International Journal of Advances in Applied Sciences (IJAAS)
Vol. 12, No. 1, March 2023, pp. 48~59
ISSN: 2252-8814, DOI: 10.11591/ijaas.v12.i1.pp48-59

Generation 4.0 of the programmer selection decision support system: MCDM-AHP and ELECTRE-elimination recommendations

Akmaludin Akmaludin, Erene Gernaria Sihombing, Rinawati Rinawati, Frisma Handayanna, Linda Sari Dewi, Ester Arisawati
Department of Information Systems, Faculty of Information Technology, Nusa Mandiri University, Jakarta, Indonesia

Article Info

Article history:

Received Aug 28. 2022
Revised Oct 14, 2022
Accepted Nov 3, 2022

Keywords:

Aggregation process
ELECTRE-elimination model
MCDM-AHP concept
Multi-criteria level
Programmers' selection

ABSTRACT

The industrial world in the era of generation 4.0 needs personnel related to human resources who can handle crucial problems, especially in terms of data digitalization. The purpose of this paper is to analyze the supporting criteria that can be used as a measure of programmer selection for the needs of the industrial world which can provide optimal decisions and pay attention to the use of multi-criteria that have different quantitative assessments such as criteria related to contradictory times in its application. The problem, in the industrial world, does not only require speed alone but requires professional staff who can transform into digital technology, digitalization technology is needed in terms of the data conversion and transferring process, so a programmer has an important role in changing favorable conditions because it requires a selection process to get the best professional from several programmers. The method that can be used in multi-criteria decision-making-analytic hierarchy process (MCDM-AHP) and *elimination et choix traduisant la realite* (ELECTRE) methods in the concept of elimination. This method is part of the MCDM, which uses eight criteria in the selection and evaluation process. The results obtained from several selected programmers produce several professionally selected people, and can be used as an optimal benchmark for the programmer selection and evaluation process with a long preference index stage through the elimination process, this provides evidence that the selection and evaluation process can determine decision making which is optimal for a select number of programmers that only a few have through the aggregate dominant matrices.

Corresponding Author:

Akmaludin Akmaludin
Department of Information Systems, Faculty of Information Technology
Nusa Mandiri University, Jakarta, Indonesia
Nusa Mandiri Tower, Jatiwaringin Raya No. 2, East Jakarta 13620, Indonesia
Email: akmaludin.akm@nusamandiri.ac.id

1. INTRODUCTION

Given the uncertainty in the current industrial 4.0 era, it is felt in all industries that have experienced a decline in overcoming uncontrolled economic conditions in the era of global competition [1]. It is not only large industries that can master the conditions of the 4.0 generation era, on the contrary, small industries that can maintain their survival are also industries that have mastery of digitalization technology [2]. All these are thanks to the support of professionals who can use and utilize technology and analyze it well. His thinking is, of course, none other than the source of the profession of a programmer. Programmers have made many breakthroughs that can change the arrangement of such complex documents into simpler ones in the form of digitization, converting a lot of data that was previously in the form of files and then converted into the digitized form [3].

Then distributed quickly and precisely to the target in need. Owned entities are converted into objects that are compiled and processed by objects and by programming languages that specifically handle object-based data. Thus, the need for professionals such as programmers is needed by the entire industrial world, especially in the 4.0 generation which is said to be able to develop business in the digital world as it is today. The problem that arises is how is the process of selecting professional programmers who have optimal abilities in handling the smooth running of the digitization industry in the 4.0 era by using many criteria that contradict their understanding, this is very difficult to solve, such as criteria related to timing to obtain optimal selection results.

To prepare professionals such as programmers, we need a method that can carry out the selection and evaluation process so that it is appropriate to choose programmers that fit the needs of the industry in the industrial era 4.0. One method that can be used is to determine the need for several criteria according to the required barometer [4]. Multi-criteria decision-making (MCDM) is a selection method that uses many criteria as measurement parameters [5] to measure needs that are prioritized in the selection process [6] for several programmers. Of the eight criteria that can be used are abstract depiction (AD), conceptual design (CD), logical data model (LD), physical data model (PD), speed coding (SC), cyclomatic logical (CL), matrices logical (ML), and region sets (RS). The eight criteria used have different data uses, meaning that there are criteria that are meaningfully in line and there are criteria that are meaningful in reverse [7]. Because the data that is processed from each criterion uses quantitative data, the data will provide a magnitude for each criterion. The novelty of this research lies in processing data which generally have similarities in data processing, in this study, the data has two different understandings, which is very difficult in the calculation process. Data that has a quantity value can give meaning such as the largest value is the value that has the best value meaning (HB), or vice versa, the smallest value is the value that has the best value meaning (LB), so that all data in the form of values attached to a criterion are not all interpreted the same way, it becomes increasingly difficult to process data from a criterion. By looking at conditions like this, the right method that can be used is the *elimination et choix traduisant la realite* (ELECTRE) method [8]. While the analytic hierarchy process (AHP) method is used to determine the importance value which is the measure of each criterion used [9], of course with the support of instrumentation in the form of a questionnaire from several respondents, so it is not determined solely following the wishes of the researcher, but from several respondents. Which provides input, then processed with the help of the AHP method or expert choice application to provide a value of importance to several criteria used [10]. Through collaboration, the AHP and ELECTRE methods provide optimal results for the selection and evaluation of the needs of professionals such as programmers. AHP is used in determining the weights through the acquisition of eigenvectors with five iteration stages with multi-criteria types with different understandings and ELECTRE as a selection elimination process through a preference stage by setting a threshold as an alternative elimination process to the unification of aggregate decisions as the final selection.

