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Analysis and Design of the Best Suppliers Selection Case Study: Department Store Kopetri with the Ahp and Topsis Methods

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Abstract- This research discusses about supplier decision support system to kopetri business engaged in marketing. Toserba should look for suppliers of basic foods, snacks, stationery, electronics, cosmetics, and other necessities. In the process of selecting supplier the problems that faced by the department store manager and manager of the cooperative division is difficulty to determining the best supplier because they only judging based on the criteria of price and the quality. To fulfill these needs an application is built that can provide output of recommendations for supplier selection based on appropriate criteria. Determination of criteria based on quality, price, delivery, and service. The method used in building the supplier selection decision support system is using Analytical hierarchy process (AHP) as the determinant of the criterion, where each value will be compared with each other and Technique for order preference by similarity to ideal solution (TOPSIS) method will be using to find a weighted sum that can ranking or evaluate suppliers. This supplier selection decision support system is built using MySQL, Php and sublime text as tools. This decision support system will be designed to be web-based.

Keywords- supplier selection; Analytical hierarchy process (AHP); Technique for order preference by similarity to ideal solution (TOPSIS); Compare.

I. INTRODUCTION

Supplier election is a strategic activity because the supplier will supply items that are critical or will be used in the long run. supplier reliability is reflected in the delivery of cheap, quality, on time and able to provide satisfactory service [5]Therefore, companies need to evaluate the performance of suppliers to get suppliers in accordance with company criteria. The main purpose from the supplier selection process is to reduce risk and maximize buyer value.

The department store is one of the kopetri business that is engaged in marketing. To fulfill the needs of members and public demand, the department store should look for suppliers of foodstuff, commodities, snacks, stationery and personal items. In the process of choosing the best supplier, the department store has not been effective, because it only judge based on price and quality offered. As a result there are still suppliers who infringe the rules of the agreement that has been agreed and the assessment results are less than optimal. There are no supplier evaluation report to support supplier selection decisions. As a result there are mistakes in determining the supplier. And the absence of ranking from the assessment of suppliers, because not using

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methods that can help ranking yet so the manager does not know the ranking and preference values for each alternative.

The method used in this supplier selection decision is the Analytical Hierarchy Process (AHP) because the AHP method is an effective decision-making framework in solving complex problems by simplifying the problem and arranging it in the hierarchy [6]. Also using the Technique for order preference by similarity to ideal solution (TOPSIS) method because the TOPSIS method is able to choose the best selected alternative not only has the shortest distance from the ideal solution but also has the longest distance from the ideal solution negative. This concept is widely used on MCDM concept to solve decision problems in practical, this is due to the concept is simple and easy to understand computing efficient, and has the ability to measure the relative performance of decision alternatives in a simple mathematical form[1].

II. RESEARCH METHODOLOGY

This will be explained about the steps that taken to obtain research methodology which is a step that must be applied so that research can be done with directional and facilitate in conducting analysis to existing problems. The stages of this study are as follows:

1. Observation
   This activity is used by direct observation to collect data related to the process of selecting the best suppliers at the department store.
2. Interview
   This method is used by asking questions that related to the process of selecting the best supplier directly to the procurement division manager. From these interviews obtained a data that will be used in the development of the decision support system of the best supplier selection.
3. Questionnaire
   This questionnaire is a process of data collecting used to determine the responses of respondents to the questions that has been asked. The results of questionnaires obtained from the respondents, there will be a result that will be used for the calculation of criteria on the selection of the best suppliers at the department store.
4. Literature Review
   Literature review is a method of collecting data by reading and collecting documents as references, such as books, articles, journals, and final project literature related to the object of research. This literature study is done by reading journals or e-books also other references related to best supplier selection theory, decision support system theory, Analytical Hierarchy Process (AHP) method theory and Technique for order preference by similarity to ideal solution (TOPSIS) method.

2.1 Decision support

According to Turban, Rainer, Potter (2010, h.321) entitled 'Decision Support systems and Intelligent systems' mentioned that "Decision Support System (DSS) a computer-based informa-tion system that combines models and data to provide support for decision makers in solving semi structured or interdependent problems with extensive user involvement". In the Indonesian language can be defined as *Sistem Pendukung Keputusan* (SPK) is a computer-based information system that combines models and data to provide support to decision makers in solving of semi-structured problem or dependency problems that involve the user deeply [2].

2.2 Supplier

Supplier is one of the most critical or important chains for profit and survival of most companies. World-class companies known that the quality of their products and services is directly related to the quality of suppliers and the products and services they provide [9].

2.3 Analytical hierarchy process (AHP)

Analytical Hierarchy Process (AHP) is a method used in the decision process of a complex problem, such as problems: planning, needs determination, demand forecasting, performance planning, optimization and conflict resolution that more objective and subjective than with MFSM method. The AHP method was first introduced by Dr. Thomas L. Saaty of the Wharton School of Business in 1970. A problem that solved using the AHP method is said to be complex if the structure of the problem is not accurate, so the input used to solve this problem is human thinking. However, this thinking, in order to have maximum results must come from people who have expertise (expert) in the field to be the object. (Saaty, 1980) in [12].

