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Application of Analytical Hierarchy Process Method in Asset Management System as Asset Tracing Optimization

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Abstract: Assets are one of the supporting tools for business processes in higher education organizations. Asset management requires a system that is systematically structured so that the tracing process becomes more effective and efficient. In this case, asset management can be implemented in a web-based information system. The development of web-based asset management information systems is carried out using the waterfall method, and for decision making in asset procurement priorities using the Analytical Hierarchy Process (AHP) method. The system development process uses a Codeigniter framework based on PHP and MySQL. Research methods conducted in this study include conducting needs analysis, designing systems, implementing and testing units, integrating and testing the system and performing operations and kinship on the system created, the criteria data used in this examination has three criteria including specification, qualitu and price, and the alternatives needed have three alternatives. Based on calculations carried out by the AHP method it is obtained that based on the three alternatives the highest value is the first alternative, namely Laptop Asus with criteria values C1 (0.038) and C2 (0.451) and C3 (0.622). Based on data shows that Asus Laptop (A1) has the highest value compared to Dell Laptop (A2) and Lenovo Laptop (A3). So it can be concluded that the recommendation to buy the best laptop assets is on an Asus laptop with a value of 0.622. The result of this development is a web-based asset management information system used to optimize asset tracking implemented at NU Pekalongan.

Keywords: *Information System, Asset Management, Analytical Hierarchy Process (AHP), Codeigniter*

INTRODUCTION

Assets are equipment supporting activities in the organization that are used to achieve the goals of the organization. Universities are one of the large organizations that have complex business processes that require a lot of assets(Pambudi & Arvianto, 2016). Assets are also part of the balance sheet items outside of current assets, long-term investments and include reserve funds and other assets(Mairuhu & Tinangon, 2014). In addition, assets can be in the form of movable and immovable goods, which include all assets or assets in an organization, which need to be identified, managed and maintained so that they can be used effectively and efficiently.(Muchtar, 2011). At the ITS NU Pekalongan college, the assets owned are in the form of movable assets and immovable assets. On moving assets in the form of official vehicles, tables, chairs, laptops, projectors and so on. While immovable assets are buildings, parking lots, canteens, gazebos and so on.

Asset inventory, asset legal audit, asset valuation, asset optimization, and asset monitoring and control are several stages in asset management to improve asset management. At each stage of asset management, if carried out effectively, it can provide appropriate benefits for a university to increase the level of efficiency, effectiveness and added value in transparent, orderly, and accountable asset management.(Siregar, 2004).

The implementation of asset management requires prior planning. Asset management planning has a function to ensure that asset management activities are carried out effectively, supervise the management process in the use of funds and the use of property assets, ensure that decision-making meetings discuss asset management issues as the basis for further planning, understand the limits of effectiveness and efficiency and consider economic stability in the preparation of asset management/management, drafting cooperation plans with third parties regarding asset management(Council, 2005).

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The complexity of implementing asset management in a university can reduce effectiveness in the performance and development of universities. Asset management can be done computerized through an information system that can be implemented with computer technology media so that it can become operational support in a higher education organization.(Rainer & Cegielski, 2013). In general, the existence of a system that interacts and works together can form a comprehensive integration that is able to help achieve organizational goals(Belanger & Slyke, 2012). One of the information systems that can be implemented is a web-based asset management information system. The information system can provide quality data and can be accessed by all users in an agency or university effectively and efficiently(IM Sari & Frisila, 2019) (Winata & Rahayu, 2019). At the Nahdlatul Ulama Institute of Technology and Science (ITS NU) Pekalongan currently asset tracking and management is still using a semi-computerized system that uses Microsoft excel, thereby increasing the risk of errors in asset data recording and asset inventory becoming less effective and efficient. In addition, there is no calculation of asset depreciation as well as recommendations for purchasing goods from the results of asset management which causes the duration of managing the latest asset data. and recommendations for prioritizing procurement of goods in the future become less than optimal.

