. The demographic data is presented in terms of the respondents' (years of experience) and organization backgrounds (number of employees).

Table 1 portrays information related to the respondents' experience with CBS. Most of the respondents (73.0%) have less than 3 years' experience with CBS, while the others have experience more than 3 years. This indicates that most of the employees that are responsible for the COTS software selection are actually lacking in experience with CBS.

Table 1. Work experience with CBS

Experience	Frequency	%
Less than 3 years	46	73.0%
3-10 years	12	19.1%
11-20 years	5	7.9%
Total	63	100.0%

Table 2 shows the data distribution related to the number of employees in each participated organization. Most of the respondents came from large size organizations (46.1%), which comprise a big number of employees of more than 250.

Table 2. Numbers of employees in the organization

Number of employees	Frequency	%
< 10	12	19.0%
10-50	10	15.9%
51-250	12	19.0%
> 250	29	46.1%
Total	63	100.0%

3.2. **Findings related to CBS practice.** This section describes the survey findings related to the current approach for building CBS, and the benefits and risks of CBS.

3.2.1. *The current CBS approaches.* The literature pointed out that the three most popular approaches used by organizations in developing their systems are: purchase and use/adopt, purchase and adapt, and purchase and integrate the COTS software [13,19]. The purchase and use/adopt approach refers to the manner in which the procured COTS software is immediately used without any adaptation or extension since it meets user's requirement. The purchase and adapt approach, on the other hand, is characterized by acquiring a single complete working system that satisfies most of the user's requirements

but needs to be adapted accordingly. The last approach, "purchase and integrate", means purchasing a number of the COTS software, each satisfying part of user's requirements and integrating these components into the system.

Based on the findings, the "purchase and adapt" approach was used by majority of the organizations (55.6%) in developing their CBS, while the "purchase and integrate" approach was only used by 28 organizations (44.4%). Only (39.7%) of these organizations choose to directly use the complete working COTS software system without adapting or extending. These results support the fact that the COTS software usually does not completely achieve the user's requirements which means that the mismatches problem between the COTS software and these requirements raises in most cases. Thus, the appropriate decision making technique is needed to prevent selecting unfit COTS software that depletes the organization resources in the adaptation process.

3.2.2. *Benefits and risks of CBS.* The first benefit is the reduction of software development costs (79.4%), followed by the reduction of development effort (78.0%), and increasing system functionalities (60.3%) (See Table 3).

Table 3. Benefits of CBS

CBS benefits	Strongly disagree		Disagree		Do not know		Agree		Strongly agree	
	N	%	N	%	N	%	N	%	N	%
Reduce development cost	2	3.2	2	3.2	9	14.2	33	52.4	17	27.0
Reduce development effort	1	1.6	6	9.2	10	15.6	31	49.2	15	28.8
Increase COTS diversity	0	0.0	6	9.5	26	41.3	31	49.2	0	0.0
Provide rich functionality	2	3.2	1	1.6	22	34.9	29	46.0	9	14.3

On the other hand, Table 4 lists the various risks of building systems from COTS software as agreed by the respondents. Among the highest score are lack of vendor's support or after sales service (58.8%), and difficulties in selecting from the vast array of the COTS software (54.0%). The second risk supports the fact that there is a lack of well-defined process for selecting the fitness of the COTS software in industry.

Table 4. Risks of CBS

CBS risks	Strongly disagree		Disagree		Do not know		Agree		Strongly agree	
	N	%	N	%	N	%	N	%	N	%
Incompatibility with other components	3	4.8	9	14.3	29	46.0	15	23.8	7	11.1
Periodic releases of COTS	0	0.0	17	27.0	24	38.1	22	34.9	0	0.0
COTS provider goes out of business	0	0.0	9	14.3	17	27.0	26	41.3	11	17.5
Difficult to select from vast array of COTS	0	0.0	4	6.3	25	39.7	24	38.1	10	15.9

3.3. **COTS software evaluation and selection.** This section addresses the practice of evaluating and selecting the COTS software by describing the related problems, the current methods, and the processes and techniques of selecting the COTS software.

