



Determination of Sub-Contractors Using AHP and SAW Method

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Abstract

One factor in the durability of a contractor company is its sub-contractor. The management of sub-contractors for companies engaged in construction services is one aspect of the company's durability to be able to complete the project that the selection is doing manually by viewing one single file That is sent by the company who wants to be a sub-contractor, it is of course besides very troublesome also inefficient and time consuming quite a while. In determining the winner of the Procurement Committee is still having difficulty determining the standard of the company that will become a sub-contractor, not to mention the assessment is subjective so the elected candidate is not the best candidate. The methods used in this research use Analytical Hierarchy Process (AHP) for weighting of criteria and for calculation of value using Simple Additive Weighting (SAW) of the results of the research obtained from the SAW method used Obtained by the best sub-contractor of PT. 4Cipta with a total of 0.962 from the 5 alternatives listed.

Keywords: Selection, Company, Contractor

1. Introduction

Recruitment of companies that will be used as a sub-contractor by PT. Arvirotech Engineering Consultant by posting the need for companies to be sub-contractors by emailing the company that has been a partner and Through the website owned, so the procurement Committee received a lot of files from the company who want to be a subcontract from PT. Arvirotech Engineering Consultant.

The file is a company profile, technical proposal for job completion, skilled personnel and a quotation letter of HPS (approximate provisional price). The file is then selected by the Procurement Committee whether the company that filed a sub-contractor PT. Arvirotech Engineering Consultant meets the qualifications established by PT. Arvirotech Engineering Consultant.

In the process of checking and selection is done manually by looking at one by one file that is sent by the company that wants to be subcontractor, this is certainly not very inconvenient also not efficient and time consuming quite long. In determining the winners of the Procurement Committee still have difficulties to determine the standards of the company to be sub-contractor, as well as subjective assessments so that the elected candidates are not the best candidates. Similar research has also been conducted by Diah Permatasari, Dewi Sartika and Suryati titled "Application of AHP method and SAW for determination of promotion of employees" problem in the research is the presence of collusion and nepotism in Employee determination. While the criteria used to determine the increase in the position of the group, the last echelon, last position and last education result of the research is a decision support system application that can provide Promotion recommendation [1].

Similar research is also conducted by Andri Syafrianto, entitled Application of AHP and SAW algorithms in the selection of accommodation in Yogyakarta. On his research discussing the selection of which lodging with the criteria used is from an average in 2 months, lodging facilities and convenience in public transport. For the weighted use AHP method and to calculate values and alignment using the SAW method. The results of its research use shows the AHP method has more objective results compared with the direct weight-giving [2].

Yustina Meisella Kristania entitled of a combination of AHP and SAW methods in the decision-making support of the people's housing credit in his research discussing the determination of the public housing credit based on the existing housing data in the city of Purwokerto. The criteria used in the research are price, design, type of house, location and facilities to access from the road. The result of his research obtained the highest value is 0.721 with the name Griya Satria Bukit Nirwana [3].

Ni Wayan ulandari title of implementation of method AHP and SAW in the decision Support system prediction student academic potential of STMIK STIKOM Bali. The criteria used are logic, English, computer, interviews

and general knowledge. Research results where The level of accuracy obtained from the developed system is 85.55%. But when calculated based on class the prediction obtained the accuracy of the level of the fondly = 85.36%, very satisfactory = 76.88%, satisfactory = 89.60%, and quite satisfactory = 90.37% [4].

One of the shortcomings owned by the method SAW is a must to provide weights before performing an alternative rating calculation process [5]. According to L. Saaty, one of the causes of complexity in a decision making is because of the diversity of criteria that affect it [6]. To overcome this, Thomas L. Saaty introduced a method of analysis of the decision named Analytical Hierarchy Process (AHP). The AHP method can be used to obtain the weight value in the SAW method by comparing the value of interest between its criteria. So that the research uses the AHP method to further the weighted process of the value of the criteria used and the SAW method to perform the assessment and the process of the alignment of each Sub-Contractors.

2. Method

The research methods used in this study are as follows :

2.1 Studi Literatur

Literature study is needed in obtaining the resources needed during the study, the source can be obtained from the final task, research journals related to the methods used as well as books supporting research.

2.2 Data Collection

Data collection is the most important step in a study. The success of research is determined by the data obtained. Not only data on the criteria that are gathered in the research but also the weight of the values and valuation parameters during the auction process.

2.3 Requirement Analysis

At the stage of Analysis needs to be analyzed what needs are needed in building a system application support decisions such as sublime, Xampp, Mozila Firefox. Hardware and software requirements are required to support the application to run smoothly without any obstacles.