In addition, in the implementation of asset management and inventory at universities there is a stage for procurement of goods. The allocation of funds for procurement and recommendations for purchasing goods sometimes cannot be fulfilled in its entirety, thus requiring the leadership to determine the priority of goods needs. This requires a decision in determining the priority of procurement of goods. To support decision making with many criteria in the selection of priorities, especially in the procurement of goods, several methods can be used, such as Generalized Data Envelopment Analysis (GDEA)(Yun et al., 2004) or the Analytical Hierarchy Process (AHP) method(Kurniawan et al., 2021), (Santriono & Rusdianto Roestam, 2019), (Atthirawong & Maccarthy, 2002), (Davidsson et al., 2006). With the AHP method, the decision-making process can be carried out systematically, so as to provide the best solution decisions through the decomposition of common problems into simple problem solutions and can formulate the factors involved in the decision-making process.(FR Sari & Sense, 2016),(Santoso et al., 2010).

Based on the problems written, a web-based information system for asset management was developed as an optimization of asset tracking at ITS NU Pekalongan using the Analytical Hierarchy Process (AHP) method.

LITERATURE REVIEW

Hendratno (2008) in Pontoh, Palar & Mauna. (2016). Demand and Supply of Rice in Indonesia (In 2003-2013). Journal of Scientific Efficiency Vol. 16(04), 836. Explains that this theory of consumer demand is based on the theory of consumer behavior, which shows consumer behavior in determining consumption of goods. While the demand itself is the desire of consumers to buy an item at various price levels during a certain period of time. The demand function is an equation that shows the relationship between the demand for goods and services and the factors that influence it. Demand itself is the amount of goods/services that consumers want to demand at various price levels during a certain period of time.

Fuzzy logic is one of the components that make up soft computing. Fuzzy logic was first introduced by Prof. Lofti A. Zadeh in 1965. The basis of fuzzy logic is fuzzy set theory. In fuzzy set theory, the role of membership degree as a determinant of the existence of elements in a set is very important. The value of membership or the degree of membership or membership function is the main characteristic of reasoning with the fuzzy logic. (Sri Kusumadewi & Purnomo, 2013: 1).

Sri Kusuma Dewi & Purnomo (2013). The Mamdani method is known as the Max-Min method. This method was introduced by Ebrahim H. Mamdani in 1975. To get the output (results), it takes 4 stages:

1. Formation of fuzzy sets, In the Mamdani method, both input and output variables are divided into one or more fuzzy sets.
2. Application of the implication function. At this stage, a rule base is compiled, namely rules in the form of fuzzy implications which state the relationship between input variables and output variables. In the Mamdani method, the implication function used is Min.
3. Composition of rules, Unlike monotonic reasoning, if the system consists of several rules, then inference is obtained from the collection and correlation between rules. There are 3 methods used in performing fuzzy system inference, namely:
   a. Max (Maximum) method In this method, the fuzzy set solution is obtained by taking the maximum value of the rule, then using that value to modify the fuzzy area and apply it to the output using the OR (combined) operator. If all proportions have been evaluated, then the output will contain a fuzzy set that reflects the contribution of each proportion. In general it can be written:

$$sf(xi) = \max(\mu sf(xi), kf(xi) \quad (1)$$

   where, sf(xi) = membership value of fuzzy solution up to rule I; kf(xi) = consequent membership value of the ith rule

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b. Method Additive (Sum)On method this, solution set fuzzy is obtained by summing all fuzzy area outputs. In general, it can be written:

$$sf(xi) = \min(1, \mu sf(xi) .+ kf(xi)) \quad (2)$$

where, sf(xi) = membership value of fuzzy solution up to rule I; kf(xi) = consequent membership value of the ith rule

c. Probabilistic method (probar) In this method, the fuzzy set solution is obtained by multiplying all the output fuzzy areas. In general, it can be written:

$$sf(xi) = (\mu sf(xi) .+ kf(xi)) - (\mu sf(xi) .* \mu kf(xi)) \quad (3)$$

where, sf(xi) = membership value of fuzzy solution up to rule I ; kf(xi) = consequent membership value of the ith rule

4. Defuzzification (Assertion)

*Input*from the affirmation process is a fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a firm real number. Thus, if a fuzzy set is given within a certain range, it must be able to take a certain firm value as the output.

