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Rank Employee Promotion Eligibility Based on AHP & Fuzzy TOPSIS

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Abstract:
The quality of human resources in an organization or a corporate is one of, if not the most significant factor in terms of corporate's performance and progress, the human resource holds an important role in the process of increasing the organization and corporate performance, this process includes aspects such as planning, leadership, skills and the ability to work together as a team. Organization or corporate use various types of rewards to employees to enhance their performance (Amabile, 1996) in practice, a performance or work evaluation is needed to choose and filter the best employees to maximize the selection of promotion, This process also needs a thorough evaluation process in order to choose the best employee in order to maximize overall organization or company performance, to bolster this process we need an efficient and effective method that can generate an objective result that can help decision makers.

Keywords: *AHP; DSS; employee assestment; fuzzy; human resource development; TOPSIS*

1. Introduction

Human resources are an essential factor in an organization or company, they offer a brief perspective as well as attributes into the organization, when resource management becomes effective, the nature and attributes of human resources can be a critical benefit to the organization as a whole [1], the main purpose of the job assessment or job evaluation is to be able to provide an input [2], the input herein may be interpreted as an action performed by the supervisor of an employee to provide information about the performance employee themselves [3]. This input or evaluation process consists of two ways discussion concerning about employee performance evaluation that will become the basis of an administrative decisions. Such as salary, promotion, dismissal and development of each employee in order to synergize with the goals of the company [4]. In the research [5] human resource management with an appreciation model with individual employee assessment increases the overall company performance through employee's engagements, it concludes that the model of resource management can improve the ability and collective motivation of individual employee. This process involves planning, organizing, directing and controlling the employee promotion process, this continues with training as well as the development and an integration of all individuals with a purpose to help an organization or a company achieve its goals [6].

2. Basic Theory

2.1. Analytical Hierarchy Process

This method was developed by prof. Thomas. L. Saaty from the University of Pittsburgh in the 1970s [20]. AHP is based on the theory of hierarchy building, priority setting, and reasonable consistency, in which the method describes a complex multi-criteria decision-making process into a hierarchy of related decision criteria, then the decision is made by comparing pairs of selected alternatives using pairwise comparisons which in its weight-of-interest judgment involves decision makers who understand and grasp the goals and objectives of the organization [21]. AHP is based on the following steps:

- MCDM (Multi Criteria Decision Making) is structured as a hierarchy. MCDM is declared into a hierarchy of interrelated decision elements. With AHP, objectives, criteria and alternatives are arranged in a hierarchical structure. Typically, the hierarchy has three levels as shown in Fig 1.

- Form a pairwise comparison matrix by assessing criteria and alternatives through paired comparisons, we need a scale of numbers that indicates how many times more important or dominant one element is over another element with respect to the criterion or property with respect to which they are compared [x] using a comparison scale shown in Table 1.

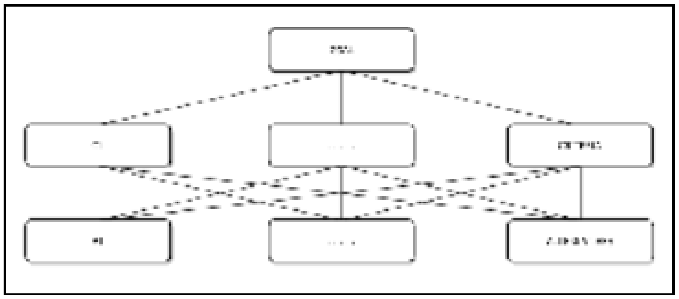

Figure 1: AHP Structure

Value	Definition
1	Equal Importance
3	Weak or Slight
5	Strong Importance
7	Very Strong or Demonstrated Importance
9	Extreme Importance
2,4,6,8	Intermediate Values

Table 1: Standard Comparison in Pairs

- Find criteria weight by calculating the relative weights, as relative weights given by the eigenvector (w) corresponding to the largest eigenvalue as (λmax), according to equation:

  (1) $A_W = \lambda_{max} w$

- Find logical consistency requirements, in which there are two parameters, Consistency Index (CI) and Consistency Ratio (CR), both are calculated by the following equations:

$$CI = \frac{\lambda_{max} - n}{n-1},$$

$$CR = \frac{CI}{RI},$$

- Where RI is a random index that adjust the amount by number of different criteria shown in Table 2, if CR (Consistency Ratio) is less than 0.10 the result is acceptable and the matrix is considered consistent [22]

n	1	2	3	4	5	6	7	8	9
RI	0.58	0	0	0.58	0.90	1.12	1.24	1.32	1.45

Table 2: Relationship between Ri Values and Criterion Count

2.2. TOPSIS

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method was first supplemented by Hwang and Yoon [23], according to the theory, the best alternative should have two features, which have the closest distance to the positive ideal solution and have the greatest distance to the negative ideal solution [24]. TOPSIS is based on following steps :

- Construct a normalized decision matrix with the equation:

(4) $$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{n} f_{ij}^2}} \quad i = 1,2\ldots m; \quad j = 1,2\ldots$$

- Calculate the weighted normalized decision matrix, the matrix is generated by multiplying the normalized decision matrix by the corresponding weights, this process is done by the equation (5) where *wj* is the weight of the attribute *j* or criterion.

(5) $\upsilon_{ij} = w_j * r_{ij} \quad i = 1,2\ldots m; \quad j = 1,2\ldots n,$

- Determine the ideal positive solution (A*) and the ideal negative solution (A-) by the equation (6),(7), where I 'is associated with the benefit criterion and I "is associated with the cost (28) criterion.

(6) $$A^* = \{\upsilon_1^*, \upsilon_2^*, \ldots, \upsilon_n^*\} = \{(\max_j \upsilon_{ij} | i \in I'), (\min_j \upsilon_{ij} | i \in I'')\} \quad i = 1,2\ldots m; \quad j = 1,2\ldots n,$$

(7) $$A^- = \{\upsilon_1^-, \upsilon_2^-, \ldots, \upsilon_n^-\} = \{(\min_j \upsilon_{ij} | i \in I'), (\max_j \upsilon_{ij} | i \in I'')\} \quad i = 1,2\ldots m; \quad j = 1,2\ldots n,$$

- Determine the distance between the value of each alternative with the positive and positive ideal solution matrix with the equation:

(8) $$D_i^* = \sum_{j=1}^{n} d(\upsilon_{ij}, \upsilon_j^*) \quad i = 1,2\ldots m.$$

(9) $$D_i^- = \sum_{j=1}^{n} d(\upsilon_{ij}, \upsilon_j^-) \quad i = 1,2\ldots m.$$

- Calculate the relative proximity to the ideal solution. The relative closeness of the alternatives is defined as:

(10) $$CC_i^* = \frac{D_i^-}{D_i^* + D_i^-} \quad i = 1,2\ldots m.$$

2.3. Fuzzy Set Theory

The fuzzy set theory [25] has been used for the modeling of decisions that are in the basics of unclear information as in judgments made by decision makers, qualitative aspects represented by linguistic variables, which are qualitatively expressed in linguistic terms and quantitatively expressed by the fuzzy set in the universe of each membership function [26], some important definitions in the fuzzy set:

- *Definition 1:* A fuzzy set A in the universe X is characterized by a membership function μa associated with each element of x in the X real number in the interval [0, 1]. The value of the function μa is called the membership level of *x* in A [25], [27].
- *Definition 2*: A fuzzy a triangle can be defined by (a1, a2, a3) where a3 is greater than a2 and a2 is larger than a1. The mathematical form of a fuzzy triangle shown as:

(11) $$\mu_{\tilde{a}}(x) = \begin{cases} 0, & x \leqslant a_1, \\ \frac{x-a_1}{a_2-a_1}, & a_1 < x \leqslant a_2, \\ \frac{a_3-x}{a_3-a_2}, & a_2 < x \leqslant a_3, \\ 0, & x > a_3. \end{cases}$$

And the operational laws of these two triangular fuzzy numbers (29), (30) expressed as:

Addition of two triangular fuzzy numbers:

(12) $\tilde{a} + \tilde{b} = (a_1, a_2, a_3) + (b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3)$

Subtraction of two triangular fuzzy numbers:

(13) $\tilde{a} - \tilde{b} = (a_1, a_2, a_3) - (b_1, b_2, b_3) = (a_1 - b_1, a_2 - b_2, a_3 - b_3)$

Multiplication of two triangular fuzzy numbers:

(14) $\tilde{a} \times \tilde{b} = (a_1, a_2, a_3) \times (b_1, b_2, b_3) = (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3$

Division of two triangular fuzzy numbers:

(15) $\tilde{a} \div \tilde{b} = (a_1, a_2, a_3) \div (b_1, b_2, b_3) = (a_1 \div b_1, a_2 \div b_2, a_3 \div b_3)$

Inverse of a triangular fuzzy number:

(16) $\tilde{a}^{-1} = (a_1, a_2, a_3)^{-1} = \left(\frac{1}{a_3}, \frac{1}{a_2}, \frac{1}{a_1}\right)$

If a = (a1, a2, a3) and b = (b1, b2, b3) are two fuzzy triangles, then the distance between them is calculated by following equation:

(17) $\tilde{a}^{-1} = (a_1, a_2, a_3)^{-1} = \left(\frac{1}{a_3}, \frac{1}{a_2}, \frac{1}{a_1}\right)$

A linguistic variable is the value of a variable expressed in linguistic terms. The concept of linguistic variables very useful in dealing with situations that are too complex or too obscure will be adequately explained in conventional quantitative expression [26]

2.4. Fuzzy TOPSIS

Fuzzy TOPSIS is an extension of TOPSIS method which was first introduced by Chen [28] to solve the problem of multi criteria decision making problems (MCDM) with uncertainty, in which linguistic variables are used by decision makers to assess the weight of the criteria and rating of the alternatives, the steps are as follows:

- Determine the weighting of the evaluation criteria, this can be acquired with AHP method.
- Determine the linguistic value (*xij*; *i* - 1,2 ... *m; j* = 1,2 ... n) for each alternative with its respective criteria, the linguistic value of fuzzy *xij* keeps the distance from the fuzzy triangle set to [0,1] thus normalization is not required.
- Develop a fuzzy decision matrix, a normalized weighted value of *vij* acquired with the equation:

(18) $v_{ij} = x_{ij} \times w_j \quad i = 1, 2 \ldots m; \quad j = 1, 2 \ldots n,$

- Determine the positive ideal solution (A+) and the negative ideal solution (A-) with the equation:

(19) $A^+ = [v_1^-, v_2^-, \ldots, v_n^-] = ((max_j v_{ij} i \sum I'), (min_j v_{ij} | i \sum I''))$

(20) $A^- = [v_1^-, v_2^-, \ldots, v_n^-] = ((min_j v_{ij} i \sum I'), (max_j v_{ij} | i \sum I''))$

- Where I 'is associated with the benefit criterion and I "is associated with the cost [28] criterion.
- Determine the distance between the value of each alternatives with the positive and negative ideal solution matrix with the equation:

(21) $D_i^+ = \sum_{j=1}^{n} d(v_{ij} v_j^+) \qquad i = 1, 2 \cdots m$

(22) $D_i^- = \sum_{j=1}^{n} d(v_{ij} v_j^-) \qquad i = 1, 2 \cdots m$

- Where d(...,) represents the distance between two fuzzy numbers corresponding to the vertex method, for the fuzzy triangle number, is expressed by equation (12)
- Calculate the relative proximity to the ideal solution, the relative closeness of the alternatives is defined as:

(23) $$CC_i = \frac{D_i^-}{D_i^* + D_i^-}.$$

3. Proposed Method

3.1. Data and Phases

The data used in this study is the employee data which includes discipline, responsibility, initiative, communication, cooperation and achievement of targets, these criteria in accordance with the criteria used in the assessment of employee performance at PT. Adhouse Indonesia Cipta in Jakarta, Indonesia for the process of appraising the feasibility of promotion of employee position. The importance of the process criteria is processed using the AHP method, by matrix of pairwise comparisons, weighted normalized matrices and consistency test to generate the criterion weight.

