Determination of the Winner of Project Tender Using Analytical Hierarchy Process

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***Abstract*— Determination of the winner project tender is a fairly complex job. This is because the selection of winners is based on various criteria. On the other hand Analytical Hierarchy Process (AHP) is one method frequently used in the development of Decision Makers System. The principle of AHP method is choice of a decision based on consideration of various criteria. Such conditions make the AHP method suitable to be applied in determining the winner of the tender project. In this research, AHP architecture uses seven criteria, and seven alternatives. The seven criteria are price, specification, time, support, warranty, experience, and the browser. Meanwhile, the company that the alternatives to be selected are companies that have passed the prequalification stage. The winner is determined based on the order of greatest priority value.**

***Index Terms*— Analytical Hierarchy Process, Project Tender, Priority**

I. INTRODUCTION

Evolution, generalization, and collaboration concepts and principles in science and technology has enabled computer role not just as a tool for data processing or presentation of information only. Some concepts on the computer gives the possibility to be able to make the learning process, given the knowledge, given the rules and so forth, so be smart and can make his own decisions.

Decision Support System is a software product developed specifically to assist in decision making processes. In accordance with its name, the purpose of this system he used is as a "second opinion" or "information sources" that can be used as a material consideration before deciding on a particular policy.

Analytical to Hierarchy Process (AHP) is one method frequently used in making decisions. Globally, this method is based on [6]: (1) analysis of quantitative and qualitative decision, (2) evaluation and representation in a simple solution through a hierarchical model, (3) logical argument; (4) evaluating the quality of decisions, and (5) the time required is relatively short. Such conditions give the likelihood that the decisions that were made through this method is more objective.

AHP method has been widely used in the development of Decision Support Systems, among others, Selection of Structural [7], Outstanding Employee Selection [1], Development of Productivity Hotel [9], Priority Determination for Component Selection Gravael Pump [8], Proposed Supplier Selection [2] , Analysis of factors affecting the use of private cars [3], and optimizing investment opportunities [8].

In this research, AHP will be applied in developing a Decision Support System for analyzing the winner of project tender. The selection of this object because the process of determining the tender winner based on criteria that many and complex. This led to a decision about the winning bidder is sometimes subjective, so that harm others. The output of this research is software that can be used to assist the committee in analyzing and assessing auction participants. Results of the analysis can then be used as a consideration in deciding the winner of the tender project.

II. ANALYTIC HIERARCHY PROCESS

Method of Analytic Hierarchy Process (AHP) is a general theory of measurement [3]. Four kinds of measurement scales that are usually used in a sequence is a nominal scale, ordinal, interval and ratio. A higher scale can be categorized into a lower scale, but not vice versa. As an illustration of the scale monthly income ratio can be categorized into an ordinal scale income level or category (high, medium, low), the nominal scale. Conversely, if at the time of the measurement data obtained is or ordinal categories, higher-scale data can not be obtained. Such problems are a large part be solved by AHP method.

AHP is used to derive ratio scales from paired comparison of several discrete and continuous natures. Pairwise comparison can be obtained through actual measurement and relative measurement of the degree of preference, or the interests or feelings. Thus this method is very useful to help get the scale ratio of the original things that are difficult to measure, such as opinions, feelings, attitudes and beliefs [6].

The use of AHP starts by creating a hierarchical structure or network of the problems who want to study [6]. In the hierarchy there are the main objectives, criteria, sub criteria,

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sub criteria and alternatives which will be discussed. Paired comparison is used to form relationships within the structure [3]. The results of this pairwise comparison matrix, which will form the ratio scale derived in the form of major eigenvectors or eigen-function [4]. Matrix is characterized by positive and negative, i.e. aij = 1 / aji.

An abstraction hierarchy structure of a system that studies the interaction between the components and functions also impacts on the system. The preparation of the hierarchy or structure of the decision made to describe the elements of a system or an alternative decision identified [4].