There are several methods of affirmation commonly used in the composition of the Mamdani rules that can be used, including:

a. Centroid(Composite Moment) Method

In this method, the crisp set solution (crips) is obtained by taking the center point (z*) of the fuzzy area. Generally formulated:

$$Z* = \frac{\int z\mu(z)dz}{\int \mu(z)dz} \text{ For Continuous Variables, or} \quad (4)$$

$$Z* = \frac{\sum_{j=1}^{n} zj\mu(zj)}{\sum_{j=1}^{n} \mu(zj)} \text{ For discrete variables} \quad (5)$$

b. Bisector Method In this method, the crisp set solution (crips) is obtained by taking a value in the fuzzy domain which has a membership value of half of the total membership value in the fuzzy area. In general it is written:

$$Z \text{ psedemikian hingga } \int_{R1}^{p} \mu(z)dz = \int_{p}^{Rn} \mu(z)dz \quad (6)$$

c. Mean of Maximum (MOM) Method In this method, the crisp set solution (crips) is obtained by taking the average value of the domain that has the maximum membership value.

d. Largest of Maximum (LOM) method In this method, the crisp set solution (crips) is obtained by taking the largest value from the domain that has the maximum membership value.

e. Smallest of Maximum (SOM) Method In this method, the crisp set solution (crips) is obtained by taking the smallest value from the domain that has the maximum membership value.

METHOD

The method implemented in the development of a web-based asset management information system as an optimization of asset tracking at ITS NU Pekalongan uses the Waterfall method. The stages in the waterfall method consist of needs analysis and definition, system design, implementation and unit testing, system integration and testing, operations and repairs which are shown in Figure 1 [17].

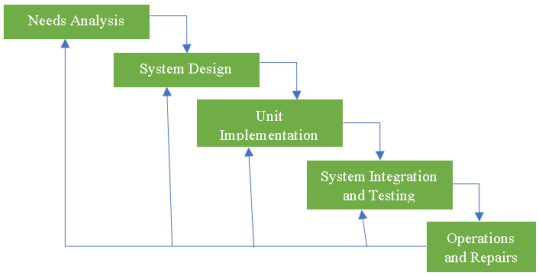

Fig.1 Stages of the Waterfall Method

The first stage in the development of a website-based asset management information system is an analysis of system requirements. This stage analyzes the objectives, system services, software and hardware requirements in the implementation of information systems. The purpose of this web-based information system on asset management is to optimize tracking and purchasing assets at ITS NU Pekalongan. System services are defined by the results of consultation with users which will be defined as information system specifications. For individuals who use information systems, namely the academic staff of ITS NU Pekalongan.

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Software requirements in the development of this information system include the CodeIgniter framework based on PHP and MySQL as the system database. Hardware requirements in the development of this information system are a set of PCs and an adequate internet network to access an online website-based asset management information system.

The second stage in the development of this information system is system design. This stage designs the flow in the development of the overall system architecture.