Algorithms of the methods Fuzzy TOPSIS and AHP were developed in Matlab© and manual calculation via Microsoft Excel© and applied to the selection process. The application is based on the phases provided as follows:

- First phase is to get a comprehensive understanding of implementation of AHP method and Fuzzy TOPSIS method in Decision Support System by reading literature related to research such as scientific journals, books, internet.
- Next phase is to determine the purpose of the problem, defining criteria, weighting criteria and sub criteria factors that determine and influence in the process of performance appraisal and promotion of employees. Assessment criterion refers to existing regulations current company and research conducted by (Calabrese et al., 2013). Data collection was done by interview and the assessment criteria on the determination of promotion eligibility are shown in Figure 3 and Table 3.
- Personnel related to the employee division are distributed questionnaires including leaders and decision makers to acquire their importance and perceptions of criterion, using the provisions listed in Table 1.
- Final ranking is determined by using fuzzy TOPSIS in this phase. Linguistic values are used for evaluation of employee criterion. The relationship between linguistic values and triangular fuzzy numbers are shown in Table 7 and the whole process is illustrated in Figure 2.

Code	Definition	Definition
C1	Disciplinary	Overall Discipline & Attendance
C2	Responsibility	Job Description Responsibility
C3	Initiative	Initiative among helping colleagues
C4	Communication	Team Communication
C5	Cooperation	Team Cooperation
C6	Target Achievement	Daily and Monthly Target Achievement

Table 3

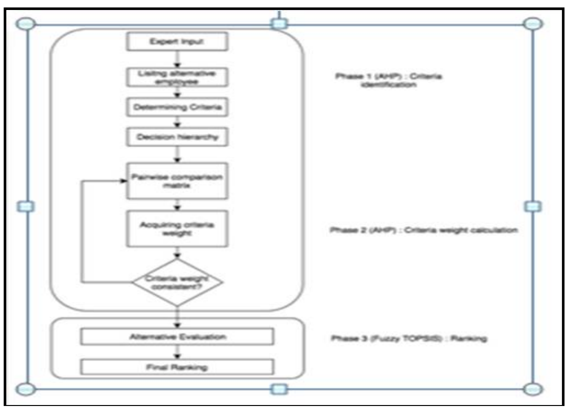

Figure 2: Phases for employee promotion eligibility

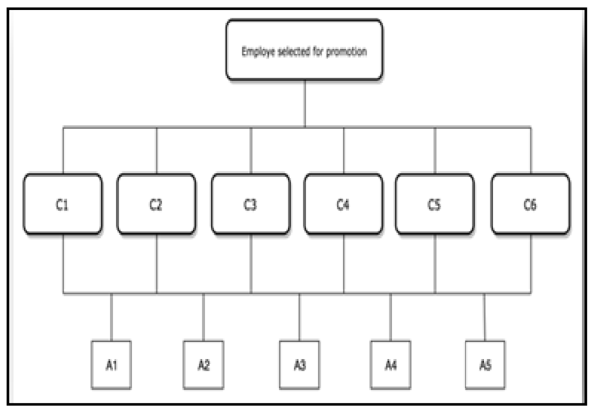

Figure 3: AHP Criterion Assessment

4. Results and Discussion

With the proposed methods and process explained, the criteria to be used are the Disciplinary (C1), Responsibility (C2), Initiative (C3), Communication (C4), Cooperation (C5), and Targets Achievements (C6), assessment of the importance weight of the criteria will be made by the immediate employee superior according to the provisions of the company and based on Table 1. The results are shown in Table 4.

	C1	C2	C3	C4	C5	C6
C1	1.00	0.14	0.20	3.00	0.33	0.20
C2	0.33	1.00	0.20	0.33	0.33	0.20
C3	0.33	5.00	1.00	3.00	0.33	0.20
C4	0.33	3.00	0.33	1.00	5.00	2.00
C5	0.33	0.33	0.33	3.00	1.00	0.20
C6	0.33	0.33	0.20	0.20	0.33	1.00
λ	2.82	9.80	2.26	10.53	7.32	3.80