One problem will be resolved, resolved into its elements, namely the criteria and alternatives, and then organized into a hierarchy structure like Figure 1.

Hierarchy serves as a tool of the easiest to understand a complex problem where the problem is decomposed into the relevant elements, arranging the elements as well as determine which decisions will be taken. The compilation process elements are hierarchical groupings include elements that are homogeneous in the components and devise tresebut components in the appropriate hierarchy level

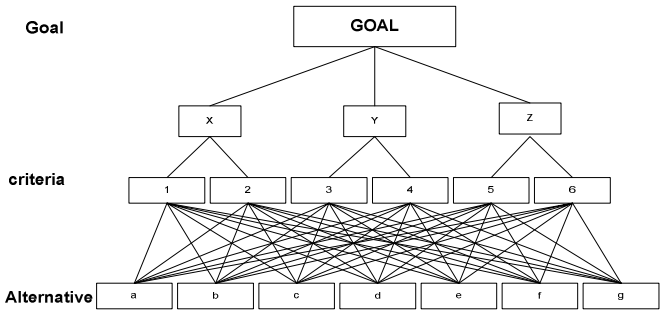

Figure 1. Structure hierarchy AHP

The lines connecting the boxes represents the relationship between the levels that need to be measured by paired comparison with the direction to a higher level.

TABLE 1
THE SAATY RATING SCALE

1	equal importance
3	weak importance (of one over the other)
5	strong importance
7	demonstrated importance over the other
9	absolute importance
2,4,6,8	intermediate values between

Given these factors was measured relative to each other, relative measurement scale of 1 to 9, as shown in Table 1, it is proposed to be used by Saaty [3.4].

Overall, the measures used in the formulation of a hierarchical structure that includes:

(1) Determine the types of criteria that will be requirements for prospective bidders who put in the form of matrix pairs. Forms of matrix pairs are shown in Table 2.

TABLE 2
PAIRWISE MATRIX CRITERIA

	A	B	C	D	E	F	G	etc
A								
B								
C								
D								
E								
F								
G								
etc								

Entry of elemen matrix :

1. a[i,j] =1, i = 1 ...n dan j = 1...n
2. Triangle of the matrix elements as input
3. a[j,i] = $a[i,j]^{-1}$, untuk setiap $i \neq j$

(2) Count sum elements of each column in the Tabel 2
(3) Determining the value of the column elements of criteria using the formula: each cell in Table 2 are divided by their respective number of columns in step (1).
(4) Determining of criteria priority with the formula of the number of lines at Table 2 divided by many criteria
(5) Enter the company name data bidders in the form of matrix pairwise (matrix of alternative). Table 3.

TABLE 3
PAIRWISE MATRIX CRITERIA

	Company							
	a	b	c	d	e	f	G	etc
a								
b								
c								
d								
e								
f								
g								
etc								

(6) Count sum elements of each column in the Table 3.
(7) Determining the value of the column elements of criteria using the formula: each cell in Table 3 is divided by their respective number of columns in step (5).
(8) Determining of the candidate winner priority with the formula of the number of lines at Table 3 divided by many candidates.
(9) Determine the consistency of each matrix element in pairs for each alternative. The formula used every element of the matrix pairs in step (2) multiplied by the value of the

priority criteria. The element of each row are added and the result divided by the priority criteria

(10) Calculate λ_{max}, CI and CR with formula (1), (2), and (3) [5]:

$\lambda_{max} = (\sum \lambda \ - n) / n$ ..... (1)
CI = λ_{max} / n – 1 ..... (2)
CR = CI / RC ..... (3)

TABLE 4. RC

N	RC	N	RC	N	RC
1	0.00	6	1.24	11	1.51
2	0.00	7	1.32	12	1.48
3	0.58	8	1.41	13	1.56
4	0.90	9	1.45	14	1.57
5	1.12	10	1.49	15	1.59

(11) Determine the value of global priorities

III. RESULT AND DISCUSSION

In accordance with the steps set forth in the AHP method, hence in this study used seven criteria to determine the winner of the tender procurement project. The seven criteria are: (1) price, (2) specifications, (3) time, (4) support resources, (5) the sale of collateral, (6) experience; (7) browser. Meanwhile, an alternative use as many as seven companies which had passed pre-qualification stage. Each company was given the index of A, B, C, D, E, F, G. Index is intended to provide a more objective assessment. Hierarchical structure that occurred in this study is Figure 2.

