SAW-TOPSIS Implementation To Determine An Appropriate DBMS Software

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Abstract—Selection an appropriate Database Management Software, is a crucial part to ensure operational excellence businesses firm. Database management software used to organize and manage the company's data so that they can be efficiently accessed and used to improve operational and decision quality. However, a senior manager as decision maker sometimes lacks the comprehensive knowledge to choose a suitable database management software which meets with business needs. Then, The manager determines a database management software based on a consultant or vendor offer. On the other hand, a consultant or vendor has an interest in to sell their product, so they tend to lead manager to choose their product even though it is not fulfilling business needs. We present a decision support application to help the manager to select an appropriate database management software (DBM) for their company, using Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. We observe SQL Server, MySQL, Oracle, DB2, and PostgreSQL as five top database management software and investigate the detail about *cost, storage capacity, security, supported the operating system and supported programming language* as key criteria to select best database management software from their official website. Then, we combining SAW and TOPSIS method to choose the best appropriate DBM software based on user requirement through computation program and validate our application performance includes the user interface, usability and accuracy result to 50 database engineers expert as respondent. The results are as follows; 1) 86 % of respondents are satisfied with application user interface, 2) 94% are happy with application usability and 3) 86% are pleased with the accuracy of the computation. Overall, this study provides a decision support application to determine an appropriate database management software based on business needs by combining SAW and TOPSIS methods.

Index Terms—Database Management System; Decision Support; SAW; TOPSIS.

I. INTRODUCTION

An appropriate database management software has a crucial role in supporting a business operational excellence. It can provide a suitable method for handling multiple types of data and able to increase the efficiency of business operations and reduces overall costs [1]. However, often the decision maker in an organisation has insufficient knowledge to decide suitable DBMS to support their organisation needs, then, they decide to procure a database management software based on consultant's or vendor's suggestion. On the other hand, consultant and vendor have the interest of conflict to sell their product. Often, It causes the DBMS which chosen is not appropriate with organisation's requirement.

There are some key criteria to select appropriate DBMS software includes cost, storage capacity, security, supported the operating system and supported programming language [1]. So, it needs to analyse the requirement and strategic business before deciding on an appropriate DBMS software for the organisation. There are various methods to make a decision based on multi-criteria as like as the decision to select appropriate DBMS software, such as Simple Additive Weighting (SAW) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [2].

The saw is a kind of multi-attribute procedure which is based on the concept of a weighted summation and can determine a weight for each attribute and then by looking for a weighted summation of rating the performance of each alternative the highest score will be taken as the best alternative [3]. There are studies used a SAW and applied to various selection problems. For instance, SAW used to develops a mapping of flood-prone areas base on many aspects to consider [4] and to select the best area for business [5]. On the other hand, TOPSIS is a decision method based on a concept that the best choice should have both the least distance from positive ideal solution and the farthest distance from negative solution [2]. Some previous researchers have been carried out using TOPSIS. For example, TOPSIS used to evaluate the effects of supply vane angle of an ambient air conditioning system on energy utilisation and thermal comfort [6] and to choose appropriate laptop [7].

The same input data is required both SAW and TOPSIS then they can find the best choice by comparing overall evaluations in SAW or closeness coefficients in TOPSIS [8]. The advantage of the SAW is straightforward and easy to use and understand; it uses a proportional linear transformation of the raw data. So, the relative magnitude order of the standardised scores remains equal [3]. On the one hand, the advantage of TOPSIS is that it is considered the positive ideal and the ideal negative solutions as anchor points to reflect the contrast of the currently available criterion performances [8].

This study aims to develop a prototype of decision support application to find the best alternative to DBMS software for an organisation based on its business requirement by combining SAW and TOPSIS method to get the best solution. This paper is organised as follows. In the next section, a brief overview about SAW and TOPSIS will be presented, in Section 3, we discuss the method. Then in Section 4, a set of steps to implementation of the methodology. Finally, the conclusion is presented in Section 5.