Table 4: Pairwise Comparison Matrix

	C1	C2	C3	C4	C5	C6
C1	0.35	0.01	0.09	0.28	0.05	0.05
C2	0.12	0.10	0.09	0.03	0.05	0.05
C3	0.12	0.51	0.44	0.28	0.05	0.05
C4	0.12	0.31	0.15	0.09	0.68	0.53
C5	0.12	0.03	0.15	0.26	0.14	0.05
C6	0.12	0.03	0.09	0.02	0.05	0.26

Table 5: Normalize Pairwise Comparison Matrix

Next, the sum of each line of criterion value divided by the number of rows to obtain the normalized matrix shown in Table 5. Then, the next step is to calculate the priority weight scale by equation (1) and compute the consistency by using equations (2) and (3) where the result is shown in Table 5

The Consistency Ratio (CR) obtained from pairwise comparison matrices calculated above is 0.04816 < 0.10 thus it can be considered consistent and can be used in alternative ranking processes, then experts or decision makers were asked to construct fuzzy evaluation matrix by linguistic variables presented on Table 6. It is formed by comparing five alternatives under six criteria separately. The result matrix is shown in Table 8 and by using equation (18) generate the weighted normalized decision matrix shown in Table 6.

Criteria	Weight	λmax, CI, IR	CR
C1	0.1398	λmax = 6.2986	0.0482
C2	0.0729	CI = 0.0597	
C3	0.2419	RI = 1.24	
C4	0.3123		
C5	0.1287		
C6	0.1044		

Table 6: Criteria Weight and Related Parameter Values

Linguistic Value	Triangular Fuzzy Numbers
Very Low (VL)	(0, 0, 0.25)
Low (L)	(0, 0.25, 0.5)
Fair (F)	(0.25, 0.5, 0.75)
High (H)	(0.5, 0.75, 1)
Very High (VH)	(0.75, 1, 1)

Table 7: Linguistic Value and Triangular Fuzzy Numbers

After a weighted decision matrix is obtained, proceed by finding the ideal positive solution distance (A+) and the negative ideal solution distance (A-) using equation (21), (22) in this process we define fuzzy positive-ideal solution (FPIS, A+) and fuzzy negative-ideal solution (FNIS, A-) as A+ = (1, 1, 1) and A- = (0, 0, 0) for benefit criterion, and A+ = (0, 0, 0) and A- = (1, 1, 1) for cost criterion, the calculation is presented as follows:

$$D_1^+ = \sqrt{(1-0.03)^2 + (1-0.06)^2 (1+0.10)^2 +}$$
$$= \sqrt{(1-0.03)^2 + (1-0.05)^2 (1+0.07)^2 +}$$
$$= \sqrt{(1-0)^2 + (1-0.06)^2 (1+0.12)^2 +}$$
$$= \sqrt{(0-0.15)^2 + (0-0.23)^2 (0+0.31)^2 +}$$
$$= \sqrt{(1-0.09)^2 + (1-0.12)^2 (1+0.12)^2 +}$$
$$= \sqrt{(1-0)^2 + (1-0.02)^2 (1+0.05)^2 +}$$

In this issue C1, C2, C3, C5, C6 is a benefit criterion and whereas C4 is cost criteria and then with equation (23) the ideal solution results can be seen in Table 10 and 11. The value of proximity of the ideal solution is the final value that becomes the benchmark in determining the ranking on all existing alternatives, based on the calculation, the ideal value of the greatest ideal closeness is A4 with 0.223 so it is concluded that alternative A4 is recommended to occupy the position xx. With rankings: A4> A5> A2> A3> A1 and represented on Figure 4.