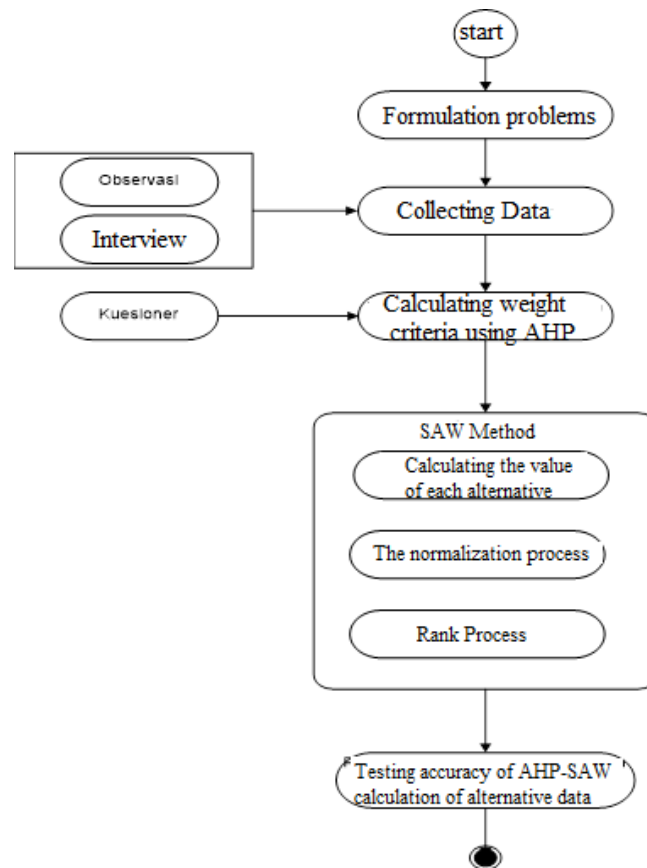


Figure 1. Research Method

2.4 Analytical Hierarchy Process (AHP)

The calculation using AHP method is as follows [7]:

- a. Define the problem and determine the desired solution, then compile the hierarchy of the problems encountered.
- b. Define the priority of the element by making a comparison of pairs, namely by comparing elements in pairs according to the given criteria.
- c. Make a comparison matrix in pairs that depicts the relative contribution or influence of each element to the purpose or criteria that are level above. [8]

Table 1. Sample comparison matrix pairs

| Criteria | C1 | C2 | C3 |
|----------|-----|-----|-----|
| C1 | 1 | C12 | C13 |
| C2 | Cij | 1 | C23 |
| C3 | Cij | Cij | 1 |

- d. Define comparison pairs. The columns C12, C13, C23 are filled with the results of a scale of the AHP comparison of each element. Calculation formula to populate the Cij field is as follows [8]

$$C_{ij} = \frac{1}{C_{ji}} \quad (1)$$

- e. The considerations on pairing comparisons are synthesized to acquire an overall priority. Process synthesis by summing values on each column of a matrix, dividing each value from a column by the total column in question to derive the normalization of the matrix by using equations 2

$$\text{new element value} = \frac{\text{Value of the initial matrix element}}{\text{Number of old columns}} \quad (2)$$

- f. The weighted by summing the values of each row and dividing them by number of criteria with equations 3.

$$\text{Priority weights} = \frac{\text{number of rows}}{\text{Number of criteria}} \quad (3)$$

- g. Calculates consistency to know how well the consistency exists. Calculate consistency by multiplying each value in first column with relative priority of first element, second column value with relative priority of second element, and so on, then each row is sum and result divided by priority Relative in question. The result is aggregated to get the value of the Lambdamax
- h. Calculating Consistency Index (CI)
- i. Calculating Consistency Ratio (CR)
- j. Checking hierarchy consistency If the value is ≤ 0.1 then the calculation result can be declared correct.