Related to this, this study aims to analyze the supporting criteria that can be used as a measure of programmer selection for the needs of the industrial world in the 4.0 era for companies in Indonesia. The contributions of this research are: i) Implementation of the use of multi-criteria with MCDM-AHP in collaboration with the ELECTRE method which can provide optimal decisions in the selection of professionals such as programmers and ii) Paying attention to the use of main factors against criteria that have different quantitative assessments such as criteria related to time and the meaning of reverse assessment, namely the smallest value is the best, in general, what is widely used in applied research is the notion of the largest value is the best. In this study, using the application of criteria by using these two understandings.

2. RESEARCH METHOD

This section will explain a lot about the basic concepts that can strengthen understanding of the content of this research discussion. As is meant by MCDM along with the methods included in the MCDM category, there is also an AHP which is a problem simplification method to narrow down the problems that are detailed through a hierarchy, and finally, the ELECTRE elimination method is a method that solves the problem by comparing the preference structure into a two-dimensional matrix for ranking. Completion of the concept in detail from this research will be explained in stages through the completion of the algorithm which can be seen in Figure 1.

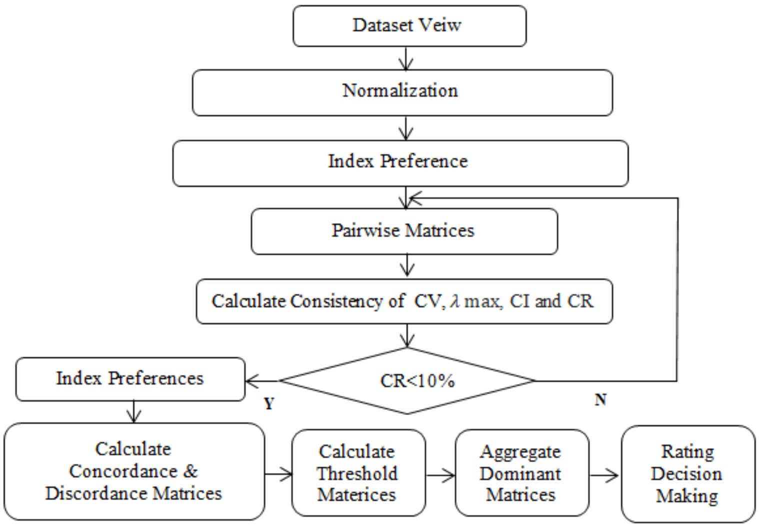

Figure 1. AHP-ELECTRE algorithm

2.1. MCDM

MCDM is a method that can be used to solve a problem by using many criteria [11] which are used as a barometer to determine a particular goal based on soft computing [12], many methods fall into this category. Several criteria used will be the determining trend until the end of the selection. This is because this method can solve various problems, both quantitative and qualitative, and can even be combined from both [13].

The MCDM methods used are AHP [14], simple additive weighting (SAW) [15], a technique for order preference by similarity to ideal solution (TOPSIS) [16], decision-making trial and evaluation laboratory (DEMATEL), preference ranking organizational methods for enrichment evaluation (PROMETHEE) [17], ELECTRE [18], multi-attribute utility theory (MAUT) [19] and *Vlse kriterijumska optimizacija i kompromisno resenje* (VIKOR) [20], [21] These methods are a series based on MCDM [22] and many more that cannot be mentioned.

2.2. AHP

The AHP method is a method that can solve a problem from a very complicated form to a simple form through a simplification process [23] into a hierarchical form so that it becomes more focused on one problem by assigning an eigenvector [24] to each level of resolution. All levels are simplified into a form of hierarchical modeling. Each level consists of three levels consisting of objectives, criteria, or sub-criteria so that in the end it will end up with alternatives. The completion technique in AHP uses a comparison scale of two objects for each level compared to each other depending on the number of comparisons used [25], the comparison scale consists of numbers 1 to 9 which will be compared by looking at the importance of the two objects being compared, then used as a pairwise matrix to calculate the matrices multiplication so that the eigenvector values of each level are obtained.

The eigenvector value obtained must go through a process called iteration to find the optimal eigenvector value [26]. Iterations are carried out to eliminate the difference between the results of matrices multiplication with a level of accuracy that is adjusted to the sharpness of the calculation. After finding the optimal eigenvector value, then a feasibility test is carried out by multiplying the optimal eigenvector value by paired matrix during initialization to determine the consistency index (CI) and consistency ratio (CR) values. As proof of acceptance or rejection, the CR value must be less than or equal to 10 percent. If the CR value is more than 10 percent [27], then the decision is rejected, otherwise, the decision can be accepted.

2.3. ELECTRE

The ELECTRE method is one of the ranking methods by using a way of eliminating preferences that are compared between one-row elements with other row elements as a whole [28]. Then determining the set of concordance and discordance that is determined according to the rules will be used as a two-dimensional matrix, through a threshold [29]. An elimination process will be carried out which will produce a binary number of 1 or 0, each of which is multiplied to determine the ranking of both the concordance and discordance matrices [30].