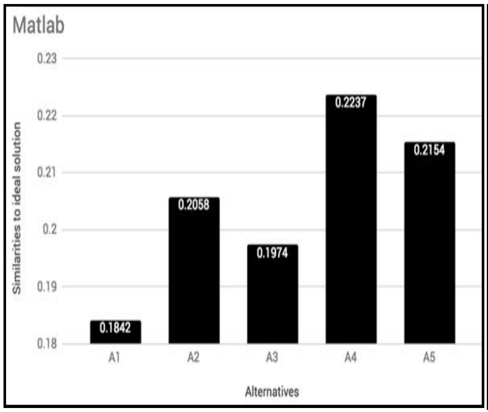

Figure 4

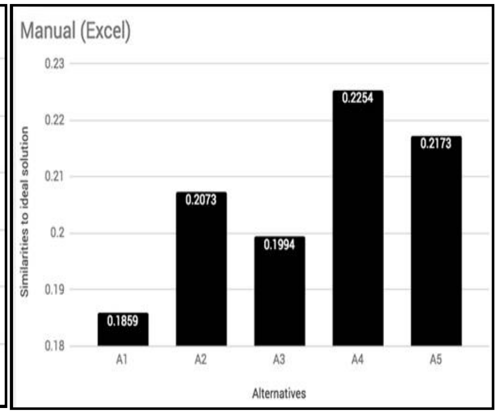

Figure 5

The incorporation of the AHP and Fuzzy TOPSIS methods in the selection process of employee's promotion eligibility, can provide a useful recommendation for decision makers, the number of subjective criteria and the vague value in the assessment requires an effective and appropriate decision-making process, merging the two methods to meet the needs of the issue. Where AHP is used for weighting criteria and Fuzzy TOPSIS is used to perform the ranking process under a Fuzzy scheme that refers to weighting. A descriptive quantitative approach was adopted as the research method. Algorithms of the methods Fuzzy TOPSIS and Fuzzy AHP were calculated by Matlab© and manual calculation, script and code used in Matlab© is shown in section below. From Table 11 we can conclude the accuracy rate of 99,83%.

	C1	C2	C3	C4	C5	C6
A1	F	H	L	H	VH	L
	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0, 0.25, 0.5)
A2	L	VH	VH	H	H	F
	(0, 0.25, 0.5)	(0.75, 1, 1)	(0.75, 1, 1)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)
A3	L	H	H	H	VH	L
	(0, 0.25, 0.5)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.75, 1, 1)	(0, 0.25, 0.5)
A4	F	VH	VH	F	VH	L
	(0.25, 0.25, 0.75)	(0.75, 1, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0, 0.25, 0.5)
A5	L	VH	VH	F	VH	VL
	(0, 0.25, 0.5)	(0.75, 1, 1)	(0.75, 1, 1)	(0.25, 0.5, 0.75)	(0.75, 1, 1)	(0, 0, 0.25)

Table 8: Fuzzy Evaluation Result

	C1	C2	C3	C4	C5	C6
A1	(0.03, 0.06, 0.10)	(0.03, 0.05, 0.07)	(0, 0.06, 0.12)	(0.15, 0.23, 0.31)	(0.09, 0.12, 0.12)	(0, 0.02, 0.05)
A2	(0, 0.03, 0.06)	(0.05, 0.07, 0.07)	(0.18, 0.24, 0.24)	(0.15, 0.23, 0.31)	(0.06, 0.09, 0.12)	(0.02, 0.05, 0.07)
A3	(0, 0.03, 0.06)	(0.03, 0.05, 0.07)	(0.12, 0.18, 0.24)	(0.15, 0.23, 0.31)	(0.09, 0.12, 0.12)	(0, 0.02, 0.05)
A4	(0.03, 0.06, 0.10)	(0.05, 0.07, 0.07)	(0.18, 0.24, 0.24)	(0.17, 0.15, 0.23)	(0.09, 0.12, 0.12)	(0, 0.02, 0.05)
A5	(0, 0.03, 0.06)	(0.05, 0.07, 0.07)	(0.18, 0.24, 0.24)	(0.07, 0.15, 0.23)	(0.09, 0.12, 0.12)	(0, 0, 0.02)

Table 9: Fuzzy Evaluation Result

Alternatives	Positive Ideal Solution	Negative Ideal Solution	Similarities to Ideal Solution
A1	4.936	1.114	0.1842
A2	4.790	1.241	0.2058
A3	4.848	1.192	0.1974
A4	4.6849	1.349	0.2237
A5	4.7346	1.2995	0.2154

Table 10: Final Ranking Result with Matlab©

A1	4.924	1.124	0.1859
A2	4.784	1.251	0.2073
A3	4.838	1.205	0.1994
A4	4.675	1.360	0.2254
A5	4.724	1.312	0.2173

Table 11: Final Ranking Result with Microsoft Excel©

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