3.3.1. *The main problems.* The findings show that the main problems encountered during the COTS software selection are lack of formal process (79.4%), mismatches between COTS software features and user requirements (66.7%), failure in handling the NFRs (63.5%), and lack of learning from previous cases in their organizations (52.4%).

The relations between the lack of formal process for COTS software evaluation and selection and other problems are illustrated in Table 5. Several consequences of not following a formal or well-defined process as pointed out by the 50 respondents (79.4%) include failure to focus on the COTS mismatches problems (68%), handle the NFRs (62%), and learn from previous evaluation and selection cases (54%). This indicates that by failing to adhere to a formal process causes the emergence of the other unanticipated problems. Examples of such problems are the inability to provide suitable mechanism in dealing with the COTS mismatches and to emphasize on the vital role of the NFR.

Table 5. The relations between lack of formal process and other problems

Problems	Lack of formal process	Total (all cases)
COTS mismatches problem	34 (68.0%)	42 (66.7%)
Lack of handling NFRs	31 (62.0%)	40 (63.5%)
Lack of learning from past selection cases	27 (54.0%)	33 (52.4%)

3.3.2. *Current selection methods.* The survey shows that most of the respondents (85.7%) did not use any methods. Only a small number of them is currently using specific method such as PORE (*Procurement-Oriented Requirements Engineering*) (3.2%), STACE (*Social-Technical Approach to COTS Evaluation*) (1.6%), and CSSP (*COTS Software Selection Process*) (4.8%).

By cross tabbing the current methods and the related problems of the COTS software evaluation and selection process (Table 6), the results indicate that those (85.7%) who do not use any systematic or formal method have high chances of facing problems such as COTS mismatches (88.1%), lack of handling NFRs (95%), and lack of learning from past COTS selection cases (87.9%).

Table 6. Current used methods cross the main problems

The main problems	Current used methods					Total
	STACE	PORE	CRE	CSSP	Do not use any method	
Lack of formal process	1 (2.0%)	1 (2.0%)	4 (8.0%)	1 (2.0%)	44 (88.0%)	50 (79.9%)
Mismatches problem	0 (0.0%)	1 (2.4%)	2 (4.8%)	3 (7.1%)	37 (88.1%)	42 (66.7%)
Lack of handling NFR	0 (0.0%)	2 (5.0%)	2 (5.0%)	0 (0.0%)	38 (95.0%)	40 (63.5%)
Lack of learning from past selections	1 (3.0%)	1 (3.0%)	3 (9.1%)	0 (0.0%)	29 (87.9%)	33 (52.4%)
Total	1 (1.6%)	2 (3.2%)	5 (7.9%)	3 (4.8%)	54 (85.7%)	

Although the STACE, PORE, CRE, and CSSP methods were used by few of respondents these methods suffer from lack of considering the COTS software mismatches like CRE (4.8%) and CSSP (7.1%), lack of NFRs like PORE (5.0%), and lack of learning from past selection cases like STACE (3.0%) and CRE (9.1%).

The previous scenario shows that instead of using any formal method, most of the respondents prefer to use ad-hoc manners in evaluating and selecting the COTS software. The examples of the ad-hoc manners, as depicted by the survey findings, include development team experiences (81.3%), managers' experiences (41.7%), developers-vendor relationships (37.5%), and relying on intuition (12.5%).

3.3.3. *The main processes and activities.* Based on the findings in Table 7, majority of the respondents agree that all of the listed processes and activities are required in the COTS software evaluation and selection. These processes and activities are searching (61.9%), selecting (61.9%), documentation (60.4%), evaluation (60.3%), screening (57.1%), and defining the evaluation criteria (54.0%).