2.4 Technique for order preference by similarity to ideal solution (TOPSIS)

TOPSIS is a multi-criteria decision-making method or alternative choice which is an alternative that has smallest distance from the ideal solution and the greatest distance from the ideal solution from a geometric point of view by using the Euclidean distance. However, the alternative that has the smallest distance from the ideal positive solution, should not have the big distance from the ideal negative solution. Therefore, TOPSIS considers both, the distance to the positive ideal solution and the distance to the negative ideal solution

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simultaneously. The optimal solution in the TOPSIS method is obtained by determining the relative proximity of an alternative to a positive ideal solution. TOPSIS will ranking alternatives based on the relative priority value of an alternative to a positive ideal solution. Alternatives that have been ranked then used as a reference for decision makers to choose the best solution desired [5].

2.5 *The Software Development Method*

Method that used in the development of this software is the prototype model method. Prototype model or prototyping model is a technique to collect certain information about user information needs quickly. Focusing on presentation of those aspects of Software that will appear to customer or user (for example input approach and output format) [8].

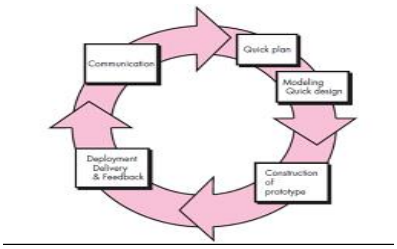

Figure 1 prototype model

Prototype method starts from the communication stage. The software development team meets with *stakeholders*to to determine the needs of the currently known software and to describe areas where further definitions for the next iteration [8].

Iteration planning of prototype making is done quickly. After that modeling is done in the form of "quick design". The design of fast design is based on representation of software aspects that will be seen by *end users* (eg user interface design or display format). Quick design is the basis for starting prototype construction [8].

The prototype is then left to the *stakeholders* to evaluate *prototype* that have been made before and provide feedback that will be used to improve the requirements specification. Iteration occurs when the developer makes improvements to the prototype [8].

III.RESULTS AND DISCUSSION

3.1 Analysis of system requirements

This application is intended to facilitate the work of managers in the selection of the best suppliers at department stores that managed by Kopetri. This application will be made to be web-based because the interface is quite flexible when it comes to dealing with various operating systems and devices. When we open a web application using a laptop that has a wider screen and greater power, the application can adjust to the needs. Conversely, when accessed with smaller devices such as smartphones, web applications can also adjust to a narrow screen. That way, users will find it much easier to interact with web-based applications.

This design of supplier selection application requires some input data such as supplier data, criterion data, criteria value, criterion of comparison value, eigenvector, alternative value, normalization matrix. Value of comparison criteria, eigenvector, alternative value have calculate function and calculating the calculation in system. For example, the comparison of suppliers criteria is calculated and then the eigenvector is consistent with the value of the consistency index (CI) and produces a value of consistency ratio (CR). And from the weight of the criteria in the matrix normalize to raise the best supplier selection. Support for the design of this system as follows:

The output of this application as follows:

- Displays the results of AHP calculation.
- Displays the results of TOPSIS calculation.
- Displays the results of comparing calculation of two methods
- Print result of the decision ranker
- Print results of the comparing
- Displays results of the supplier evaluation report
- Display update supplier’s data report

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3.2 Discussion on the calculation method of AHP

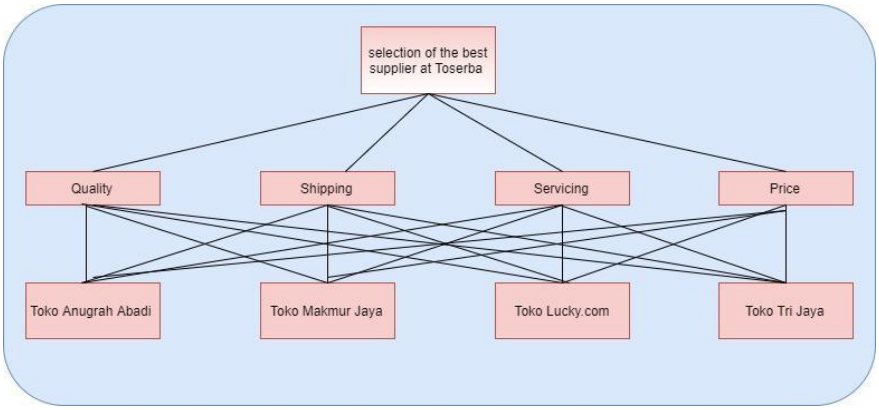

Figure 2 Structural Hierarchy Selection of Best Supplier

1. Comparison of Interests Between Criteria

Based on the questionnaire that has been proposed to the respondents experts, the didapatlah table comparison matrix per the following criteria:

Criteria	Quality	Delivery	Service	Price
Quality	1	1	1	7
Delivery	1	1	1	5
Service	1	1	1	5
Price	1/7	1/5	1/5	1

Table 1 Conversion matrix per criterion

Step 1: Describe the above matrix in alternative form.

$$\begin{pmatrix} 1{,}0000 & 1{,}0000 & 1{,}0000 & 7{,}0000 \\ 1{,}0000 & 1{,}0000 & 1{,}0000 & 5{,}0000 \\ 1{,}0000 & 1{,}0000 & 1{,}0000 & 5{,}0000 \\ 0{,}1429 & 0{,}2000 & 0{,}2000 & 1{,}0000 \end{pmatrix}$$

Step 2 : Multiplying the matrix by itself (1st iteration)

$$\begin{pmatrix} 1{,}0000 & 1{,}0000 & 1{,}0000 & 7{,}0000 \\ 1{,}0000 & 1{,}0000 & 1{,}0000 & 5{,}0000 \\ 1{,}0000 & 1{,}0000 & 1{,}0000 & 5{,}0000 \\ 0{,}1429 & 0{,}2000 & 0{,}2000 & 1{,}0000 \end{pmatrix} X \begin{pmatrix} 1{,}0000 & 1{,}0000 & 1{,}0000 & 7{,}0000 \\ 1{,}0000 & 1{,}0000 & 1{,}0000 & 5{,}0000 \\ 1{,}0000 & 1{,}0000 & 1{,}0000 & 5{,}0000 \\ 0{,}1429 & 0{,}2000 & 0{,}2000 & 1{,}0000 \end{pmatrix}$$

Step 3: The result of the 1st iteration matrix multiplication.

$$\begin{pmatrix} 4{,}0003 & 4.4 & 4.4 & 24 \\ 3{,}7145 & 4 & 4 & 22 \\ 3{,}7145 & 4 & 4 & 22 \\ 0.6858 & 0.7429 & 0.7429 & 4{,}0003 \end{pmatrix}$$

Step 4:each result line from the 1st matrix multiplication.

$$\begin{pmatrix} 36{,}8003 \\ 33{,}7145 \\ 33{,}7145 \\ 6{,}1719 \end{pmatrix} +$$

$$110{,}4012$$

Step 5: Normalize by dividing each number of rows in the matrix by the total rows that will produce the 1st iteration eigenvector

$$\begin{pmatrix} 0.3333 \\ 0.3054 \\ 0.3054 \\ 0\,,\,0559 \end{pmatrix} +$$

$$1$$

After iterating, then do AHP model testing by calculating Consistency Index (CI) value and Consistency Ratio (CR) value.

Step 1: Multiply the number lterna value of each matrix of criteria with eigenvector

$$\begin{pmatrix} 1{,}0000 & 1{,}0000 & 1{,}0000 & 7{,}0000 \\ 1{,}0000 & 1{,}0000 & 1{,}0000 & 5{,}0000 \\ 1{,}0000 & 1{,}0000 & 1{,}0000 & 5{,}0000 \\ 0{,}1429 & 0{,}2000 & 0{,}2000 & 1{,}0000 \end{pmatrix} X \begin{pmatrix} 0{,}3333 \\ 0{,}3054 \\ 0{,}3054 \\ 0{,}0559 \end{pmatrix} \xrightarrow{\text{result}} \begin{pmatrix} 1{,}3354 \\ 1{,}2236 \\ 1{,}2236 \\ 0{,}2257 \end{pmatrix}$$

Step 2: Calculate the vector consistency with determining the average value ie dividing the result from the previous calculation with the result of the 2nd iteration eigenvector.

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$$\begin{pmatrix} 1.3354 \\ 1.2236 \\ 1.2236 \\ 0.2257 \end{pmatrix} : \begin{pmatrix} 0.3333 \\ 0.3054 \\ 0.3054 \\ 0.0559 \end{pmatrix} = \begin{pmatrix} 4.0063 \\ 4.0068 \\ 4.0068 \\ 4,0371 \end{pmatrix}$$

Step 3: Calculate the average value of the consistency vector.

$$\Pi = \frac{4,0063 + 4,0068 + 4,0068 + 4,0371}{4} = 4,0143$$

Step 4: Calculate the value of the consistency index (CI) by using the formula. $CI = (\pi\text{-}n)$ the number of alternatives $\frac{}{n-1}$

$$CI = \frac{(4,0143 - 4)}{4 - 1} = 0,0048$$

Step 5: Calculating the consistency ratio (CR), required random index (RI) value obtained from:

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

Given: n = number of criteria

n = 4

Based on the number of criteria is 4, the RI value is 0.90, in accordance with the provisions already given as follows:

n	2	3	4	5	6	7
RI_n	0	0,58	0,90	1,12	1,24	1,32

$$CR = \frac{0.0048}{0.90}$$

$$= 0.0053$$

Thus, the value of the consistent ratio (CR) for the best supplier selection criterion at the Co-op storehouse is 0.0053. Comparative assessment is said to be consistent if the consistency ratio (CR) is no more than 0.10 so that the comparison criteria for the selection of the best suppliers in the Cochlear Shop is consistent and does not require revision of the assessment.