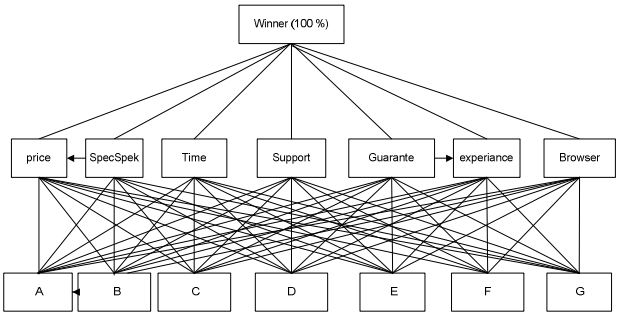

Figure 2. Hierarchical structure of project tender

From the hierarchical structure in the figure 2, the pairwise matrix comparison was developed, and followed by counting the number of columns from the matrix. The results are shown in Table 5.

TABLE 5. PAIRWISE MATRIX

	Prace	Spec	Time	Support	Guarantee	Experience	Browsur
price	1	2	5	3	3	3	2
Spec	0.500	1	2	3	2	3	2
Time	0.2	0.500	1	2	2	5	2
support	0.333	0.333	0.5	1	2	3	2
Guarantee	0.333	0.5	0.5	0.5	1	3	3
experience	0.333	0.333	0.2	0.333	0.333	1	3
Browsur	0.5	0.500	0.5	0.333	0.333	0.333	1
Total	3.200	5.167	9.7	10.167	10.667	18.333	15

The next step, determining the value of the column elements of criteria using the formula: each cell in Table 2 is divided by their respective number of columns in Table 5. The results are shown in Table 6.

TABLE 6. VALUE AND NUMBER OF CLASSIFIED COLUMN ELEMENT

	Price	Spec	Time	Support	Guarantee	experience	Browsur	Total
price	0.313	0.387	0.515	0.295	0.281	0.164	0.133	2.088
Spec	0.156	0.194	0.206	0.295	0.188	0.164	0.133	1.336
Time	0.063	0.097	0.103	0.197	0.188	0.273	0.133	1.053
support	0.104	0.065	0.052	0.098	0.188	0.164	0.133	0.803
Guarantee	0.104	0.097	0.052	0.049	0.094	0.164	0.200	0.759
experience	0.104	0.065	0.021	0.033	0.031	0.055	0.200	0.508
Brochure	0.156	0.097	0.052	0.033	0.031	0.018	0.067	0.453

After the value of the column elements and the number of rows is known. The next step is to assign priority criteria. The formula used is the number of rows in Table 6 divided by many criteria. The results of these calculations are shown in Table 7.

After getting the priority criteria, the next step is to calculate the priority of candidates for the winning tender for each criteria. Comparison pairs values for each of the potential winners for each criteria are shown in Table 8A, 8B, 8C, 8D, 8E, 8F, 8G.

After the comparison matrix is obtained, then the next xtep is to calculate the priority score of each alternative for each criteria. The results are shown in Table 9 below.

Next, calculate the logical consistency, with a provision divided by the number of lines priority criteria. The results are shown in Table 10.