ELECTRE has its unique way of building a ranking system by eliminating all the criteria in each row in aggregation. Several formulas can be used in ELECTRE to form the dataset into normalized data, if the meaning of the numerical dataset has the same meaning, then use (1), if the meaning of the numerical dataset has a different meaning, then the normalization process is used (2) and (3), so it is necessary to make adjustments to the normalization process by looking at the condition of the dataset.

$$R_{(i,j)} = \frac{x_{(i,j)}}{\sqrt{\sum_{i=1}^{m} x^{2}{}_{(i,j)}}} \tag{1}$$

$$P_{(i,j)} = \frac{x_{(i,j)} - x'_{(j)}}{x*_{(j)} - x'_{(j)}} \tag{2}$$

$$Q_{(i,j)} = \frac{x_{(i,j)} - x*_{(j)}}{x'_{(j)} - x*_{(j)}} \tag{3}$$

After the datasets are normalized, the size of each dataset is adjusted to the weight that has been determined at the paired matrices acquisition stage by finding the eigenvector value as the preference of interest for each criterion, the optimal eigenvector is the result obtained from the paired matrices obtained through the AHP method as a preference for each criterion. This can be done using the formula listed in (4).

$$V = R.W \tag{4}$$

Thus, the criteria will be grouped into two subsets of concordance sets and discordance sets, for concordance sets they will be grouped using (5), while for discordance sets, they will be grouped using (6). By grouping, the concordance set and the discordance set, each of them can be calculated and in the end will form a two-dimensional matrix, for concordance using (8). Next is to look for the suitability of the dominant matrices and the discrepancy of the dominant matrices at (9) and (10) with the help of a threshold as a barometer to determine the element matrices $f_{(k,l)}$ and $G_{(k,l)}$ with the rules at (11) with the final ranking value for several alternatives.

$$C_{(k,l)} = \{j, y_{(k,j)} > y_{(i,j)}\} \tag{5}$$

$$D_{(k,l)} = \{j, y_{(k,j)} < y_{(i,j)}\} \tag{6}$$

$$C_{(k,l)} = \sum_{jC_w} w_j \tag{7}$$

$$d_{(k,l)} = \frac{\{\max(\mathrm{v_{mn}} - \mathrm{v_{mn-ln}})\}; \mathrm{m,n}\ \varepsilon\ d_{(k,l)}}{\{\max(\mathrm{v_{mn}} - \mathrm{v_{mn-ln}})\}; \mathrm{m,n=1,2,3,...n}} \tag{8}$$

$$\sqsubseteq = \frac{\sum_{k=1}^{n} \sum_{l=1}^{n} c_{(k,l)}}{m*(m-1)}\ ; f_{(k,l)} = 1, \text{if } c_{(k,l)} \geq \sqsubseteq\ ; f_{kl} = 0, \text{if } c_{(k,l)} < \tag{9}$$

$$\sqsupseteq = \frac{\sum_{k=1}^{n} \sum_{l=1}^{n} d_{(k,l)}}{m*(m-1)};\ g_{kl} = 1, \text{if } c_{(k,l)} \geq \sqsupseteq\ ; g_{(k,l)} = 0, \text{if } d_{(k,l)} < \tag{10}$$

$$E_{(k,l)} = F_{(k,l)}\ x\ G_{(k,l)} \tag{11}$$

To calculate the value of interest preferences against several criteria, of course, use the best rules using the AHP method. Several formulas will be used to calculate the consistency index (CI).

$$CI = \frac{\lambda max - n}{n-1} \tag{12}$$

While the consistency ratio (CR) is a determinant of whether a decision is accepted [31] or rejected with a set limit greater than or equal to 10 percent, with (13).

$$CR = \frac{CI}{RI} \tag{13}$$

To find the amount of CR, a random index (RI) table is needed to determine the value of each order of the matrices (N), pay attention to Table 1.

Table 1. Random index CI [32]

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54	1.56	1.57	1.58

3. RESULTS AND DISCUSSION

In its implementation, the selection and evaluation of several professional programmers must first determine the number of criteria that will be used as a barometer of measurement, eight criteria will be used. From each of the criteria, it is necessary to first understand how these types of criteria work. It is said that all criteria use data entry in the form of quantitative data in the form of numbers that are ready to be processed, but some criteria have different meanings in processing, especially for criteria related to time. This criterion contains an inverse meaning, usually, each criterion value is filled with quantitative data containing the following meaning, the largest value is the best value (HB), it turns out that not all of them mean the same, for example, the speed coding (SC) criterion, this criterion also contains numeric data, but This criterion has the meaning of the smallest value is the best value (LB), so it requires a slightly different formulation from the others.

Starting from the display of the dataset that can be used as a reference for the unique programmer selection process on the SC criteria, which means it is inversely proportional to other criteria, this criterion implies that the LB, while the other is HB. Pay attention to Table 2 which is a view of the dataset of 23 programmers. The data processing that will be carried out has a somewhat different and unique understanding because several criteria have an inversely proportional understanding of the data. Data processing like this must pay close attention to the location of the data within the specified range so that the data is structured in a structured manner and can facilitate the data normalization process that must be carried out before the calculation process is carried out using AHP or ELECTRE, the key to completion is by positioning the weight value. Each alternative in a criterion of each and just carry out the process of normalizing several assessments of the alternatives to provide the right results for the decisions to be made. The ultimate goal of this data processing is to make an accurate decision on each weight that has been calculated through the collaboration of the two methods. This does require full attention to achieve the optimal value as an acceptable decision. With this strong concern, it is hoped that what must be fully considered is the placement of each value in determining each number, both containing the meaning of HB or LB from each criterion, if this is true, then all processes to the next stage of collaborative methods will produce decisions as expected.