II. SAW AND TOPSIS METHOD

A. *Simple Additive Weighting (SAW)*

Simple Additive Weighting (SAW) is a method used to find the optimal alternative of some alternatives with certain criteria. The concept of the SAW is determining the value weights for each attribute, then proceed with the sorting process to select an option. There are steps to apply SAW methods, firstly identify the candidates [A_i] (as an alternative), then determine criteria and weighting value as a reference to make a decision [Cj]. Secondly, develop a decision matrix [X] from pairwise comparison table of each alternative to each criterion[3]. Value [X] include each alternative (A_i) on each criterion (Cj) that have been determined, wherein, i = 1,2, ... m and j = 1,2, ... n as shown as follow.

$$X = \begin{bmatrix} x_{11} x_{12} & \cdots & x_{1j} \\ \vdots & \ddots & \vdots \\ x_{i1} x_{i2} & \cdots & x_{ij} \end{bmatrix}$$

Thirdly, normalizing the decision matrix by calculating values normalized performance rating (r_{ij}) of alternative A_i on the criteria Cj, as follows.

$$r_{ij} = \begin{cases} \frac{x_{ij}}{Max_i(x_{ij})} & if\ j\ is\ benefit\ criteria \\ \frac{x_{ij}}{Min_i(x_{ij})} & if\ j\ is\ cost\ criteria \end{cases}$$

Then, the result is a matrix of normalized [R] as follow.

$$R = \begin{bmatrix} r_{11} r_{12} & \cdots & r_{1j} \\ \vdots & \ddots & \vdots \\ r_{i1} r_{i2} & \cdots & r_{ij} \end{bmatrix}$$

B. *Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)*

TOPSIS is one method of multi-criteria decision making first introduced by Yoon and Hwang in 1981. With the basic idea is that the selected alternative has a distance closest to the ideal solution has a positive and the distance of the farthest away from the ideal solution negative [4].

Yoon and Hwang developed the TOPSIS method based on an intuition that choice is the alternative that has the nearest distance from the ideal positive solution and the farthest distance from the ideal negative solution from a geometric point of view by using the Euclidean distance. However, alternatives that have the smallest distance from the ideal negative solution should not have the most significant distance from the ideal positive solution. Therefore, TOPSIS considers both, the distance to the ideally positive solution and the distance to the ideally negative solution 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 rank options based on the relative value priority value of an alternative to a positive ideal solution. The options that have been ranked are then used as a reference for decision-makers to select the best-desired solution [6].

III. METHODS

There are three steps to integrate SAW and TOPSIS method. The first step is using a SAW, and TOPSIS for selecting the appropriate DBMS is determining some options of DBMS platform and some criteria to consider on choosing DBMS. Based on top five ranks of DBMS platform in http//www.db-engines.com. These alternatives are MySQL, Microsoft SQLServer, Oracle, DB2, dan PostgreSQL. There are seven criteria which are considered to choose DBMS platform [1], License Cost, Maintenance Cost, Storage, Programing Language, Operating system, Security, and Technical support. Then, We observe five top database management software includes SQL Server, MySQL, Oracle, DB2, and PostgreSQL and investigate the detail about *cost, storage capacity, security, supported the operating system and supported programming language* as key criteria to select best database management software from their official website as shown in Table 1.

Table 1
Official Website Of Database Management Software

DBMS	Official Website
SQLServer 2014	https://msdn.microsoft.com/en-us/library/bb669078(v=vs.110).aspx
MySQL v5.7	https://dev.mysql.com/doc/mysql-security-excerpt/5.1/en/security.html
Oracle 12c	https://www.oracle.com/database/security/index.html
DB2 10.5	http://www-01.ibm.com/software/data/db2/linux-unix-windows/security/
PostgreSQL 9.5	http://www.ibm.com/developerworks/library/os-postgresecurity/

