Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management
Kuala Lumpur, Malaysia, January 22 – 24, 2011

Evaluating Simulation Software Alternatives through ANP

Zeki Ayağ
Department of Industrial Engineering
Kadir Has University, Fatih, İstanbul, 34083, TURKEY

Abstract

In literature, there are a limited number of studies especially focusing on the methodologies of simulation software selection, although the selection of proper simulation software is of considerable importance to any simulation analyst in a simulation project or environment. To help fill the gap on this subject in the literature, in this study, an approach is presented to help any simulation practitioner select most suitable simulation software based on his/her needs. On the other hand, the best satisfying simulation software selection from a possible set of alternatives is a typical multiple criteria decision making (MCDM) problem in the presence of evaluation criteria, and there are many methods in the literature, one of which is the analytic network process (ANP) method. The ANP method as a more general form of AHP, uses uncertain human preferences as input information in the decision-making process, because AHP cannot accommodate the variety of interactions, dependencies and feedback between higher and lower level elements. In short, in this paper, an ANP-based approach is proposed to evaluate a set of simulation software alternatives in order to reach to the ultimate one among possible alternatives. In addition, a numerical example is presented to illustrate the proposed approach.

Keywords
Multiple criteria decision making, analytic network process, simulation software.

1. Introduction

In a period of continuous change in global business environment, organizations, large and small, are finding it increasingly difficult to deal with, and adjust to the demands for such change. Simulation is a powerful tool for allowing designers imagine new systems and enabling them to both quantify and observe behavior. Currently the market offers a variety of simulation software packages. Some are less expensive than others. Some are generic and can be used in a wide variety of application areas while others are more specific. Some have powerful features for modeling while others provide only basic features. Modeling approaches and strategies are different for different packages. Companies are seeking advice about the desirable features of software for manufacturing simulation, depending on the purpose of its use. Because of this, the importance of an adequate approach to simulation software selection is apparent [1].

Selecting the most appropriate simulation software tool for an application always requires thought and care. Typical items meriting consideration are the animation required (two- or three-dimensional), the level of programming skill required to use the tool effectively (e.g., familiarity with object-oriented or agent-based concepts), the availability of any constructs explicitly needed (e.g., bridge cranes, conveyors, automatic guided vehicles), the level of vendor support for the software, and many other interacting considerations [2].

In this study, an approach is presented to help any simulation practitioner select most suitable simulation software based on his/her needs. On the other hand, the best satisfying simulation software selection from a possible set of alternatives is a typical multiple criteria decision making (MCDM) problem in the presence of evaluation criteria, and there are many methods in the literature, which have been used to successfully carry out this difficult and time-consuming process. As one of the most commonly used techniques for solving MCDM problems, AHP was first introduced by [3]. In AHP, a hierarchy considers the distribution of a goal amongst the elements being compared, and judges which element has a greater influence on that goal. In reality, a holistic approach like ANP is needed if all attributes and alternatives involved are connected in a network system that accepts various dependencies. Several decision problems cannot be hierarchically structured because they involve the interactions and dependencies in higher or lower level elements. Not only does the importance of the attributes determine the importance of the alternatives as in AHP, but the importance of alternatives themselves also influences the importance of the attributes [4].

Shortly, in this paper, an ANP-based approach is presented to evaluate a set of simulation software alternatives in order to reach to the best software satisfying the needs and expectations of simulation practitioners.

2. Literature Review

In the literature, to the best of my knowledge, a limited number of works has been done for simulation software evaluation recently. Some of them are summarized as follows:

Tewoldeberhan *et al.* [5] proposed a two-phase evaluation and selection methodology for simulation software selection. As , phase-1 quickly narrows down the number of sofware package list to a short one, phase-2 matches the requirements of the company with the features of the simulation package more in detail. Various methods are used for a detailed evaluation of each package, participating their vendors in both phases. Hlupic and Mann [6] developed a software tool called as SimSelect that selects simulation software given the required features. It is evident form the material presented within this research that simulation modeling is the "cost-effective" method of exploring "what-if" scenarios quickly, and finding a solution to or providing a better understanding of the problem, as this method is supported by a number of software tools (similar to Simul8) that provide a graphical representation of the business processes through executable models. Seila *et al.* [7] presented a framework for evaluating simulation software alternatives for discrete-event simulation. The proposed framework evaluates nearly 20 software packages, and first tries to identify the project objective, since a common understanding of the objective will help frame discussions with internal company resources a well as vendors and service providers. It is also prudent to define long-term expectations. Other important questions deal with model dissemination across the organization for others to use, model builders and model users, type of process (assembly lines, counter operations, material handling) the models will be focused, range of systems represented by the models etc. Popovic *et al.* [8] developed criteria that can help experts in a flexible selection of business process management tools. They classified the simulation tools selection criteria in seven categories: model development, simulation, animation, integration with other tools, analysis of results, optimization, and testing and efficiency. The importance of individual criteria (its weight) is influenced by the goal of simulation project and its members (i.e., simulation model developers and model users).