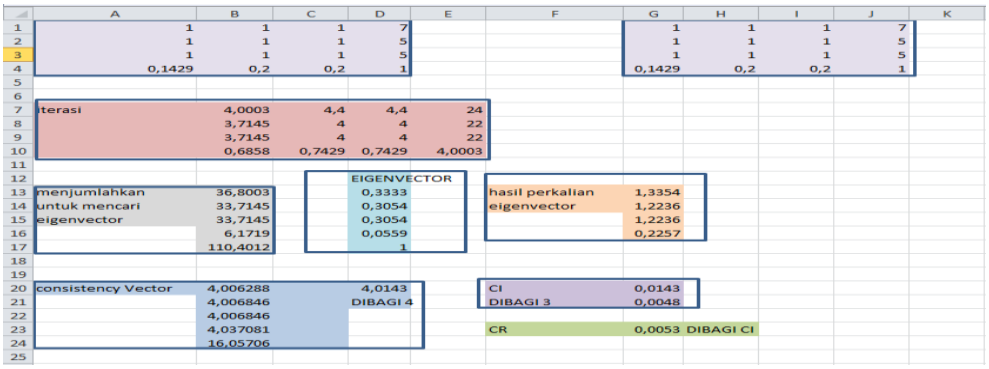

Figure 3 Ahp method calculation using excel

3.3 **calculation using Topsis method**

Generally, TOPSIS steps are as follows:

- Create a normalized decision matrix.
- Create a normalized weighted decision matrix.
- Determine the matrix of positive and negative ideal solutions.
- Determine the distance between alternative values of each alternative with the positive and negative ideal solution matrices.
- Specifies the preference value for each alternative.
- TOPSIS requires performance rating of each alternative Ai on each of the normalized Ci criteria:

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

A positive ideal A + solution and an alternative A alternative can be determined based on a normalized weighted rating

(y_{ij}) as: The

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$$y_{ij} = w_i r_{ij}$$

$$A^+ = \left(y_1^+, y_2^+, \Lambda\ , y_n^+\right);$$

$$A^- = \left(y_1^-, y_2^-, \Lambda\ , y_n^-\right);$$

$$y_j^+ = \begin{cases} \max\limits_i y_{ij}; & jika\ \text{j adalah atribut keuntungan} \\ \min\limits_i y_{ij}; & \text{jika j adalah atribut biaya} \end{cases}$$

$$y_j^- = \begin{cases} \min\limits_i y_{ij}; & jika\ \text{j adalah atribut keuntungan} \\ \max\limits_i y_{ij}; & \text{jika j adalah atribut biaya} \end{cases}$$

distance between Ai lternative with the ideal ideal solution is defined as: The

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (y_i^+ - y_{ij})^2}\ ;$$

distance between alternative Ai and ideal solution lternat is formulated as:

$$D_i^- = \sqrt{\sum_{j=1}^{n} (y_{ij} - y_i^-)^2}\ ;$$

The preference value for each lternative (Vi) is given as:

$$Vi = \frac{D_i^-}{D_i^- - D_i^+}\ ;$$

The larger Vi value indicates that the lternative Ai is preferred.

Alternative	Criteria			
	Quality	Delivery	Service	Price
Shop endowment	2	4	4	3
Store prosperous jaya	4	5	4	4
Shop lucky.com	3	1	2	4
Shop tri jaya	3	4	3	3
Weight	0.3333	0,3054	0,3054	0,0559

