Summary

The process of COTS system selection is difficult due to the large number of existing COTS components on the marketplace. Moreover, a high level of complexity characterizes the process of knowledge acquisition about the available COTS systems. In this paper an approach for COTS selection is proposed. The application of ontology (the ontology for methodologies supporting COTS component selection and the ontology for COTS ERP components) enables the knowledge systematization about the available solutions and provides a set of results with reference to decision-maker preferences. The application of a selected methodology (as a result of using an ontology) supporting the COTS selection and evaluation process provides a ranking of alternatives. Based on this, a decision-maker can consider a reasonable choice.

Keywords: COTS software, COTS components, ERP system, ontology

1. Introduction

The choice of appropriate software components from any number of available software solutions is one of the most important issues in the selection and development process of an enterprise’s Information System. The existence of a large amount of diffused information is one of the current inconveniences related to the selection process. Moreover, it could increase the risk of the decision-making process.

The increasing role of COTS (Commercial Off-The-Shelf) components in the software marketplace influences the growth of popularity of that kind of software solutions and enables the construction of a complete system from COTS components [6]. The COTS market offers a wide range of software components supporting enterprise functions in different domains. The proper location of the available components (and after that the choice of an optimal solution) is one of the existing problems for modern enterprises. The COTS market is still developing (it still offers new COTS systems) and enables the reusing of existing solutions. The COTS selection process is difficult due to the large number of existing COTS components. Moreover, the price of a mistake is great due to the complex nature of information systems. The adaptation of one existing method that supports the COTS component selection and evaluation process should support the decision-making process.

The general aim of this paper is to present a complex process of COTS components selection and evaluation. In this case, the process of knowledge acquisition from the author’s ontologies is introduced. The application of COTS ontologies provides a set of results that fulfil pre-defined requirements by a decision-maker. In the first step, the ontology supporting COTS components selection and evaluation was applied. It indicates the best-suited method to a given decision’s
Next, the second ontology for COTS ERP components was used. This ontology indicates a set of systems that fulfil a set of pre-defined requirements by a decision-maker. The final ranking of alternatives was built on the basis of AHP method adaptation.

2. COTS knowledge acquisition process

In the last decade the use of COTS (Commercial Off-The-Shelf components) as a part of larger systems has grown steadily [9]. In the literature, COTS products are defined as ready to sell products [3], available and sold in many copies with minimal changes [11]. A customer has no control over specification, schedule and evolution. COTS products can be part of a bigger and more complex COTS-based System (CBS) [5]. The increasing role of COTS components in the software marketplace influences the growth of popularity of that type of software solution and enables the construction of an entire system from COTS components [9].

The one of essential aspects for a modern enterprise is the proper selection of an information system [1]. Very often an information system is built or developed on the basis of available COTS software components. The principal problem referring to COTS components selection is access to the information about the available solutions on the market [4]. It is worth emphasizing that very often vendors do not provide complete documentation or they do not want to publicize the weaknesses of a particular component. As a consequence, a set of evaluated components selected by a decision-maker can be incomplete or can include imprecise information.

Moreover, there are many differences between COTS software products available in the marketplace considering both the libraries and the applied components [1, 2]. Hence, a high level of complexity characterizes the problem of COTS component selection and evaluation. There are many approaches for COTS software selection that apply dissimilar methods in supporting the same software evaluation process. The analysis of the literature identified a number of methodologies that support COTS software component selection and evaluation. The specified characteristics of analysed solutions are presented in [8]. The analysed methodologies do not indicate how to acquire the knowledge about available COTS components in the marketplace.

It is worth noting that one of the important constraints in the selection process is access to functional characteristics of the available components. Information about COTS components can be obtained from different sources (e.g. independent reports, taxonomy, expert knowledge, repositories, supporting tools, information provided by a vendor, traditional searching mechanisms, component tests etc.). In many cases, these solutions provide only general knowledge about components, based on the subjective information provided by vendors or experts. Moreover, the application of a traditional searching mechanism (e.g. Google) provides an incomplete set of results (very often not referred to a posed question). A decision-maker has to check many websites to find information about COTS components [2, 7].
The adaptation of knowledge-engineering mechanisms should improve the process of knowledge acquisition of COTS components and methodologies supporting COTS selection and evaluation. Based on this, the ontologies for supporting COTS selection process are proposed. The general aim of this approach is to provide mechanisms for updating information about particular components and methods, and extracting the information about these components according to inquiries defined by a decision-maker. It is premised that the ontologies for supporting COTS component selection enables a reduction in most research problems (e.g. knowledge systematization about COTS methodologies, the choice of a proper methodology for a given decision or problem).