Table 2. Dataset view

Criteria (Alt)	AD (HB)	CD (HB)	LD (HB)	PD (HB)	SC (LB)	CL (HB)	ML (HB)	RS (HB)
PR01	80.34	75.43	75.63	78.54	15.22	86.87	75.97	76.63
PR02	82.05	75.73	75.69	79.56	17.34	83.44	76.04	78.52
PR03	92.45	82.92	75.43	74.78	16.34	84.03	75.77	75.72
PR04	89.45	86.93	77.23	72.74	16.58	85.47	77.58	71.43
PR05	91.40	77.61	74.81	80.34	18.32	81.41	75.15	82.31
PR06	86.40	78.56	78.15	82.34	18.26	90.21	78.51	83.42
PR07	77.89	80.34	80.18	80.36	18.64	86.06	80.55	78.65
PR08	89.67	82.04	80.23	80.22	17.48	85.06	80.60	79.28
PR09	90.45	84.56	78.45	78.34	15.39	80.52	78.81	77.41
PR10	93.45	83.51	74.04	80.09	18.45	80.05	74.38	80.29
PR11	84.56	74.18	76.89	81.82	17.42	81.03	77.24	82.22
PR12	85.12	81.48	80.51	78.84	16.33	84.16	80.88	76.48
PR13	88.46	78.84	81.04	78.93	17.32	79.65	81.41	78.13
PR14	85.23	80.64	80.33	80.13	20.12	80.18	80.70	80.22
PR15	83.00	72.23	75.05	80.23	18.38	80.36	75.39	78.63
PR16	83.67	63.93	77.04	82.90	18.14	79.05	77.39	83.92
PR17	75.87	68.58	73.05	75.88	16.24	79.04	92.48	80.28
PR18	80.45	82.28	76.92	78.05	16.43	80.56	77.27	70.25
PR19	85.42	82.54	80.52	80.03	17.32	79.17	80.89	82.23
PR20	86.72	88.46	78.33	78.86	17.33	78.98	78.69	72.16
PR21	86.16	70.34	79.41	84.04	17.82	78.21	79.77	82.34
PR22	82.43	79.75	81.29	79.58	15.40	81.49	81.66	78.38
PR23	83.11	80.00	82.03	75.41	16.44	82.38	82.40	77.31

Thus, the data set must be normalized, so that it can be processed using the ELECTRE method, the normalized table can be seen in Table 3. The normalized table will then become an index preference that will be compared between one row and another until a concordance set and a discordance set are found. And to be used as two-dimensional concordance and discordance matrices.

The dataset view listed in Table 2 illustrates that the data obtained have different understandings of the categories owned by each criterion, meaning that the layout is in two different conditions which can be seen from the type of criteria HB and LB, this will affect the determination of numbers in normalization. The normalization results listed in Table 3 are the application of (2) and (3) by taking into account the type of criteria that appear in the resulting dataset and the results are normalized data. After finding the normalization results in Table 3, we have to determine the magnitude of the value of importance by using the AHP using mathematical algebra matrices and testing the truth using the expert choice application as proof that the results of eigenvector values are optimal and must have the same value to the value. The eigenvector is a mathematic algebra matrix and expert choice application.

Calculations for each data in Table 3 are normalized using (2) and (3) by taking into account the characteristics of the criteria high is the best (HB) or low is the best (LB) that have been previously determined. If the criteria are HB then use (2) and if LB uses (3). For the first row of HD criteria are HB, then use (2), if written with the following equation = $(element\ matrices\ (i,j) - maximum\ value\ of\ the\ criteria\ column)$ divided by (the largest value of the criteria column-the smallest value of the criteria column), so the resulting value is 0.25 while in the first row for SC criteria which are LB by using (3), if written with the following equation = $(element\ matrices\ (i,j) - the\ value\ of\ the\ smallest\ criteria\ column)$ divided by (The small value of the criteria column-the largest value of criteria column), so the resulting value is 1.00. So do this until the 23rd row of programmer data in Table 1 until the results of the normalization process can be seen in Table 3.