Secondly, applying SAW method by determining weight value for each seven criteria selection based on various information on the official and reputable website [11] [12] [13] [14] [15] [16] [17] [18]. There are three types of license. Proprietary license, General, Public License (GPL), and Open Source. Then, normalise the decision matrix by calculating values normalised performance rating (r_{ij}) of alternative A_i on each criteria $C_{j...7}$ using the Equation (1) as follow.

$$r_{ij} = \begin{cases} \frac{x_{ij}}{Max_i(x_{ij})} & if\ j\ is\ benefit\ criteria \\ \frac{x_{ij}}{Min_i(x_{ij})} & if\ j\ is\ cost\ criteria \end{cases} \quad (1)$$

The third step is used part of TOPSIS step using Equation (2):

$$Y_{11} = w_i r_{ij} \quad (2)$$

Then, determining the ideal solution A^+ using Equation (3).

$$A^+ = (y_1^+, y_2^+, \cdots, y_n^+) \quad (3)$$

Next, determining negative-ideal solution A^- using the Equation (4).

$$A^- = (y_1^-, y_2^-, \cdots, y_n^-) \quad (4)$$

Then, measure the distance between solution from the ideal-positive by calculating using Equation (5).

$$D_i^+ = \sqrt{\sum_{j=1}^n (y_i^+ - y_{ij})^2}; \quad (5)$$

Then, the distance between solution from the ideal-negative can be calculated using Equation (6).

$$D_i^- = \sqrt{\sum_{j=1}^{n}(y_{ij} - y_i^-)^2};$$ (6)

Then, the relative proximity Ci to the ideal can be calculated using Equation (7).

$$V_1 = \frac{D_i^-}{D_i^- + D_i^+}$$ (7)

Finally, ranking options will be obtained by sort the descending order of Ci. The highest value is the best candidates.

IV. IMPLEMENTATION AND SIMULATION METHOD

We use seven criteria as a parameter to choose a database management software includes; *License Cost, Maintenance Cost, Storage, Programing Language, Operating system, Security, and Technical supportI*[1]. Before applying SAW and TOPSIS, we defined whether each of the seven criteria included cost category or benefit category as described in Table 2.

Table 2
Cost and Benefit Criteria

Criteria	Cost / Benefit	Code
License Cost	Cost	C1
Maintenance Cost	Cost	C2
Storage	Benefit	C3
Programing Language	Benefit	C4
System Operation	Benefit	C5
Security	Benefit	C6
Technical Support	Benefit	C7

Weight value for each selection criteria is determined as follows.

A. License Cost, Maintenance Cost, And Storage

There are three types of license. Proprietary license, General, Public License (GPL), and Open Source. Based on this official website, maintenance cost is annual amount of cost which spent by DBMS user in the dollar, and storage is the maximum capacity which offered by DBMS platform in terabytes. License, maintenance cost and storage for each alternatives DBMS as shown in Table 3.

Table 3
License Cost of DBMS Platform

DBMS	License type	License Cost ($)	Maintenance Cost ($/year)	Storage (Terra Byte)
SQLServer	Proprietary	3717	513322	524.272
MySQL	GPL and Proprietary	2000	20000	256
Oracle	Proprietary	3500	220000	8.388.224
DB2	Proprietary	5449	29810	2.097.152
PostgreSQL	Open source	257	52500	4

B. Operating system

The weight value of the operating system is given based on the number of the operating systems which support to DBMS platform. This value is shown in Table 4.

Table 4
Supported Operating System To DBMS Platform

DBMS	Supported OS	Number of OS
SQLServer	Microsoft Windows	1
MySQL	FreeBSD, Linux, OS X, Solaris, Windows	5
Oracle	AIX, HP-UX, Linux, OS X, Solaris, Windows, z/OS	7
DB2	Linux, Unix, Windows, z/OS	4
PostgreSQL	FreeBSD, HP-UX, Linux, NetBSD, OpenBSD, OS x, Solaris, Unix, Windows	9

C. Programing Language

Programing language (PL) is given weight based on the number of a programming language that supports to DBMS platform as like as shown in Table 5.

