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Web-Based Decision Support System for Best Laptop Selection Using MABAC Method

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ABSTRACT

The advancement of technology in the modern era has made devices such as laptops essential in daily life. According to a report from Ministry of Communication and Information Technology of Indonesia that published in 2017, from a survey of 2,121 respondents showed that more than half percent respondent use laptop for work and study, while 34.94% use laptop for entertainment. However, selecting the right laptop often poses a challenge, especially for students in the Informatics Engineering Department at Universitas Negeri Surabaya, who frequently use outdated laptops. To address this issue, a Decision Support System (DSS) is needed, utilizing the Multi-Attributive Border Approximation Area Comparison (MABAC) method. In this study, the MABAC method was used to select laptops based on criteria such as price, CPU, RAM, and storage. By applying the MABAC method, the DSS is believed to effectively address the issue of selecting the most suitable laptop, thereby enhancing productivity and performance. This research successfully developed a web-based Decision Support System (DSS) for selecting the best laptops using the Multi-Attributive Border Approximation Area Comparison (MABAC) method, which simplifies the evaluation process for users. The DSS incorporates 10 criteria: price, processor, RAM, storage, storage type, screen size, graphics card, laptop weight, battery, operating system, and warranty. The MABAC calculations ranked the Asus Vivobook 14 A1400EA as the best laptop with a score of 0.15, followed by the HP 14s EP0022TU and Lenovo Ideapad Slim 3 14ITL6 with scores of 0.05, while the Dell Latitude 3420 ranked last with a score of -0.05.

Keyword: Decision Support System, Multi-Attributive Border Approximation Area Comparison, Laptop, Criteria, Results.

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1. INTRODUCTION

The advancement of modern technology plays a crucial role in daily activities. Rapidly evolving technology continues to produce various high-tech products for consumers, such as transportation tools, household appliances, communication devices, business tools, information search platforms, and many more [1]. Laptops, also known as mobile or portable computers, can be easily carried anywhere and are highly beneficial for many people as they facilitate the

completion of various tasks or jobs. Nowadays, laptops are no longer considered luxury items but have become an integral part of modern lifestyles, especially for those who consistently keep up with technological advancements [2]. According to the Indonesia Baik report, a survey of 2,121 respondents revealed that laptop usage for work and study accounts for a high and nearly balanced proportion, with 54.55% for work and 53.65% for study. Meanwhile, laptop usage for entertainment was recorded at 34.94% [3]. A lack of knowledge, limited information, and budget constraints regarding various brands and specifications frequently leave inexperienced individuals feeling confused about choosing a laptop that meets their requirements [4]. Choosing the right laptop is crucial as it significantly impacts productivity, performance, and user satisfaction.

In this era, many students now utilize laptops as a key tool in their learning process. While most students already own laptops, the devices they use are often outdated compared to the latest generations, making them less optimal for learning purposes. As a medium for teaching and learning, laptops play a crucial role in education, especially in the Informatics Engineering Department at Universitas Negeri Surabaya. To address this issue, a Decision Support System (DSS) was developed to help select the best laptops. A Decision Support System (DSS) is a part of an information system that is computer-based [2]. A Decision Support System is designed to help decision-makers solve problems at various management levels, not to replace the role of humans as decision-makers [5]. In this research, the author applies the MABAC (Multi-Attributive Border Approximation Area Comparison) method to determine the best laptop. MABAC is a reliable, consistent, and stable multi-criteria comparison method, making it capable of producing accurate criteria for selecting the best laptop[6].

The MABAC method was developed by Pamucar and Cirovic in 2015 [7]. Due to its strong stability, the MABAC method is often compared and combined with other methods [8]. This method is chosen because, compared to other multi-criteria comparison methods such as SAW, COPRAS, MOORA, TOPSIS, and VI-KOR, MABAC produces consistent solution rankings and is considered a reliable method for rational decision-making, as explained in detail in the journal by Indic D. & Lukovic [9]. The following section will present the procedure for applying the MABAC (Multi-Attributive Border Approximation Area Comparison) method in the form of mathematical formulations.

Several previous studies relevant to the method used in this research serve as references for the author. One such study conducted by Rima Tamara Aldisa in 2022 discusses the application of the MABAC method in selecting the best hotel booking application. The results of the study showed that Traveloka received a score of 0.51283 and was considered the best hotel booking application [10]. A study conducted by Indah Sari and Mas Ayoe Elhias Nst in 2023 discusses the use of the MABAC method in determining the feasibility of teacher certification. The results of this study showed that the alternative A5, named Dinda Cindy Anggraini, with a score of 0.220, was eligible to receive the certification[11]. A study by Fifto Nugroho and his colleagues in 2023 discusses the application of the MABAC method and ROC weighting in a decision support system for recommending tourist attractions. The results of the study showed that the highest-ranked alternative was Paropo nature tourism, which received a score of 0.6343 [12].

Based on the explanation provided, the author will apply the MABAC (Multi-Attributive Border Approximation Area Comparison) method for decision-making in selecting a laptop, considering various criteria and alternatives that have been defined. The criteria to be used include price, CPU, RAM, and storage. It is expected that the use of the MABAC method will help resolve the issues that arise in the laptop selection process.

