



# Completion of Multi-Criteria Decision Making Using the Weighted Product Method on the Server Maintenance Vendor Selection System

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## ABSTRACT

For companies that use information systems or websites in their business activities, server maintenance is an important thing. For this reason, the selection of a server maintenance vendor is crucial. Vendor determination usually begins with gathering information and holding a leadership meeting based on the assumptions of the decision maker. But this method is time consuming and less objective. Vendor selection is a multi-criteria problem where each criterion has a different importance. This can be solved by using the Multi-Criteria Decision Making (MCDM) approach. Weighted Product (WP) is one of the methods of solving MCDM. The purpose of this research is to develop a decision support system to determine the best maintenance vendor using the Weighted Product (WP) method. The system is built using a waterfall system development approach that starts from analysis, design, coding and testing. The developed system has the ability to manage alternatives, criteria, alternative assessments, calculations with WP, and displays the best alternative results with WP. From the results of black-box testing, it shows that the developed system can function and run well. In addition, the results of manual calculations with the system show the same results.

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## 1. Introduction

The term vendor is known as another party originating from an institution or individual in charge of supplying and assisting the company in running its business. Selection of the right vendor among existing vendors is a serious problem for top management [1]. One area that requires vendors is server maintenance. For companies that use information systems or website applications in their business activities, server maintenance is an important thing. Server maintenance has an important role to maintain the continuity of company activities [2]. Determination of vendors for server maintenance is crucial in the company [3]. Vendor determination starts from collecting data and information from potential vendors. Next, the decision makers hold a meeting to discuss the advantages and disadvantages of each potential vendor. But this method is time consuming and less objective. So, to get maximum vendor performance, a system is needed to assist in decision making so that the solutions offered are relevant to the company's goals. Based on this, to determine the server maintenance vendor requires a decision support system by looking at the criteria needed by the company to facilitate decision making.



Vendor selection is a multi-criteria problem where each criterion used has different interests and information about it is not known precisely [4].

Basically, decision making aims to choose the best solution from the available alternatives systematically [5]. While the Decision Support System (DSS) is a system that assists in making decisions for a leader or decision maker in solving semi-structured problems by providing the best alternative solutions or suggestions [6]. DSS can also be interpreted as an interactive information system that helps in managing data into information that can solve problems and provide the right decisions [7]. In other words, decision support systems provide information, models, and data processing that support decision makers to make decisions [8][9].

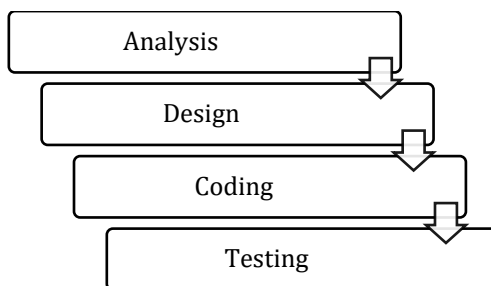
There are several methods that can be used to solve MCDM. Several previous studies in the completion of MCDM related to the selection of vendors or suppliers, including research on the selection of suppliers in TB. Nammene [10]. In this study, the completion of MCDM using the Simple Additive Weighting (SAW) method. SAW works by finding the weighted sum of the performance ratings for each alternative on all attributes. However, SAW has a weakness that is very dependent on the accuracy of weight determination, so as not to cause errors when ranking criteria. Another research, regarding the vendor selection decision support system at PT. Bukit Asam Tarahan Unit [11]. In this study, the completion of MCDM using the Analytical Hierarchy Process (AHP) method. This method solves complex problems with criteria arranged in a hierarchy with criteria values through pairwise comparisons between criteria. However, the problem of AHP is the inability to overcome the uncertainty factor experienced by decision makers to provide value criteria through pairwise comparisons. Furthermore, research on decision support systems for selecting furniture suppliers at CV. Indomeuble [12]. In this study using the TOPSIS method. TOPSIS has the ability to calculate relative performance and decision alternatives. However, TOPSIS has not determined the priority weights which are the priority calculations against the criteria.