2.5 Simple Additive Weighting (SAW)

Calculations using Simple Additive Weighting (SAW) [9] are as follows:

- a. Determining alternatives
- b. Determine the criteria that will be used as reference in decision making
- c. Determine the preference weight or importance level of each criterion
- d. Specifying the match value of each criterion
- e. Make the decision matrix gained from the match rating on each alternative with each criterion.
- f. Perform the normalization of the decision matrix step by calculating the normalized performance rating value from the alternate on the criteria with the following formula:

$$r_{ij} = \left\{ \begin{array}{l} \frac{x_{ij}}{\max_i x_{ij}} \\ \frac{\min_i x_{ij}}{x_{ij}} \end{array} \right\} \quad (4)$$

r_{ij} = Normalized performance ratings from alternative

max_i= Maximum value of each row and column
 min_i= Minimum value of each row and column
 x_{ij}= Rows and columns of matrices

g. Result of Normaliazation (rij) Will form the normalized matrix (R)

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{1j} \\ r_{i1} & r_{i2} & r_{ij} \end{bmatrix} \quad (5)$$

h. The final preference value (Vi) is derived from the summation of the multiplication of the normalized (R) line element with a preference weight (W) corresponding to the matrix column element (W).

$$V_i = \sum_{j=1}^n w_j r_{ij} \quad (6)$$

description :

V_i= Rank for each alternative

W_j= The weight value of each criterion

r_{ij}= Normalized Performance rating values.

3. Result and Discussion

3.1 The process of processing criteria using the method of Analytical Hierarchy Process (AHP).

In this research, we will use a sub-contractor data of 5 companies with criteria of 5 pieces.

Here is the table of companies shown in table 2 as follows

Table 2. Company Table

| No | Company Code | Name Company |
|----|--------------|-------------------------|
| 1 | P01 | CV. Ria Prima |
| 2 | P02 | PT. Arfa Tunas Makmur |
| 3 | P03 | CV. Sarwo Bathi Permana |
| 4 | P04 | PT. Nambur Marlata |
| 5 | P05 | PT. 4Cipta |

And for the criteria table will be shown in table 3 as follows.

Table 3. Criteria Table

| Code | Name Criteria | Attribut |
|------|-------------------------------|----------|
| 1 | Company Profile | Benefit |
| 2 | Work experience | Benefit |
| 3 | Experts | Benefit |
| 4 | Human resources and equipment | Benefit |
| 5 | Working capital | Benefit |

Furthermore, the Director will be given a questionnaire to find the level of importance of the existing criteria and then used AHP method to determine the weight of each – each criterion that will be used as the benchmark assessment. Here is a table of importance of the survey form summary result given by the user according to the Saaty scale shown by table 4.

Table 4. User Criteria table to be weighted

| | CP | PK | TA | SDM | MK |
|-----|----|-------|-------|-----|----|
| CP | 1 | 0.143 | 0.333 | 1 | 1 |
| PK | 7 | 1 | 3 | 2 | 3 |
| TA | 3 | 0.333 | 1 | 1 | 3 |
| SDM | 1 | 0.5 | 1 | 1 | 1 |
| MK | 1 | 0.333 | 0.333 | 1 | 1 |

Description :

CP = Company Profile

PK = Work experience

TA = Experts

SDM = Human resources and equipment

MK = Working capital

Then sum up the weighted criteria that will be used

Table 5. Table of Total weighted criteria

| | CP | PK | TA | SDM | MK |
|-------|----|--------|--------|-----|----|
| CP | 1 | 0.143 | 0.333 | 1 | 1 |
| PK | 7 | 1 | 3 | 2 | 3 |
| TA | 3 | 0.333 | 1 | 1 | 3 |
| SDM | 1 | 0.5 | 1 | 1 | 1 |
| MK | 1 | 0.333 | 0.333 | 1 | 1 |
| Total | 13 | 2.3095 | 5.6667 | 6 | 9 |

The total row is derived from the processing of table 5 by summing each row of each column. A total example of CP obtained from $1 + 7 + 3 + 1 + 1 = 13$

Then each value of interest criteria divided by the amount of value of importance criteria (normalization of matrices). After that the values are sum to the right divided by the number of criteria to calculate the weight of the criteria, as in the following table 6

Table 6. Matrix normalization table and criterion weight

| | CP | PK | TA | SDM | MK | Priority weights |
|-----|--------|--------|--------|--------|--------|------------------|
| CP | 0.0769 | 0.0619 | 0.0588 | 0.1667 | 0.1111 | 0.0951 |
| PK | 0.5385 | 0.433 | 0.5294 | 0.3333 | 0.3333 | 0.4335 |
| TA | 0.2308 | 0.1443 | 0.1765 | 0.1667 | 0.3333 | 0.2103 |
| SDM | 0.0769 | 0.2165 | 0.1765 | 0.1667 | 0.1111 | 0.1495 |
| MK | 0.0769 | 0.1443 | 0.0588 | 0.1667 | 0.1111 | 0.1116 |

How to normalize a matrix is to divide each matrix element by a total row. Example of cell CP = 0.0769 obtained from $1/13 = 0.0769$. So on for the other cell.

