Assessment and Choice of Software Solution with the Analytic Network Process Method

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Abstract: Assessment and choice of software solution belong of the most difficult tasks facing business and IT experts. Multiple criteria decision methods can help in making that kind of a decision. However most of the methods is based on the assumption of criteria independence which is rarely fulfilled in practice. We applied the Analytic Network Process (ANP) as an aid for a choice of software solution and compare its results with the Analytic Hierarchy Process (AHP) method which is more often used in such a task.

1 INTRODUCTION

Under the pressure of rapid development of information and communication technologies (ICT) and the growing importance of information systems in business, the organizations often face the problem of matching the available ICT to business needs. A choice and successful implementation of the versatile ICT system is a serious challenge for an organization. Such a project lasts a long time, needs substantial investment and re-organization of most of the business procedures. A complete ICT system is a compound structure with many specialized components and an exchange of information between its components.

The aim of our work was to develop the effective decision aid for an assessment and choice of ICT solution characterized by a wide range of attributes by applying the Analytic Network Process (ANP) method for ranking the decision alternatives. The ANP seems to be more suitable then the other methods as it has the ability to handle the complicated decision model with many criteria and dependencies among them.

The article is structured as follows. Sec. 2 defines a research problem, Sec. 3 presents the ANP method. Sec. 4 contains the model of Business Intelligence (BI) systems assessment. Sec. 5 concludes the article.

2 THE PROBLEM OF CHOOSING THE ICT SYSTEM

Selecting a specific software is a stage of the whole decision process, where requirements formulated in the sphere of business and ICT meet together. Managers want the software to give them the greatest possible business opportunities and focus mainly on the software functionalities, while the ICT professionals have to take into account many technological limitations, existing and legacy systems, the possibility of performing additional tasks (administration, support and safety) and many others.

Selecting a software for the large-scale systems is a strategic decision because it determines the operating environment for a long time and bounds an organization to a particular vendor. It can be implemented in different ways (Woitsch et al., 2009). The most common approaches to that task can be described as heuristic approach as they are based on knowledge of experts involved in the process of software assessment. Hence, a quality of the decisions depends primarily on a quality of knowledge and an experience of experts. Yet, the serious difficulty encumber the heuristic procedure in practice. It is evoked by the enormous quantity of information that have to be processed on the way to final decision. ICT is a highly compound system of several components with many various sub-elements that are characterized by a large number of qualitative and quantitative features.

Risk of making the wrong choice is high because

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of the variety of offers, the high cost of software implementation that excludes rapid changes of environment, very long time needed for software deployments and because of technological and hardware linkages established during the project. All these risks can be reduced by a precise projection of business needs and technological constraints during the procedure of software selecting. Unfortunately, the desired properties of the system are often dependent on each other and they create a net rather then a simple hierarchy. So, it is necessary to use a method that gives the possibility of more than just a simple imposition of a set of weights.

Some number of formal methods that support software selection has been reported. The authors of Computer Science Technical Report mentioned, among others, 4 papers that use the linear weighted attribute method (simple additive weighting) (Fritz and Carter, 1994). The other similar multiple criteria decision methods, like SMART (Valiris et al., 2005) or ELECTRE II (Stamelos et al., 2000), also have been tested. Lai et al. report the results of a case study where the AHP method was employed to support the selection of multimedia authoring system (Lai et al., 2002). Selecting the best software product among the alternatives for each module in the development of modular software systems has also been done with the aid of AHP (Jung and Choi, 1999).

All methods mentioned above base on an assumption that the criteria, considered in the evaluation of alternatives, are independent. Yet, the ICT system is compounded from the interfering modules and it leads to some dependencies between criteria. Use of a method that can involve dependencies in the analyzed system may substantially improve the results.

Wu proposed a hybrid model that combines the Decision Making Trial and Evaluation Laboratory (DEMATEL) with the ANP and the zero-one goal programming (ZOGP) to get an effective solution that considers both financial and non-financial factors (Wu, 2008). Recently, ANP has been used to select most suitable simulation software (Ayağ, Zeki, 2011) and ERP system (Wieszała et al., 2011).

Almost all of the publications cited above concern the assessment of single, specialized software or consider (Wu, 2008) the series of the mutually non-excluded IT projects. Our evaluation deals with more complex implementation of a whole, multi-modular ITC system in an enterprise when only one alternative is to be selected.