2. METHODS

This research includes several theories to complement the study. The research involves creating a website for laptop selection, so the required components are a decision support system, laptops, MABAC, and the website. Below is the workflow that will be used.

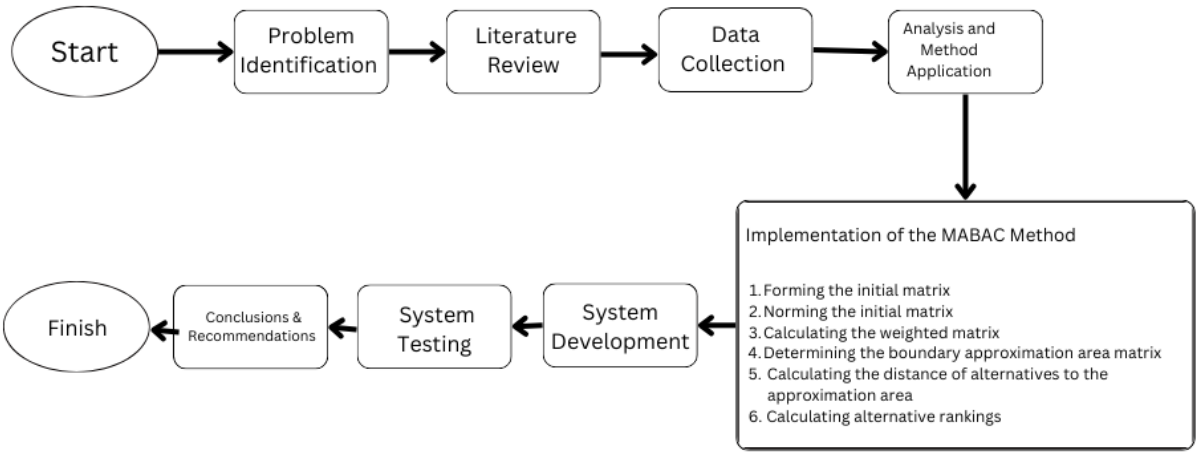

Figure 1. Research Flow

2.1 Multi Atributive Border Approximation Area Comparison (MABAC)

The MABAC method, developed by Pamucar and Cirovic in 2015, is recognized as a method that provides solutions for decision-making compared to other methods. In the MABAC method, the best alternative can be determined based on the distance between the boundary area, also known as the Border Approximation Area (BAA).

MABAC is an approach in decision support systems used to evaluate decision alternatives by considering various relevant attributes or criteria. The purpose of this approach is to assist in decision-making in complex situations by comparing and selecting the best options based on the boundary approximation area formed by each alternative in the attribute space [18], [19].

The MABAC method is chosen because, compared to other multi-criteria decision-making methods such as SAW, COPRAS, MOORA, TOPSIS, and VI-KOR, MABAC is considered to provide stable and consistent solutions. This method is known as a reliable approach for rational decision-making, as detailed in the journal by Indic D. & Lukovic. In the context of this paper, the MABAC method is used to rank alternatives. The basic assumption of the MABAC method is reflected in the definition of the criterion function distance for each alternative, which is evaluated based on the border approximation area. The following section will outline the procedure for applying the MABAC (Multi-Attributive Border Approximation Area Comparison) method, including its mathematical formulation.

The procedure for applying the MABAC method, including the mathematical formulation, consists of six steps:

1. Forming the Initial Decision Matrix (X).

The first step involves evaluating the alternatives "m" and "n" criteria. These alternatives are represented by the vector $A_i = (X_{i1}, X_{i2}, X_{i3}, \dots, X_{in})$, where X_{ij} is the value of th e“i” th alternative with respect to the “j” (i = 1,2,3, …, m; j = 1,2,3, …, n).

$$X = \begin{matrix} & C_1 & C_2 & \cdots & C_n \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Where m is the alternative number, and n is the total number of criteria.

2. Initial Matrix Normalization (X).

$$N = \begin{matrix} & C_1 & C_2 & \cdots & C_n \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} T_{11} & T_{12} & \cdots & T_{1m} \\ T_{21} & T_{22} & \cdots & T_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ T_{m1} & T_{m2} & \cdots & T_{mn} \end{bmatrix} \quad (2)$$

The value of the normalized matrix (N) is determined using the following formulas:

$$T_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \text{ (for benefit criteria)} \quad (3)$$

$$T_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \text{ (for cost criteria)} \quad (4)$$

x_i^+ = max (x1, x2, x3, ..., x_m) represents the maximum value of the criterion observed by the alternatives. x_i^- = min (x1, x2, x3, ..., x_m) represents the minimum value of the criterion observed by the alternatives

3. Calculate the weighted matrix, where the formula can be seen as follows.

$$v = \begin{matrix} & C_1 & C_2 & \cdots & C_n \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix} \quad (5)$$