3. Ontology-based approach to COTS system selection and evaluation

The main advantage of the proposed COTS ontologies is to provide systematic and repeatable knowledge about available COTS ERP components and methodologies supporting COTS component selection process. The ontologies were built using the Protégé application. The language supporting building the ontologies is OWL (Ontology Web Language). The aim of the first ontology is to provide knowledge systematization about the available methodologies supporting COTS component selection and evaluation (http://www.semanticweb.org/ontologies/2010/11/Ontology1292334387792.owl). The ontology provides information about 38 methods and techniques. The second ontology supports COTS ERP component selection, and it includes the specified characteristics of 50 COTS ERP systems (http://www.semanticweb.org/ontologies/2010/5/Ontology1277282694667.owl). The specified analysis of available solutions allows one to define the set of classes and subclasses for each of the proposed ontologies.

The case study is divided into 3 main phases. The first phase encompasses the selection of a methodology that supports a decision-maker in an evaluation process. The second phase includes the process of COTS ERP system selection. As a next step, the application of a selected methodology for COTS ERP component evaluation is presented.

In the first phase, on the basis a decision-maker’s experience, a preferable set of criteria was defined. It is supposed that a decision-maker is looking for the COTS methodology that fulfils a set of pre-defined requirements. In this case the decision-maker identified the following requirements. The preferable methodology should satisfy the following criteria: (1) defining criteria importance:
hierarchical decision model, (2) software evaluation: usage of the AHP method and software evaluation tools, (3) process of defining criteria: interview or questionnaire. The application of the reasoning mechanism provides a set of results with regard to the pre-defined requirements. In this case, only one methodology (Wang) fulfils these defined criteria (Fig. 2).

Fig. 2. A set of results provided by the ontology for methodologies supporting COTS component selection and evaluation

The complete description of method proposed by Wei and Wang et al. is presented in: [12, 13]. The general aim of that method is to provide ERP-selected framework to support the selection of a suitable ERP system. The procedure proposed by Wei and Wang is composed of the following steps: Steps 1–5 encompass: collection of information about available systems and vendors, the identification of ERP system characteristics, construction of a structure of objectives to develop the fundamental-objective hierarchy and means-objective network, extraction of the attributes for evaluating ERP systems from the structure of objectives and the filtration of unqualified vendors by asking specific questions, which are formulated according to the system requirements. In the next steps, the evaluation of ERP systems using the AHP method is performed.

In the second phase, the process of COTS ERP component selection is performed. On the basis of the author’s ontology for COTS ERP component selection processes, the set of results is provided. Before this step, a decision-maker indicates a set of functionalities that should be fulfilled by a preferable COTS ERP system. The application of the author’s ontology supporting the COTS ERP components selection helps in defining requirements. It is supposed that a decision-maker is looking for an ERP system that fulfils the following criteria: (1) small-sized enterprise, (2) medium-sized enterprise, (3) SaaS, (4) Database: Microsoft SQL Server. On the basis of pre-defined requirements by a decision-maker, the ontology provides a set of results: SAP ERP, Comarch Altum, MAKS V, Comarch CDN XL, MAX eBiznes (Fig. 3).

Fig. 3. A set of results provided by the ontology for COTS ERP components

Altum, MAKS V, Comarch CDN XL, MAX eBiznes (Fig. 3).
4. Case study: COTS methodology application for ERP system selection

The application of both ontologies (the ontology supporting COTS component selection and evaluation and the ontology for COTS ERP components) indicates the preferable methodology (Wang) and the set of COTS ERP systems: SAP ERP, Comarch Altum, MAKS V, Comarch CDN XL, MAX eBiznes. The next step encompasses an evaluation process of obtained COTS ERP systems. Owing to the preferable set of COTS, ERP was provided by the ontology supporting COTS component selection and evaluation; the process of the alternatives selection will be omitted.

The methodology proposed by Wang adapts the AHP method for COTS selection and evaluation process. An algorithm of the AHP method is presented in many publications (e.g. [10]). In this case study, the general aim of an application of the AHP method is to evaluate 5 selected COTS ERP components (SAP ERP, Comarch Altum, MAKS V, Comarch CDN XL, MAX eBiznes). These components were selected using the author’s ontology for COTS ERP components.