Table 2 Alternative value per-criteria

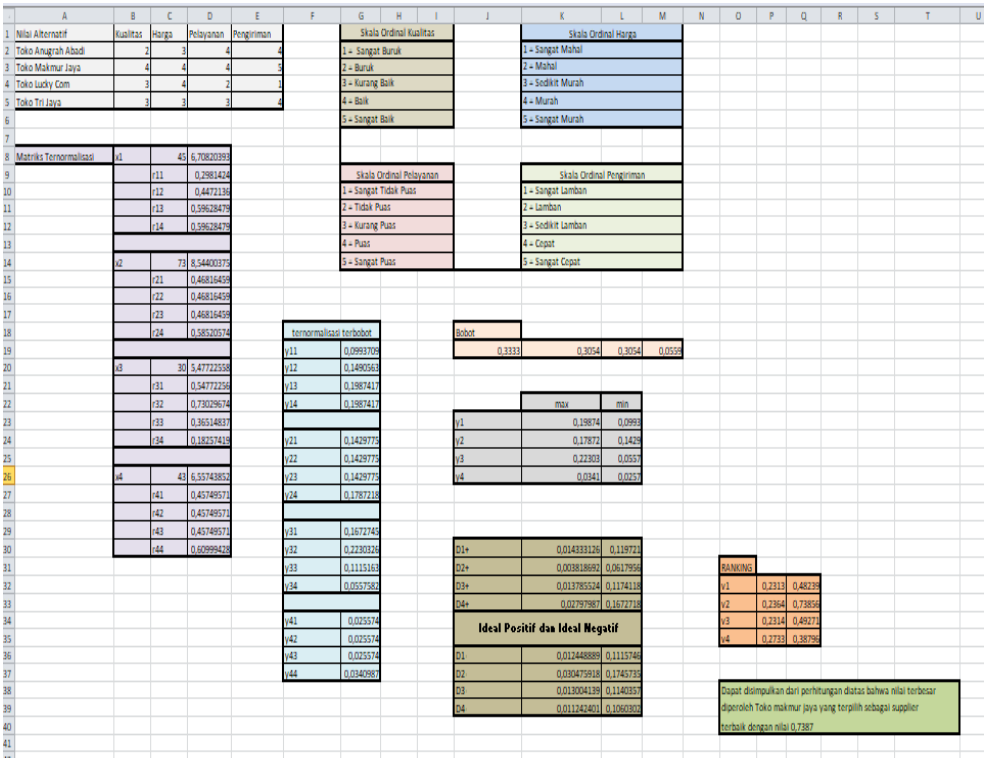

Figure 4 topsis method calculation using excel

3.3 System Design Phase

Before building a system, UML will be designed first, such as class diagrams, sequence diagrams, and use case diagrams, mock ups, and database design as follows:

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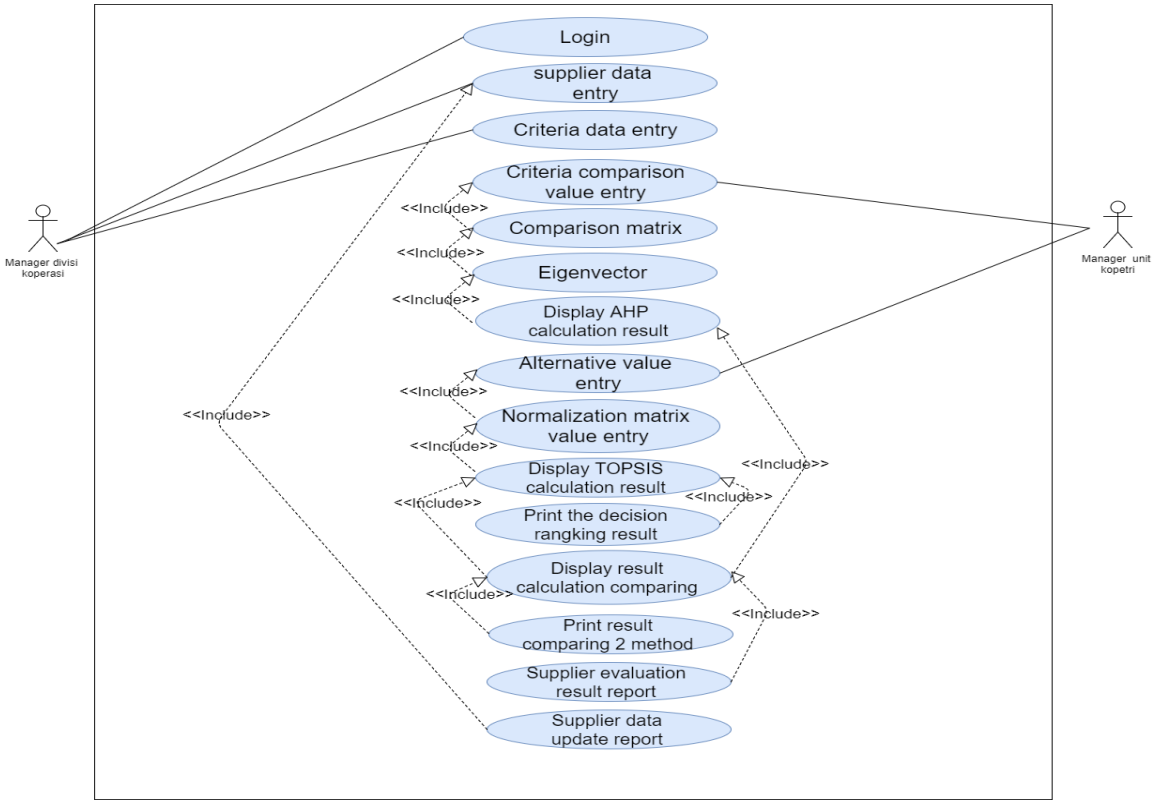