The elements of the weighted matrix (V) are calculated based on the following formula:

$$V_{ij} = \left(w_i * t_{ij}\right) + w_i \quad (6)$$

By applying formula (6), the weighted matrix (V) is obtained, which can also be written as follows:

$$V = \begin{bmatrix} (w_1 * t_{11}) + w_1 & (w_2 * n_{12}) + w_2 & \cdots & (w_n * n_{1n}) + w_n \\ (w_1 * t_{21}) + w_1 & (w_2 * n_{22}) + w_2 & \cdots & (w_n * n_{2n}) + w_n \\ \vdots & \vdots & \ddots & \vdots \\ (w_1 * t_{m1}) + w_1 & (W_2 * n_{m2}) + w_2 & \cdots & (w_n * n_{mn}) + w_n \end{bmatrix} \quad (7)$$

4. Determination of the Boundary Approximation Area Matrix (G).

$$G_1 = (\pi_{J=1}^{m} V_{ij})^{\frac{1}{m}} \quad (8)$$

After calculating the value of gi for each criterion, the area matrix G is formed in an n x 1 format (where n is the number of criteria used in the alternative selection).

$$C_1 \quad C_2 \quad \cdots \quad C_3$$

$$G = [G_1 \quad G_2 \quad \cdots \quad G_n] \tag{9}$$

5. Calculating of the distance of alternatives from the boundary approximation area for the matrix elements (Q).

$$Q = [q_{11}\, q_{12} \cdots q_{1m}\, q_{21}\, q_{22} \cdots q_{2n} \vdots \ddots \vdots q_{1n}\, q_{2n} \cdots q_{mn}\,] \tag{10}$$

The distance of the alternative from the approximation area (qij) is calculated as the difference between the elements of the weighted matrix (V) and the values of the boundary approximation area (G).

$$V = [v_{11-}g_1\, v_{12-}g_2 \cdots v_{1n-}g_n\, v_{21-}g_1\, v_{22-}g_2 \cdots v_{2n-}g_n \vdots \ddots \vdots \\ v_{m1-}g_1\, v_{m2-}g_2 \cdots v_{mn-}g_n\,] \tag{11}$$

6. Ranking alternatives

The criterion function value for each alternative is obtained by summing the distances of the alternatives from the boundary approximation area (Q). The higher the value of Si, the better the alternative.

$$S_i = \sum_j^n \quad = 1 q_{ij} \tag{12}$$

In determining the criteria for the decision support system, there are 10 attributes used to determine the best laptop, including:

1. Laptop Price (C1), This is a primary consideration for users when purchasing a laptop that fits their budget.
2. Processor (C2), The second consideration, as the processor affects the overall performance.
3. RAM (C3), An important factor when purchasing a laptop, as RAM allows the laptop to run multiple applications simultaneously without performance degradation.
4. Storage Capacity (C4), The fourth criterion, as storage capacity determines how much data can be stored on the laptop.
5. Storage Type (C5), This criterion is considered because it affects data transfer speed and system responsiveness.
6. Screen Size (C6), A key component where users will enjoy a larger screen compared to a smaller one.
7. VGA Card (C7), The seventh criterion, Video Graphics Array Card, is an additional point as few laptops use a dedicated VGA card. Most laptops use integrated graphics from the processor that takes memory from RAM.
8. Laptop Weight (C8) An additional point when looking for a laptop, as the lighter the laptop, the less burden it adds when carried around.
9. Battery (C9), The ninth criterion, as the battery is essential for use in situations where there is limited access to electricity.

10. Warranty (C10), The final criterion, as it is important to have a warranty in case of any software or hardware issues with the laptop.

3. RESULTS AND DISCUSSION.

3.1 Problem Analysis

The first stage of the research is problem identification. The researcher will identify issues related to the research topic, which is the Decision Support System using the MABAC (Multi-Attributive Border Approximation Area Comparison) Method. A literature review is conducted to achieve the research objectives and solve problems by studying theories related to Decision Support Systems and MABAC.

This research consists of several stages. The first stage is the analysis and application of the method. In this stage, the researcher analyses recommendations for selecting the best laptop using the MABAC (Multi-Attributive Border Approximation Area Comparison) method to obtain accurate results. There are two types of questionnaires: open-ended and closed-ended. In this study, the researcher uses a closed-ended questionnaire, where predefined answers are provided, and the respondents only need to choose and respond. The questionnaire is distributed directly to the respondents, with the research targeting 100 students from the Department of Informatics Engineering, State University of Surabaya.

3.2 Application Metode MABAC

The Multi-Attributive Border Approximation Area Comparison method, abbreviated as MABAC, is a multi-criteria comparison method. In addition to having multi-criteria comparison features similar to other methods such as SAW, COPRAS, MOORA, TOPSIS, and VI-KOR, it also offers consistent solutions and is considered reliable as a rational tool in decision-making, as explained in detail in the data.

The criterion evaluation data used was obtained from the author's research at the State University of Surabaya. With this data, the comparison can be made using the MABAC method, leading to the right decision.

And the resolution or comparison using the MABAC (Multi-Attributive Border Approximation Area Comparison) method, there are several stages.