Table 7. The COTS software evaluation and selection processes and activities

Main processes/Activities	Strongly disagree		Disagree		Do not know		Agree		Strongly agree	
	N	%	N	%	N	%	N	%	N	%
Defining the evaluation criteria	2	3.2	2	3.2	25	39.6	24	38.1	10	15.9
COTS searching	2	3.2	2	3.2	20	31.7	26	41.3	13	20.6
COTS screening	2	3.2	8	12.7	17	27.0	30	47.6	6	9.5
COTS evaluation	2	3.2	3	4.8	20	31.7	30	47.6	8	12.7
COTS selecting	2	3.2	5	7.9	17	27.0	28	44.4	11	17.5
Documentation	4	6.3	7	11.1	14	22.2	27	42.9	11	17.5

3.3.4. *The most frequently used techniques.* To discover the most frequent techniques used in evaluating and selecting the COTS software, the respondents were asked to rate their agreement according to the given factors.

The main purpose of identifying the potential COTS alternatives that meet the user requirements is to enable a more rigorous evaluation. The findings (Table 8) show that the COTS inventory is the most frequent technique (79.4%: 66.7% regularly and 12.7% always used) used by the respondents for searching the COTS software. The next preferred techniques are market research (77.8%) and customer prior and past experience (57.2%).

Table 8. Techniques for identifying COTS software

Techniques	Never		Rarely		Sometimes		Regularly		Always	
	N	%	N	%	N	%	N	%	N	%
Customer prior & past experience	0	0.0	2	3.2	25	39.6	27	42.9	9	14.3
COTS inventory	2	3.2	3	4.8	8	12.7	42	66.6	8	12.7
Prototyping and user demonstrations	0	0.0	7	11.1	33	52.4	18	28.6	5	7.9
Market research	0	0.0	2	3.2	12	19.0	39	61.9	10	15.9
Provider adverts and promotions	2	3.2	15	23.9	20	31.7	20	31.7	6	9.5
Internet search	0	0.0	1	1.6	32	50.8	25	39.7	5	7.9

Table 9 demonstrates that the documents analysis is the most frequent technique used by the respondents (69.9%) for collecting data. This is followed by experimentation users group advice (65%), and COTS demonstration attending (57.2%).

Table 9. Data collection technique

Techniques	Never		Rarely		Sometimes		Regularly		Always	
	N	%	N	%	N	%	N	%	N	%
Documents analysis	0	0.0	1	1.6	18	28.6	27	42.9	17	27.0
Experimentation users group advice	0	0.0	7	11.1	15	23.8	29	46.0	12	19.0
COTS demonstration attending	0	0.0	4	6.3	23	36.5	34	54.0	2	3.2
Questionnaires	2	3.2	2	3.2	29	46.0	21	33.3	9	14.3
Checklists	2	3.2	5	7.9	35	55.6	18	28.6	3	4.8

Table 10 portrays that the COTS demonstration attending technique is the most preferred by 69.9% of the respondents for the data analysis purposes, followed by the customer experience (68.2%) and the extensive experimentation (58.8%). It is important to mention that in the literature, the most used techniques are the Multi-Criteria Decision Making (MCDM) techniques such as the AHP and WSM because in these findings, the MCDM is not preferable. The reason is that the evaluators do not have sufficient experience and well-defined method to deal with these techniques especially when they require many calculations like in AHP technique.

Table 10. Analysis techniques

Techniques	Never		Rarely		Sometimes		Regularly		Always	
	N	%	N	%	N	%	N	%	N	%
COTS demonstration attending	0	0.0	2	3.2	17	27.0	33	52.3	11	17.5
Customer experience	0	0.0	2	3.2	18	28.6	31	49.2	12	19.0
Extensive experimentation	0	0.0	3	4.8	23	36.5	27	42.9	10	15.9
AHP (*Analytical Hierarchy Process*)	3	4.8	10	15.9	30	47.5	19	30.2	1	1.6
WSM (*Weighting Scoring Method*)	2	3.2	13	20.6	39	61.9	8	12.7	1	1.6

4. **Discussion.** This survey investigates several issues related to the COTS software evaluation and selection. They were carefully discussed according to the following survey's objectives.