The Weighted Product (WP) method is one of the approaches to solving MCDM. WP can be interpreted as an approach that goes through a multiplication process to link the attribute rating then the attribute will be raised to the level of importance or weight value [13]. The WP method has been applied to several previous studies, and is considered to have success in implementing a decision support system, including: research on the best employee selection decision support system at Zain Toppas MSMEs [14], a decision support system for selecting the best lecturer at the University of Muhammadiyah Bengkulu [15], and a decision support system for selecting a sales manager [16].

In this study, a decision support system for the selection of server maintenance vendors will be developed, which can find alternatives based on the weight of each predetermined criterion using the Weighted Product (WP) method. As a problem-solving method, the selection process is carried out using the WP method which will provide an alternative order of vendor maintenance servers. The WP method was chosen because the best alternative was obtained by weighting the attribute rating, so that the chosen alternative was more optimal.

## 2. Research Method

This research involves developing a system, for that the research stages used refer to the system development methodology. The system development method used is the Waterfall system development. The Waterfall approach has successive stages of software development from analysis, design, coding and testing [17]. The stages of the research are arranged so that the research activities carried out are planned, organized, and systematic and the research objectives are achieved [18]. Figure 1 below is the stages of the research carried out.



**Fig 1.** Research Stages

### 2.1. Analysis

At the analysis stage begins with the identification of the problem. The main problem in this research is to determine the best maintenance vendor based on the criteria set by the decision maker. Vendor selection starts from collecting data and information from potential vendors. Then, decision makers hold a meeting to discuss the advantages and disadvantages of each potential vendor. However, this method is time consuming and less objective. These problems will be solved by developing a decision support system. The criteria used for the selection of server maintenance vendors include Price, Number of Certified Professional Technic, Work Implementation Methodology and Company Experience. The method used in overcoming multi-criteria is the Weighted Product (WP) method. The WP method will provide a solution based on the multiplication process to connect attribute ratings and continue by raising the attributes with their weights. As a problem solving method, the best selection process is carried out using the WP method which will provide an alternative sequence of prospective server maintenance vendors.

### 2.2. Design

After the next analysis stage, a design is carried out based on the results of the solutions obtained at the analysis stage. In the design resistance, the system is modeled so that it can be the basis of reference in building and developing the system. In this study, the design uses a use case diagram. Use case diagrams describe the interaction between one or more actors and the system to be developed [19]. In addition, use case diagrams describe the functionality that can be performed by the system.

### 2.3. Coding

At this stage the implementation is carried out by applying the results of the analysis and also the designs that have been made previously into a certain programming language to later become a system. In this study, the coding process uses the PHP programming language with the Sublime Text 3 compiler and MySQL database.

### 2.4. Testing

Furthermore, the system that has been implemented is tested first. This is to ensure the software is working properly [20]. In this study, testing was carried out using a black-box testing approach [21]. Where in this test will be tested on the functionality of the system

## 3. Results and Discussion

In this study, a decision support system for the selection of a server maintenance vendor will be developed by solving multi-criteria using a Weighted Product (WP). There are several steps in solving multi-criteria decision making using WP. Here are the steps to solve it.

- a. Determine the criteria and the level of importance or weight of each criterion.

The criteria and the weight of each criterion are determined by the decision maker. The weighting value consists of values from 1 to 5, with the weights: Very Important (5) ; Important (4); Quite Important (3); Not Important (2); Very Unimportant (1). In addition, the criteria have other types of criteria in the form of Benefit and Cost criteria. The benefit criterion is a criterion that if the value is getting bigger, the better, on the contrary for the cost criterion, if the value is getting smaller, the better. The criteria used to select a server maintenance vendor include: Price (In Millions), Number of Certified Professional Technicians, Work Execution Methodology (3=Very Good; 2=Good; 1=Not

Good) and Company Experience (In Years). The table of criteria and weights can be seen in Table 1.