1. Form an initial Decision Matrix (X)
   Based on the data table, it will be described or converted into a value according to the criteria, along with the initial decision matrix (X):

$$X = \begin{matrix} \\ A1 \\ A2 \\ A3 \\ A4 \end{matrix} \begin{bmatrix} 0.5 & 0.6 & 0.4 & 0.6 & 1 & 0.4 & 0.2 & 0.4 & 0.4 & 1 & 1 & 0.6 & 0.8 & 0.4 & 0.6 & 1 & 0.4 & 0.2 & 0.4 & 0.4 & 1 & 1 \\ 0.7 & 0.8 & 0.6 & 0.6 & 1 & 0.4 & 0.2 & 0.4 & 0.4 & 1 & 1 & 0.5 & 0.6 & 0.4 & 0.4 & 1 & 0.4 & 0.2 & 0.4 & 0.4 & 1 & 1 \end{bmatrix}$$

2. Initial Decision Matrix Normalization (X)
   In the initial decision matrix normalization, there are 2 types, namely costs and benefits. The price criteria namely as cost and other criteria namely as benefit.
   For benefit criteria

$$T_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-}$$

   For cost criteria

$$T_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+}$$

Determine the normalization value of the initial decision matrix using the criteria of price, processor, RAM, storage, storage type, screen size, VGA, weight, battery, warranty, and operating system.

Criteria 1 (cost)

$$T_{11} = \left(\frac{0.6-1}{0.6-1}\right) = \frac{-0.4}{-0.4} = 1$$

$$T_{21} = \left(\frac{1-1}{0.6-1}\right) = \frac{0}{-0.4} = 0$$

$$T_{31} = \left(\frac{1-1}{0.6-1}\right) = \frac{0}{-0.4} = 0$$

$$T_{41} = \left(\frac{0.6-1}{0.6-1}\right) = \frac{-0.4}{-0.4} = 1$$

Criteria 2 (benefit)

$$T_{12} = \left(\frac{0.6-0.6}{0.8-0.6}\right) = \frac{0}{0.2} = 0$$

$$T_{22} = \left(\frac{0.8-0.6}{0.8-0.6}\right) = \frac{0.2}{0.2} = 1$$

$$T_{32} = \left(\frac{0.8-0.6}{0.8-0.6}\right) = \frac{0.2}{0.2} = 1$$

$$T_{42} = \left(\frac{0.6-0.6}{0.8-0.6}\right) = \frac{0}{0.2} = 0$$

Criteria 3 (benefit)

$$T_{13} = \left(\frac{0.4-0.4}{0.6-0.4}\right) = \frac{0}{0.2} = 0$$

$$T_{23} = \left(\frac{0.4-0.4}{0.6-0.4}\right) = \frac{0}{0.2} = 0$$

$$T_{33} = \left(\frac{0.6-0.4}{0.6-0.4}\right) = \frac{0.2}{0.2} = 1$$

$$T_{43} = \left(\frac{0.4-0.4}{0.6-0.4}\right) = \frac{0}{0.2} = 0$$

Criteria 4 (benefit)

$$T_{14} = \left(\frac{0.6-0.4}{0.6-0.4}\right) = \frac{0.2}{0.2} = 1$$

$$T_{24} = \left(\frac{0.6-0.4}{0.6-0.4}\right) = \frac{0.2}{0.2} = 1$$

$$T_{34} = \left(\frac{0.6-0.4}{0.6-0.4}\right) = \frac{0}{0.2} = 1$$

$$T_{44} = \left(\frac{0.4-0.4}{0.6-0.4}\right) = \frac{0}{0.2} = 0$$

Criteria 5 (benefit)

$$T_{15} = \left(\frac{1-1}{1-1}\right) = \frac{0}{0} = 0$$

$$T_{25} = \left(\frac{1-1}{1-1}\right) = \frac{0}{0} = 0$$

$$T_{35} = \left(\frac{1-1}{1-1}\right) = \frac{0}{0} = 0$$

$$T_{45} = \left(\frac{1-1}{1-1}\right) = \frac{0}{0} = 0$$

Criteria 6 (benefit)

$$T_{16} = \left(\frac{0.4-0.4}{0.4-0.4}\right) = \frac{0}{0} = 0$$

$$T_{26} = \left(\frac{0.4-0.4}{0.4-0.4}\right) = \frac{0}{0} = 0$$

$$T_{36} = \left(\frac{0.4-0.4}{0.4-0.4}\right) = \frac{0}{0} = 0$$

$$T_{46} = \left(\frac{0.4-0.4}{0.4-0.4}\right) = \frac{0}{0} = 0$$

Criteria 7 (benefit)

$$T_{17} = \left(\frac{0.2-0.2}{0.2-0.2}\right) = \frac{0}{0} = 0$$

$$T_{27} = \left(\frac{0.2-0.2}{0.2-0.2}\right) = \frac{0}{0} = 0$$

$$T_{37} = \left(\frac{0.2-0.2}{0.2-0.2}\right) = \frac{0}{0} = 0$$

$$T_{47} = \left(\frac{0.2-0.2}{0.2-0.2}\right) = \frac{0}{0} = 0$$

Criteria 8 (benefit)