Table 5
Supported Programing Language Platform

DBMS	Supported Programing Language (PL)	Total
SQLServer	.Net, Java, PHP, Phyton, Ruby, Visual Basic	6
MySQL	Ada, C, C#, C++, D, Eiffel, Erlang, Haskell, Java, Objective-C, OCaml, Perl, PHP, Phyton, Ruby, Scheme, Tcl	17
Oracle	C, C#, C++, Clojure, Cobol, Eiffel, Erlang, Fortran, Groovy, Haskell, Java, Javascript, Lisp, Objective-C, Caml, Perl, PHP, Phyton, R, Ruby, Scala, Tcl, Visual Basic	23
DB2	C, C#, C++, Cobol, Fortran, Java, Perl, PHP, Phyton, Ruby, Visual Basic	11
PostgreSQL	.Net, C, C++, Java, Perl, Phyton, Tcl	7

D. Security

There are various types of recognised attacks are excessive privileges, privilege abuse, unauthorised privilege elevation, platform vulnerabilities, SQL injection, weak audit, denial of service, database protocol vulnerabilities, weak authentication, and exposure of backup data. Security weight defined by considering robustness of each DBMS against various types of attacks. It is given value 1 when the attacker was resolved and given value 0 when the attacker either has not fixed yet or has not happened yet. The attack defined based on the official website in Table 1. Then, Security weight for each alternative as described in Table 6.

Table 6
Type of Attacks Solved And Security Weight

Type of Attacks	SQL server	My SQL	Oracle	DB2	Postgre SQL
Excessive privileges	0	1	1	0	1
Privilege abuse	1	1	1	0	1
Unauthorized privilege elevation	1	1	1	0	1
Platform vulnerabilities	1	1	0	1	0
SQL injection	1	1	1	1	1
Weak audit	1	1	1	1	1
Denial of service	1	1	1	1	1
Database protocol vulnerabilities	0	0	0	0	1
Weak authentication	1	1	1	1	1
Exposure of backup data	1	1	1	1	1
Total	**8**	**9**	**8**	**6**	**9**

E. Technical Support

Technical support is a service provided by DBMS vendors to users. Some categories of technical support are Call in,

Block Hours, Managed Service, and Crowdsources Technical Support.

The weight of technical support is determined based on the number of services provided by each DBMS vendor where the value 1 indicates the availability of the technical support service and the value 0 indicates the unavailability of the service. The weight of technical support as shown in Table 7.

Table 7
Weight of Technical Support

DBMS	Call in	Block Hours	Managed Service	Crowdsources Technical Support	Total
SQLServer	1	0	1	1	**3**
MySQL	1	0	1	1	**3**
Oracle	1	0	1	1	**3**
DB2	1	1	0	1	**3**
PostgreSQL	1	0	0	1	**2**

F. Implementation SAW And TOPSIS On Computer Program

To apply SAW and TOPSIS method, firstly, we should define The Weight of criteria (by the user) and the total number of the weight should 100 to make computation process easier. Let say the number Weight of criteria as shown in Table 8 as an example of calculation.

Table 8
Sample of The Weight of Criteria For User

Criteria	License Cost	MTC Cost	Storage	Programing Language	System Operation	Security	Technical Support
Notation	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*
Wheight	50	30	4	5	3	5	3

Based on information in the Table 1-8 we obtain a summary table of the DBMS weight selection criteria as illustrated in Table 9 and also develop a decision matrix as shown in Figure 1.