TABLE 6. PRIORITY VALUE CRITERIA

Criteria	Priority
price	0.2983375
Spec	0.1907908
Time	0.1503784
support	0.1147228
Guarantee	0.1084363
experience	0.0725548
Brochure	0.0647794

TABLE 8A. PAIRWISE COMPARISON MATRIX FOR EACH ALTERNATIVE PRICE CRITERIA

	A	B	C	D	E	F	G
A	1	2	3	3	2	3	5
B	0.5	1	5	3	3	2	3
C	0.333	0.2	1	3	5	5	5
D	0.333	0.333	0.333	1	2	3	3
E	0.5	0.333	0.2	0.5	1	5	2
F	0.333	0.2	0.2	0.333	0.2	1	2
G	0.2	0.2	0.333	0.333	0.5	0.5	1
Total	3.2	4.267	10.067	11.167	13.7	19.5	21

TABLE 8B. PAIRWISE COMPARISON MATRIX FOR EACH ALTERNATIVE SPESIFICATION CRITERIA

	A	B	C	D	E	F	G
A	1	3	2	3	2	3	3
B	0.333	1	3	3	2	2	3
C	0.500	0.333	1	3	5	5	5
D	0.333	0.333	0.333	1	5	3	3
E	0.5	0.500	0.2	0.2	1	5	5
F	0.333	0.2	0.2	0.333	0.2	1	2
G	0.333	0.2	0.333	0.333	0.2	0.5	1
Total	3.333	5.567	7.067	10.867	15.4	19.5	22

TABLE 8C. PAIRWISE COMPARISON MATRIX FOR EACH ALTERNATIVE EXECUTION TIME CRITERIA

	A	B	C	D	E	F	G
A	1	2	3	3	2	5	3
B	0.5	1	3	3	2	2	3
C	0.333	0.333	1	5	5	5	5
D	0.333	0.333	0.200	1	5	3	3
E	0.5	0.500	0.2	0.2	5	5	5
F	0.200	0.2	0.2	0.333	0.2	1	5
G	0.333	0.2	0.333	0.333	0.2	0.2	1
Total	3.2	4.567	7.933	12.867	19.4	21.2	25

TABLE 8D. PAIRWISE COMPARISON MATRIX FOR EACH ALTERNATIVE FOR RESOURCE SUPPORT CRITERIA

	A	B	C	D	E	F	G
A	1	2	2	3	2	3	2
B	0.5	1	3	2	2	2	3
C	0.500	0.333	1	5	5	5	5
D	0.333	0.500	0.200	1	5	3	3
E	0.5	0.500	0.2	0.2	5	5	5
F	0.333	0.2	0.2	0.333	0.2	1	5
G	0.5	0.2	0.333	0.333	0.2	0.2	1
Total	3.667	4.733	6.933	11.867	19.4	19.2	24

TABLE 8E. PAIRWISE COMPARISON MATRIX FOR EACH ALTERNATIVE FOR WARRANTY SUPPORT CRITERIA

	A	B	C	D	E	F	G
A	1	3	3	3	2	3	2
B	0.333	1	3	5	5	2	3
C	0.333	0.333	1	5	5	5	5
D	0.333	0.200	0.200	1	5	3	2
E	0.5	0.200	0.2	0.2	5	5	5
F	0.333	0.2	0.2	0.333	0.2	1	5
G	0.5	0.2	0.500	0.500	0.2	0.2	1
Total	3.333	5.133	8.100	15.033	22.4	19.2	23

TABLE 8F. PAIRWISE COMPARISON MATRIX FOR EACH ALTERNATIVE FOR EXPERIENCE CRITERIA

	A	B	C	D	E	F	G
A	1	3	2	3	2	3	2
B	0.33 3	1	2	2	3	2	3
C	0.50 0	0.5	1	2	2	3	2
D	0.33 3	0.500	0.500	1	3	3	2
E	0.5	0.333	0.5	0.333	5	5	3
F	0.33 3	0.333	0.333	0.333	0.2	1	5
G	0.5	0.5	0.500	0.500	0.333	0.2	1
Total	3.5	6.167	6.833	9.167	15.53 3	17.2	18