$$T_{18} = \left(\frac{0.8-0.8}{0.8-0.8}\right) = \frac{0}{0} = 0$$

$$T_{28} = \left(\frac{0.8-0.8}{0.8-0.8}\right) = \frac{0}{0} = 0$$

$$T_{38} = \left(\frac{0.8-0.8}{0.8-0.8}\right) = \frac{0}{0} = 0$$

$$T_{48} = \left(\frac{0.8-0.8}{0.8-0.8}\right) = \frac{0}{0} = 0$$

Criteria 9 (benefit)

$$T_{19} = \left(\frac{0.4 - 0.4}{0.4 - 0.4}\right) = \frac{0}{0} = 0$$

$$T_{29} = \left(\frac{0.8 - 0.8}{0.8 - 0.8}\right) = \frac{0}{0} = 0$$

$$T_{39} = \left(\frac{0.8 - 0.8}{0.8 - 0.8}\right) = \frac{0}{0} = 0$$

$$T_{49} = \left(\frac{0.8 - 0.8}{0.8 - 0.8}\right) = \frac{0}{0} = 0$$

Criteria 10 (benefit)

$$T_{110} = \left(\frac{1 - 1}{1 - 1}\right) = \frac{0}{0} = 0$$

$$T_{210} = \left(\frac{1 - 1}{1 - 1}\right) = \frac{0}{0} = 0$$

$$T_{310} = \left(\frac{1 - 1}{1 - 1}\right) = \frac{0}{0} = 0$$

$$T_{410} = \left(\frac{1 - 1}{1 - 1}\right) = \frac{0}{0} = 0$$

Criteria 11 (benefit)

$$T_{110} = \left(\frac{1 - 1}{1 - 1}\right) = \frac{0}{0} = 0$$

$$T_{210} = \left(\frac{1 - 1}{1 - 1}\right) = \frac{0}{0} = 0$$

$$T_{310} = \left(\frac{1 - 1}{1 - 1}\right) = \frac{0}{0} = 0$$

$$T_{410} = \left(\frac{1 - 1}{1 - 1}\right) = \frac{0}{0} = 0$$

$$X = \begin{matrix} \\ A1 \\ A2 \\ A3 \\ A4 \end{matrix} \begin{bmatrix} 1.0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0.5 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