Objective 1: *To verify the current practices of CBS development in the Jordanian firms*: The most frequent approaches for building the systems from the COTS components are "purchase and adapt", and "purchase and use". In these approaches a single complete working COTS software product that satisfies most of customers' requirements is used either with adaptation for local needs or without any adaptation. This suggests that selecting COTS software that achieves most of the customer requirements is more desirable than selecting several COTS software to meet the customer requirements.

Objective 2: *To determine the benefits and risks of using COTS software*: The majority of the organizations are using the COTS software to reduce the costs and effort of systems development and to increase the system functionality. Using the COTS software for building systems is cheaper because the total costs are shared with many users. These findings are consistent with most of other studies such as [7,24,25]. Despite the benefits, most of the organizations are also worry about getting continuous COTS support especially when the vendor goes out of business, and selecting from vast amounts of the COTS software products. This is because most of the organizations in Jordan did not follow any formal process in selecting appropriate COTS software.

Objective 3: *To identify the main problems and challenges related to the COTS software selection*: The survey indicates that 85.7% of the Jordanian organizations do not use any formal method when selecting the COTS software. This indicates that they are using ad-hoc manners such as by relying on the experience of the development team or depending on the relationships with specific vendor. As a result, the organizations are facing various problems, which are: lacking of a well-defined method, difficulty in identifying the COTS mismatches, failure in handling the NFRs, and failure in learning from past selection cases.

Objectives 4: *To identify the important processes, activities and techniques for evaluating and selecting the COTS software*: From the developers' perspectives, the related activities of the COTS software evaluation and selection practices comprise the evaluation criteria definition, COTS searching, screening, evaluating and selecting, and documentation. Several techniques are applied to facilitating the execution of those activities. The

frequent techniques used for defining the evaluation criteria are documents review, observation and brainstorming. For the COTS searching, the respondents choose the inventory and market searching techniques. As for the data collection and analysis, the techniques applied are documents review, user group advices experimentations, and attending COTS demonstrations. However, the findings showed that the MCDM techniques that have highly attention by the researchers in literature like AHP technique were not used by most of the organizations. One of the reasons for not using the AHP technique is due to certain limitations, which requires some form of complex calculation.

5. **Conclusion.** This paper aims to elicit and synthesize the current practices of the COTS software evaluation and selection in terms of its activities, techniques, and challenges involving various organizations in Jordan. Besides highlighting the problems of the COTS software selection, the achievement of the survey objectives is also presented in this paper. The survey results provide better understanding of how CBS can support the Jordanian organizations in developing more effective information systems. For future work, these findings will be used as the basis for constructing the COTS software evaluation and selection framework. The detail of the proposed framework will be discussed in the next paper.

