MEASUREMENT OF SECURITY QUALITY OF E-COMMERCE USING FUZZY ANALYTICAL HIERARCHY PROCESS

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Abstract. The importance of e-commerce website security is to protect e-business and user information. A number of e-commerce security problems arise along with increasing transactions through e-commerce. This research uses Fuzzy Analytic Hierarchy Process (FAHP) method because Fuzzy is used for uncertainty or vague variables, while AHP is very suitable in considering both qualitative and quantitative characteristics that are closer to the real situation. From the research that has been done, the Tokopedia.com site is the best e-commerce in terms of website security. Tokopedia is on first on secure web tests, and on second rank on web asafa tools and observatory tools.

Keywords: e-Commerce, Security, Fuzzy Analytical Hierarchy Process

1. Introduction

According to Siregar in Irmanawi explained that "Electronic Commerce (e-commerce) is the process of buying, selling or exchanging products, services and information through a computer network". E-Commerce is part of e-business, where the scope of e-business is broader, not just commerce but also includes the collaboration of business partners, customer service, job openings, etc. In addition to www network technology, e-Commerce also requires database technology, e-mail, and other non-computer technologies such as goods delivery systems, and payment tools for e-Commerce. There are three factors that should be observed by us if we want to build e-Commerce stores, namely: variability, visibility and velocity [1].

In Indonesia, many businesses use the internet in marketing their products, such as Gramedia bookstores, Rabbani Muslim fashion stores, etc. Business to customer (B2C) implementation is usually through making e-Commerce websites to transact directly with consumers. The e-Commerce website makes the market reach of a business more global. This has become very important for many industries, especially Small and Medium Enterprises (SMEs) in interacting with stakeholders and consumers [2].

E-commerce is growing rapidly beyond the initial use as a commercial website or electronic shopping window, where visitors can see the products and services provided, but cannot buy them directly. An e-commerce must have security requirements, because consumers provide their personal data and conduct financial transactions on the website.

Some e-commerce website security research is focused on e-commerce website security solutions. According to Zuccato in Samuel Ongkowijoyo there is an approach to obtaining security requirements and developing a security management framework to improve the security of e-commerce websites. The strength of this research is to have e-commerce security factors which consist of 27 security criteria, while the difficulty is to look for experts in the field of e-commerce security [3]. The purpose of this study is to measure the accuracy of the FAHP method on the quality of e-commerce website security.

1.1 Analytic Hierarchy Process
Analytic Hierarchy Process (AHP) is one of the Multi Criteria Decision Making (MCDM) methods introduced by Saaty in 2001. AHP is very useful as a tool in decision making analysis and has been widely used in various fields such as evaluation, assessment, forecasting, selection employees, product concept evaluators, etc. Basically, the AHP method breaks down a complex and unstructured situation into its component parts. Then arrange these parts or variables in a hierarchical arrangement and give a numerical value to subjective considerations about the relative importance of each variable. After that synthesizing these considerations to determine the variables that have the highest priority and act to influence the results of the situation [8].

AHP has an axiomatic basis consisting of [8]:

a. Reciprocal Comparison, which means that the paired comparison matrix that is formed must be opposite. For example, if A is k times more important than B then B is 1 times more important than A.

b. Homogenity, which means the similarity in comparison. For example, it is not possible to compare oranges with tennis balls in terms of taste, but more relevant when comparing weight.

c. Dependence, which means that each level has a complete hierarchy even though there may be an incomplete hierarchy.

d. Expection, which means highlighting expectations that are expectations and preferences of decision making. Assessment can be quantitative data (numbers) or qualitative ones.

In solving problems with the AHP Method, there are several basic principles that must be understood, namely:

a. Decomposition (principle of arranging hierarchy)

Decomposition is solving or dividing the whole problem into its elements into a hierarchy of decision-making processes, where each element is interconnected. To get accurate results, the solution is done to the elements until it is not possible to do further solutions, so that there are several levels of the problem to be solved. The hierarchical structure of the decision can be categorized as complete and incomplete. A decision hierarchy is called complete if all elements at a level have a relationship to all elements that exist at the next level (Figure 1), while in the incomplete hierarchy of decisions not all elements in each level have a relationship. In general, real problems have incomplete structural characteristics.

