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The Selection of an E-Wallet by Mathematics Students at the University of North Sumatra Using the Analytical Hierarchy Process (AHP) Method

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ABSTRACT

Choosing an e-wallet is an important decision for students at the University of North Sumatra because it affects their financial management. The Analytical Hierarchy Process (AHP) method is used to evaluate and compare available e-wallets based on criteria that are relevant to students. The research results show that the most common criteria used by University of North Sumatra mathematics students in choosing an E-Wallet is user friendly, where students are comfortable using the E-Wallet. The best E-Wallet based on eigenvector normalization calculations is DANA, with a value of 0,500444. The Analytical Hierarchy Process method allows students to determine the e-wallet that best suits their needs and priorities.

Keyword: e-wallet, management, Analytical Hierarchy Process, eigenvector normalization

1. INTRODUCTION

The emergence of new habits is a result of rapid technological advancements over time. One tangible piece of evidence that can be felt in daily life is the change in methods of non-cash transaction payments from cash to non-cash. This change has been increasingly applied during the COVID-19 pandemic because we must reduce direct contact to reduce the spread of COVID-19 [1]. Previously, non-cash payments could be made using payment cards, which can be credit or debit cards issued by various government and private banks under the umbrella of Bank Indonesia [2]. Now, there are non-cash payments that can be made using digital applications, namely electronic wallets (E-Wallet), created by companies that are currently pioneering in the technology and information sectors.

Based on Bank Indonesia Regulation No. 18/40/PBI/2016 on the Implementation of Payment Transaction Processing, 2016, E-Wallet is an electronic service for storing payment instrument data, such as payment cards and/or electronic money, which can also hold funds for making payments. An e-wallet is a type of prepaid account protected by a password where users can store money for each online transaction [3]. These applications can be downloaded for free on a personal smartphone. The use of e-wallets in the era of technological advancement has made them a necessity as a legitimate payment method.

Among students, the use of E-Wallet is known to be practical and fast, especially among mathematics students at USU. Mathematics students at USU directly experience the development of technology in the ease of transactions. In this case, mathematics students at USU apply E-Wallet payment methods for transactions at convenience stores, supermarkets, transportation, and for sending money. Additionally, E-Wallet has used current and accurate technology so that the balance amount can be known through a personal smartphone without having to go to the nearest ATM [4-5].

With the emergence of e-wallet payment methods, transactions have become more convenient and do not require carrying cash or cards [2]. As stated in the Bank Indonesia regulations previously mentioned, E-Wallet must have a permit from Bank Indonesia before it can be used as a payment method. This wallet is to be considered a legitimate payment method today, alongside cash, credit cards, and debit cards. Some e-wallets that are quite familiar among mathematics students at USU and have obtained licenses from Bank Indonesia are DANA, OVO, and GoPay.

The Increasing use of e-wallets in daily life and the numerous types available have raised concerns about which e-wallet application is most effective to use among students. To address this issue, a decision support system was conducted to determine alternative e-wallets by identifying any factors that encourage the use of alternative e-wallets.

Based on the above explanation, the writers conducted scientific research with the title "E-Wallet Selection for Mathematics Students at USU using the Analytical Hierarchy Process (AHP)" to obtain recommendations that are suitable and effective for their needs. The selection of e-wallets uses three criteria consisting of user friendly, promotion, and merchant.

2. METHODS

This research develops a analytical hierarchy process (AHP) method for the problem to get the best e-wallet selection

2.1 Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a decision support system developed by Thomas L. Saaty in the 1970s. The AHP method is used to find priorities or rankings among several alternatives to obtain continuous or discrete pair-wise comparisons. One of the advantages of AHP is that it can systematically and rationally understand the structure of a problem when making decisions. Its limitations are that pair-wise comparisons cannot explain the inaccuracy when the decision-maker needs to attach specific values to product concepts based on criteria. As for the steps of the AHP method, they are:

1. Identifying the problem and selecting the expected solution.
2. Creating a hierarchical structure that starts with the main goal.
3. Creating a pair-wise comparison matrix on criteria and performing pair-wise comparisons. The pair-wise comparison scale is a tool used in the analytical hierarchy process (AHP) to evaluate the relative importance of different criteria or alternatives. The scale consists of the following values:

Table 1. Paired Comparison Rating Scale

Level of Importance	Definition
1	Same importance as the other
3	Moderate importance compared to the other
5	Strong importance compared to the other
7	Very strong importance compared to the other
9	Extremely important compared to the other
2, 4, 6, 8	Values between two adjacent judgments

4. Determining the eigenvalue. As for the steps to determine the eigenvalue, they are:
   a. Squaring the pair-wise comparison matrix
   b. Determining the sum of the squared pair-wise comparison matrix
5. Performing pair-wise comparisons on alternatives at each criterion and determining the eigenvalue using the equation (1).

$$Wci = \frac{tA^2}{\sum_i^1 tA^2} \tag{1}$$

where,

$Wci = Eci$: Criteria eigen of the i

tA^2 : Eigen number of pairwise matrices

$\sum_i^1 tA^2$: The total of the sums tA^2

6. Test the concentration on the ratio of the pairwise comparison matrix; if the value is 10%, then the consistency is valid, but if it exceeds 10%, it is mandatory to correct the calculation. Stages for selecting ratio consistency, namely:
   A. Determine the *Weighted Sum Vector* (WSV) in equation (2):

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} & C_{15} & C_{16} \\ C_{21} & C_{22} & C_{23} & C_{24} & C_{25} & C_{26} \\ C_{31} & C_{32} & C_{33} & C_{34} & C_{35} & C_{36} \\ C_{41} & C_{42} & C_{43} & C_{44} & C_{45} & C_{46} \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} & C_{56} \\ C_{61} & C_{62} & C_{63} & C_{64} & C_{65} & C_{66} \end{bmatrix} \times \begin{bmatrix} W_{11} \\ W_{12} \\ W_{13} \\ W_{14} \\ W_{15} \\ W_{16} \end{bmatrix} = \begin{bmatrix} Cv_{11} \\ Cv_{21} \\ Cv_{31} \\ Cv_{41} \\ Cv_{51} \\ Cv_{61} \end{bmatrix} \quad (2)$$

where,

WSV : *Weighted Sum Vector*

A : Pairwise Comparison Matrix

W : *Eigen Vector*

B. Calculate lambda (λ) in the equation (3):

$$\lambda = \sum_{i=1}^{n} Cv_{ij} \quad (3)$$

where,

λ : The average value of all criteria

Cv : *Consistence Vector*

n : Number of comparison matrix for a criterion

C. *Consistence Index* (CI) in the equation (4):

$$CI = \frac{\lambda - n}{n - 1} \quad (4)$$

where,

CI : *Consistence Index*

λ : The average value of all criteria

n : Number of comparison matrix for a criterion

D. Calculate *Consistence Ratio* (CR) in the equation (5):

$$CR = \frac{CI}{RI} \quad (5)$$

where,

CR : *Consistence Ratio*

CI : *Consistence Index*

RI : *Random Index*

The values contained in the random index are issued by Oakridge Laboratory, as shown in Table 2:

Table 2. *Random Index*

Matrix Size	Random Index (Inconsistent)
1, 2	0,00
3	0,58

4	0,90
5	1,12
6	1,24
7	1,32
8	1,41
9	1,45
10	1,49
11	1,51
12	1,48
13	1,56
14	1,57
15	1,59

3. RESULT AND DISCUSSIONS

1. Define the problem.

   Determine the objectives, criteria, and alternatives as follows:

   Goal : Choose the best E-Wallet

   Criteria : User-Friendly, Promo, and Merchant

   Alternatives : DANA, OVO, and GoPay

2. Create a hierarchical structure.

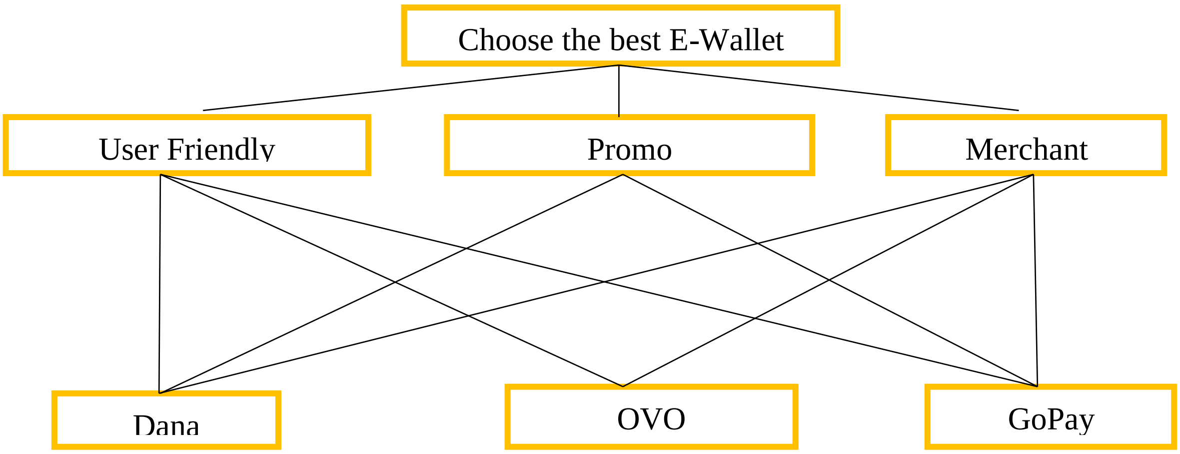


Figure 1. hierarchical structure

3. Create a comparison matrix.

   In this case, it has 3 criteria, namely C = {User-Friendly, Promo, and Merchant}, and 3 alternatives, namely A = {DANA, OVO, and GoPay}. Then four pairwise comparisons were carried out as follows:

   a. Comparison between criteria will form a 3x3 matrix

   b. Comparison of each alternative against the user-friendliness criteria will form a 3x3 matrix.

c. The comparison of each alternative against the promotion criteria will form a 3x3 matrix.
d. The comparison of each alternative against the merchant's criteria will form a matrix of 3x3.
e. From each pairwise comparison matrix, we will calculate the eigenvector normalization and check for hierarchical consistency.

Calculations for Comparison Between Criteria.

Based on the assumptions of the decision-makers, we change them in quantitative form:

- User Friendly is **between moderate and strong importance** compared to Promo, scale 4
- User Friendly is **very strong importance** compared to Merchant, scale 7
- Promo is **between moderate and strong importance** compared to Merchant, scale 4

There is a hierarchical sub – system with a number, $C = \{C_1, C_2, \ldots, C_n\}$. Then the pairwise comparison matrix to compare one criterion with another criterion is made in matrix form as follows:

Table 3. Pairwise Comparison Matrix for Criteria

Criteria	C_1	C_2	C_3
C_1	a_{11}	a_{12}	a_{13}
C_2	a_{21}	a_{22}	a_{23}
C_3	a_{31}	a_{32}	a_{33}

Table 4. Pairwise Comparison Matrix for Alternative

Alternative	A_1	A_2	A_3
A_1	a_{11}	a_{12}	a_{13}
A_2	a_{21}	a_{22}	a_{23}
A_3	a_{32}	a_{32}	a_{33}

Referring to Table 3, we can form a pairwise comparison matrix as follows:

Table 5. Pairwise Comparison Matrix for Each Criteria

	User Friendly	Promo	Merchant
User Friendly	1	4	7
Promo	0,25	1	4
Merchant	0,14	0,25	1
	1,39	5,25	12

Based on the comparison in Table 3, we look for the comparison value for:

- User Friendly compared to Promo

$$a_{21} = \frac{1}{a_{12}} = \frac{1}{4} = 0,25$$

- User Friendly compared to Merchant

$$a_{31} = \frac{1}{a_{13}} = \frac{1}{7} = 0{,}14$$

- Merchant compared to Promo

$$a_{32} = \frac{1}{a_{23}} = \frac{1}{4} = 0{,}25$$

For the value i = j, then value $a_{ij} = 1$. This means $a_{11} = 1, a_{22} = 1, a_{33} = 1$