In addition, Liang and Lien [9] used fuzzy AHP method to select the optimal ERP software by combining the ISO 9126 standard. Yazgan *et al.* [10] also focused for ERP software selection problem and utilized the combination of artificial neural network and the ANP. Assadi and Sowlati [11] proposed an approach to select a design and manufacturing package at a Canadian cabinet manufacturing company. They used several tangible and intangible criteria assessed in a group decision making using the AHP method. In another work, Wei *et al.* [12] used the AHP method to evaluate a set of ERP packages in terms of a group of evaluation criteria. Mulebeke and Zheng [13] used the ANP to help in the selection of appropriate software inn order to suit the product development process of a particular product in manufacturing systems.

3. Analytic Network Process (ANP)

The schematic representation of the ANP-based framework and its decision environment related to simulation software selection is illustrated in Figure 1. The overall objective is to find out the best simulation software among a set of alternatives. The clusters and elements in each cluster that are constructed for evaluating software alternatives are determined based on the needs and expectations of any simulation analyst in a simulation project or environment. So, they are very critical at the stage of the evaluation, and should be well-defined due to the fact that they play important role in finding out the best software out of the available options. For representation of pair wise comparison, firstly, the hierarchy of software selection should be established. The ANP method represents relationships hierarchically but does not require as strict a hierarchical structure and therefore allows for more complex interrelationships among the decision levels and attributes. After constructing flexible hierarchy, the decision-maker(s) is asked to compare the elements at a given level on a pair wise basis to estimate their relative importance in relation to the element at the immediate proceeding level.

