APPLICATION OF THE AHP METHOD IN SELECTING SOFTWARE COMPONENTS

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Summary

The purpose of this paper is an attempt to apply the AHP method in selecting software components in an enterprise. The article presents a recapitulation of research conducted hitherto on the selection process of components of the enterprise information infrastructure. Respectively, the concept of multi-dimensional methods was presented and an evaluation model of the functional quality of software applying the AHP method was constructed. Conclusion drawn from the research conducted ends the study.

Keywords: information technology, analytic hierarchy process, software evaluation

1. Introduction

The diversification and vicissitude of information needs of potential IT system users, as well as different strategic targets of enterprises (resultant from the size, changing activity profiles and capital available) makes it impossible to develop a universal class of IT solutions. In result, an organization finds itself in need of a computerization plan which defines rules, norms and information needs, as well as ways of satisfying them. The main body of these activities relates to the optimal selection of computer equipment and software, their effective exploitation and the rationalization of the above investment process.

A wide range of IT solutions available on the market enforce upon a potential user a problem of selecting the “way of getting the company equipped in the IT armament”. The multitude of available software solutions (classes, areas of application, functional scope, proper approach, implementation cycle) forms a set of choice alternatives. What is thus the best (optimal) way to organize the information system and verify whether it is properly suited to the information needs of an organization? Literature on the subject widely discusses the concepts of IT tools being inefficiently used in an organization and corresponding implementation risks. The exploitation of methods and procedures of selecting an IT strategy is the more complicated due to their complex nature, whereas the methodologies and commercial studies form a hermetic knowledge on implementation relevant only to particular parameterized solutions.

2. Recapitalizing methodological experience relating to the selection of program components

The analysis of the literature on the subject provides one with a complex set of methods of software components selection. The criteria of classification of given methods are the scope of application, size of the IT system implemented, the stage of the organization and computerization of the enterprise. Taking into account the applied mathematical apparatus of estimation methods of the IT program components, following A. Gospadarowicz, one may distinguish [1]:
- one-dimensional methods (comparative cost calculation, calculation of profitability, calculation of depreciation),
- multi-dimensional methods.

Multi-dimensional methods belong to a class of synthetic indicator methods. The results are obtained through a gradual aggregation of sets of singular indicators until achieving a summary value being the synthetic estimation of the object examined. The aggregation is performed using empirical data and mathematical methods (including statistical and econometrical methods), whereas the final value (summary synthetic estimation) is determined as a linear combination of individual values.

A. Gospodarowicz [1] underlines that depending on the way the particular indicators are selected and the weights ascribed to them, one may distinguish two types of synthetic indicator systems:
- not related to the method (selection of indicators, and their weights, being most suitable in a given situation, performed according to subjective knowledge and preferences of the researcher or analyst),
- related to the method (systems are designed with the application of statistic-mathematical and econometrical methods).

In matrix methods the issue of evaluation and selection of software components is presented as a matrix, lines and columns of which constitute a set of objectives subjected to evaluation and their values in terms of all criteria being analyzed.

Table 1. Presentation of problems in matrix methods

<table>
<thead>
<tr>
<th>K_1</th>
<th>O_1</th>
<th>O_2</th>
<th>...</th>
<th>O_n</th>
</tr>
</thead>
<tbody>
<tr>
<td>K_1</td>
<td>O_{11}</td>
<td>O_{21}</td>
<td>...</td>
<td>O_{n1}</td>
</tr>
<tr>
<td>K_2</td>
<td>O_{21}</td>
<td>O_{22}</td>
<td>...</td>
<td>O_{n2}</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>K_m</td>
<td>O_{m1}</td>
<td>O_{m2}</td>
<td>...</td>
<td>O_{mn}</td>
</tr>
</tbody>
</table>

Source: own study

The total estimation is determined by maximizing the sum total of objects’ criteria values or else, by determining the minimal variation from the value desired.

An essential part of the enterprise IT environment is the problem of selecting the user software. When analyzing the literature on this subject, one notices an extensive development of methods and models for software quality evaluation. A particularly useful solution is the methodology proposed by M. Sikorski [9]. Other methods are synthetically presented in the work of M Morisio [4]. Most proposals are focused on supporting the evaluation process and selection of suitable software from a set of ready-made solutions, with consideration for the individual preference system of a given decision-maker. Among them one may distinguish evaluation models constructed on the basis of multi-criteria decision aid [3,4,10]. These are successively [6]:
- aggregation to the relational system,
- aggregation to the utility function.

A recapitulation of these approaches based on the multi-criteria apparatus is presented in Table 2.
Table 2. Software evaluation models

<table>
<thead>
<tr>
<th></th>
<th>N. Meskens</th>
<th>V.R. Basili</th>
<th>G. Bolioz’i in</th>
<th>A. Kontio</th>
<th>B. Boehm</th>
<th>M. Morisio</th>
<th>M. Sikorski</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem description aspect (more than 1 problem evaluated)</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>The evaluation aspect (many variants and attributes)</td>
<td>• •</td>
<td>• •</td>
<td>• • • • •</td>
<td>• • • • •</td>
<td></td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Defining one’s own attributes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existent knowledge</td>
<td>• •</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision-making support mechanism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• • •</td>
<td></td>
<td>•</td>
</tr>
</tbody>
</table>