3. Calculating the Weighted Matrix (V)
   The following is the formula for finding the weighted matrix values.

$$V_{ij} = \left(w_i * t_{ij}\right) + w_i$$

Criteria 1

$$V_{11} = (0.2 \times 1) + 0.2 = 0.4$$

$$V_{21} = (0.2 \times 0) + 0.2 = 0.2$$

$$V_{31} = (0.2 \times 0) + 0.2 = 0.2$$

$$V_{41} = (0.2 \times 1) + 0.2 = 0.4$$

Criteria 2

$$V_{12} = (0.2 \times 0) + 0.2 = 0.2$$

$$V_{22} = (0.2 \times 1) + 0.2 = 0.4$$

$$V_{32} = (0.2 \times 1) + 0.2 = 0.4$$

$$V_{42} = (0.2 \times 0) + 0.2 = 0.2$$

Criteria 3

$$V_{13} = (0.1 \times 0) + 0.1 = 0.1$$

$$V_{23} = (0.1 \times 0) + 0.1 = 0.1$$

$$V_{33} = (0.1 \times 1) + 0.1 = 0.2$$

$$V_{43} = (0.1 \times 0) + 0.1 = 0.1$$

Criteria 4

$$V_{14} = (0.1 \times 1) + 0.1 = 0.2$$

$$V_{24} = (0.1 \times 1) + 0.1 = 0.2$$

$$V_{34} = (0.1 \times 1) + 0.1 = 0.2$$

$$V_{44} = (0.1 \times 0) + 0.1 = 0.1$$

Criteria 5

$$V_{15} = (0.1 \times 0) + 0.1 = 0.1$$

$$V_{25} = (0.1 \times 0) + 0.1 = 0.1$$

$$V_{35} = (0.1 \times 0) + 0.1 = 0.1$$

$$V_{45} = (0.1 \times 0) + 0.1 = 0.1$$

Criteria 6

$$V_{16} = (0.075 \times 0) + 0.075 = 0.8$$

$$V_{26} = (0.075 \times 0) + 0.075 = 0.8$$

$$V_{36} = (0.075 \times 0) + 0.075 = 0.8$$

$$V_{46} = (0.075 \times 0) + 0.075 = 0.8$$

Criteria 7

$$V_{17} = (0.025 \times 0) + 0.025 = 0.5$$

$$V_{27} = (0.025 \times 0) + 0.025 = 0.5$$

$$V_{37} = (0.025 \times 0) + 0.025 = 0.5$$

$$V_{47} = (0.025 \times 0) + 0.025 = 0.5$$

Criteria 8

$$V_{18} = (0.075 \times 0) + 0.075 = 0.3$$

$$V_{28} = (0.075 \times 0) + 0.075 = 0.3$$

$$V_{38} = (0.075 \times 0) + 0.075 = 0.3$$

$$V_{48} = (0.075 \times 0) + 0.075 = 0.3$$

Criteria 9

$$V_{19} = (0.075 \times 0) + 0.075 = 0.8$$

$$V_{29} = (0.075 \times 0) + 0.075 = 0.8$$

$$V_{39} = (0.075 \times 0) + 0.075 = 0.8$$

$$V_{49} = (0.075 \times 0) + 0.075 = 0.8$$

Criteria 10

$$V_{110} = (0.025 \times 0) + 0.025 = 0.3$$

$$V_{210} = (0.025 \times 0) + 0.025 = 0.3$$

$$V_{310} = (0.025 \times 0) + 0.025 = 0.3$$

$$V_{410} = (0.025 \times 0) + 0.025 = 0.3$$

Criteria 11

$$V_{110} = (0.025 \times 0) + 0.025 = 0.3$$

$$V_{210} = (0.025 \times 0) + 0.025 = 0.3$$

$$V_{310} = (0.025 \times 0) + 0.025 = 0.3$$

$$V_{410} = (0.025 \times 0) + 0.025 = 0.3$$

$$X = \begin{bmatrix} 0.4\ 0.2 & 0.1\ 0.2 & 0.1\ 0.08 & 0.03\ 0.08 & 0.08\ 0.03\ 0.03 \\ 0.3\ 0.\ 4 & 0.1\ 0.2 & 0.1\ 0.08 & 0.03\ 0.08 & 0.08\ 0.03\ 0.03 \\ 0.2\ 0.4 & 0.2\ 0.2 & 0.1\ 0.08 & 0.03\ 0.08 & 0.08\ 0.03\ 0.03 \\ 0.4\ 0.2 & 0.1\ 0.1 & 0.1\ 0.08 & 0.03\ 0.08 & 0.08\ 0.03\ 0.03 \end{bmatrix}$$

4. Calculating the determination of the border approximation matrix (G)
   The following is the formula for determining the border approximation matrix:

$$G_1 = \left(\pi_{J=1}^{m}\ V_{ij}\right)^{\frac{1}{m}}$$

$$G_1 = (0.4 \times 0.2 \times 0.2 \times 0.4)^{\frac{1}{4}} = 0.28$$

$$G_2 = (0.2 \times 0.4 \times 0.4 \times 0.2)^{\frac{1}{4}} = 0.28$$

$$G_3 = (0.1 \times 0.1 \times 0.2 \times 0.1)^{\frac{1}{4}} = 0.12$$

$$G_4 = (0.2 \times 0.2 \times 0.2 \times 0.1)^{\frac{1}{4}} = 0.17$$

$$G_5 = (0.1 \times 0.1 \times 0.1 \times 0.1)^{\frac{1}{4}} = 0.1$$

$$G_6 = (0.08 \times 0.08 \times 0.08 \times 0.08)^{\frac{1}{4}} = 0.08$$

$$G_7 = (0.03 \times 0.03 \times 0.03 \times 0.03)^{\frac{1}{4}} = 0.03$$

$$G_8 = (0.08 \times 0.08 \times 0.08 \times 0.08)^{\frac{1}{4}} = 0.08$$

$$G_9 = (0.08 \times 0.08 \times 0.08 \times 0.08)^{\frac{1}{4}} = 0.08$$

$$G_{10} = (0.03 \times 0.03 \times 0.03 \times 0.03)^{\frac{1}{4}} = 0.3$$

$$G_{11} = (0.03 \times 0.03 \times 0.03 \times 0.03)^{\frac{1}{4}} = 0.3$$

$$G_i = [0.31\ 0.28\ \ 0.12\ 0.17\ \ \ 0.1\ 0.08\ 0.05\ \ 0.08\ 0.08\ 0.03\ \ ]$$

