A Comparative Study of an Improved pAHP Implementation in SOA Architecture

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***Abstract*—This article presents preliminary findings of practical comparative study of a new improved Probabilistic Analytic Hierarchy Process (pAHP) in comparison to classic AHP method in service selection problem in SOA architecture. The experiment illustrates the possibility of using an pAHP algorithm for selecting a proxy server in SOA architecture. A comparative study shows the use of the pAHP algorithm on data from servers of a real company. The effectiveness of the algorithm was tested and the statistically significance of pAHP over classical AHP was demonstrated in the defined case.**

***Index Terms*—SOA Architecture, Analytic Hierarchy Process.**

I. Introduction

A method for multi-criteria decision making is Analytic Hierarchical Process (AHP), presented by Thomas Saaty [1]. Classic AHP includes the reduction of decision problems to a series of comparisons and the synthesis of results using mathematical equations [2]. The AHP also includes the technique of examining the coherence of the decision-maker's assessments [3]–[8]. Classic AHP considers a set of criterias and a set of alternatives out of which the best alternative is determined [9]. A number of restrictions [10] of classic AHP [11] was our motivation to propose a new pAHP algirithm and to implement and assess its effectiveness for selecting optimal service in SOA architecture.

II. Probabilistic Analytic Hierarchical Process

The first step of pAHP is the acquisition of decision criteria and alternatives. The output of the step is a set of criteria and alternatives denoted by a and c. These are the vectors of alternatives and criteria, where $a^{(i)}$ is the i-th alternative, for $i \in \{1, 2, ..., m\}$, c_i is the i-th criterion for $i \in \{1, 2, ..., n\}$, m is the number of alternatives, n is the number of criteria [12]. In the second step, the process of determining the probability density function for the distribution of a random variable should start by calculation from the distribution of the random variable obtained from the sample based on the formula for Kernel estimation [13]:

$$\tilde{f}(x) = \frac{1}{mh} \sum_{i=1}^{m} K(\frac{x - x_i}{h}), \tag{1}$$

where: m is the number of sample elements, h - smoothing parameter, x_i are the next numerical values from the sample, K - this function is called kernel [14]. The third step is to set the weights of the criteria and alternatives. The output will be a vector of alternative weights against the criteria: w_j, for $j = 1, 2, ..., n$, where n is the number of criteria or the vector weighting criteria: $w^{(0)}$. Vector w_j, for $j = 1, ..., n$ is m-dimensional, where m is the number of alternatives, while $w^{(0)}$ is n-dimensional [15].

The fourth step is final ranking. Results for each alternative are obtained using the formula:

$$v^{(i),k} = \sum_{j=0}^{n} w_j^{(0)} \cdot w_j^{(i)}, \tag{2}$$

where: $v^{(i),k}$ is the point score of the i-th alternative in the k-th iteration, and $i \in \{1, ..., m\}$, $k \in \{1, 2, ..., N\}$, m is the number alternatives, N is the number of iterations, in (0) is the weight of the jth criterion, $w_j^{(0)}$ is the weight of the i-th alternative to j-th criterion for $i \in \{1, ..., m\}$ and $j \in \{1, 2, ..., n\}$, n is the number of criteria. The fifth step is to establish a probabilistic final ranking based on knowledge about the distributions. Our method is called P-THRESHOLD and calculates the probability of obtaining a score above a given threshold t: $v_{prob}^{(i)} = P(V^{(i)} > t)$.

III. Service selection with AHP and pAHP

In order to test the effectiveness of the pAHP, an algorithm for selecting a proxy server has been implemented. The environment based on Hetzner dedicated server type PX70-SSD enabled monitoring network traffic parameters such as: connection time (c_1), query response time (c_2), average transfer speed (c_3), success of delivery (c_4) which where used as algorithm criterias. The data forms where sent every minute to the test part of the office service. Four proxy servers were used. The observation lasted 30 days with 1800 parameter values collected for each hour. This was sufficient to determine for

TABLE I
Examples of average values of criteria

Alternative	c_1	c_2	c_3	c_4
$a^{(1)}$	0.54	12.21	25.2	0.87
$a^{(2)}$	2.12	10.12	35.4	0.90
$a^{(3)}$	0.31	3.42	192.3	0.91
$a^{(4)}$	0.87	15.23	20.4	0.90

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each criterion, the alternatives and the time of the probability density function of the criterion value. Examples of average values are shown in Table I. Identical comparisons with the pairs of criteria were proposed in Table II. The weight

TABLE II
COMPARISONS IN PAIRS OF CRITERIA

	c_1	c_2	c_3	c_4
c_1	1	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{9}$
c_2	3	1	2	$\frac{1}{3}$
c_3	3	$\frac{1}{2}$	1	$\frac{1}{3}$
c_4	9	3	3	1

vector for criteria, calculated using the matrix's own vector method, is: [0.062, 0.224, 0.158, 0.556]. This vector of weights was adopted regardless of the hour, because the validity of the criteria does not change over time. Normalization for the pAHP was performed by the expected value method. The P-THRESHOLD method was chosen to determine the final results. Probability density function of ranking random variables is presented in Figure 1. For each hour, one proxy server was selected for the classical and probabilistic AHP. Only hours in which decisions were different were selected for the satisfaction survey. The company's server used alternately

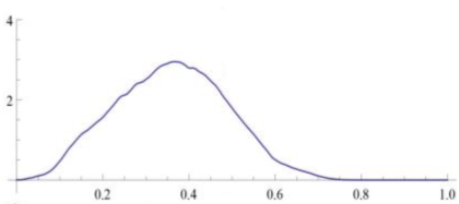

Fig. 1. Probability density function of ranking random variables

proxy servers selected by the classical and probabilistic AHP. The users assessed satisfaction with the shipment (quality of experience) according to their own criteria. The user did not know that he was involved in the study and had no knowledge about the method of sending data forms carried out by the company. The effectiveness of the algorithm is understood as

TABLE III
RESULTS OF THE USER SATISFACTION SURVEY

Grade	AHP	P-AHP
1	2	3
2	2	0
3	20	11
4	42	34
5	142	166
	222	226

the satisfaction of the system user. After sending the form, the user was asked about the satisfaction of shipping and assessed it on a scale of 1-5, where 1 is a lack of satisfaction, 5 is full satisfaction. The study was carried out for one week during the dispatch of annual testimonies. The test results were saved to the database and then made available to the author. The results are summarized in Table III. Classic AHP algorithm obtained the average of: 4.538, the variance 0.617 and the standard deviation: 0.785. The pAHP algorithm obtained an average of: 4.673, variance 0.503 and standard deviation: 0.709. Average rating indicates better results for pAHP.

IV. CONCLUSION AND FUTURE WORK

In this paper, we presented preliminary findings of comparative study of new improved probabilistic Analytic Hierarchy Process (pAHP) in comparison to classic AHP method. The experiment illustrated the possibility of using the implemented pAHP scheme for selecting a service in SOA architecture. The problem of selecting a proxy server to send queries was resolved. The statistically significance of probabilistic AHP over classical AHP was demonstrated in the defined case. The algorithm uses additional knowledge about probability distributions of criteria values for alternatives. This knowledge allows to make automated decisions without the participation of a decision maker. The conclusions confirm the thesis about the possibility of constructing a decision making algorithm in probabilistic conditions, which is significantly better than the classical Analytical Hierarchical Process. Our future work will focus on more detailed performance comparison of classical AHP and new improved pAHP by performing experiments on different case scenarios.

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