b. Comparative Judgment

Comparative Judgment is carried out by assessing the relative importance of two elements at a certain level in relation to the level above. This assessment is the core of AHP because it will affect the priority order of the elements. The results of this assessment are more easily presented in the form of a matrix pairwise comparison. The paired comparison matrix contains the preference level of several alternatives for each preference scale criteria used, namely a scale of 1 that shows the lowest level to 9 which indicates the extreme importance.

c. Synthesis of Priority

Synthesis of Priority is done by using Eigen vector method to get relative weight for elements of decision making.

d. Logical Consistency

Logical Consistency is an important characteristic of AHP. This is achieved by expressing all Eigen vectors obtained from various levels of hierarchy to obtain a weighted composite vector that results in a sequence of decision making.

AHP steps are as follows:

a. Analyze real problems in a hierarchical structure of the supporting elements.
b. Make an assessment of the relative importance between the two elements presented in the form of a comparison matrix using a priority scale. If there are n elements, a pairwise comparison matrix will be obtained in equation 1 dimension n x n, and the number of judgments needed is as much as n (n-1) / 2. The steps taken in the assessment of the elements that are compared are: (1) which elements are more important / influential / preferred, (2) How many times are more important / influential / preferred to an element than other elements.

\[
A = \begin{bmatrix}
    a_{11} & a_{12} & a_{13} & \ldots & a_{1n} \\
    a_{21} & a_{22} & a_{23} & \ldots & a_{2n} \\
    a_{31} & a_{32} & a_{33} & \ldots & a_{3n} \\
    \vdots & \vdots & \vdots & \ddots & \vdots \\
    a_{n1} & a_{n2} & a_{n3} & \ldots & a_{nn}
\end{bmatrix}
\]

Calculates the consistency of Matrix A as follows:

Normalization of Matrices

\[
\text{Calculate the average matrix that has been normalized}
\]

\[
\text{Multiplication Initial matrix (A) with average (AR)}
\]

\[
\text{The sum of each line in the matrix above:}
\]

Information:
AR = Average matrix
W = matrix weight
B = Matrix Multiplication Element A with AR
C = Number of each matrix row B
To test the consistency of matrix of pairwise comparison each respondent need to find value of $\lambda_{\text{max}}$, CI, CR.

$$\lambda_{\text{max}} = \sum_{i=1}^{c} \frac{a_{ii}}{n}$$

To calculate CI:

$$CI = \frac{\lambda_{\text{max}} - n}{n - 1}$$

To calculate CR:

$$CR = \frac{C}{I}$$

Information:

- $\lambda_{\text{max}}$ = maximum eigen value
- CI = Consistency Index
CR = Consistency Ratio  
IR = Random Index  
N = Number of elements compared

With the random index (RI) in Table 1 below:

| Or do | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|-------|---|---|---|---|---|---|---|---|---|----|
| Index Random Matrix | 0 | 0 | 0.5 | 0.9 | 1.1 | 1.3 | 1.4 | 1.4 | 1.5 | 1.4 |

After the matrix of pairwise comparison is consistent then the value is converted to triangular fuzzy number (TFN) in the form (low, middle, upper) as in numerical scale and linguistic scale for importance level.

1.2. Fuzzy Analytic Hierarchy Process (FAHP)

FAHP is a theory that combines AHP with Fuzzy logic. In FAHP, the Fuzzy ratio scale is used to indicate the relative strength of the factors on the criterion. The final value of the criteria is also presented in Fuzzy numbers. The process of Fuzzy logic transformation to AHP in this study was conducted by following the method developed by Gungor, et al., (2009). The comparison matrix operation is performed using Triangular Fuzzy Number (TFN), which is a Fuzzy number whose membership is defined by three real numbers as low, middle, upper [8].