3 THE ANALYTIC NETWORK PROCESS

The Analytic Network Process (ANP) (Saaty, 2005) is defined as a multiple criteria method that derives priority scales of absolute numbers from individual judgments. The numbers come out from the pairwise comparisons of elements of the studied system. One provides the judgment by answering two kinds of questions: 'Which of the two elements is more dominant with respect to a criterion?' or 'Which of the two elements influences the third element more with respect to a criterion?'

The ANP procedure can be summarized in the following steps:

1. Set up: a) the control criterion representing the decision problem, b) the main groups of criteria (named components or clusters) characterizing the decision problem, c) the criteria that belong to each cluster, d) the decision alternatives, e) the relations between elements of the decision model (criteria and alternatives).
2. Make all pairwise comparisons for relations in the model using the two kinds of questions mentioned above.
3. Perform the following operations: a) calculate priority vectors for supermatrix and cluster matrix, b) build the unweighted supermatrix, c) weight the unweighted supermatrix with the cluster matrix, d) calculate the limit supermatrix.
4. Read out the overall priorities for alternatives from the limit supermatrix. Discuss the results. If needed, make the suitable modifications of the model and repeat the procedure.

All steps besides Step 3, are the tasks that need to be made by people engaged in the decision process (decision maker(s) and/or analyst). Step 3 has a computational character and can be automatized with a suitable software (in this work, like in many others, the specialized software "Superdecisions" has been used). The short description of the operations of Step 3 is presented below.

A priority vector is derived from paired comparisons matrix by normalizing its columns and taking the geometric mean form rows (in the same way as in the AHP). Let's assume that we need to compare p elements of the model with respect to some control criterion. So, the pairwise comparison matrix C will be the square matrix of size $p \times p$. Saaty (Saaty, 2005) suggests to use the following scale to translate the verbal comparisons (easier to obtain from decision makers) into numbers: equal importance = 1; moderate importance = 3, strong importance = 5, very strong importance = 7, extreme importance = 9. The even numbers 2, 4, 6, 8 are used for an assessment lying between the above main points of scale.

Each priority vector becomes a column of matrix $W_{ij} = [w_{kl}]_{n_i \times n_j}$, where n_i (n_j) is a number of elements in cluster i (j). Let's assume that there is a system of N clusters. Then the supermatrix will be constructed from $N \times N$ blocks, i.e. $W = [W_{ij}]_{N \times N}$. W_{ij} represents the influence of the elements from cluster i on the elements from cluster j. The supermatrix W represents the influence priority of the element on the left of the matrix on the element at the top of the matrix.

In the next step, the supermatrix is transformed into a weighted supermatrix, i.e. to the matrix, whose columns sums to unity. Initially the supermatrix columns are made up of several eigenvectors which, in normalized form, sum to one and hence that column sums to the number of nonzero eigenvectors. The weighted supermatrix can be obtained by weighting the initial supermatrix with the cluster matrix. The cluster matrix contains eigenvectors representing the priorities of clusters with respect to the general control criterion (in most cases it will be a main objective).

In the end the limit matrix is derived by raising the weighted matrix to an arbitrarily high power. This procedure sums up the influences along paths of different length in the underlying network and determines the overall priorities.

4 THE ANP MODEL FOR BI SYSTEM SELECTION

The need for analysis and evaluation of BI environments results from the fact that none of the largest vendors of integrated analytical platforms offers full functionality required in management practice of business or public organizations. Moreover, an open source software often has functionality similar to commercial tools or even enhances specific business analytic modules. Flexibility and ease of adaptation to the particular needs are the advantages of an open source software.

Our example follows and supplements BI environments evaluation presented in (Dudała et al., 2010). The evaluation was conducted in five modules (according to classical architecture of BI environments): Database/Data Warehouse server, ETL tools, OLAP, Data Mining and Reporting tools. In each module a set of criteria was proposed. This modules take a role of criteria clusters in the ANP model. They are complemented by two other clusters: Main objective and Alternatives. The structure of the model, generated by Superdecisions software, is presented in fig. 1.