**Table 1.**  
Criteria and Weights

No	ID	Criteria	Value Weight	Criteria Type
1	C1	Price (In Millions)	5	Cost
2	C2	Number of Certified Professional Technic	5	Benefit
3	C3	Work Implementation Methodology	4	Benefit
4	C4	Company Experience (In Years)	3	Benefit

b. Determine alternatives.

An alternative is a prospective server maintenance vendor whose services will be used. In this study as an example, there are 4 vendors who will be assessed and one vendor is selected as the best from the other vendors based on pre-defined criteria. Alternatives in this study can be seen in Table 2.

**Table 2.**  
Alternative

No	ID	Criteria
1	A1	PT Mitra Informatika
2	A2	PT IT Pedia Indonesia
3	A3	PT Surya Tech
4	A4	PT Nusantara Network

c. Provide alternative values for each criterion.

After the alternatives and criteria are set, the next step is to provide alternative values. Alternative values to the criteria based on data and information from prospective server maintenance vendors. The alternative value list table can be seen in Table 3.

**Table 3.**  
Alternative Value

Alternative	Criteria			
	C1 Price (In Millions)	C2 Number of Certified Professional Technic	C3 Work Implementation Methodology	C4 Company Experience (In Years)
PT Mitra Informatika (A1)	120	10	3	12
PT IT Pedia Indonesia (A2)	100	15	3	9
PT Surya Tech (A3)	150	15	3	10
PT Nusantara Network (A4)	110	10	2	15

d. Determination of the value of the weight (W).

The weight is the level of importance of each criterion. The weight that has been determined by the decision maker is then calculated by equation (1).

$$W_j = \frac{W_j}{\sum W_j} \tag{1}$$

The calculation of the normalized weight value (Wj) for the case of server maintenance vendor selection is as follows:

$$W_1 = \frac{5}{5 + 5 + 4 + 3} = \frac{5}{17} = 0.294$$

$$W_2 = \frac{5}{5+5+4+3} = \frac{5}{17} = 0.294$$

$$W_3 = \frac{5}{5+5+4+3} = \frac{4}{17} = 0.235$$

$$W_4 = \frac{5}{5+5+4+3} = \frac{3}{17} = 0.176$$

e. Determination of vector value (S).

The next step is to calculate the vector value (S) obtained from normalizing each alternative. To calculate the vector value (S) through equation (2).

$$S_i = \prod_{j=1}^n X_{ij}^{W_j} \quad (2)$$

For the benefit criteria the value (W) is positive (+), on the other hand if the cost criteria is negative (-). The calculation of the value (S) for the case of server maintenance vendor selection is as follows:

$$S_1 = (120^{-0.294}) \times (10^{0.294}) \times (3^{0.235}) \times (12^{0.176}) = 0.966$$

$$S_2 = (100^{-0.294}) \times (15^{0.294}) \times (3^{0.235}) \times (9^{0.176}) = 1.091$$

$$S_3 = (150^{-0.294}) \times (15^{0.294}) \times (3^{0.235}) \times (10^{0.176}) = 0.987$$

$$S_4 = (110^{-0.294}) \times (10^{0.294}) \times (2^{0.235}) \times (15^{0.176}) = 0.937$$

f. Preference value determination (V).

The last step is to calculate the preference value for each alternative. The highest preference value is the best alternative. To calculate the preference value using equation (3).

$$V_i = \frac{\prod_{j=1}^n X_{ij}^{W_j}}{\prod_{j=1}^n X_{ij}^{W_j} \times W_j} \text{ atau } V_i = \frac{S_i}{\sum S_i} \quad (3)$$