TABLE 8G. PAIRWISE COMPARISON MATRIX FOR EACH ALTERNATIVE FOR BROWSUR CRITERIA

	A	B	C	D	E	F	G
A	1	2	2	3	2	3	2
B	0.5	1	2	2	3	3	3
C	0.500	0.5	1	3	3	3	2
D	0.333	0.500	0.333	1	3	3	2
E	0.5	0.333	0.333	0.333	5	2	3
F	0.333	0.333	0.333	0.333	0.5	1	5
G	0.5	0.5	0.500	0.500	0.333	0.2	1
Total	3.666 7	5.167	6.500	10.16 7	16.83 3	15. 2	1 8

TABLE 9. PRIORITY SCORE EACH ALTERNATIVE

	Price	Spec	Time	Suppo rt	Guara ntee	experi ence	Broch ure
A	0.269	0.260	0.260	0.226	0.255	0.258	0.241
B	0.231	0.193	0.186	0.183	0.208	0.178	0.197
C	0.197	0.205	0.198	0.214	0.189	0.143	0.167
D	0.107	0.131	0.114	0.121	0.100	0.120	0.118
E	0.103	0.119	0.143	0.145	0.133	0.155	0.126
F	0.052	0.050	0.059	0.066	0.066	0.083	0.088
G	0.040	0.043	0.039	0.045	0.050	0.063	0.064

TABLE 10. VALUE λ FOR EACH CRITERIA

Row Total	Priority Criteria	Result (λ)
0.8668	0.2983	2.9056
0.4416	0.1908	2.3144
0.2132	0.1504	1.4175
0.2110	0.1147	1.8390
0.2368	0.1084	2.1841
0.1927	0.0726	2.6566
0.2892	0.0648	4.4637
Total λ		17.78098

From the table above can be calculated λ_{max} , CI and CR with formula (1), (2), (3), the results were :

λ_{max} = 17.78098 : 7 = 2.540141
CI = (λ_{max} – n) : (n – 1) =(2.540141 – 7) / 6 = -0.74331
CR = (CI : RC) = - 0.74331 : 1.32 = -0.56311

From these calculations it appears that CR <0.1, which means the pairwise values on matrix criteria provided is consistent.

The next step is to calculate the value of each alternative criteria (prospective tenders) for each item criteria in a way, the matrix in Table 7 multiplied by the matrix in Table 7, so the results are shown in Table 11.

TABLE 10. VALUE CRITERIA EACH ALTERNATIVE

	Price	Spec	Time	Suppo rt	Guara ntee	experi ence	Broch ure
A	0.080	0.050	0.039	0.026	0.028	0.019	0.016
B	0.069	0.037	0.028	0.021	0.023	0.013	0.013
C	0.059	0.039	0.030	0.025	0.020	0.010	0.011
D	0.032	0.025	0.017	0.014	0.011	0.009	0.008
E	0.031	0.023	0.021	0.017	0.014	0.011	0.008
F	0.015	0.010	0.009	0.008	0.007	0.006	0.006
G	0.012	0.008	0.006	0.005	0.005	0.005	0.004

Last set global priorities, namely by summing up the rows in Table 12.

TABLE 12. GLOBAL PRIORITY VALUE FOR EACH ALTERNATIVE

Alternatives	Global Priority
A	0.256965
B	0.203023
C	0.193901
D	0.114950
E	0.125484
F	0.060337
G	0.045340

From Table 12, it can be the order of the winning tenders is :

TABLE 13. SEQUENCE PRIORITY TENDER WINNER

Rank	Company Index	Global Priority
1	A	0.256965
2	B	0.203023
3	C	0.193901
4	E	0.125484
5	D	0.114950
6	F	0.060337
7	G	0.045340

IV. CONCLUSION

Software for determining the winner of the tender procurement projects by AHP methods have been developed. The winner of the project tender generated by this software is more objective compared with manual calculation

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