Figure 5 Use case diagram

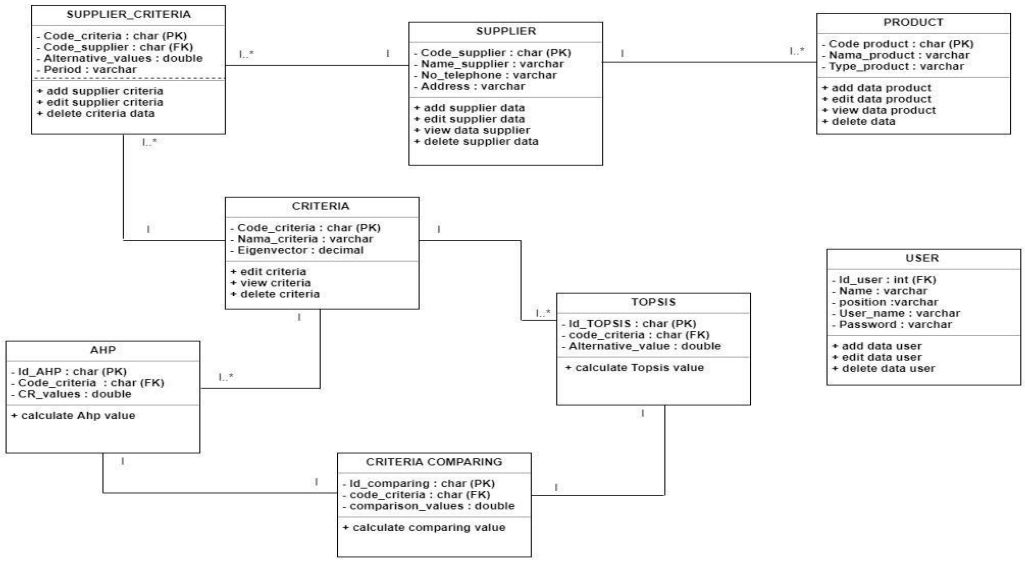

Figure 6 Class diagram

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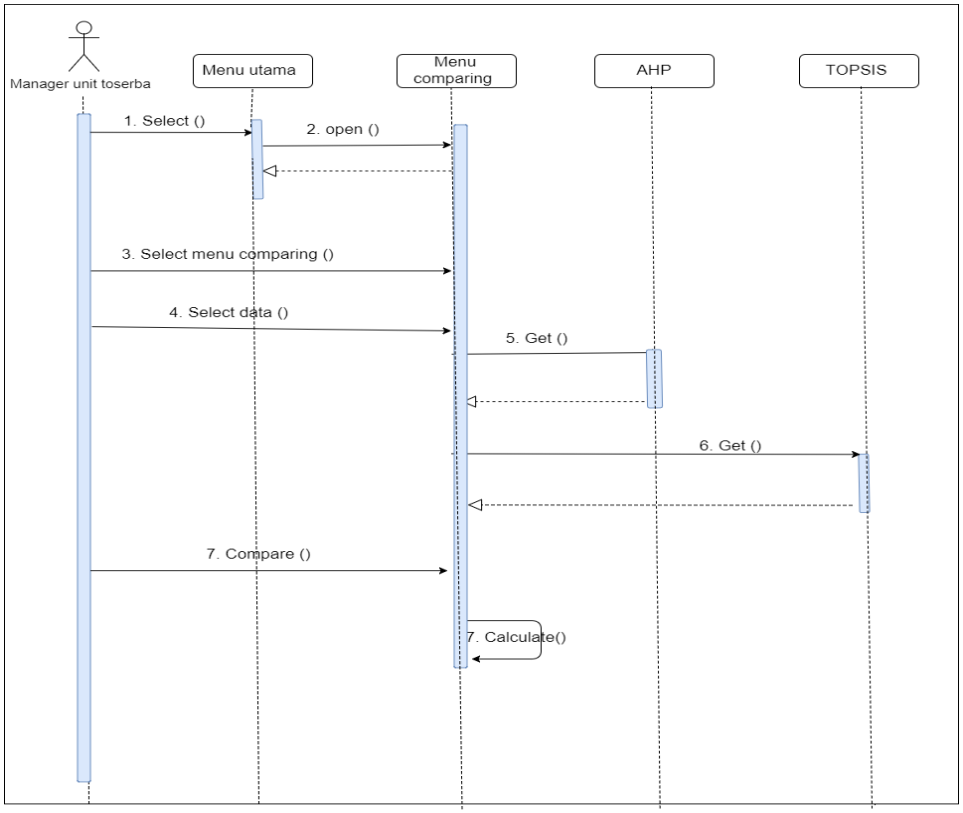

Figure 7 sequence diagram (compare)