Table 9
DBMS Weight Selection Criteria

DBMS		License Cost ($)	Mtc Cost ($/yr)	Storage (TB)	P L	OS	Security	Tech Support
Catagory		Cost	Cost	Benefit	Benefit	Benefit	Benefit	Benefit
Code		C1	C2	C3	C4	C5	C6	C7
SQLServer	A1	3717	513322	524.272	6	1	8	3
MySQL	A2	2000	20000	256	17	5	9	3
Oracle	A3	3500	220000	8.388.224	23	7	8	3
DB2	A4	5449	29810	2.097.152	11	4	6	3
PostgreSQL	A5	257	52500	4	7	9	9	2

$$X = \begin{pmatrix} 3717 & 513322 & 52427 & 6 & 1 & 8 & 3 \\ 2000 & 20000 & 256 & 17 & 5 & 9 & 3 \\ 3500 & 220000 & 8388220 & 23 & 7 & 8 & 3 \\ 5449 & 29810 & 2097150 & 11 & 4 & 6 & 3 \\ 257 & 52500 & 4 & 7 & 9 & 9 & 2 \end{pmatrix}$$

Figure 1: DBMS Decision Matrix Weight Selection Criteria

Then, after normalising decision matrix using formula (1) of SAW method, we get the normalised matrix as describes in Figure 2.

$$R = \begin{pmatrix} 14.46303502 & 25.6661 & 0.06250098352 & 0.2608695652 & 0.1111111111 & 0.8888888889 & 1 \\ 7.782101167 & 1 & 0.00003051898973 & 0.7391304348 & 0.5555555556 & 1 & 1 \\ 13.61867704 & 11 & 1 & 1 & 0.7777777778 & 0.8888888889 & 1 \\ 21.20233463 & 1.4905 & 0.2500113254 & 0.4782608696 & 0.4444444444 & 0.6666666667 & 1 \\ 1 & 2.625 & 0.0000004768592145 & 0.3043478261 & 1 & 1 & 0.6666666667 \end{pmatrix}$$

Figure 2: DBMS Normalized Decision Matrix

The next step is calculating weighted decision matrix using formula (2) as part of TOPSIS. The result is a matrix Y as shown in Figure 3.

$$Y = \begin{pmatrix} 723.151751 & 769.983 & 0.2500039341 & 1.304347826 & 0.3333333333 & 4.444444444 & 3 \\ 389.1050584 & 30 & 0.0001220759589 & 3.695652174 & 1.666666667 & 5 & 3 \\ 680.9338521 & 330 & 4 & 5 & 2.333333333 & 4.444444444 & 3 \\ 1060.116732 & 44.715 & 1.000045302 & 2.391304348 & 1.333333333 & 3.333333333 & 3 \\ 50 & 78.75 & 0.000001907436858 & 1.52173913 & 3 & 5 & 2 \end{pmatrix}$$

Figure 3: DBMS Weighted Decision Matrix

The positive ideal solution A^+ and negative ideal solution A^- are determined using formula (3) and (4). The result for the ideal solution for $y_{1...7}$ is $A^+ = \{50; 30; 4; 5; 3; 5; 3\}$ for the positive ideal solution.

And $A^- = \{1060.116; 769.983; 0.0000019; 1.304; 0.333; 3.3333; 2\}$ for the negative-ideal solution. Then, the distance solution from ideal positive is measured using formula (5), and the distance solution from the ideal negative is measured using formula (6). The result as shown in Table 10

Table 10
The Distance Solution From Ideal Positive And Ideal Negative

Distance from ideal positive	Distance from ideal negative
$D_1^+ = 1000.371561$	$D_1^- = 336.968389$
$D_2^+ = 339.133777$	$D_2^- = 998.9208075$
$D_3^+ = 698.6259935$	$D_3^- = 580.861936$
$D_4^+ = 1010.234479$	$D_4^- = 725.2708828$
$D_5^+ = 49.04753596$	$D_5^- = 1223.988892$

To get the best choice, we should consider relative proximity between criteria (C_i) from ideal positive solution using formula (7), and the result is as follow:

$$V_1 = \frac{336.968389}{336.968389 + 1000.371561} = 0.2519691339 \text{ (SQL server)}$$
$$V_2 = \frac{998.9208075}{998.9208075 + 339.133777} = 0.7465471282 \text{ (MySQL)}$$
$$V_3 = \frac{580.861936}{580.861936 + 698.6259935} = 0.4539800045 \text{ (Oracle)}$$
$$V_4 = \frac{725.2708828}{725.2708828 + 1010.234479} = 0.4179018392 \text{ (DB2)}$$
$$V_5 = \frac{1223.988892}{1223.988892 + 49.04753596} = 0.9614720091 \text{ (PostgreSQL)}$$

By sort options with the descending order of Ci, we will have the best candidate to choose. The greatest value is the best candidates. Based on results we get the result that the best candidate for the defined weight of criteria as seen in Table 7 is PostgreSQL (V_5).