The application of AHP method allows one to identify a ranking of alternatives. It is possible to customize each of selected ERP systems for individual preferences. In this case, the preferences were acquired from AAA company. Based on the interview with a decision-maker from AAA company, the Saaty scale was proposed. It involves comparing elements in pairs: identifying the dominant one and determining the degree of dominance on the nine-point scale.

It is supposed that a decision-maker is looking for an ERP system for a logistics enterprise. The preferable system should satisfy the following criteria: (1) warehouse management, (2) logistics and distribution, (3) CRM (Customer Relationship Management), (4) retail. A decision-maker determines the importance of objectives (see: Table 1, preference vector). It informs which of the analysed alternatives evaluations will have the greatest impact on the decision. As the result, the eigenvectors for main criteria and sub-criteria in a first level were provided. On the basis of expert evaluations of the following systems, the computational process was performed. Next, the usability values for the given alternatives were indicated. The specified ranking of alternatives is presented in Table 1.

Table 1. Partial utility values, priority vector and a final ranking of alternatives for selected COTS ERP systems

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Partial utility values</th>
<th>Preference vector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAP</td>
<td>Comarch CDN</td>
</tr>
<tr>
<td>CRM</td>
<td>4,76</td>
<td>42,86</td>
</tr>
<tr>
<td>Logistics and distribution</td>
<td>33,83</td>
<td>31,79</td>
</tr>
<tr>
<td>Retail</td>
<td>20,32</td>
<td>20,32</td>
</tr>
<tr>
<td>Warehouse management</td>
<td>34,83</td>
<td>15,85</td>
</tr>
<tr>
<td>outcome values</td>
<td>31,76</td>
<td>26,83</td>
</tr>
</tbody>
</table>

The final ranking aggregates the relative importance of criteria and alternatives evaluations. The final ranking of alternatives is presented in Figure 4. The analysis of the obtained results indicates the best-fitted system for decision-maker preferences. On the basis of the obtained results, the most preferable system for a decision-maker from AAA company is SAP. The next table (Table 2) provides a partial ranking of alternatives.
### Table 2. Partial evaluation values, priority vectors and utility values of alternatives for a first-level of sub-criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>SAP</th>
<th>Conarch CDN</th>
<th>Conarch Alman</th>
<th>MAKS V</th>
<th>MAX eBusiness</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CRM/Clerk Relationship Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Client characteristics</td>
<td>4.76</td>
<td>42.36</td>
<td>42.86</td>
<td>4.76</td>
<td>4.76</td>
<td>19.47</td>
</tr>
<tr>
<td>Clients' clustering</td>
<td>4.76</td>
<td>42.36</td>
<td>42.86</td>
<td>4.76</td>
<td>4.76</td>
<td>8.81</td>
</tr>
<tr>
<td><strong>CRM sub-criterion</strong></td>
<td>4.76</td>
<td>42.36</td>
<td>42.86</td>
<td>4.76</td>
<td>4.76</td>
<td>71.72</td>
</tr>
<tr>
<td>Partial utility</td>
<td>42.36</td>
<td>42.36</td>
<td>4.76</td>
<td>4.76</td>
<td>4.76</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Logistics and distribution</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed asset management</td>
<td>24.32</td>
<td>24.32</td>
<td>2.7</td>
<td>24.32</td>
<td>24.32</td>
<td>7.07</td>
</tr>
<tr>
<td>Logistics and distribution</td>
<td>24.32</td>
<td>24.32</td>
<td>2.7</td>
<td>24.32</td>
<td>24.32</td>
<td>22.61</td>
</tr>
<tr>
<td>Maintenance management</td>
<td>31.03</td>
<td>31.03</td>
<td>3.45</td>
<td>31.03</td>
<td>3.45</td>
<td>3.43</td>
</tr>
<tr>
<td>SCM</td>
<td>31.03</td>
<td>31.03</td>
<td>3.45</td>
<td>31.03</td>
<td>3.45</td>
<td>26.31</td>
</tr>
<tr>
<td>SRM</td>
<td>42.86</td>
<td>42.86</td>
<td>4.76</td>
<td>4.76</td>
<td>4.76</td>
<td>25.7</td>
</tr>
<tr>
<td>Transport management</td>
<td>31.03</td>
<td>31.03</td>
<td>3.45</td>
<td>31.03</td>
<td>3.45</td>
<td>7.45</td>
</tr>
<tr>
<td>VA3</td>
<td>69.23</td>
<td>7.69</td>
<td>7.69</td>
<td>7.69</td>
<td>7.69</td>
<td>3.32</td>
</tr>
<tr>
<td>WMS</td>
<td>42.86</td>
<td>42.86</td>
<td>4.76</td>
<td>4.76</td>
<td>4.76</td>
<td>4.13</td>
</tr>
<tr>
<td>Partial Utility</td>
<td>55.83</td>
<td>31.79</td>
<td>15.49</td>
<td>11.12</td>
<td>3.76</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Retail</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Import support</td>
<td>24.32</td>
<td>24.32</td>
<td>2.7</td>
<td>24.32</td>
<td>24.32</td>
<td>7.43</td>
</tr>
<tr>
<td>Order request</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>8.41</td>
</tr>
<tr>
<td>Order management system</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>44.45</td>
</tr>
<tr>
<td>Retail planning</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>12.29</td>
</tr>
<tr>
<td>Retail product registration</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>23.94</td>
</tr>
<tr>
<td>Retail sub-criterion</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>3.46</td>
</tr>
<tr>
<td>Partial Utility</td>
<td>26.32</td>
<td>26.32</td>
<td>20.32</td>
<td>18.12</td>
<td>18.12</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Warehouse Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barcode</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>10.08</td>
</tr>
<tr>
<td>Documentation</td>
<td>31.03</td>
<td>3.45</td>
<td>3.45</td>
<td>31.03</td>
<td>31.03</td>
<td>3.24</td>
</tr>
<tr>
<td>Inventory management</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>14.12</td>
</tr>
<tr>
<td>RFID</td>
<td>69.23</td>
<td>7.69</td>
<td>7.69</td>
<td>7.69</td>
<td>7.69</td>
<td>20.4</td>
</tr>
<tr>
<td>Stockkeeping</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>4.62</td>
</tr>
<tr>
<td>Warehouse management</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>38.58</td>
</tr>
<tr>
<td>Partial Utility</td>
<td>34.83</td>
<td>16.74</td>
<td>16.74</td>
<td>15.85</td>
<td>15.85</td>
<td>100.0</td>
</tr>
</tbody>
</table>
5. Conclusion