3.3.1 The prototype design of supplier selection

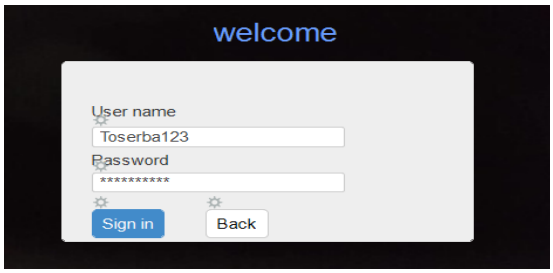

Figure 1 user home page

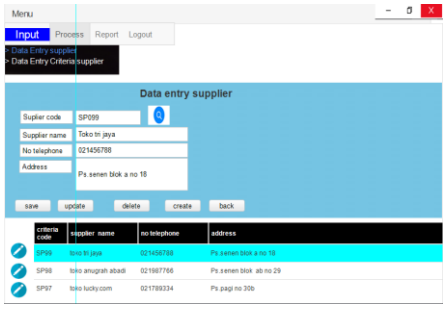

Figure 2 data entry suppliers

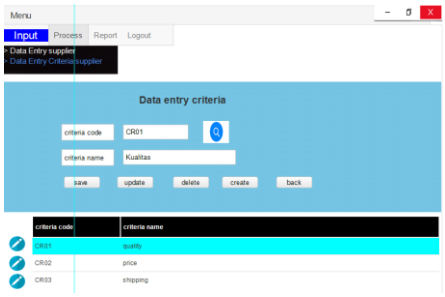

Figure 3 data entry criteria

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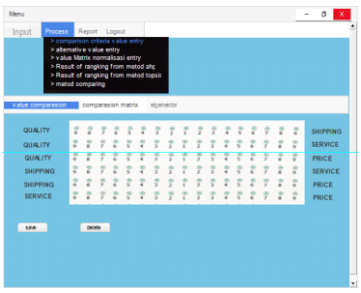
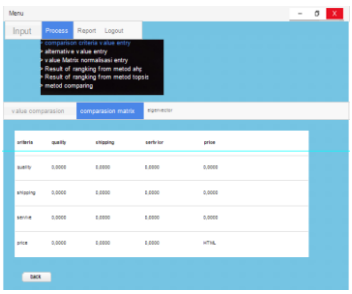
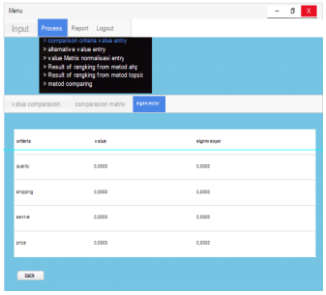

Figure 4, 5, 6 comparision criteria value entry

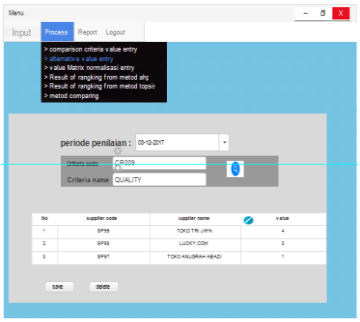

Figure 7 alternative value entry

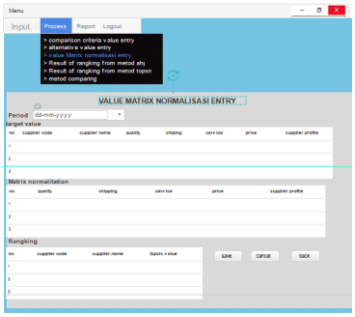

Figure 8 value matrix normalization entry

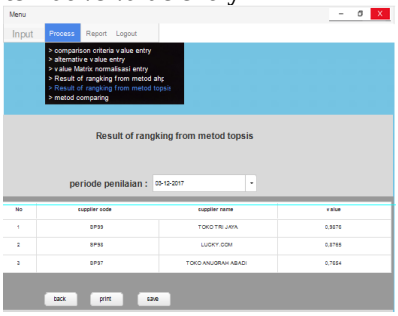
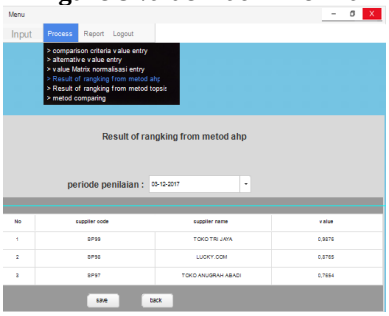

Figure 9, 10 result of ranking from ahp and topsis method

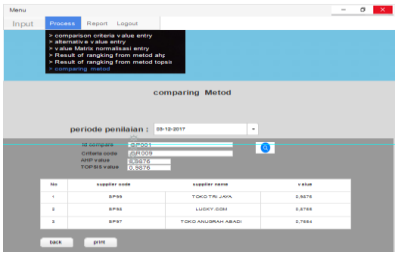

Figure 11 result comparing method

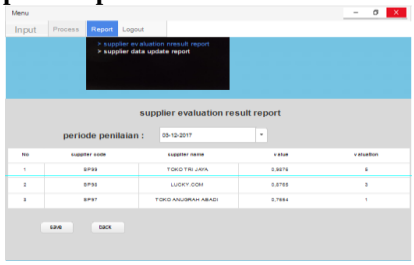

Figure 12 supplier evaluation result report

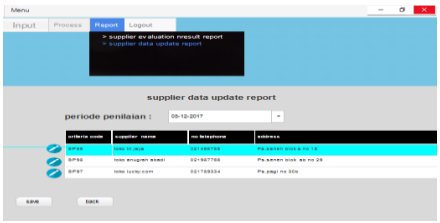

Figure 13 supplier data update report

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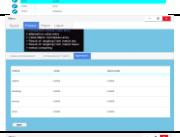
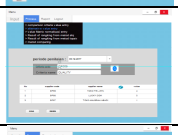
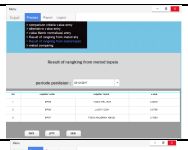
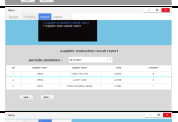
3.3.2 Scrum blackbox testing