SAW and TOPSIS are applied to develop the prototype of decision support application using PHP language. The interfaces of the application developed in Bahasa and described in Figure 4 and Figure 5.
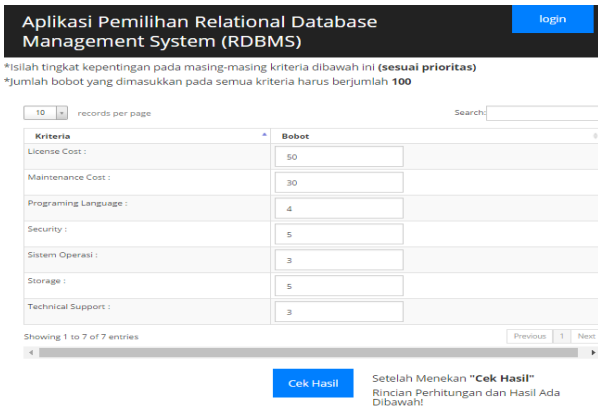
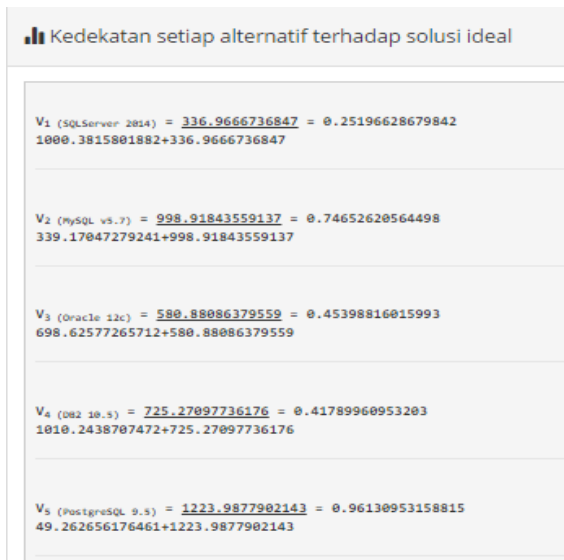Figure 4: Interface to input weight of each criterion

Figure 5: The result of close-ness each alternative toward ideal solution

G. Validation Of Prototype

We validate the application prototype for three parameters includes a user interface, usability and accuracy by asking feedback from 50 expert user as respondent through a questionnaire. The expert user is the person who has at least two years of experience as a database engineer. We obtain the respondents from various database engineer forum on the internet. Then we ask them to try the prototype and give us a feedback questionnaire includes interface, usability and accuracy of computation result of the application.

The results are as follows;
1. 86 % of respondents are satisfied with application user interface.
2. 94% are happy with application usability .
3. 86% are pleased with the accuracy of the computation. The result of verification shown in Table 11.

Table 11
Validation Result For Application Prototype

Criteria	Very satisfied	Satisfied	Not Satisfied
User Interface	52%	34%	14%
Usability	54%	40%	6%
Accuracy	8%	78%	14%

V. CONCLUSION

This study shows that combining SAW and TOPSIS methods can be used for selecting the best alternative of database management software. Then, based on the validation by 50 numbers of expert users we get the results that 1) 86 % of respondents are satisfied with application user interface, 2) 94% are happy with application usability and 3) 86% are pleased with the accuracy of the computation. To conclude, this study provides a decision support application to determine an appropriate database management software based on business needs by combining SAW and TOPSIS methods.

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