Decision support system selection of tender winners project development building of STMIK STIKOM Indonesia with TOPSIS method

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Abstract. STMIK STIKOM Indonesia is a college that has been established since 2008. In the process to build the existing building on STMIK STIKOM Indonesia, should used the contractor that have to meet some criteria such as Letter of Offer, Certificate of Registered as a service provider, Tax Document, Building Design Picture, Implementation schedule, Construction Business License, Company's experience in last 3 years and price, which takes at least 2 months to get a winning contractor whereas the desired building should be built immediately to be used in teaching and learning activities. To produce a decision support system for the selection of the tender winner, this study using the TOPSIS method. TOPSIS is one of the multicriteria decision-making methods that are widely used to process decisions practically. The resulting system can help the decision maker to determine the contractor who won the tender of building projects in STMIK STIKOM Indonesia.

1. Introduction
STMIK STIKOM Indonesia is a college that has been established since 2008 often called by name STIKI Indonesia. This college is located at Tukad Pakerisan street number 97, Panjer, Denpasar. Based on the interviews that have been made against Nyoman Suarya as a vice chairman who is in charge of facilities and infrastructure in STMIK STIKOM Indonesia, in the process to build the existing building on STIKI Indonesia, should used the contractor that have to meet 8 criteria such as Letter of Offer, Certificate of Registered as a service provider, Tax Document, Building Design Picture, Implementation schedule, Construction Business License, Company's experience in last 3 years and price.

Nyoman Suarya as the vice chairman of facilities and infrastructure at STMIK STIKOM Indonesia have difficulties to choosing a contractor that meet 8 criteria mentioned above. In addition must meet the criteria that have been determined, the time it takes to choose the contractor who win the tender is approximately 2 months even though the building should already be used to teaching and learning activities.

Decision Support System is a system to support decision makers in semi-structural decision situations [1]. There are several methods in decision support systems one of them is Technique For Others Reference by Similarity to Ideal Solution method (TOPSIS) [2].

The TOPSIS method is one of the multicriteria decision-making methods introduced by Hwang and Yoon [3]. This method is one of the many methods used to solve practical decision making. TOPSIS has concept whereby the chosen alternative is the best alternative that has the shortest distance from the ideal positive solution and the farthest distance from the ideal negative solution. The more factors that
must be considered in the decision making process the more difficult it is also to take decision on a problem [4].

Based on the background above then it is necessary to design and build “Decision Support System of The Winners Tender Determination within TOPSIS Method”.

2. Previous research
Astuti and Wardoyo made a decision support system for determining the winner of the construction work tender using the Fuzzy AHP method [5]. This system is used for decision-making in determining the winner of the construction work tender in the construction of the Udayana University Faculty of Economics lecture building which was previously manually carried out by the tender committee in the Udayana University Rector’s equipment department. The result of this study is a decision support system that was built using the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) method to determine the winner of the construction work tender can help decision makers (tender committee) in generating valid and fast bidder ranking.

Rakhmanto made a research on determining the winner of the tender for 10 MBPS internet hosting using the TOPSIS method [6]. This system was successfully used to facilitate the procurement committee in the process of determining the winner of the tender for 10 MBPS internet hosting with a case study at the National Aeronautics and Space Agency (LAPAN), Rumpin. The final result of this study resulted in PT. Platinum Network Indonesia ranks first (winner), PT. Palapa Network Nusantara in second place (first reserve), and PT. Indonesia Super Corridor is third (second reserve).

The current study adopted the criteria for determining the winner of the construction work tender conducted by Astuti and Wardoyo [5] and adopted the steps to use the TOPSIS method in determining the tender winner in the research conducted by Rakhmanto [6].

2.1. Tender
According to the Kamus Besar Bahasa Indonesia (KBBI), tenders are offers to submit prices, buy jobs, or provide goods. Tenders can also be interpreted as a series of bidding activities that aim to select, obtain, determine and designate which companies are the most appropriate and appropriate to work on a work package [7].