Table 2 Fuzzy Triangle Value Scale

| Intensity of Interest AHP | The Linguistic Set | TFN | Reciprocal |
|---------------------------|-------------------|-----|------------|
| 1 | Comparison of the same element | (1, 1, 1) | (1, 1, 1) |
| 2 | Low | (1/2, 1, 3/2) | (2/3, 1, 2) |
| 3 | Element one is quite important from the others | (1, 3/2, 2) | (1/2, 2/3, 1) |
| 4 | Mid | (3/2, 2, 5/2) | (2/5, 1/2, 2/3) |
| 5 | Element one strong importance from the other | (2, 5/2, 3) | (1/3, 2/5, 1/2) |
| 6 | Mid | (5/2, 3, 7/2) | (2/7, 1/3, 2/5) |
| 7 | Elements one is stronger in importance than others | (3, 7/2, 4) | (1/4, 2/7, 1/3) |
| 8 | Mid | (7/2, 4, 9/2) | (2/9, ¼, 2/7) |
| 9 | One absolute element is more important than the other | (4, 9/2, 9/2) | (2/9, 2/9, ¼) |

The steps of the FAHP are as follows [8]:

1. Construction of pairwise comparison matrices based on criteria in AHP. Can be defined as follows:

\[
X = \begin{bmatrix}
1 & x_{12} & x_{13} & \ldots & x_{1n} \\
x_{21} & 1 & x_{23} & \ldots & x_{2n} \\
x_{31} & x_{32} & 1 & \ldots & x_{3n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
x_{n1} & x_{n2} & x_{n3} & \ldots & 1
\end{bmatrix}
\]
With

\[ x_{j}^{i} = \left( x_{j}^{i}, x_{j}^{\min}, x_{j}^{\max} \right), \quad x_{j}^{-1} = \left( \frac{1}{x_{j}^{i}}, \frac{1}{x_{j}^{\max}}, \frac{1}{x_{j}^{\min}} \right) \]

With i, j = 1, 2, ... n.

2. Calculate the geometric mean
   The result of paired comparison of several respondents was calculated with geometric mean. The geometric mean calculation is denoted by the matrix S as follows:

\[
\begin{bmatrix}
    x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\
    x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\
    x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\
    \vdots & \vdots & \vdots & \ddots & \vdots \\
    x_{n1} & x_{n2} & x_{n3} & \cdots & x_{nn}
\end{bmatrix}
\]

\[ \bar{x}_{j} = \left( \left( \prod_{i=1}^{n} x_{i}^{j} \right)^{\frac{1}{n}}, \left( \prod_{i=1}^{n} x_{i}^{\min} \right)^{\frac{1}{n}}, \left( \prod_{i=1}^{n} x_{i}^{\max} \right)^{\frac{1}{n}} \right) \]

With i, j = 1, 2, ... n.

3. Calculate the criterion weight of the matrix S.
   The weighted result of the matrix S criterion is denoted by U. The weight of the criterion for triangular fuzzy number according to Gungor, et al., (2009) can be expressed as follows:

\[
U = \begin{bmatrix} u_{1} \\ u_{2} \\ \vdots \\ u_{n} \end{bmatrix}
\]

\[ u_{j} = \frac{\prod_{i=1}^{n} \left( z_{j}^{i} \right)^{x_{i}^{j}}}{\sum_{i=1}^{n} z_{j}^{x_{i}^{j}}} \cdot \frac{\prod_{i=1}^{n} \left( z_{j}^{\min} \right)^{x_{i}^{j}}}{\sum_{i=1}^{n} z_{j}^{\min}} \cdot \frac{\prod_{i=1}^{n} \left( z_{j}^{\max} \right)^{x_{i}^{j}}}{\sum_{i=1}^{n} z_{j}^{\max}} \]

With i, j = 1, 2, ... n.

4. Calculate the defuzzyfication of
   Defuzzyfication is used to convert fuzzy output to firm / crisp values using Best Nonfuzzy Performance (BNP) method. BNP can be stated as follows:

\[ BNP_{j} = \frac{u_{j}^{u} - u_{j}^{l}}{3} = u_{j}^{*} \]

With i, j = 1, 2, ... n.

Fuzzy AHP Flowchart that begins by entering criteria and web e-Commerce data. If the criteria data has been filled, then go to the rating scale and construct a pairwise comparison matrix between the criteria / subcriteria, then specify the TFN (low, middle, upper) boundary and the comparison matrix conversion into the TFN scale and will be normalized, and will get the criteria weight, Enter the weight of e-commerce, the priority of the criteria matrix multiplied by the priority of e-commerce, the latter will get the results of the calculation.
CDM is a model created that is based on the assumption that the world is an object and each object has a relationship. Benefits of using CDM, among others, can provide a complete picture of the database structure. Here is a CDM overview of the system.