5. Calculating the Alternative Distance (Q)
   The formula for the alternative distance is as follows:

$$Q_{ij} = V_{ij} - G_i$$

Criteria 1

$$V_{11} = (0.4 - 0.31) = 0.12$$

$$V_{21} = (0.3 - 0.31) = -0.08$$

$$V_{31} = (0.2 - 0.31) = -0.08$$

$$V_{41} = (0.4 - 0.31) = 0.12$$

Criteria 2

$$V_{12} = (0.2 - 0.28) = -0.08$$

$$V_{22} = (0.4 - 0.28) = 0.12$$

$$V_{32} = (0.4 - 0.28) = 0.12$$

$$V_{42} = (0.2 - 0.28) = -0.08$$

Criteria 3

$$V_{13} = (0.1 - 0.12) = -0.02$$

$$V_{23} = (0.1 - 0.12) = -0.02$$

$$V_{33} = (0.2 - 0.12) = 0.08$$

$$V_{43} = (0.1 - 0.12) = -0.02$$

Criteria 4

$$V_{14} = (0.2 - 0.17) = 0.03$$

$$V_{24} = (0.2 - 0.17) = 0.03$$

$$V_{34} = (0.2 - 0.17) = 0.03$$

$$V_{44} = (0.1 - 0.17) = -0.07$$

Criteria 5

$$V_{15} = (0.1 - 0.1) = 0$$

$$V_{25} = (0.1 - 0.1) = 0$$

$$V_{35} = (0.1 - 0.1) = 0$$

$$V_{45} = (0.1 - 0.1) = 0$$

Criteria 6

$$V_{16} = (0.08 - 0.08) = 0$$

$$V_{26} = (0.08 - 0.08) = 0$$

$$V_{36} = (0.08 - 0.08) = 0$$

$$V_{46} = (0.08 - 0.08) = 0$$

Criteria 7

$$V_{17} = (0.05 - 0.05) = 0$$

$$V_{27} = (0.05 - 0.05) = 0$$

$$V_{37} = (0.05 - 0.05) = 0$$

$$V_{47} = (0.05 - 0.05) = 0$$

Criteria 8

$$V_{18} = (0.08 - 0.08) = 0$$

$$V_{28} = (0.08 - 0.08) = 0$$

$$V_{38} = (0.08 - 0.08) = 0$$

$$V_{48} = (0.08 - 0.08) = 0$$

Criteria 9

$$V_{19} = (0.08 - 0.08) = 0$$

$$V_{29} = (0.08 - 0.08) = 0$$

$$V_{39} = (0.08 - 0.08) = 0$$

$$V_{49} = (0.08 - 0.08) = 0$$

Criteria 10

$$V_{110} = (0.03 - 0.03) = 0$$

$$V_{210} = (0.03 - 0.03) = 0$$

$$V_{310} = (0.03 - 0.03) = 0$$

$$V_{410} = (0.03 - 0.03) = 0$$

Criteria 11

$$V_{110} = (0.03 - 0.03) = 0$$

$$V_{210} = (0.03 - 0.03) = 0$$

$$V_{310} = (0.03 - 0.03) = 0$$

$$V_{410} = (0.03 - 0.03) = 0$$

$$X = [0.09\ -0.08\ -0.02\ 0.03\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ -0.01\ 0.12\ -0.02\ 0.03\ 0\ 0\ 0\ 0\ 0\ 0\ 0$$
$$-0.11\ 0.12\ 0.08\ 0.03\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0.09\ -0.08\ -0.02$$
$$-0.07\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ ]$$

6. Ranking alternatives (S)

The formula for ranking alternatives is as follows:

$$S_i = \sum_{j}^{n} = 1q_{ij}$$

S_1= 0.12 + (-0.08) + (-0.02) + 0.03 + 0 + 0 + 0 + 0 + 0 + 0 + 0 = 0.05

S_2= (-0.08) + 0.12 + (-0.02) + 0.03 + 0 + 0 + 0 + 0 + 0 + 0 + 0 = 0.05

S_3= (-0.08) + 0.12 + 0.08 + 0.03 + 0 + 0 + 0 + 0 + 0 + 0 + 0 = 0.15

S_4= 0.12 + (-0.08) + (-0.02) + (-0.07) + 0 + 0 + 0 + 0 + 0 + 0 + 0 = -0.05

Table 1. Ranking Results

Ranking	Alternative	Total
1	HP 14S EP0022TU	0.15
2	ASUS Vivobook 14 A1400EA	0.05
3	LENOVO Ideapad SLIM 3 14ITL6	0.05
4	Dell Latitude 3420	-0.05

Based on the table above, the best laptop is the HP 14S EP0022TU with a score of 0.15, while the LENOVO Ideapad SLIM 3 14ITL6 and ASUS Vivobook 14 A1400EA both have the same score of 0.05. The last in the ranking is the Dell Latitude 3420 with a score of -0.05

3.3 Implementation

Implementation is the process of putting a plan or strategy into action to achieve specific goals, involving steps such as needs analysis, system design, development, testing, training, and monitoring, as well as evaluation to ensure that the system or project operates as expected and produces optimal results.

In its implementation, both hardware and software components are required. The hardware used in this research is a laptop with the following specifications, Processor AMD

Ryzen 5 4500U, RAM 8 GB, SSD 512 GB, and Windows 11 as the Operating System. For running the code, this research using application XAMPP and Visual Studio Code. This research user PHP with Laravel, Bootstrap framework and mySQL.

On the initial page of the Decision Support System website, there is a login form where users are required to log in first in order to use the decision support system with the MABAC method. Figure 1 shows the login page layout.

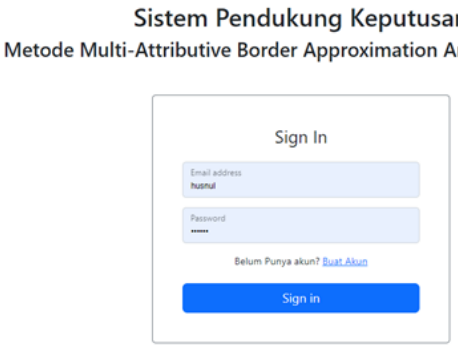

Figure 2. Login Page

If the user do not have an account or has not registered yet, they will be prompted to create one. To do so, the user simply needs to click on the "Create Account" text, which will display the registration form. Figure 2 shows the registration page.