2.2. System
The system is an order or integration consisting of a number of functional components (with units of functions / special tasks) that are interconnected together aiming to fulfill a particular process/work [8]. A system consists of a number of components that interact and relate to form one unit so that the system’s objectives can be achieved.

2.3. Decision
Decisions are activities or actions taken as a solution to a problem [2]. According to Igor H. Ansoff based on the importance of the decision divided into three categories [9], namely:

2.3.1. Strategic decision. Strategic decisions are decisions to address environmental challenges and changes and are usually long-term. This decision was taken by top management.

2.3.2. Administrative / Tactic decisions. Administrative decisions/tactics are decisions relating to the management of resources (finance, engineering, and personnel). This decision was taken by middle management.

2.3.3. Operational decisions. Operational decisions are decisions related to daily operational activities. This decision was taken by the lower management.
2.4. Decision making process
The decision-making process according to Larkin et al., decision making includes four stages that are interconnected and sequential [10]. The four processes are:

2.4.1. Intelligence. This stage is a process of tracking and detecting the scope of the problem and the process of identifying problems. Enter data is obtained, processed, and tested in order to identify problems.

2.4.2. Design. This stage is the process of finding, developing, and analyzing alternative actions that can be done. This stage includes the process of understanding the problem, lowering the solution, and testing the feasibility of the solution.

2.4.3. Choice. At this stage, the process of selecting between various alternative actions that might be carried out is carried out. This stage includes searching, evaluating, and recommending solutions that are appropriate for the model that has been made. The solution of the model is the specific value for the outcome variable in the chosen alternative.

2.5. Decision support system
According to Little, the SPK concept can be a computer-based system that produces various alternative decisions to assist management in dealing with various structured and unstructured problems using data and models [2].

SPK application will only succeed if the system is simple, easy to use, easy to supervise, easy to adapt to changes in the environment and easy to communicate with other types of entities. SPK can be applied to situations where the final system can only be developed through an adaptive learning process and evolution.

2.6. TOPSIS method
The category of the TOPSIS method is the Multi-Criteria Decision Making (MCDM) category, which is a decision-making technique from several alternative choices, especially MADC (Multi Attribute Decision Making). TOPSIS aims to determine positive ideal solutions and negative ideal solutions. Positive ideal solutions maximize benefit criteria and minimize cost criteria, while negative ideal solutions maximize cost criteria and minimize benefit criteria [11].

TOPSIS uses the principle that the chosen alternative not only has the shortest distance from the positive ideal solution, but also has the longest distance from the negative ideal solution. This concept is widely used to solve decision problems practically. The concept is simple and easy to understand, its computation is efficient and has the ability to measure the relative performance of decision alternatives into simple mathematical form [12].
3. Research methods
This study is accomplished through the following stages [13]:

3.1. Criteria for determining tender winner
There are several criteria to determine the winner tender:

- Offering Letter (proposal)
- Certificate of Registration as a Service Provider
- Tax Document
- Project Design
- Implementation Schedule
- Construction Business License
- Experience last 3 years
- Price

Each of these criteria has its own weight. The weight of these criteria can be seen in the following table.
Table 1. Weight and rating categories.

| No | Aspect                                      | Weight and Rating Categories                       |
|----|--------------------------------------------|----------------------------------------------------|
| 1  | Offer Letter (Proposal)                    | 3 Ready and procedurally                          |
|    |                                             | 2 Ready but unprocedurally                         |
|    |                                             | 1 None                                             |
| 2  | Certificate of registration as a Service Provider | 3 Ready and legalized                           |
|    |                                             | 2 Ready but unlegalized                            |
|    |                                             | 1 None                                             |
| 3  | Tax Document                                | 3 Tax Number (NPWP) and proof of the last complete annual tax payment |
|    |                                             | 2 Tax Number (NPWP) or proof of the last complete annual tax payment |
|    |                                             | 1 Tax Number (NPWP) and proof of the last complete annual tax payment not complete |
| 4  | Project Design                              | 3 Ready and as needed                             |
|    |                                             | 2 Ready but not as needed                          |
|    |                                             | 1 none                                             |
| 5  | Implementation Schedule                     | 3 As you wish                                      |
|    |                                             | 2 Back 1 month                                     |
|    |                                             | 1 Back more than 1 month                           |
| 6  | Construction Business License               | 3 has a business license for large-scale construction services |
|    |                                             | 2 has a business license for medium-scale construction services |
|    |                                             | 1 has a business license for small-scale construction services |
| 7  | Experience Last 3 Years                     | 3 Can finish project more than 600 million rupiah  |
|    |                                             | 2 Can finish project between 330 – 600 million rupiah |
|    |                                             | 1 Can finish project less than 600 million rupiah  |
| 8  | Price                                      | 3 Below budget                                     |
|    |                                             | 2 Within budget                                    |
|    |                                             | 1 Over Budget                                      |