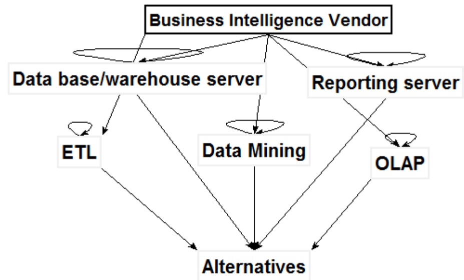

Figure 1: Clusters and their interrelations in the ANP model.

The cluster numbering and priorities of criteria clusters are as follows: 1. Alternatives; 2. Business Intelligence Vendor (main objective); 3. Data Base/Data warehouse server (0.042); 4. Data Mining (0.193); 5. ETL (0.229); 6. OLAP (0.418); 7. Reporting server (0.116).

The limited space prevent us to present the complete input data. Below, there are given only some parts of the unweighted supermatrix. Table 1 contains the example of criteria and their initial priorities.

Table 1: Criteria in cluster 6 OLAP.

No.	Criterion	Priority
61	Diff. data sources OLAP	0.139376
62	Graph. interf. OLAP	0.163747
63	Lic/fin cond. OLAP	0.162196
64	MDX language	0.139376
65	MS Office int. OLAP	0.139376
66	Security OLAP	0.127965
67	User supp. OLAP	0.127965

The priorities of alternatives with respect to the selected criteria are presented in Tab. 2 (sample for the cluster OLAP).

Table 2: Selected alternatives' priorities with respect to criteria from cluster 6 OLAP.

Alternative	Diff. data sources OLAP	User supp. OLAP
V1	0.084863	0.187670
V2	0.459105	0.187670
V3	0.154541	0.363056
V4	0.154541	0.199955
V5	0.146949	0.061648

A number of dependencies between criteria have to be considered. They regard criteria belonging to the same cluster and are represented by 'inner dependence loops' in fig. 1. The dependence of 'Lic/fin cond.' on other criteria in cluster 'Performance' on 'Scalability', 'Paralell computing' and in cluster 'OLAP' is a good example (see Tab. 3).

Table 3: The dependence of 'Lic/fin cond.' in cluster 6 OLAP.

No.	Criterion	Priority
62	Graph. interf. OLAP	0.113512
64	MDX language	0.539254
65	MS Office int. OLAP	0.244404
67	User supp. OLAP	0.102830

Calculations for the ANP and AHP models have been done with Superdecisions software (ANP Team, 2012). Fig. 2 shows the final priorities of alternatives given by ANP. For the sake of comparison the results of AHP are also presented.

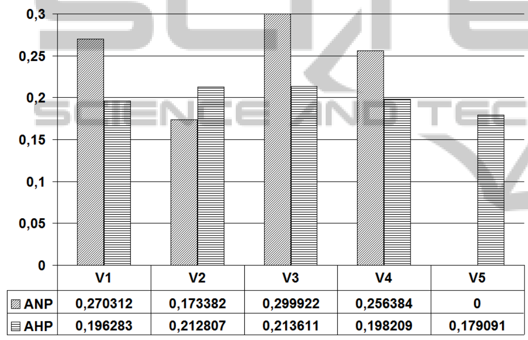

Figure 2: Final priorities of alternatives given by ANP and AHP models.

As it can be seen at Fig 2, the assessment with the ANP not only has changed the overall ranking but also has differentiated vendors much more then AHP. Hence, the ANP gives a better base for the final decision.

5 CONCLUSIONS

A software selection is a task that have to take into account multiple, often interdependent factors. This article shows how this task can be done with the ANP method. In comparison with the other methods, ANP allows better modeling of the needs of users as it allows for the relationships between elements of the modeled system. In fact, our example has demonstrated that an inclusion of the interrelations among factors may lead to different results in comparison to methods with independence principle (represented here by AHP).

We have built and solved the ANP model for an extended problem of BI system selection, in which all main modules has been considered: Data Base/Data Warehouse Server, Data Mining, ETL, OLAP and Reporting Server. Each of these modules, in turn, contained 7-14 criteria. Altogether the problem embodied 49 criteria, and additionally there were some dependencies between them. Inevitably, requiring the hundreds of comparisons, the procedure became really labor intensive and high demanding. The only excuse of this inconvenience is that several hours spent on pair-wise comparisons may be assumed as not so high cost in comparison with the overall time and money expense of such a big and important project. This also suggests a potential direction of the future study towards the methods with similar capabilities but less laborious and less demanding.

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