Source: own study

3. The application of AHP method in selecting IT infrastructure components

The analytic hierarchy process method (AHP) is a decision-aid for discrete multiple criteria decision-making process [1,2]. The AHP method embraces a multiple criteria approach, based on the compensating strategy of preference modelling, with the presupposition of the comparability of variants [7]. The idea behind the method is based on presenting the results of comparisons of evaluation criteria and choice alternatives in the form of square matrix [1]. Synthetic indicators are the values of utility function of successive decision variants and are determined with the application of additive form [8]:

\[ U(A_i) = \sum_{j=1}^{n} w_j * e_{ij} \]

where:
- \( U(A_i) \) - value of the utility function of ‘i’ decision variant,
- \( e_{ij} \) – value of the ‘i’ alternative in view of ‘j’ attribute (criterion),
- \( w_j \) – weight of ‘j’ criterion.

In the experimental research the possibility of modelling of preferences was analyzed from the point of view of particular software components. In the first phase, the evaluation model of software supporting the management and production subsystems of an enterprise, in compliance with the MRP specification, was structuralized. Data regarding expert evaluation were acquired from ranking reports. The complex character of the compilation, as well as the multi-level structuralization of the set of evaluation criteria make the process of clear-cut evaluation and the selection of suitable solution difficult. The detailed, lengthy set of system functional criteria presented is not directly useful for a decision-maker. It is thus necessary to determine aggregated values of systems’ evaluations. In order to obtain aggregated utility values of partial decision variants the soft-
ware user quality model according to ISO 9126 [5] (see Table 3) was applied, whereas the aggregation was executed with the use of AHP method.

Table 3. Software evaluation criteria according to ISO 9126 norm

<table>
<thead>
<tr>
<th>No</th>
<th>Name of criterion / subcriterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Functionality</td>
</tr>
<tr>
<td>1.1</td>
<td>Suitability</td>
</tr>
<tr>
<td>1.2</td>
<td>Accuracy</td>
</tr>
<tr>
<td>1.3</td>
<td>Interoperability</td>
</tr>
<tr>
<td>1.4</td>
<td>Security</td>
</tr>
<tr>
<td>1.5</td>
<td>Functional compliance</td>
</tr>
<tr>
<td>2.</td>
<td>Reliability</td>
</tr>
<tr>
<td>2.1</td>
<td>Maturity</td>
</tr>
<tr>
<td>2.2</td>
<td>Fault tolerance</td>
</tr>
<tr>
<td>2.3</td>
<td>Recoverability</td>
</tr>
<tr>
<td>2.4</td>
<td>Reliability compliance</td>
</tr>
<tr>
<td>3.</td>
<td>Usability</td>
</tr>
<tr>
<td>3.1</td>
<td>Understandability</td>
</tr>
<tr>
<td>3.2</td>
<td>Learnability</td>
</tr>
<tr>
<td>3.3</td>
<td>Operability</td>
</tr>
<tr>
<td>3.4</td>
<td>Attractiveness</td>
</tr>
<tr>
<td>3.5</td>
<td>Usability compliance</td>
</tr>
<tr>
<td>4.</td>
<td>Efficiency</td>
</tr>
<tr>
<td>4.1</td>
<td>Time behaviour</td>
</tr>
<tr>
<td>4.2</td>
<td>Resource utilization</td>
</tr>
<tr>
<td>4.3</td>
<td>Efficiency compliance</td>
</tr>
<tr>
<td>5.</td>
<td>Maintainability</td>
</tr>
<tr>
<td>5.1</td>
<td>Analyzability</td>
</tr>
<tr>
<td>5.2</td>
<td>Changeability</td>
</tr>
<tr>
<td>5.3</td>
<td>Stability</td>
</tr>
<tr>
<td>5.4</td>
<td>Testability</td>
</tr>
<tr>
<td>5.5</td>
<td>Maintainability compliance</td>
</tr>
<tr>
<td>6.</td>
<td>Portability</td>
</tr>
<tr>
<td>6.1</td>
<td>Adaptability</td>
</tr>
<tr>
<td>6.2</td>
<td>Installability</td>
</tr>
<tr>
<td>6.3</td>
<td>Co-existence</td>
</tr>
<tr>
<td>6.4</td>
<td>Replaceability</td>
</tr>
<tr>
<td>6.5</td>
<td>Portability compliance</td>
</tr>
</tbody>
</table>

Source: own study

Two additional economic criteria were introduced: purchase and implementation costs of the system (K7) and maintenance costs within a set time frames (K8). Moreover, the impact of changes in evaluation in the priority vectors upon the utility values of partial alternatives was examined. The results are presented in Graph 1.
Graph 1. The values of partial utilities in relation to changes in the priority vector.

Source: own calculations
When determining the priority vector the maximum own value method and the logarithmic smallest squares method were applied each time. It was observed that when the evaluations are highly compliable (indicator value CI < 0,1), the values obtained using both methods are very similar. The pattern of partial utilities presented in Graph 1. simultaneously is a base for determining the value of the global preferences vector.

4. Concluding remarks

It is possible to apply the AHP method both to dedicated and ready-made management information systems, simultaneously taking into account the requirement of their gradual implementation. Its clear algorithm and the possibility of applying the method in small and medium manufacturing enterprises account for the utility of this solution. An additional advantage is its lack of dependency on the degree of advancement of the information technology in an enterprise.

Bibliography