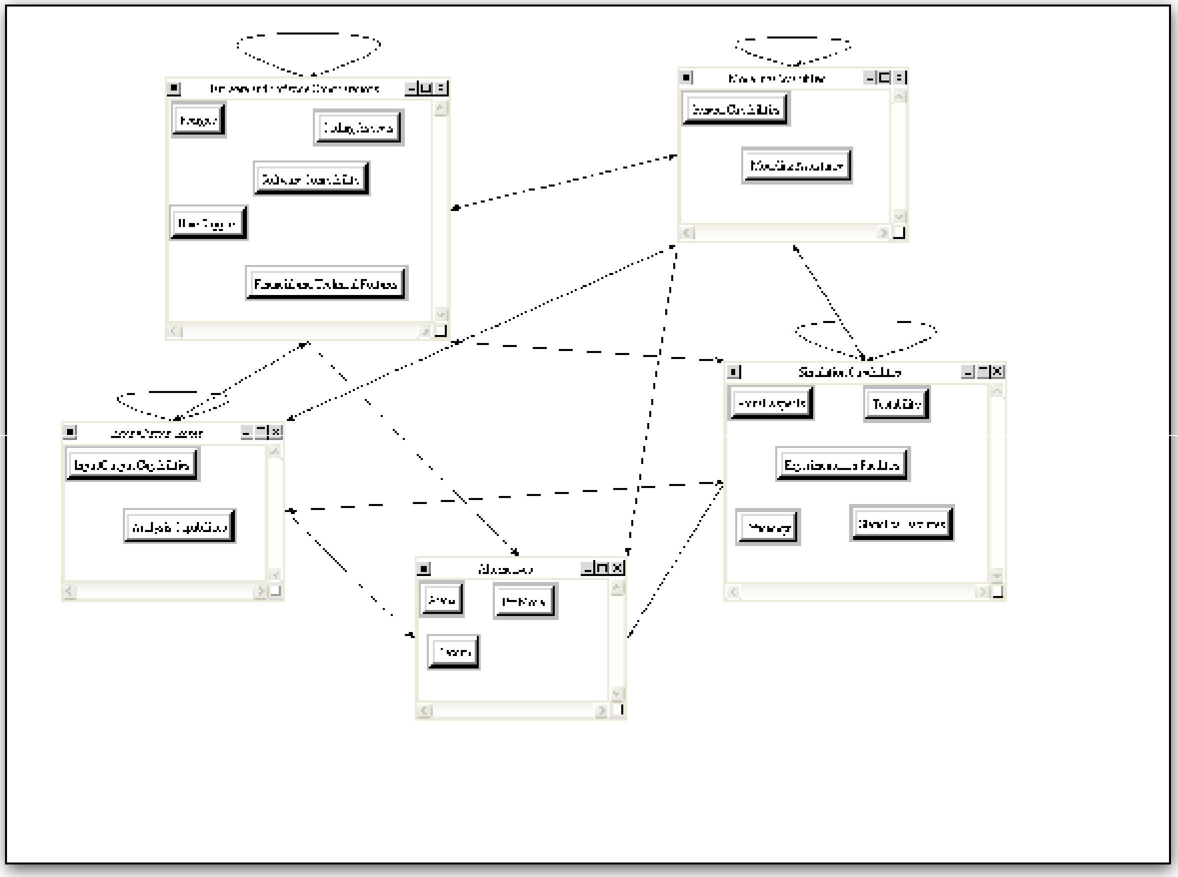

Figure 1: ANP network for simulation software selection problem

The method of ANP comprises four main steps [14]:

Step 1: Model construction and problem structuring: The problem should be stated clearly and decomposed into a rational system like a network. The structure can be obtained by the opinion of decision-makers.

Step 2: Pairwise comparisons matrices and priority vectors: In ANP, like AHP, decision elements at each component are compared pairwise with respect to their importance towards their control criterion, and the components themselves are also compared pairwise with respect to their contribution to the goal. The relative importance values are determined with Saaty's nine-point scale [1/9, 9]. A reciprocal value is assigned to the inverse comparison; that is, $a_{ij}=1/a_{ji}$, where a_{ij} (a_{ji}) denotes the importance of the ith (jth) element. Like AHP, pairwise comparison in ANP is made in the framework of a matrix, and a local priority vector can be derived as an estimate of relative importance associated with the elements (or components) being compared by solving the following equation, $A*w = \lambda max* w$, where A is the matrix of pairwise comparison, w is the eigenvector, and λmax is the largest eigenvalue of A.

Step 3: Supermatrix formation: The supermatrix concept is similar to the Markov chain process. To obtain long-term weights in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As a result, a supermatrix is actually a partitioned matrix, where each matrix segment represents a relationship between two nodes (components or clusters) in a system. Since there usually is interdependence among clusters in a network, the columns of a supermatrix usually sum to more than one. The supermatrix must be transformed first to make it stochastic, that is, each column of the matrix sums to unity. Raising a matrix to powers gives the long-term relative influences of the elements on each other. To achieve a convergence on the importance weights, the weighted supermatrix is raised to the power of $2k+1$, where k is an arbitrarily large number, and this new matrix is called the limit supermatrix. The limit supermatrix has the same form as the weighted supermatrix, but all the columns of the limit supermatrix are the same. By normalizing each column of this supermatrix, the final priorities of all the elements in the matrix can be obtained.

Step 4: Selection of the best alternative: If the supermatrix formed in Step 3 covers the whole network, the priority weights of alternatives can be found in the column of alternatives in the normalized supermatrix. On the other hand, if a supermatrix only comprises of components that are interrelated, additional calculation must be made to obtain the overall priorities of the alternatives. The alternative with the largest overall priority should be the one selected.

4. Numerical Example

In this section, a numerical example is presented to show the applicability of the ANP for software selection problem. First, to determine evaluation criteria, I utilized the work of Verma *et. al.* [15]. In their work, they derived the criteria that can be applied to the evaluation of any general or special purpose simulation package, and defined four main groups to develop an evaluation framework. Features within each group are further classified into subcategories based on their characters. The main and subcategories are given as follows:

The main categories:

- Hardware and software considerations: Pedigree, coding aspects, software compatibility, user support, financial and technical features.
- Modeling capabilities: General features, modeling assistance.
- Simulation capabilities: Visual aspects, efficiency, testability, experimentation facilities, statistical facilities.
- Input/Output issues: Input/Output capabilities, analysis capabilities.

Especially, in their work, each subcategory in a main category has also the elements listed more in detail. Furthermore, in the evaluation process, they used different scale system for each subcategory to reach the ultimate simulation software package. But, in my study, we only used the main and subcategories as the evaluation criteria, due to the fact that we should narrow down the number of the criteria to a reasonable level for both less computation time and effectiveness of the method.