The priority weight column is obtained from Merata-ratakan each matrix row results in normalization. Example of weight first row priority = $(0.0769 + 0.0619 + 0.0588 + 0.1667 + 0.1111)/5 = 0.0951$

The next step is to calculate the lambda max. To calculate a lambda max is 2 steps: Step 1 that is the value of each criterion's importance Multiplied by the weight of each – each criterion (Matrik's consistency) is then in the sum then in divide by the weights of each. Step 2 is the sum values in step 1 divided by the number of criteria. The first step is calculating the matrix's consistency:

Table 7. Matrix normalization table and criterion weight

| | CP | PK | TA | SDM | MK | KM |
|-----|--------|--------|--------|--------|--------|--------|
| CP | 0.0769 | 0.0619 | 0.0588 | 0.1667 | 0.1111 | 0.0951 |
| PK | 0.5385 | 0.433 | 0.5294 | 0.3333 | 0.3333 | 0.4335 |
| TA | 0.2308 | 0.1443 | 0.1765 | 0.1667 | 0.3333 | 0.2103 |
| SDM | 0.0769 | 0.2165 | 0.1765 | 0.1667 | 0.1111 | 0.1495 |
| MK | 0.0769 | 0.1443 | 0.0588 | 0.1667 | 0.1111 | 0.1116 |

The matrix's consistency is derived from multiplying the matrix in the 4.5 table with the weighted priority of each line. Example for the first line of $KM = [(1 * 0.0769) + (0.143 * 0.0619) + (0.333 * 0.0588) + (1 * 0.1667) + (1 * 0.1111)]/0.0951 = 5,135$

Next step is to calculate Lamda Max, Lambda Max It is the average of KM (consistent Matrik) obtained from the total sum of KM divided by the number of criteria = $(5,135 + 5.4527 + 5.3458 + 5.2379 + 5.1159)/5 = 5.2575$

And the last step is to calculate the CI (Consisten Index) value, set the value of RI (Ratio Index) and the value of CR (Consisten Ratio). The value of RI already has a default value set by Saaty

Table 8. Value Table RI

| Ordo Matrik | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-------------|---|---|------|-----|------|------|------|------|
| Ratio Index | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 |

Appropriate number of criteria. In this study has 5 criteria, the value of the RI is 1.12. The formula for calculating the CI value is: $(\text{The value of } \lambda \text{ Max} - \text{the criterion of criteria}) / (\text{POPL} - 1)$. Then the CI value is $(5.2575 - 5) / (5 - 1) = 0.064$. The formula for calculating the CR value is: CI / RI value. Then the CR value is $0.064 / 1.12 = 0.057$. CR value is consistent due to below 0.1.

3.2 Calculation process using Simple Additive Weighting method (SAW)

After each company is given assessment then obtained the following data.

Table 9. Company Valuation Table

| No | Code Company | C01 | C02 | C03 | C04 | C05 |
|----|-----------------|-----|-----|-----|-----|-----|
| 1 | P01 | 70 | 80 | 40 | 80 | 70 |
| 2 | P02 | 50 | 50 | 50 | 70 | 65 |
| 3 | P03 | 70 | 40 | 85 | 70 | 60 |
| 4 | P04 | 70 | 80 | 85 | 85 | 90 |
| 5 | P05 | 60 | 90 | 80 | 85 | 80 |

After each sub-contractor will get the assessment then the next stage is normalization process normalization process function to look for benefit group or cost if Benefit is the biggest value of line used for dividing, But if cost then the smallest value of the row used to divide.

For Company Profile (C001) criteria, because of Benefit, then we are looking for Max (70, 50, 70, 70, 60) = 70. So to:

$$P01 = 70 / 70 = 1$$

$$P02 = 50 / 70 = 0,714$$

$$P03 = 70 / 70 = 1$$

$$P04 = 70 / 70 = 1$$

$$P05 = 60 / 70 = 0.857$$

For work experience criteria (C002), because of Benefit, then we are looking for Max (80, 50, 40, 80, 90) = 90. So to:

$$P01 = 80 / 90 = 0.089$$

$$P02 = 50 / 90 = 0.556$$

$$P03 = 40 / 90 = 0.444$$

$$P04 = 80 / 90 = 0.089$$

$$P05 = 90 / 90 = 1$$

For the criteria of Experts (C003), because of Benefit, then we look for Max (40.50, 85, 85, 80) = 85. So to:

$$P01 = 40 / 85 = 0.471$$

$$P02 = 50 / 85 = 0.588$$

$$P03 = 85 / 85 = 1$$

$$P04 = 85 / 85 = 1$$

$$P05 = 80 / 85 = 0.941$$

For HR criterion & Equipment (C003), because of Benefit, then we are looking for Max (80.70, 70, 85, 85) = 85. So to:

$$P01 = 80 / 85 = 0.941$$

$$P02 = 70 / 85 = 0.824$$

$$P03 = 70 / 85 = 0.824$$

$$P04 = 85 / 85 = 1$$

$$P05 = 85 / 85 = 1$$

For the criteria of Experts (C003), because of Benefit, then we look for Max (70.65, 60, 90, 80) = 90. So to:

$$P01 = 70 / 90 = 0.778$$

$$P02 = 65 / 90 = 0.722$$

$P03 = 60 / 90 = 0.667$
 $P04 = 90 / 90 = 1$
 $P05 = 80 / 90 = 0.889$

Table 10. Normalization result table

| No | Code Company | C01 | C02 | C03 | C04 | C05 |
|----|-----------------|-------|-------|-------|-------|-------|
| 1 | P01 | 1 | 0.889 | 0.471 | 0.941 | 0.778 |
| 2 | P02 | 0.714 | 0.556 | 0.588 | 0.824 | 0.722 |
| 3 | P03 | 1 | 0.444 | 1 | 0.824 | 0.667 |
| 4 | P04 | 1 | 0.889 | 1 | 1 | 1 |
| 5 | P05 | 0.857 | 1 | 0.941 | 1 | 0.889 |

The next step is to calculate the weighted matrix by multiplying the normal results with priority weights. The example in column C001 obtained from $1 \times 0.0951 = 0.0951$, while the C002 column obtained from $0.889 \times 0.4335 = 0.3853$. As well as other columns. Thus obtained the results as in Table 10 as follows

Table 11. Weighted results table

| No | Code Company | C01 | C02 | C03 | C04 | C05 |
|----|-----------------|--------|--------|--------|--------|--------|
| 1 | P01 | 0.0951 | 0.3853 | 0.099 | 0.1407 | 0.0868 |
| 2 | P02 | 0.0679 | 0.2408 | 0.1237 | 0.1231 | 0.0806 |
| 3 | P03 | 0.0951 | 0.1927 | 0.2103 | 0.1231 | 0.0744 |
| 4 | P04 | 0.0951 | 0.3853 | 0.2103 | 0.1495 | 0.1116 |
| 5 | P05 | 0.0815 | 0.4335 | 0.1979 | 0.1495 | 0.0992 |

The last step is the digging process. To find the final value of the way is to multiply the weighted result on each criterion.

$P01 = 0.0951 \times 0.3853 \times 0.099 \times 0.1407 \times 0.0868 = 0.807$
 $P02 = 0.0679 \times 0.2408 \times 0.1237 \times 0.1231 \times 0.0806 = 0.636$
 $P03 = 0.0951 \times 0.1927 \times 0.2103 \times 0.1231 \times 0.0744 = 0.696$
 $P04 = 0.0951 \times 0.3853 \times 0.2103 \times 0.1495 \times 0.1116 = 0.952$
 $P05 = 0.0815 \times 0.4335 \times 0.1979 \times 0.1495 \times 0.0992 = 0.962$

So the following results are obtained

Tabel 12. Rank Table

| No | Code | Name Company | Total | Rank |
|----|------|----------------------------|-------|------|
| 1 | P01 | CV. Ria Prima | 0.807 | 3 |
| 2 | P02 | PT. Arfa Tunas Makmur | 0.636 | 5 |
| 3 | P03 | CV. Sarwo Bathi Permana | 0.696 | 4 |
| 4 | P04 | PT. Nambur Marlata | 0.952 | 2 |
| 5 | P05 | PT. 4Cipta | 0.962 | 1 |

Based on the calculation of total value of the number obtained that the alternative that has the highest performance or best is an alternative with the code A05 on behalf of PT. 4 Cipta. While a low-value alternative is an alternative with the A02 code on behalf of PT. Arfa Tunas Makmur.

4. Conclusion

After learning the problems and applications that have been made, it can be concluded that the application of decision support system using the AHP-SAW algorithm, the chairman can decide who the selected sub-contractor So that the AHP-SAW algorithm can be applied to PT. Arvirotech Engineering Consultant, with the results of what is expected by the company leadership. The suggestions that can be submitted for further system development are as follows: SAW algorithm can be developed using other methods and the criteria used can be replaced according to the problems that occur In the research.

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