PDM is a model that displays a number of tables to describe the data and relationships between tables. Each table has a number of columns where each column has a unique name or is called a primary key. Here is a picture of PDM model.
A. Criteria Tools Secure Web Test
The criteria weight page works when the admin will add a weight ratio to each criterion. Here is the page weighting criteria look.

![Figure 5 Weigh Criteria](image)

The AHP Weight page works when the admin will see the comparative weight of the criteria that has been entered and stored. Here is an AHP page weight view.

![Figure 6 AHP Weight](image)

Conversion page tfn works for conversion weights ahp to Triangular Fuzzy Number (TFN), here is the display page tfn conversion.

![Figure 7 TFN Conversion](image)

Fuzzy calculation page serves to process sums of each point, namely low, middle, and upper. Normalization LMU obtained from the amount of low value divided by low number, middle value divided by middle number, and upper value divided by upper number. The weight of the criteria is the result of the above process, so we get the weight of each criterion, here is the view of fuzzy calculation page.
The final result page serves to display the results of a multiplication process between the priority weight of the criteria and the e-commerce priority value, and the sum of the values obtained, as well as the descending rankings, here is the final results page display.

### Table 3 Rank of result

| No | Nama E-Commerce | Nama Tools  | Jumlah |
|----|-----------------|-------------|--------|
|    |                 | Secure      | Asafa Web | Observatory |
| 1  | Lazada          | 5           | 1       | 4           | 10 |
| 2  | Jd.id           | 5           | 5       | 1           | 11 |
| 3  | Mataharimall    | 5           | 2       | 2           | 9  |
| 4  | Bukalapak       | 5           | 1       | 5           | 11 |
| 5  | Tokopedia       | 5           | 5       | 4           | 14 |

The final result page serves to display the results of a multiplication process between the priority weight of the criteria and the e-commerce priority value, and the sum of the values obtained, as well as the descending rankings, here is the final results page display.
Table 3 shows the ranking results obtained from the system that is tokopedia.com site ranked 1 with the final score of 14, bukalapak.com and jd.id was ranked 2nd with the final value 11, bukalapak ranked third with a value of 10, while the mataharimall occupied Ranking 4 with a value of 9.

a. Accuracy Analysis

This section will explain the accuracy of each tool, where the level of importance of the criteria is obtained by finding factors that influence the e-commerce website. The following is the result of the consistency ratio from the comparison of the criteria for each tool.

1. Secure Web Test

In Figure 13 below, the results of the consistency ratio of secure web test tools are 0.04, because 0.04 is less than 0.1, the comparison weight of the criteria is consistent or proven accuracy.

![Figure 13 Consistency Ratio Tools Secure Web Test](image)

2. AsafaWeb

In Figure 14 below is the result of the consistency ratio of AsafaWeb tools that is 0.00061, because 0.00061 is less than 0.1, the comparison weight of the criteria is consistent or proven accuracy.

![Figure 14 Consistency Ratio Tools AsafaWeb](image)

3. Observatory by Mozilla

In Figure 15 below, the results of the consistency ratio of the Observatory by Mozilla tools are 0.00148, because 0.00148 is less than 0.1, the comparison weight of the criteria is consistent or proven accuracy.

![Figure 15 Consistency Ratio Tools Observatory by Mozilla](image)

The consistency or accuracy of paired assessments is evaluated by calculating Consistency Ratio (CR). I specify that if the CR is 1 0.1 then the assessment is said to be consistent. From the assessment made by the three tools above, it can be concluded that the tools are already consistent, because Consistency Ratio (CR) is less than 0.1.

Conclusion

1. Fuzzy Analytical Hierarchy Process can sort e-commerce in descending terms based on comparison of the criteria and value of e-commerce obtained from the scanned web security tools.
2. Of the 3 tools used, Tokopedia.com was produced as the best e-commerce in terms of website security, because Tokopedia.com was ranked first in the secure web test, and ranked second on the web Asafa and Observatory by Mozilla.
3. From the calculations that have been made, the ranking obtained from the system is that the tokopedia.com site is ranked first with a final score of 14, bukalapak.com and jd.id are ranked second with the final score of 11, Lazada is ranked third with the final score 10, while Mataharimall is ranked fourth with a final score of 9.

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