REFERENCES

[1] C. T. Couts and P. F. Gerdes, Integrating COTS software: Lessons from a large healthcare organization, *IT Professional*, vol.12, no.2, pp.50-58, 2010.
[2] P. Gupta, M. K. Mehlawat and D. Mahajan, Data envelopment analysis based multi-objective optimization model for evaluation and selection of software components under optimal redundancy, *Annals of Operations Research*, 2018.
[3] N. Madaan, R. Kalra and N. Madaan, A review on major issues in software component selection, *International Journal of Advanced Research in Computer Science*, vol.7, no.6, pp.201-203, 2016.
[4] F. Al-Tarawneh, F. Baharom and J. H. Yahaya, Toward quality model for evaluating COTS software, *International Journal of Advancements in Computing Technology*, vol.5, no.14, pp.112-125, 2013.
[5] H. Ibrahim, A.-H. H. Elamy, B. H. Far and A. Eberlein, UnHOS: A method for uncertainty handling in Commercial Off-The-Shelf (COTS) selection, *International Journal of Energy, Information and Communications*, no.3, pp.21-48, 2011.
[6] R. Garg, R. Sharma and K. Sharma, Ranking and selection of commercial off-the-shelf using fuzzy distance based approach, *Decision Science Letters*, vol.5, no.2, pp.201-210, 2016.
[7] A. Konys, Knowledge-based approach to COTS software selection processes, in *Advances in Intelligent Systems and Computing – Soft Computing in Computer and Information Science*, A. Wiliński, I. Fray and J. Pejaś (eds.), Cham, Springer, 2015.
[8] D. Falessi, G. Cantone, R. Kazman and P. Kruchten, Decision-making techniques for software architecture design: A comparative survey, *ACM Computing Surveys (CSUR)*, vol.43, no.4, p.33, 2011.
[9] H. Lin, A. Lai, R. Ullrich, M. Kuca, K. McClelland and J. Shaffer-Gant, COTS software selection process, *The 6th International IEEE Conference on Commercial-off-the-Shelf (COTS)-Based Software Systems*, Banff, Canada, pp.114-122, 2007.
[10] J. Pande, On some critical issues in component selection in component based software development, *International Journal of Computer Applications*, vol.46, no.4, pp.44-50, 2012.
[11] F. Tarawneh, F. Baharom, J. H. Yahaya, A. Zainol, N. M. Darus and Z. M. Matt, An exploratory investigation into current practice of non functional requirements for COTS software in Jordan firms, *International Soft Science Conference 2011 (ISSC2011)*, Ho Chi Minh, Vietnam, 2011.
[12] S. Farshidi, S. Jansen, R. Jong and S. Brinkkemper, A decision support system for software technology selection, *Journal of Decision Systems*, vol.27, no.1, pp.98-110, 2018.
[13] M. Saunders, P. Lewis and A. Thornhill, *Research Methods for Business Students*, 4th Edition, Prentice Hall, London, UK, 2007.
[14] R. J. Fox, *Non Probability Sampling*, Wiley International Encyclopedia of Marketing, USA, 2010.
[15] U. Sekaran and R. Bougie, *Research Methods for Business: A Skill Building Approach*, 5th Edition, John Willey & Sons Ltd., Chichester, UK, 2010.
[16] K. Bailey, *Methods of Social Research*, 4th Edition, Free Press, New York, USA, 2008.
[17] J. T. Roscoe, *Fundamental Research Statistics for the Behavioral Sciences*, Holt, New York, USA, 1975.

[18] L. R. Gay, G. E. Mills and P. Airasian, *Educational Research: Competencies for Analysis and Application*, 8th Edition, Pearson Merrill Prentice Hall, Upper Saddle River, NJ, 2006.

[19] D. Kunda, *A Social-Technical Approach to Selecting Software Supporting COTS-Based Systems*, Ph.D. Thesis, Department of Computer Science, University of York, 2002.

[20] M. Gerea, *Selection and Evaluation of Open Source Components*, Ph.D. Thesis, Department of Computer and Information Science, Norwegian University of Science and Technology (NTNU), 2006.

[21] J. Pallant, *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows Version 15*, 3rd Edition, Open University Press, UK, 2007.

[22] A. S. A. S. Mohamed, *Decision Support for Selecting COTS Software Products Based on Comprehensive Mismatch Handling*, Ph.D. Thesis, Department of Electrical and Computer Engineering, University of Calgary, 2007.

[23] C. Ayala, A. Nguyen-Duc, X. Franch, M. Höst, R. Conradi, D. Cruzes and M. A. Babar, System requirements-OSS components: Mismatching and mismatch resolution practices – An empirical study, *Empir. Software Eng.*, 2018.

[24] G.-M. Fang, J.-M. Lin, K.-Y. Chin and C.-Y. Lee, Software integration for applications with audio/video stream, *International Journal of Innovative Computing, Information and Control*, vol.6, no.3(B), pp.1421-1433, 2010.

[25] N. Yanes, S. B. Sassi and H. B. Ghezala, *A Theoretical and Empirical Evaluation of Software Component Search Engines, Semantic Search Engines and Google Search Engine in the Context of COTS-Based Development*, Cornell University Library, NY, USA, http://arxiv.org/abs/1204.2079, 2012.