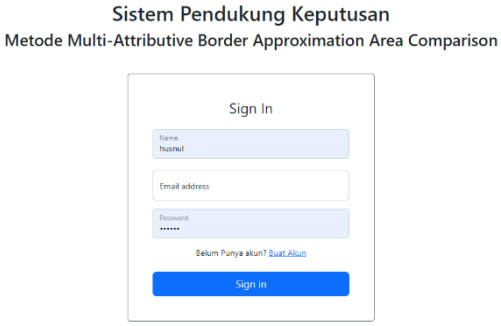

Figure 3. Registration Page

Once logged in, users will be directed to the dashboard page, where they will be informed about how to use the MABAC method. Additionally, there is a slider feature that allows users to navigate between pages simply by pressing the buttons on the sidebar. Figure 3 shows the display of the dashboard page.

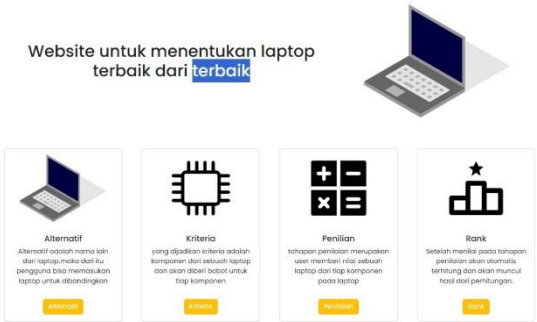

Figure 4. Dashboard Page

The first step in using the decision support system is to fill in the alternatives to compare which laptops will be evaluated. On the alternative page, the laptops to be compared are Lenovo Ideapad, Asus Vivobook, HP 14s, and Dell Latitude. Figure 4 shows the display of the alternative page.

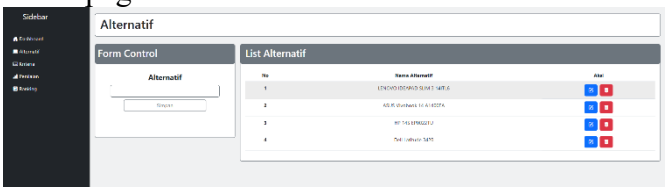

Figure 5. List of Alternative Page

After entering the laptops to be compared, the next step is to go to the criteria page. On this page, users must enter the criteria they wish to select. The researcher uses 11 criteria to be compared across the 4 laptops, with a total weight value of 1. The criteria page is displayed in Figure 5.

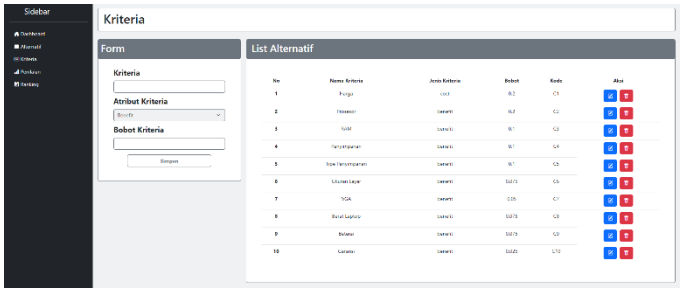

Figure 6. List of Criteria Page

The next step is to enter the criterion values for each laptop, also known as the initial matrix. Below is the display of the evaluation page shown in Figure 6.

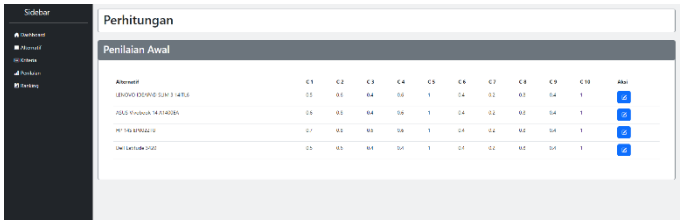

Figure 7. Assessment Page

Finally, the ranking or results displayed on the ranking page are shown. In addition to displaying the results or rankings of a laptop, users can also view the calculations from steps 1 to 5. Figure 7 shows the display of the ranking page.

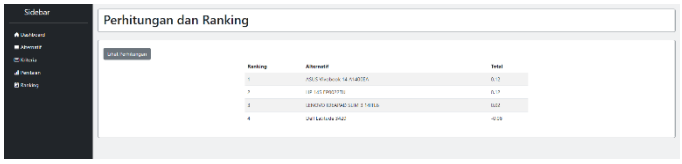

Figure 8. Page of Ranking Result

CONCLUSION

Based on the research conducted by the author, several conclusions can be drawn. The decision support system for selecting the best laptop using the Multi-Attributive Border Approximation Area Comparison (MABAC) method was successfully developed in the form of a web-based application, making it easier for evaluators to select laptops. In this study, 10 criteria were used: price, processor, RAM, storage, storage type, screen size, graphics card, laptop weight, battery, and warranty. The results of the calculations using the MABAC method provided rankings for the best laptops from highest to lowest values as follows: Asus Vivobook 14 A1400EA, HP 14s EP0022TU, Lenovo Ideapad Slim 3 14ITL6, and Dell Latitude 3420. Meanwhile, the public's assessment through a questionnaire showed the ranking of the best laptops from highest to lowest as follows: Lenovo, Asus, HP, Dell, MSI, Xiaomi, and Acer.

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