Table 3. Normalization

Criteria	AD	CD	LD	PD	SC	CL	ML	RS
(Alt)	0.297	0.180	0.164	0.161	0.089	0.050	0.038	0.022
PR01	0.25	0.47	0.29	0.51	1.00	0.72	0.09	0.47
PR02	0.35	0.48	0.29	0.60	0.57	0.44	0.09	0.60
PR03	0.94	0.77	0.27	0.18	0.77	0.49	0.08	0.40
PR04	0.77	0.94	0.47	0.00	0.72	0.61	0.18	0.09
PR05	0.88	0.56	0.20	0.67	0.37	0.27	0.04	0.88
PR06	0.60	0.60	0.57	0.85	0.38	1.00	0.23	0.96
PR07	0.11	0.67	0.79	0.67	0.30	0.65	0.34	0.61
PR08	0.78	0.74	0.80	0.66	0.54	0.57	0.34	0.66
PR09	0.83	0.84	0.60	0.50	0.97	0.19	0.24	0.52
PR10	1.00	0.80	0.11	0.65	0.34	0.15	0.00	0.73
PR11	0.49	0.42	0.43	0.80	0.55	0.24	0.16	0.88
PR12	0.53	0.72	0.83	0.54	0.77	0.50	0.36	0.46
PR13	0.72	0.61	0.89	0.55	0.57	0.12	0.39	0.58
PR14	0.53	0.68	0.81	0.65	0.00	0.16	0.35	0.73
PR15	0.41	0.34	0.22	0.66	0.36	0.18	0.06	0.61
PR16	0.44	0.00	0.44	0.90	0.40	0.07	0.17	1.00
PR17	0.00	0.19	0.00	0.28	0.79	0.07	1.00	0.73
PR18	0.26	0.75	0.43	0.47	0.75	0.20	0.16	0.00
PR19	0.54	0.76	0.83	0.65	0.57	0.08	0.36	0.88
PR20	0.62	1.00	0.59	0.54	0.57	0.06	0.24	0.14
PR21	0.59	0.26	0.71	1.00	0.47	0.00	0.30	0.88
PR22	0.37	0.64	0.92	0.61	0.96	0.27	0.40	0.59
PR23	0.41	0.66	1.00	0.24	0.75	0.35	0.44	0.52

Thus, the dataset must be normalized, so that it can be processed using the ELECTRE method. The normalization in Table 3 becomes a preference index that will be compared between one row and another until a concordance set and a discordance set are found to be used as concordance matrices along with the discordance matrices data. The number of records developed into 506 matrix elements to obtain a set of concordance and discordance sourced from 23 dataset views. Table 4 shows the results of the calculation of eigenvectors using mathematical algebraic matrices.

Grouping the concordance set can be done using (5), while the grouping for the discordance set can be done using (6). The results of the concordance set are arranged into a two-dimensional matrix as shown in Table 5, while the discordance set can be searched using (7) the results of the discordance set if arranged into a two-dimensional matrix will look like the one in Table 6. The grouping of data included in the concordance matrices is data that has a positive value that is compared to each other, while the data included in the discordance matrices is data that has a negative value so that no data is free from the process of elimination, thus the grouping of data will easy to insert according to the location in concordance matrices and discordance matrices. Figure 2 shows eigenvector calculation results using the expert choice apps.

Table 4. Eigenvector calculation results using mathematic algebra matrices

Criteria	AD	CD	LD	PD	CT	CC	MS	RS	Eigenvector
Abstract depiction (AD)	1.000	2.965	2.234	1.963	3.984	4.378	6.900	6.600	0.297
Conceptual design (CD)	0.337	1.000	1.956	1.274	2.126	3.782	4.578	7.000	0.180
Logical data model (LD)	0.448	0.511	1.000	1.565	2.976	3.466	3.842	6.900	0.164
Physical data model (PD)	0.509	0.785	0.639	1.000	3.462	3.568	3.996	7.000	0.161
Speed coding (SC)	0.251	0.470	0.336	0.289	1.000	2.962	3.226	6.000	0.089
Cyclomatic complexity (CC)	0.228	0.264	0.289	0.280	0.338	1.000	1.722	3.000	0.050
Matrices score (MS)	0.145	0.218	0.260	0.250	0.310	0.581	1.000	2.278	0.038
Region set (RS)	0.152	0.143	0.145	0.143	0.167	0.333	0.439	1.000	0.022
Consistency =	0.040		Consistency index =			0.056			
λ max =	8.391		Consistency ratio =			0.040	(Acceptable)		