The third stage is implementation, this stage realizes the system design into a series of system units. The system was developed with the Codeigniter framework based on PHP and for the database using MySQL. The method that is implemented as an optimization of asset tracking uses the Analytical Hierarchy Process (AHP) method. This method includes a method that can support a multi-criteria decision support system that is implemented to obtain a weight for each criterion. In addition, it can also be used to determine an alternative priority scale that is structured based on the results of pairwise comparisons(Liu et al., 2020). The AHP calculation in this study was carried out in several phases, namely:(Kaganski et al., 2018):

1) Define the problem through the hierarchy and establish objectives, criteria and alternatives.
2) Create a pairwise comparison matrix
3) Pairwise comparison matrix is formed based on the criteria. Then form a matrix with numbers to represent the level of importance of the alternative criteria against other criteria in the form of a scale from a scale of 1 to a scale of 9.
4) Synthesis Calculation, aims to obtain the overall priority.
5) Calculating the Consistency Ratio, this calculation uses the consistency index (CI) value and the Consistency Ratio (CR) value if the value (CR) <= 0.01 means that the value is appropriate and consistent.
6) Ranking of alternatives according to the criteria, ranking these alternatives according to each criterion which aims to get the best value from each alternative. This calculation performs multiplication between the eigenvector values of each criterion and the eigenvector values of each alternative so that the final value is obtained as an assessment of each alternative.

Table 1
AHP Comparison Scale

AHP Comparison Scale	
AHP Scale	**Description**
1.00	Equally Important
3.00	Quite important
5.00	Very important
7.00	Very More Important
9.00	Absolute More Important

In addition, there is a weighting that refers to 3 criteria, namely specifications, quality and price as shown in Table 2.

Table 2
Criteria

No.	Code	Criteria
1	C1	Specification
2	C2	Quality
3	C3	Price

The next stage is to test the system unit by verifying the suitability of each feature of the asset management website information system unit.

RESULT

In the development of this system in the form of a website-based information system for asset tracking which is implemented at ITS NU Pekalongan. Optimization of asset tracking and purchase is carried out using the Analytical Hierarchy Process (AHP) method. In this study, the data used for optimizing the purchase of assets is the type of laptop, namely Asus laptops, Lenovo laptops, and Dell laptops. In the analysis using the AHP method, several steps are used, namely:

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1). Define the problem and 3 components, namely objectives, criteria and alternatives and then create a mapping hierarchy. In this study, the purpose of the first stage is to choose the best type of laptop. The criteria are specifications, quality and price. Then for alternatives, namely Asus laptops, Lenovo laptops, and Dell laptops. The hierarchical structure of the mapping can be seen in Figure 4

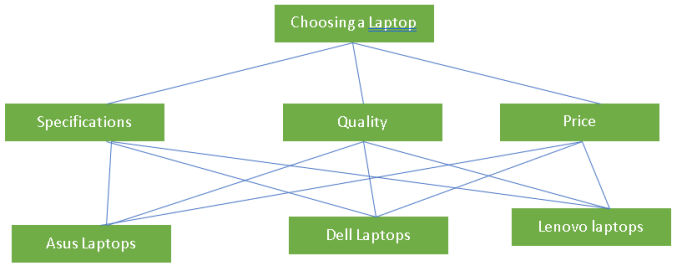

Fig.2 Hierarchical Structure

2). Create a pairwise comparison matrix.

At this stage, a pairwise comparison of 3 criteria is formed, namely C={Specification, Quality, Price} and 3 alternative laptop assets, namely A={Asus laptop, Dell Laptop, and Lenovo Laptop}. In the formation of paired matrices using the AHP comparison scale shown in Table 1. At this stage there are 4 matrix comparisons made, namely:

Comparison between criteria that make up the 3x3 . matrix
Comparison of each alternative against the Specification criteria that make up the 3x3 . matrix
Comparison of each alternative against the Quality criteria that make up the 3x3 . matrix
Comparison of each alternative against the Price criteria that make up the 3x3 . matrix

The following is a comparison table between the criteria shown in Table 3. As for the comparison of alternatives (Asus laptops, Dell laptops and Lenovo laptops) against each criterion, it is shown in Table 4, Table 5, and Table 6.