Finally, we have 4 clusters (based on the main categories) and total 14 criteria (or subcategories) in all the clusters. Also, we formed 5th cluster for alternatives namely, Arena, Flexsim and Promodel. These alternatives were obtained from a set of possible alternatives by eliminating extreme ones. Later, an ANP framework was constructed as seen in Figure 1. The computation steps of the ANP method include a great deal of pairwise comparisons, constructing unweighted matrix showing all the interrelations in the hierarchy, calculation of weighted matrix, finding limit matrix and ranking alternatives. To facilitate these hard and time-consuming computations, I used Super Decisions Software. This software was invented by Thomas L. Saaty, and especially developed to easily and reliable solve multiple criteria decision making problems through the ANP method. It uses a nine-point scale, and also checks out the consistency of the judgments of decision-maker(s). The samples of the pairwise comparisons and final limit matrix are also given in Table 1, 2 and 3. Table 4 shows the final weights of alternatives and their rankings. All these tables and figure were produced through Super Decisions Software, freeware and most effective tool for the ANP applications in the related literature.

The results obtained from Super Decisions Software are shown in the Table 4. As seen in the table, the best alternative is Arena with highest weight.

Table 1: Cluster comparisons

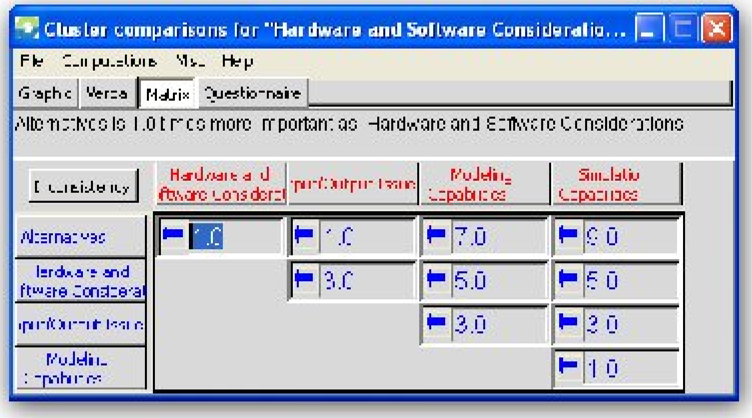

Table 2: Comparisons wrt “Pedigree” node in “Simulation Capabilities” cluster

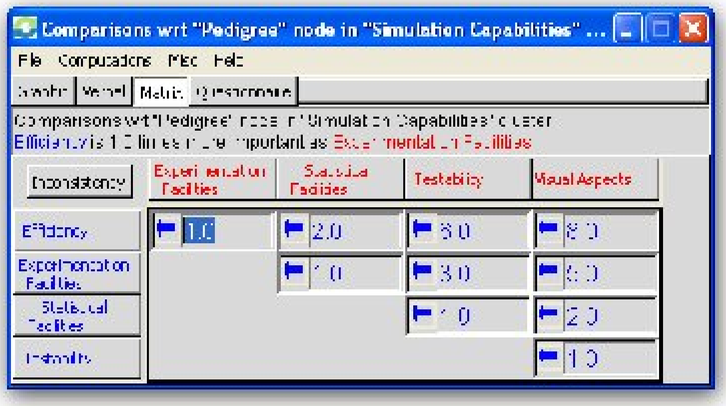

Table 3: Final limit matrix

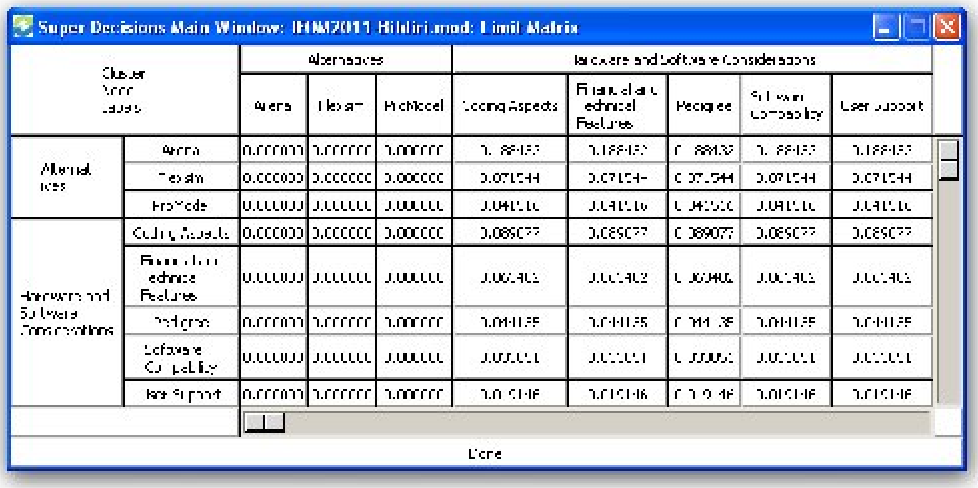

Table 4: Alternative rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Arena	0.1884	0.6244	1.0000	1
	Flexsim	0.0719	0.2382	0.3814	2
	Promodel	0.0415	0.1374	0.2201	3