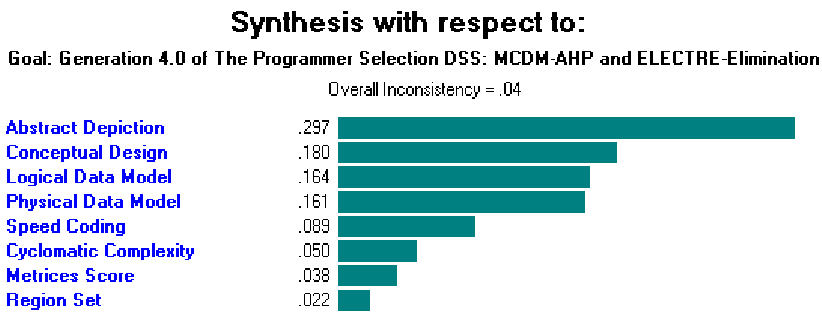

Figure 2. Eigenvector calculation results using the expert choice apps

Table 5. Concordance matrices

Alt	PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08	PR09	PR10	PR11	PR12	PR13	PR14	PR15	PR16	PR17	PR18	PR19	PR20	PR21	PR22	PR23
PR01	0.000	0.139	0.523	0.323	0.340	0.090	0.436	0.139	0.300	0.340	0.319	0.162	0.139	0.139	0.520	0.319	0.941	0.323	0.139	0.162	0.319	0.139	0.300
PR02	0.861	0.000	0.384	0.183	0.817	0.566	0.386	0.090	0.233	0.340	0.319	0.183	0.233	0.139	0.520	0.319	0.851	0.530	0.050	0.233	0.319	0.072	0.233
PR03	0.477	0.616	0.000	0.569	0.817	0.566	0.566	0.566	0.347	0.340	0.616	0.477	0.616	0.616	0.817	0.616	0.690	0.638	0.616	0.458	0.616	0.526	0.616
PR04	0.678	0.817	0.431	0.000	0.520	0.566	0.566	0.319	0.230	0.520	0.817	0.526	0.616	0.616	0.817	0.817	0.690	0.750	0.616	0.436	0.616	0.526	0.526
PR05	0.660	0.660	0.183	0.480	0.000	0.297	0.408	0.480	0.530	0.523	0.549	0.530	0.530	0.619	0.799	0.526	0.874	0.530	0.530	0.530	0.526	0.480	0.480
PR06	0.911	0.911	0.434	0.434	0.703	0.000	0.619	0.233	0.233	0.523	0.911	0.530	0.233	0.619	1.000	0.727	0.874	0.731	0.530	0.233	0.549	0.530	0.530
PR07	0.564	0.614	0.434	0.434	0.592	0.381	0.000	0.211	0.434	0.412	0.431	0.233	0.413	0.300	0.614	0.431	0.851	0.434	0.211	0.434	0.431	0.413	0.413
PR08	0.861	0.911	0.434	0.681	0.520	0.767	0.789	0.000	0.523	0.412	0.817	0.799	0.799	0.687	0.750	0.727	0.941	0.820	0.597	0.820	0.727	0.799	0.799
PR09	0.700	0.767	0.654	0.770	0.470	0.767	0.566	0.566	0.000	0.520	0.767	0.588	0.616	0.616	0.817	0.817	0.941	0.950	0.616	0.659	0.616	0.566	0.749
PR10	0.660	0.660	0.660	0.480	0.477	0.477	0.588	0.499	0.480	0.000	0.477	0.660	0.710	0.588	0.499	0.526	0.874	0.660	0.687	0.530	0.526	0.660	0.660
PR11	0.681	0.681	0.384	0.183	0.451	0.090	0.569	0.273	0.233	0.523	0.000	0.183	0.233	0.323	1.000	0.616	0.874	0.530	0.211	0.233	0.319	0.480	0.480
PR12	0.838	0.817	0.523	0.474	0.520	0.470	0.767	0.290	0.412	0.340	0.817	0.000	0.319	0.520	0.817	0.817	0.851	0.820	0.139	0.363	0.520	0.526	0.777
PR13	0.861	0.767	0.384	0.384	0.470	0.767	0.587	0.290	0.384	0.290	0.767	0.681	0.000	0.587	0.587	0.767	0.817	0.874	0.658	0.570	0.798	0.817	0.319
PR14	0.861	0.861	0.384	0.384	0.381	0.381	0.700	0.223	0.384	0.412	0.678	0.480	0.413	0.000	0.700	0.727	0.851	0.681	0.211	0.434	0.431	0.660	0.660
PR15	0.480	0.480	0.183	0.183	0.201	0.000	0.386	0.161	0.183	0.501	0.000	0.183	0.233	0.300	0.000	0.230	0.851	0.480	0.211	0.233	0.230	0.480	0.183
PR16	0.681	0.681	0.384	0.183	0.474	0.273	0.569	0.183	0.183	0.474	0.384	0.183	0.183	0.273	0.770	0.000	0.694	0.681	0.183	0.233	0.072	0.480	0.480

Table 5. Concordance matrices *(Continued)*

Alt	PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08	PR09	PR10	PR11	PR12	PR13	PR14	PR15	PR16	PR17	PR18	PR19	PR20	PR21	PR22	PR23
PR17	0.059	0.149	0.310	0.310	0.127	0.127	0.149	0.149	0.059	0.127	0.127	0.149	0.149	0.149	0.149	0.306	0.000	0.149	0.127	0.199	0.176	0.059	0.310
PR18	0.678	0.470	0.362	0.250	0.470	0.269	0.566	0.269	0.050	0.340	0.470	0.180	0.319	0.319	0.520	0.319	0.851	0.000	0.139	0.139	0.319	0.180	0.430
PR19	0.861	0.950	0.384	0.384	0.470	0.470	0.789	0.493	0.384	0.313	0.789	0.861	0.363	0.789	0.789	0.817	0.874	0.861	0.000	0.523	0.520	0.660	0.660
PR20	0.838	0.767	0.542	0.564	0.470	0.767	0.566	0.269	0.341	0.470	0.767	0.637	0.180	0.566	0.767	0.767	0.801	0.861	0.477	0.000	0.616	0.477	0.637
PR21	0.681	0.681	0.384	0.384	0.474	0.451	0.569	0.183	0.384	0.474	0.681	0.480	0.183	0.569	0.770	0.928	0.824	0.681	0.480	0.384	0.000	0.480	0.480
PR22	0.861	0.928	0.474	0.474	0.520	0.470	0.587	0.290	0.434	0.340	0.520	0.474	0.703	0.340	0.520	0.520	0.941	0.820	0.340	0.523	0.520	0.000	0.273
PR23	0.700	0.767	0.384	0.474	0.520	0.470	0.587	0.290	0.251	0.340	0.520	0.223	0.520	0.340	0.817	0.520	0.690	0.570	0.340	0.363	0.520	0.727	0.000

The next normalized table will be the index preference that will be compared to the first row with other rows, even all rows must be compared one by one with other rows. The comparison results for each row will form a two-dimensional matrix as shown in Table 5 which are called concordance matrices. with the help of a threshold (average of the overall two-dimensional concordance matrices) which is obtained mathematically by (7), with the resulting value of 0.5; while the discordance matrices in Table 6 with the help of a threshold (the average value of the entire two-dimensional discordance matrices) is 2.95 which can be found using (8) from the acquisition of the two concordance and discordance matrices through the process of multiplying the two matrices for each location of the data element.