4. Calculate normalized eigenvectors

To calculate the normalized eigenvector, we use Table 5. Multiply the rows and columns as follows:

Determine the eigenvector normalization

C1	1	1	0,98	2,98
C1	4	4	1,75	9,75
C1	7	16	7	30
First row				42,73
C2	0,25	0,25	0,56	1,06
C2	1	1	1	3
C2	1,75	4	4	9,75
Second row				13,81
C3	0,14	0,0625	0,14	0,3425
C3	0,56	0,25	0,25	1,06
C3	0,98	1	1	2,98
Third row				4,3825

The normalized vector eigenvalues are generated by dividing the sum of each row by a total of 60,9225

Then the results of the calculations above are made in a Table 6

Table 6. Normalized eigenvectors for comparison criteria

Criteria	User Friendly	Promo	Merchant	TOTAL	EVN
User Friendly	2,98	9,75	30	42,73	0,701383
Promo	1,06	3	9,75	13,81	0,226681
Merchant	0,3425	1,06	2,98	4,3825	0,071936
Total				60,9225	

5. Calculate consistency ratio

The consistency ratio is used to determine the level of consistency of criteria comparison assessments.

- Determine the maximum eigenvalue (λ_{maks})

$$\lambda_{maks} = (1,39*0,701)+(5,25*0,226)+(12*0,071) = 3,028$$

- Calculate consistency index (CI) :

$$CI=\lambda_{maks}\text{-n/n-1} = 3,028 - 3/3\text{-}1 = 0,28/2 = 0,014$$

- Calculate consistency ratio (CR)

Based on the consistency index table, the IR for the 3x3 matrix is 0,58, so we get:

$$CR = CI/IR = 0,014/0,58 = 0,024$$

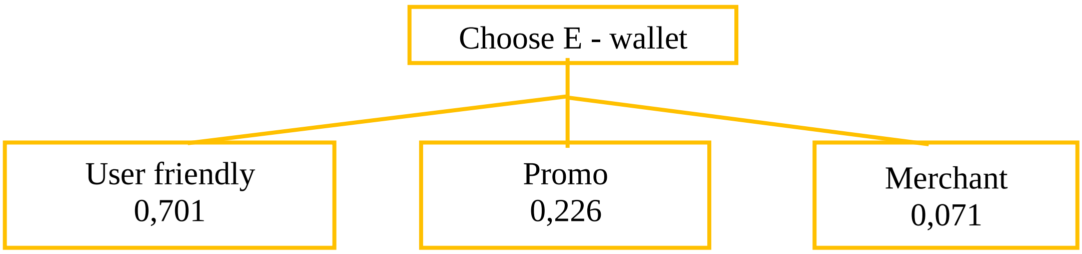
Because CR < 0.1, then the weighting preferences are consistent.

The result of the above calculations can be described with a sub-hierarchy that compares the following criteria:

User friendly = 0,701

Promo = 0,226

Merchant = 0,071



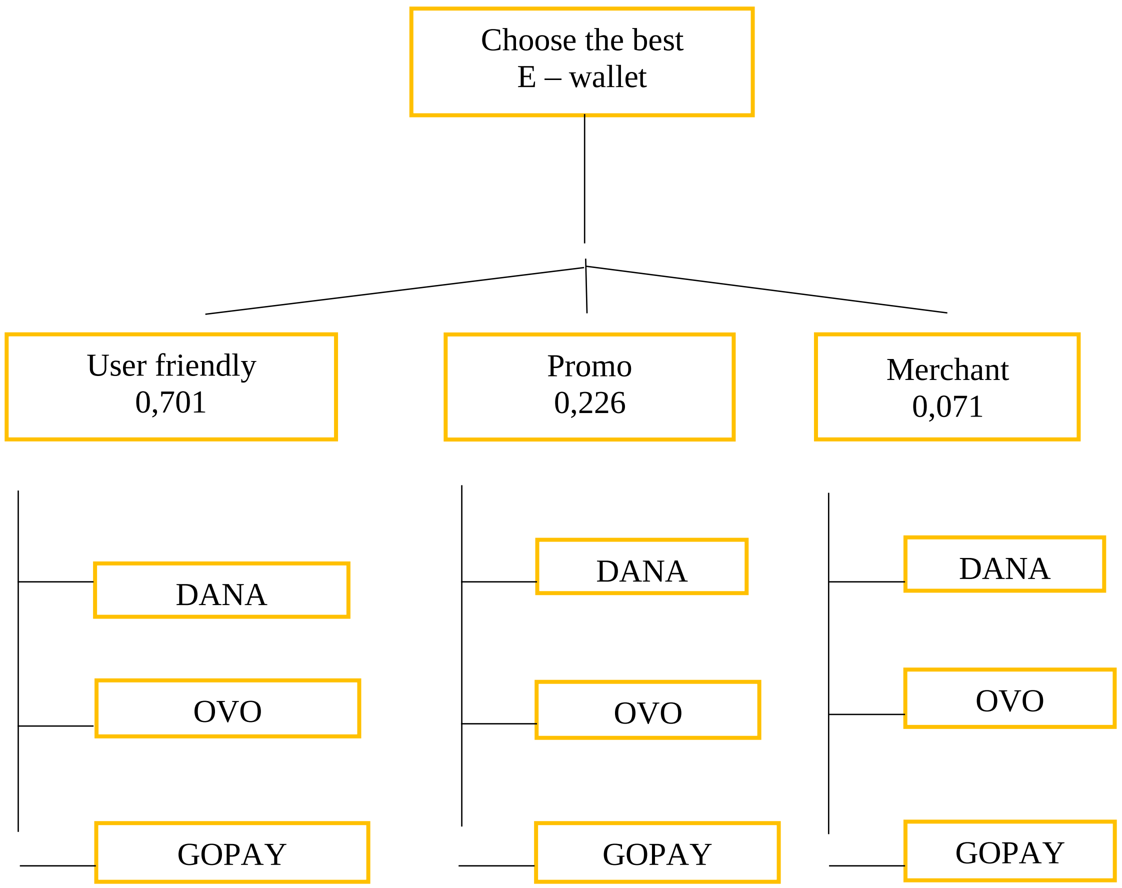
The qualitative assessment given by the decision maker stating that merchants are more important than user friendly, merchant are absolutely more important than promo, and user friendly is more important than the promo is converted into quantitative data, which is the weight value of each criteria, namely

u : 0,256, p : 0,102, dan m : 0,640

Decision-making statement is as follows:

- Alternative > User friendly Criteria
  1. DANA is a little better than OVO
  2. DANA is better than GoPay
  3. OVO is slightly better than GoPay
- Alternative > Promo Criteria
  1. OVO is slightly better than GoPay
  2. OVO is better than DANA
  3. GoPay is a little better than DANA
- Alternative > Merchant Criteria

1. GoPay is better than DANA
2. GoPay is absolutely better than OVO
3. DANA is better than OVO



4. Perform E-Wallet ranking calculations based on normalized eigenvectors
   a. DANA : (0,656*0,701)+(0,094*0,226)+(0,256*0,071) = 0,500444
   b. OVO : (0,248*0,701)+(0,656*0,226)+(0,256*0,071) = 0,330856
   c. GOPAY : (0,094*0,701)+(0,248*0,226)+(0,640*0,071) = 0,1687

The best E-Wallet is DANA

4. CONCLUSIONS

Based on the results and discussion that have been described, it can be concluded that:

You can find out that the E-Wallet application can make people, especially young people, Mathematics students believe in non-cash transactions and non-banking as substitutes or alternatives to cash payments. Criteria that form the basis for the level of trust in transactions using the application E-Wallet is a merchant criterion because it is the most frequently found. Meanwhile, promo as the smallest criteria is that the E-Wallet provider provides minimal promotions, which is quite a large transaction for students. DANA is the E-Wallet application that is most popular and trusted for this research. This makes the author believe that all the features or uses provided by DANA will make E-Wallet application users trust and feel safe when making transactions and making their payment tool digital.

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