Table 3
Criteria matrix comparison

Criteria	C1	C2	C3
C1	1	0.14	0.2
C2	7	1	5
C3	5.00	0.2	1
Total	1.47	4.2	13

Table 4
Comparison of Alternatives to Specification Criteria

Alternative	A1	A2	A3
A1	1	3	7
A2	0.33	1	5
A3	0.14	0.2	1
Total	1.53	4.14	13

Table 5
Comparison of Alternatives on Quality Criteria

Alternative	A1	A2	A3
A1	1	3	5
A2	0.33	1	7
A3	0.20	0.14	1
Total	1	3	5

Table 6

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Comparison of Alternatives on Pricing Criteria

Alternative	A1	A2	A3
A1	1	3	5
A2	0.33	1	5
A3	0.20	0.2	1
Total	1.53	4.20	11

3). Synthesis Calculation

At this stage, calculate the normalized eigenvectors from the matrix results obtained in stage 2. This stage aims to obtain the overall priority. This calculation is carried out on each criterion and alternative with reference to each criterion. The results of the calculation of the eigenvector values of the criteria are shown in Table 7. While the results of the calculation of the alternative eigenvector values based on each criterion are shown in Table 8, Table 9 and Table 10.

Table 7
Criteria Eigen Vector Value\

Criteria	Vector Eigen Value
Specification (C1)	0.515
Quality (C2)	0.375
Price (C3)	0.109

Table 8
Eigen Vector on Specification Criteria

Alternative	Vector Eigen Value
Asus Laptops (A1)	0.635
Dell Laptops (A2)	0.292
Lenovo Laptops (A3)	0.073

Table 9
Vector Eigen on Quality Criteria

Alternative	Vector Eigen Value
Asus Laptops (A1)	0.619
Dell Laptops (A2)	0.315
Lenovo Laptops (A3)	0.0659

Table 10
Vector Eigen on Price Criteria

Alternative	Vector Eigen Value
Asus Laptops (A1)	0.627
Dell Laptops (A2)	0.293
Lenovo Laptops (A3)	0.080

4.) Calculating Consistency Ratio

At this stage, the Consistency Index (CI) and Consistency Ratio (CR) calculations are carried out which aims to determine the level of consistency of the comparison criteria values. In the calculation of CI and CR, it is necessary to calculate max, namely by doing a cross calculation between the total value of the criteria in Table 3 and the eigenvector value of the criteria in Table 4, Table 5 and Table 6 so that the resulting value of max is 3.0757. Then the calculation of the CI criteria is carried out using the formula in equation (1) as follows:

$$CI = ((\lambda \text{ max-n})/(n-1)) \quad (1)$$

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CI= ((3,0757-3)/(3-1))
CI= 0.037

After performing the calculation of C1 then perform the calculation of CR. CR calculation requires Index Consistency (IR) value. This value is obtained from the Index Random Consistency table which has a value based on the number of matrices created. Comparison of the criteria using a 3x3 matrix so that the IR value obtained is 0.58. The calculation of the CR criteria uses the formula in equation (2) as follows:

$$CR = CI/IR \quad (2)$$

CR= 0.037/0.58
CR= 0.07

In addition to calculating CI and CR on the criteria, CI and CR calculations are also carried out on alternatives based on 3 criteria, namely specifications, quality and price so that the values shown in Table 11.

Table 11
Value Vector Eigen Price

Criteria	CI value	CR Value
Specification (C1)	0.056	0.096
Quality (C2)	0.056	0.096
Price (C3)	0.036	0.062

Based on the CR calculations that have been calculated for each criterion, the CR values <= 0.01. This shows that the weighting preferences of each criterion are consistent.