Table 6. Discordance matrices

Alt	PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08	PR09	PR10	PR11	PR12	PR13	PR14	PR15	PR16	PR17	PR18	PR19	PR20	PR21	PR22	PR23
PR01	0.000	0.320	2.070	1.010	0.994	0.801	0.726	1.151	1.087	1.131	0.840	2.399	1.001	0.523	0.235	0.818	1.397	0.531	0.849	0.808	0.674	1.406	1.905
PR02	3.129	0.000	1.399	0.757	2.659	3.005	1.885	17.695	1.964	2.295	1.348	3.597	1.886	0.911	0.231	0.821	2.478	0.441	1.512	1.115	0.950	3.838	1.922
PR03	0.483	0.715	0.000	0.639	1.218	1.707	0.639	2.298	1.150	1.091	1.388	1.357	1.712	0.707	0.897	0.928	0.979	0.424	1.400	0.858	1.598	1.145	1.383
PR04	0.990	1.322	1.566	0.000	2.095	2.558	1.026	3.321	1.201	1.440	1.546	2.192	1.129	0.905	1.106	0.974	1.065	0.918	1.505	1.001	1.479	1.516	1.482
PR05	1.006	0.376	0.821	0.477	0.000	2.578	0.778	2.723	1.668	1.628	0.595	1.488	2.269	1.673	0.056	0.445	1.084	0.437	1.869	0.596	1.719	1.414	1.705
PR06	1.249	0.333	0.586	0.391	0.388	0.000	0.467	0.540	0.725	0.474	0.224	0.776	0.366	0.290	0.000	0.053	0.829	0.388	0.287	0.431	0.150	0.803	0.662
PR07	1.378	0.531	1.566	0.975	1.285	2.141	0.000	8.041	1.548	1.294	0.905	2.970	1.126	0.852	0.509	0.576	0.830	0.734	0.746	0.851	0.719	1.736	1.025
PR08	0.869	0.057	0.435	0.301	0.367	1.853	0.124	0.000	0.555	0.608	0.204	0.062	0.150	0.541	0.092	0.148	0.861	0.026	0.085	1.056	0.326	0.147	0.276
PR09	0.920	0.509	0.870	0.832	0.599	1.379	0.646	0.887	0.000	0.337	0.832	1.000	0.732	0.217	0.274	0.566	0.911	0.006	0.895	0.402	0.870	0.693	0.955
PR10	0.884	0.436	0.916	0.694	0.614	2.111	0.773	3.206	2.964	0.000	0.628	1.521	2.746	1.498	0.189	0.419	1.000	0.557	1.580	0.803	1.114	1.288	1.513
PR11	1.190	0.742	0.720	0.647	1.680	4.463	1.105	1.729	1.203	1.593	0.000	0.960	1.545	0.695	0.000	0.298	1.601	0.377	2.552	0.791	1.194	1.744	1.009
PR12	0.417	0.278	0.737	0.456	0.672	1.289	0.337	1.103	1.000	0.658	1.042	0.000	0.506	0.354	0.259	0.761	0.772	0.072	1.012	0.659	0.928	0.853	0.558
PR13	0.999	0.530	0.584	0.885	0.441	2.734	0.888	4.998	1.366	0.364	0.647	1.978	0.000	0.268	0.186	0.635	0.578	0.687	0.654	0.345	1.300	1.305	1.142
PR14	1.911	1.098	1.414	1.105	0.598	3.443	1.174	7.835	4.611	0.668	1.438	2.827	3.738	0.000	0.604	0.593	0.977	1.033	6.789	0.966	1.118	6.048	1.798
PR15	4.262	4.329	1.115	0.904	17.878	-33.517	1.965	651.826	3.648	5.285	-4.704	3.866	5.798	1.656	0.000	1.144	2.327	0.668	6.143	1.398	2.710	12.080	1.822
PR16	1.222	1.218	1.077	1.026	2.246	18.766	1.735	2.175	1.766	2.389	3.360	1.315	1.435	1.686	0.874	0.000	1.342	0.748	2.987	1.162	2.283	1.591	0.988
PR17	0.716	0.404	1.022	0.939	0.923	1.206	1.204	1.218	1.098	1.000	0.624	1.296	1.455	1.024	0.430	0.745	0.000	0.665	1.299	1.064	1.029	1.535	1.797
PR18	1.883	2.266	2.359	1.089	2.287	2.580	1.362	3.083	170.648	1.794	2.652	13.974	3.174	0.968	1.496	1.337	1.504	0.000	4.825	1.942	1.817	5.766	2.436