5. Conclusions

In this work, an ANP based approach has been proposed to help any simulation analyst involving a simulation project evaluate a set of alternatives in terms of a group of tangible and intangible criteria. In our model, there are 3 alternatives and 14 evaluation criteria given in five clusters. It means that a great deal of pairwise comparisons needed execute the steps of the ANP method. To facilitate the calculations of the method, the Super Decisions software was used. The method could not be practical in the case that we have more than a reasonable number of alternatives and criteria, because the time needed to make all pairwise comparisons and calculations dramatically increases. For further work, the fuzzy logic can be integrated to the ANP method (called fuzzy ANP) by improving the nine-point scale with the fuzzy numbers in order to more accurately model vagueness in the judgments of decision-maker(s). Furthermore, an expert system for the problem can be developed to reflect the knowledge of an expert on the simulation software selection. This expert system helps the professionals to select the proper software without having deep knowledge of expertise.

References

1. Gupta, A., Verma, R., and Singh, K., 2009, "SmartSim Selector: A Software for Simulation Software Selection", International Journal of Applied Engineering Research, 4(6), 975-987.
2. Vasudevan, K., Lote, R., Williams, E., and Ulgen, O., 2009, "High Speed Bottle Manufacturing Lines: Case Studies and Simulation Software Selection Techniques", Proc. of the 2009 Winter Simulation Conference, Austin, Texas, 322-332.
3. Saaty, T.L., 1981, The Analytical Hierarchy Process, McGraw-Hill, New York.
4. Ayag, Z. and Özdemir, R.G., 2006, "An intelligent approach to ERP software selection through Fuzzy ANP", International Journal of Production Research, 45 (10), 2169-2194.
5. Tewoldeberhan, T.W., Verbraeck, A., Valentine, E., and Bardonnet, G., 2002, "An Evaluation and Selection Methodology for Discrete-Event Simulation Software", Proc. of the 2002 Winter Simulation Conference, Orlando, Florida, 67-75.
6. Hlupic, V. and Mann, A.S., 2002, "A System for Simulation Software Selection", Proc. of the 2002 Winter Simulation Conference, Orlando, Florida, 720-727.
7. Seila, A.F., Ceric, V., and Tadikamalla, P., 2003, Applied Simulation Modeling, Thomson Learning, Australia.
8. Popovic, A., Jaklic, J., and Vuksic, V.B., 2005, "Business Process Change and Simulation Modeling", System Integration Journal, 13(2), 29-37.
9. Liang, S.K., Lien, C.T., 2007, "Selecting the Optimal ERP Software by Combining the ISO 9126 Standard and Fuzzy AHP Approach", Contemporary Management Research, 3(1), 23-44.
10. Yazgan, H.R., Boran, S., Goztepe, K., 2009, "An ERP Software Selection Process with Using Artificial Neural Network Based on Analytic Network Process Approach", Expert Systems with Applications, 36, 9214-9222.
11. Assadi, P., Sowlati, T., 2009, "Design and Manufacturing Software Selection in the Wood Industry using Analytic Hierarchy Process", International Journal of Business Innovation and Research, 3(2), 182-198.
12. Wei, C.C., Chien, C.F., Wang, M.J.J., 2005, "An AHP-Based Approach to ERP System Selection", International Journal of Production Economics, 96, 47-62.
13. Mulebeke, J.A.W., Zheng, L., 2006, "Analytic Network Process for Software Selection in Product Development: A Case Study", Journal of Engineering Technology Management", 23, 337-352.
14. Saaty, T.L., 1996, Decision Making with Dependence and Feedback: The Analytic Network Process, RWS Publication, Pittsburgh, PA.
15. Verma, R., Gupta, A., and Singh, K., 2008, "Simulation Software Evaluation and Selection: A Comprehensive Framework", Journal of Automation and Systems Engineering (in-press).