5). Alternative ranking according to criteria

At this stage, a ranking of alternatives is carried out according to each criterion which aims to get the best value from each alternative as a recommendation for purchasing laptop assets in the future. The ranking calculation is the result of the calculation between the eigenvector values of each criterion and the eigenvector values of each alternative so that equation (3) is generated as follows:

$$A1=(EV\ C1*EV\ A1C1)+ \quad (3)$$

(EV C2*EV A1C2) + (EV C3 * EV A1C3)
A2=(EV C1*EV A2C1)+(EV C2*EV A2C2) + (EV C3 * EV A2C3)
A3=(EV C1*EV A3C1)+(EV C2*EV A3C2) + (EV C3 * EV A3C3)
So that it produces:

A1=(0.060*0.635)+(0.728*0.6189)+(0.211*0.627)
A2 =(0.060*0.292)+(0.728*0.315)+(0.211*0.293)
A3 =(0.060*0.730)+(0.728*0.659)+(0.211*0.080)
A1 =0.038+0.451+0.133=0.622
A2 = 0.018+0.229+0.062=0.309
A3 =0.004+0.048+0.017=0.069

The results of the ranking calculation are calculations for each alternative, namely Asus Laptops (A1), Dell Laptops (A2), and Lenovo Laptops (A3) with specification criteria (C1), quality criteria (C2) and price criteria (C3). These results are also shown in Table 12.

Table 12
Value Vector Eigen Price

Alternative	C1	C2	C3	Mark
Asus Laptops	0.038	0.451	0.133	0.622
Dell Laptops	0.018	0.229	0.062	0.309
Lenovo Laptops	0.004	0.048	0.017	0.069

Based on the data, Table 12 shows that the Asus Laptop (A1) has the highest value than the Dell Laptop (A2) and Lenovo Laptop (A3). So it can be concluded that the recommendation for buying the best laptop assets is on an Asus laptop with a value of 0.622.

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DISCUSSIONS

Based on the data, Table 12 shows that the Asus Laptop (A1) has the highest value than the Dell Laptop (A2) and Lenovo Laptop (A3). So it can be concluded that the recommendation for buying the best laptop assets is on an Asus laptop with a value of 0.622.

In the implementation of an information system based on website asset management, there is information related to the appearance of the application that has been made. For information on procurement or purchase of assets, it is shown on the procurement.

Testing on the asset management information system is carried out by blackbox testing, which is to ensure the suitability of the performance of the system(Rizky, 2011). The results of blackbox testing on this information system are shown in Table 13.

Table 13
Blackbox Testing Results

description	System view	Test result
Admin input username and password	On the system can display the dashboard page	Successfully logged in and can display the dashboard page (Received)
Admin can input wrong username and password	The system cannot display the dashboard page	Can't login successfully and can't display the dashboard page (Received)
Menu Inventory, Procurement, Depreciation, Goods Data, Monitoring, Repair, Report	The system can display the Inventory, Procurement, Depreciation, Goods Data, Monitoring, Repair, Report halaman pages	Successfully display the Inventory, Procurement, Depreciation, Goods Data, Monitoring, Repair, Reports page (Received)
Menu on the Specification, Quality and Price Criteria Page	The system can be used to create, read, update, delete rating scales on the Specification, Quality and Price Criteria Pages	Successfully create, read, update, delete the rating scale on the Specifications, Quality and Price Criteria Pages (Received)
Admin can logout from the system	On the system can do logout	Successfully logged out of the system (Received)

Based on Table 13, the results of blackbox testing on the asset management information system show that there are no errors/bugs in each menu and operational system so that the system can be used to support decision making on tracking and purchasing assets at ITS NU Pekalongan.

CONCLUSION

Based on the results of the system development, an asset management information system was produced at ITS NU Pekalongan using the Analytical Hierarchy Process (AHP) method. This information system is used to support decision making on asset tracking and purchase priorities, so that asset tracking and purchases are carried out in a targeted manner. Based on the results of the calculation of sample data that has been carried out on the asset selection information system with the Asus laptop brand, Lenovo laptop and Dell laptop, the best priority is generated on the Asus laptop with a result of 0.622. The test results with blackbox testing on the system show that there are no errors or bugs in each menu and its operations.

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