In this paper an approach for COTS ERP systems selection and evaluation was presented. The application of the ontologies (the ontology for methods and techniques supporting COTS component selection and evaluation processes and the ontology for COTS ERP components) allows one to identify the most preferable methodology (Wang) and the set of the most preferable systems (SAP ERP, Comarch Altum, MAKS V, Comarch CDN XL, MAX eBiznes) that fulfil pre-defined requirements determined by a decision-maker. The COTS ontologies enabled knowledge systematization about the available solutions (methodologies and COTS ERP components). It is worth emphasizing that a decision-maker does not have to have a broad knowledge of the available solutions (methodologies and COTS ERP components) but can still make a reasonable choice.

The practical example of an AHP method application enabled the evaluation of selected COTS ERP systems. The analysis of obtained results indicated the best-suited system for decision-maker preferences (SAP). Moreover, it was possible to perform a sensitivity analysis of the results to check how ranking behaves in response to changes in the relative importance of criteria. It is worth noting that a ranking of alternatives depends on both the preferences and the determining level of importance for each of analysed criteria defined by a decision-maker.
Bibliography


ZARZĄDZANIE WIEDZĄ W PROCESIE OCENY I DOBORU SKŁADNIKÓW COTS

Streszczenie

W artykule podjęto problem oceny skalowalnych składników oprogramowania COTS. Zaproponowano dwuetapowe podejście, w którym dobór wariantów potencjalnych realizowany jest z użyciem metod inżynierii wiedzy, a proces ewaluacji z użyciem metod wielokryterialnego wspomagania decyzji. W dalszej części przeprowadzono weryfikację praktyczną proponowanego podejścia. Całość kończą wnioski z przeprowadzonych badań.

Słowa kluczowe: ontologia, metody wielokryterialne, składniki COTS

Agnieszka Konys
e-mail: akonys@wi.ps.pl
Zachodniopomorski Uniwersytet Technologiczny
Wydział Informatyki
Katedra Inżynierii Systemów Informacyjnych
Żołnierska 49, 71-210 Szczecin, Poland