No	Item testing	Detail testing	image	Tasted by	Testing date
1	Login	Verify login		Dara	
2	Data processing supplier	delete, create, update, save back		Dara	
3	Data processing criteria	delete, create, update, save, back		Dara	
4	processing value from AHP method	Comparative value, comparison matrix, eigenvector, save, back		Dara	
5	Alternative value processingvalue	Period, Code criteria, search, update, save, delete, back		Dara	
6	Processing matrix normalization	Period of assessment, target value data, normalization matrix data, ranking result, save, cancel, back		Dara	
7	Processing of Topsis	Period, best result data result, save, print, back		Dara	
8	Processing result comparing	Period, id compare, code criteria, ahp value, topsis value, process, back, print		Dara	
9	Data processing supplier report	Period, data prangkingan, save, back		Dara	
1 0	Data processing update report	Period, supplier data, button update, save, delete		Dara	

3.4 Specification

Recommendation Specifications that can run well are as follows:

Hardware:

- Processor intel (R) core (TM) I3 CPU
- Ram 1gb (911MB usable)
- harddisk at least 250 gb
- 14 inch monitor
- Canon Mx377 Printer

Software:

- Windows XP OS ultimate or more
- Browser google chrome, mozilla firefox, internet explorer
- MySQL database system 5.0.10
- Using sublime text 2, Adobe Dreamweaver, Notepad ++ for editing source code

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3.5 Data base design

user

No	attributes	type	leght	Information
1	Id_user	char	4	Primary key
2	name	varchar	20	
3	position	varchar	20	
4	User_name	varchar	20	
5	password	varchar	6	

supplier database specification

No	attributes	type	length	information
1	Code_supplier	char	4	Primary key
2	Nama_supplier	varchar	30	
3	No_telephone	int	12	
4	address	varchar	50	

Type product database specification

No	attributes	type	length	Information
1	Code_product	char	4	Primary key
2	Name_product	varchar	30	
3	Type_product	varchar	15	

Criteria database specification

No	attributes	type	leght	decimal	information
1	Code_criteria	char	4		Primary key
2	Nama_criteria	varchar	30		
3	Eigenvector	decimal	5	4	

Supplier criteria database specification

No	Attributes	Type	Leght	decimal	information
1	Code_criteria	char	4		Primary key
2	Code_supplier	char	4		Fk
3	Alternative_values	double	5	2	
4	period	vharchar	4		

database specification ahp

No	attributes	type	leght	decimal	Information
1	Id_AHP	Char	4		Primary key
2	Code_criteria	char	4		FK
5	CR Value	decimal	5	4	

database specification topsis

No	attributes	Type	leght	decimal	information
1	Id_topsis	char	4		Primary key
2	Code_criteria	char	4		FK
4	Alternative_value	double	5	2	

Comparing database specification

No	attributes	type	leght	decimal	Information
1	Id_comparing	char	4		Primary key
2	Code_criteria	char	4		Fk
3	Comparison_values	decimal	5	4	

IV. CONCLUSION

Based on case study ever conducted at CoC Store, the conclusion is:

1. The decision support system is expected to facilitate in determining the best supplier effectively, because data processing, calculation of final result, and printing report from assessment result are in one system.
2. It is expected that the interim results from this decision support system are accurate. Assessment based on 4 predefined criteria to support the assessment of the selection of the best suppliers of Quality, Price, Service, Delivery, Supplier Profile that has been obtained the weight of each criterion by using Analytical Hierarchy Process (AHP) method. The weight of the criteria calculated after being obtained based on the questionnaire, Quality with eigenvector value 0.3333; Delivery with eigenvector value 0,3054, Service with eigenvector value 0,3054; Price with eigenvector value 0.0559; And the eigenvector value is consistent with Consistency Ratio value that is 0,0053.
3. This decision support system utilizes Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method as supplier calculation process according to predetermined criteria so it can make it easier to know the best supplier.
4. From the results obtained for the combination of the two AHP and TOPSIS methods, the topsis method is better to complete the selection of suppliers because with the topsis method can handle the difference of alternative that the difference is quite small. This does not mean closing the possibility that the AHP method is no better.

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V. SUGGESTIONS

To support this Decision Support System, the authors suggest the following:

1. In order for the system to overcome the addition of criteria, further development is needed. For example the addition of criteria to assess company profile.
2. In further research, can be examined in more detail about the continuity aspect of supplier's ability to supply continuity, durability and safety of the product offered.
3. For further development can do research by using new methods of jam ahp and topsis, such as promethee method for example.

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