3.2. System overview
Overview of the system can be seen in the picture below:

**Figure 2. Overview of the system.**

3.2.1. Calculation of TOPSIS method. Suppose there are 4 contractor companies who want to be involved in the construction of the building in STMIK STIKOM Indonesia and will be searched the sequence of tender winner.

- Build a decision matrix
  The first stage of TOPSIS Method is determine the decision matrix that contains the weighting value of each rating category. The decision matrix can be seen in the table 2 below
Table 2. Decision matrix.

|   | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|----|----|----|----|----|----|----|----|
| K1| 3  | 2  | 1  | 3  | 3  | 3  | 3  | 2  |
| K2| 3  | 3  | 2  | 2  | 3  | 1  | 3  | 3  |
| K3| 3  | 2  | 3  | 2  | 3  | 3  | 2  | 3  |
| K4| 3  | 3  | 1  | 2  | 3  | 2  | 2  | 1  |

Note:
K1 = Company 1  
K2 = Company 2  
K3 = Company 3  
K4 = Company 4  
C1 = Offering Letter (Proposal)  
C2 = Certificate of registration as a Service Provider  
C3 = Tax Document  
C4 = Project Design  
C5 = Implementation Schedule  
C6 = Construction Business License  
C7 = Experience Last 3 Years  
C8 = Price

- Normalized decision matrix
  Normalized Decision Matrix is obtained using the following equation:

  \[ r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \]  

  (1)

Table 3. Normalized decision matrix.

|   | C1    | C2    | C3    | C4    | C5    | C6    | C7    | C8    |
|---|-------|-------|-------|-------|-------|-------|-------|-------|
| K1| 0.500 | 0.392 | 0.258 | 0.655 | 0.500 | 0.626 | 0.588 | 0.417 |
| K2| 0.500 | 0.588 | 0.516 | 0.436 | 0.500 | 0.209 | 0.588 | 0.626 |
| K3| 0.500 | 0.392 | 0.775 | 0.436 | 0.500 | 0.626 | 0.392 | 0.626 |
| K4| 0.500 | 0.588 | 0.258 | 0.436 | 0.500 | 0.417 | 0.392 | 0.209 |

- Weighted normalized decision matrix
  Before you can determine a weighted normalized decision matrix, we must determine the weight of each criteria.

Table 4. Weight of each criteria.

|   | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|----|----|----|----|----|----|----|----|
|   | 3  | 2  | 1  | 3  | 1  | 3  | 2  | 3  |

The weighted normalized decision matrix is obtained by multiplying each element present in the normalized decision matrix by its weight value.
Table 5. Weighted normalized decision matrix.

|   | C1  | C2  | C3  | C4  | C5  | C6  | C7  | C8  |
|---|-----|-----|-----|-----|-----|-----|-----|-----|
| K1| 1.5 | 0.78| 0.26| 1.96| 0.5 | 1.87| 1.17| 1.25|
| K2| 1.5 | 1.17| 0.52| 1.31| 0.5 | 0.62| 1.17| 1.87|
| K3| 1.5 | 0.78| 0.76| 1.31| 0.5 | 1.87| 0.78| 1.87|
| K4| 1.5 | 1.17| 0.26| 1.31| 0.5 | 1.25| 0.78| 0.62|

- Determine the matrix of positive and negative ideal solution
The positive ideal solution matrix is obtained by finding the maximum value of each criteria on a weighted normalized decision matrix. While the negative ideal solution matrix is obtained by finding the minimum value of each criteria on a weighted normalized decision matrix.