The calculation of the preference value (V) for the case of server maintenance vendor selection is as follows:

$$V_1 = \frac{0.966}{0.966+1.091+0.987+0.937} = 0.243$$

$$V_2 = \frac{1.091}{0.966+1.091+0.987+0.937} = 0.274$$

$$V_3 = \frac{0.987}{0.966+1.091+0.987+0.937} = 0.248$$

$$V_4 = \frac{0.937}{0.966+1.091+0.987+0.937} = 0.235$$

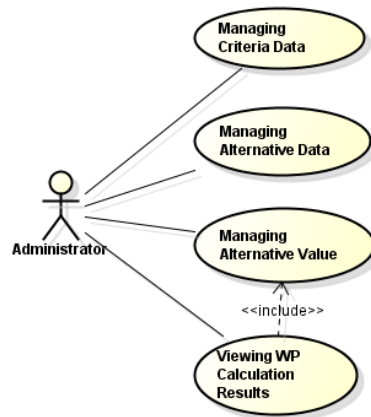
The results of the calculation of the value of Vi can be seen in Table 4.

**Table 4.**  
Reference Value Results

Alternative	Alternative Name	Vi	Order/Rank
A1	PT Mitra Informatika	0.243	3
A2	PT IT Pedia Indonesia	0.274	1
A3	PT Surya Tech	0.248	2
A4	PT Nusantara Network	0.235	4

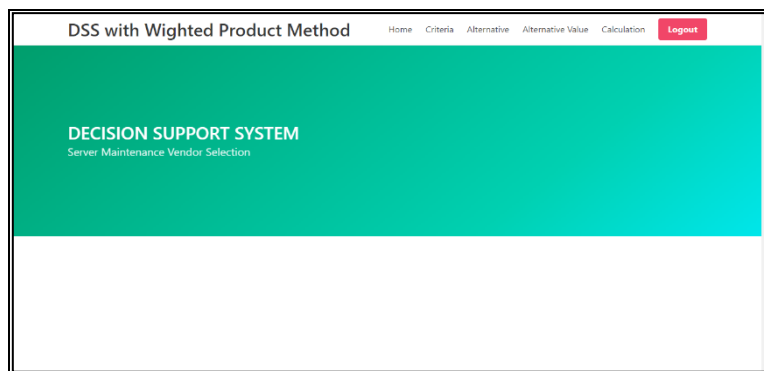
From the results of calculations using the Weighted Product (WP) method manually in determining the server maintenance vendor ranking, the highest preference value ( $V_i$ ) is alternative A, namely PT IT Pedia Indonesia. The highest preference value ( $V_i$ ) is the best alternative.

Prior to implementation, the design was carried out. In this study, the design uses a use case diagram. This diagram describes the relationship between one or more actors and the system to be developed. Figure 2 below is a use case diagram of the system to be developed.



**Fig 2.** Use Case Diagram of the System Developed

Furthermore, the results of the design and application of the WP method are implemented in the form of coding using the PHP programming language using the Sublime Text 3 compiler and MySQL database. Figure 3, shows the main page view of the decision support system for selecting a server maintenance vendor using the web-based WP method that has been implemented.



**Fig 3.** Main Menu Display of Maintenance Vendor Selection Decision Support System

In the decision support system developed, the user in this case is the company admin who will look for server maintenance vendors, can manage criteria, manage alternatives, manage alternative values and can see the best alternative results using the WP method. In the criteria menu, users can manage criteria by adding criteria and deleting criteria and assigning weights to each criterion. The criteria menu display can be seen in Figure 4.

No	Criteria ID	Criteria Name	Weight	Status	Action
1	C1	Price (In Millions)	5	COST	[Add] [Delete]
2	C2	Number of Certified Professional Technic	5	BENEFIT	[Add] [Delete]
3	C3	Work Implementation Methodology	4	BENEFIT	[Add] [Delete]
4	C4	Company Experience (In Years)	3	BENEFIT	[Add] [Delete]

Fig 4. Display of the Criteria Menu on the Maintenance Vendor Selection Decision Support System

Meanwhile, to manage alternatives, users can enter the alternative menu. In this menu the user can add alternatives and delete alternatives. Furthermore, in the alternative value menu, the user can provide a value for each alternative against each criterion based on data and information on prospective vendors. Figure 5 is an alternative value menu display.