Table 6. Matrix of positive ideal solution.

|   | C1  | C2  | C3  | C4  | C5  | C6  | C7  | C8  |
|---|-----|-----|-----|-----|-----|-----|-----|-----|
|   | 1.5 | 1.17| 0.76| 1.96| 0.5 | 1.87| 1.17| 1.87|

Table 7. Matrix of negative ideal solution.

|   | C1  | C2  | C3  | C4  | C5  | C6  | C7  | C8  |
|---|-----|-----|-----|-----|-----|-----|-----|-----|
|   | 1.5 | 0.78| 0.25| 1.30| 0.5 | 0.62| 0.78| 0.62|

- Counting the separation
Separation is the distance from each value on each criteria with the positive or negative ideal solution matrix.

Table 8. Positive separation.

|   | S1+ | S2+ | S3+ | S4+ |
|---|-----|-----|-----|-----|
|   | 0.901| 1.435| 0.858| 1.675|

Table 9. Negative separation.

|   | S1- | S2- | S3- | S4- |
|---|-----|-----|-----|-----|
|   | 1.593| 1.393| 1.843| 0.738|

- Calculating the proximity to positive ideal solution
The relative proximity of each alternative to a positive ideal solution can be calculated using the following equation.

\[ c_i^+ = \frac{s^-_i}{(s^-_i + s^{+}_i)}, \quad 0 \leq c_i^{+} \leq 1 \]  

(2)
Table 10. Proximity to positive ideal solution.

|   |    |
|---|----|
| C1 | 1.901 |
| C2 | 2.435 |
| C3 | 1.858 |
| C4 | 2.675 |

- Alternative ranking
  Alternative is sorted from the largest $C^+$ to the smallest value. Alternative with the largest $C^+$ value is the best solution.

Table 11. Alternative sorting result.

|   |    |
|---|----|
| C4 | 2.675 |
| C2 | 2.435 |
| C1 | 1.901 |
| C3 | 1.858 |

4. Results and discussion
Based on system design that has been done by following the mentioned research stages, then obtained the following result:

4.1. Homepage

![Homepage](image)

Figure 3. Homepage.

In the preview image above can be seen there is little explanation about the system to be made and the criteria used in building the system. There are 8 criteria that must be met to obtain an alternative decision in determining the tender winner.

4.2. Login page
In figure 4 below can be seen that the user must enter the username and password that has been determined. The user of this system is Nyoman Suarya as the vice chairman of facilities and infrastructure at STMIK STIKOM Indonesia. Nyoman Suarya as the decision maker in the
determination of winner tender has the authority to input data contractor candidate and the criteria owned.

**Figure 4. Login page.**

4.3. **Page list of applicants**
The figure 5 below is a display to show the sample data participant who participated in tender of STMIK STIKOM Indonesia building. Sample participant data can be changed and deleted.

**Figure 5. Page list of applicants.**

4.4. **Page list of criteria**
Figure 6 below shows the list of criteria used to determine the winning tender for the construction of STMIK STIKOM Indonesia. Each criteria has its own weight according to the level of importance of each. Each criteria can be changed and deleted.
4.5. Normalized decision matrix
Once inputted list of sample participant and criteria that must be met will be generated a normalized decision matrix as figure 7 below.

![Normalized decision matrix](image)

Figure 7. Normalized decision matrix.

4.6. Alternative ranking table
After passing through several stages using topsis method, then obtained the ranking result of winning tender based on predetermined criteria and the result can be seen on figure 8 below.

![Alternative ranking table](image)

Figure 8. Alternative ranking table.
5. Conclusion

Based on the research that has been done, then obtained the following conclusions:

- This study was completed with stages problem definition, data collection, data analysis, database design, user interface design, programming, input data sample, and testing system.
- The system can produce results according to manual calculations.

The resulting system can help the vice chairman of STMIK STIKOM Indonesia to determine the winner of the tender for the construction building in STMIK STIKOM Indonesia.

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