No	Criteria	Alternative	Value	Action
1	Price (In Millions)	PT Mitra Informatika	120	[Add] [Delete]
2	Number of Certified Professional Technic	PT Mitra Informatika	10	[Add] [Delete]
3	Work Implementation Methodology	PT Mitra Informatika	3	[Add] [Delete]
4	Company Experience (In Years)	PT Mitra Informatika	12	[Add] [Delete]

Fig 5. Display of the Alternative Value Menu in the Maintenance Vendor Selection Decision Support System

Furthermore, users can see the results of calculations using the WP method on the calculation menu. This menu will show the WP calculation process and the best alternative results generated by the system. Figure 6 below is a display of alternative results generated by the system.

No	Alternative	Price (In Millions)	Number of Certified Professional Technic	Work Implementation Methodology	Company Experience (In Years)
1	PT Mitra Informatika	120	10	3	12
2	PT IT Pedia Indonesia	100	15	3	9
3	PT Surya Tech	150	15	3	10
4	PT Nusantara Network	110	10	2	15

No	Alternative	Value
1	PT Mitra Informatika	0.243
2	PT IT Pedia Indonesia	0.274
3	PT Surya Tech	0.248
4	PT Nusantara Network	0.235

Fig 6. Display of Weighted Product (WP) Method Calculation Results

It can be seen in Figure 6, with the same input data as the manual calculation case study, producing the highest  $V_i$  value is PT IT Pedia Indonesia with a  $V_i$  result of 0.274.

Furthermore, the system that has been implemented will be tested to ensure the system is free from errors. Testing is done by using Black-box testing. This test is an approach that tests the function of each feature on the system. Table 5 below is the result of Black-box testing.

**Table 5.**  
Test Results Black-Box Testing

No	Tested features	Expected results	Conclusion
1	Main Menu	Can display the main menu	Valid
2	Displaying Criteria	Can display criteria menu	Valid
3	Adding Criteria	Can add criteria	Valid
4	Deleting Criteria	Can delete criteria	Valid
5	Displaying Alternative	Can display alternative menu	Valid
6	Adding Alternative	Can add alternative	Valid
7	Deleting Alternative	Can delete alternative	Valid
8	Show alternative values	Can display the value of each alternative	Valid
9	Adding alternative value	Can add alternative value	Valid
10	Removing alternative values	Can delete alternative values	Valid
11	Displaying Weighted Product (WP) Calculation Results	Can display Weighted Product (WP) calculation results	Valid

In this research, the development of a decision support system for choosing a maintenance server vendor is applied by the WP algorithm. The WP algorithm process starts from determining the weight value (W), determining the vector value (S) and determining the preference value (V). The alternative that is the best solution is the alternative with the highest preference value (V). In the case study discussed earlier, the results of manual calculations show that the highest  $V_i$  value is alternative A, namely PT IT Pedia Indonesia with a  $V_i$  result of 0.274. The case study was then also applied to the system and produced the same value and result, namely the highest  $V_i$  value was PT IT Pedia Indonesia with a  $V_i$  result of 0.274. From the results of the application of the Weight Product (WP) method, that the results of manual calculations with system outputs show the same results. This is because the WP algorithm has simple stages so it is easy to implement into the system. Meanwhile, on the results of black-box testing, it can be seen that all the features in the system can run and function properly.

#### 4. Conclusion

This study develops a decision support system for server maintenance selection using the Weighted Product (WP) method. The TOPSIS method is able to produce the best alternative based on multiplication to relate attribute ratings and then sort them by attribute weights. The system developed has the ability to manage alternatives, manage criteria, manage alternative values, perform calculations using the WP method, and display the best alternative results using the WP method. The results of manual calculations with system outputs show the same results. This is because the WP algorithm has simple stages so it is easy to implement into the system. While the black box test results show that the developed system can function and run well. However, improvements are needed for future research. The weight of the WP method is very dependent on the accuracy of the value determined by the decision maker, for that we need a weighting method that can convert uncertainty, for example by combining it with the Fuzzy algorithm.

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