Table 6. Discordance matrices *(Continued)*

Alt	PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08	PR09	PR10	PR11	PR12	PR13	PR14	PR15	PR16	PR17	PR18	PR19	PR20	PR21	PR22	PR23
PR19	1.178	0.662	0.715	0.665	0.535	3.486	1.340	2.274	1.117	0.633	0.392	0.989	0.577	0.147	0.163	0.335	0.770	0.207	0.000	0.207	0.714	1.391	0.654
PR20	1.238	0.897	1.166	0.999	1.679	2.319	1.175	1.990	2.490	1.245	1.264	1.517	1.114	1.036	0.715	0.860	0.940	0.515	3.052	0.000	1.008	1.281	1.195
PR21	1.483	1.052	0.626	0.676	0.582	6.647	1.391	1.689	1.149	0.898	0.837	1.077	0.766	0.895	0.369	0.438	0.972	0.550	1.402	0.992	0.000	1.251	0.516
PR22	0.711	0.261	0.873	0.660	0.707	1.245	0.576	0.970	1.442	0.776	0.573	1.172	0.875	0.165	0.083	0.628	0.651	0.173	0.719	0.780	0.799	0.223	0.525
PR23	0.525	0.520	0.723	0.675	0.587	1.510	0.976	2.006	1.047	0.661	0.991	1.793	1.369	0.556	0.549	1.012	0.557	0.411	1.528	0.837	1.939	4.478	0.000

The matrices will provide a rank for each row of the concordance matrices and the row of discordance matrices which can be seen in Table 7 as a decision that can be taken by a professional in the field of programmers that can be used as decision support, and others until they find a set of concordance sets and the set of discordance, to be used as concordance and discordance matrices. From the results of the acquisition of both concordance and discordance matrices, the last step is to perform the multiplication process of these matrices to be used as the aggregation dominant matrices which is the result of multiplying the two matrices as a decision-making. For the result of the process that has a value of one, it will provide decision support as the chosen alternative and vice versa describes the decision support that is not selected for the alternative. To determine whether the concordance matrices element is 1 or 0 you can use (9) and to determine discordance matrices element is 1 or 0 you can use (10) and the product of the two concordance matrices with discordance matrices the results are as obtained in Table 7 in the form of dominant matrices aggregation, can be done using (11).

Table 7. Aggregation dominant matrices

Alt	PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08	PR09	PR10	PR11	PR12	PR13	PR14	PR15	PR16	PR17	PR18	PR19	PR20	PR21	PR22	PR23	RESULT
PR01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR02	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
PR03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
PR15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7. Aggregation dominant matrices *(Continued)*

Alt	PR01	PR02	PR03	PR04	PR05	PR06	PR07	PR08	PR09	PR10	PR11	PR12	PR13	PR14	PR15	PR16	PR17	PR18	PR19	PR20	PR21	PR22	PR23	RESULT
PR19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

4. CONCLUSION

The MCDM-AHP collaboration method with ELECTRE provides optimal results in selecting professional programmers through many criteria that have been passed and with the conditions of determining criteria with contradictory conditions. The selection process from 23 programmers gave the best results using the MCDM-AHP and ELECTRE elimination methods. Some programmers experience elimination which can be seen from the results of the dominant matrix aggregation. The results showed that of the 23 programmers who passed the selection process, 3 professionals in their fields had the highest dominant aggregation matrix with a value of 2, namely PR02, while the weight value was followed by a dominant aggregation matrix with a weight of 1, namely PR14 and PR23, while the others were removed automatically with the ELECTRE elimination method through a soft computing base. Thus, the selection and evaluation process of professional programmers using the MCDM-AHP and ELECTRE elimination methods can be proven in detail for decision support based on the score of each alternative as a scientifically proven ranking as a form of proof of optimal decision-making. The most important thing to note is the type of criteria whose understanding is contradictory, especially concerning time.

REFERENCES

[1] A. Nadeem, B. Abedin, N. Cerpa, and E. Chew, "Editorial: Digital transformation & digital business strategy in electronic commerce - The role of organizational capabilities," *Journal of theoretical and applied electronic commerce research*, vol. 13, no. 2, pp. I–VIII, May 2018, doi: 10.4067/S0718-18762018000200101.

[2] N. Verina and J. Titko, "Digital transformation: conceptual framework," in *Proceedings of 6th International Scientific Conference Contemporary Issues in Business, Management and Economics Engineering '2019*, May 2019, pp. 9–10. doi: 10.3846/cibmee.2019.073.

[3] G. Agushi, "Understanding the digital transformation approach – a case of Slovenian enterprises," Master's Thesis, University of Ljubljana, Ljubljana, 2019.

[4] M. Velasquez and P. T. Hester, "An Analysis of Multi-Criteria Decision Making Methods," *International Journal of Operations Research*, vol. 10, no. 2, pp. 56–66, 2013.

[5] L. Chybowski, M. Twardochleb, and B. Wiśnicki, "Multi-criteria Decision making in Components Importance Analysis applied to a Complex Marine System," *Naše more*, vol. 63, no. 4, pp. 264–270, Dec. 2016, doi: 10.17818/NM/2016/4.3.

[6] H. Wang, Q. Jian, and X. Xie, "Application of AHP for Liquefaction Risk Assessment of Bulk Mineral Ores during Marine Transportation," in *Proceedings of the 2019 International Conference on Robotics, Intelligent Control and Artificial Intelligence - RICAI 2019*, 2019, pp. 545–550. doi: 10.1145/3366194.3366291.

[7] F. Dianawati and P. Rebecca, "Analytic Hierarchy Process (AHP) and Goal Programming In Selecting New Rest Area Location in Trans Jawa Highway," in *Proceedings of the 2019 5th International Conference on Industrial and Business Engineering*, Sep. 2019, pp. 233–236. doi: 10.1145/3364335.3364393.

[8] L. Oubahman and S. Duleba, "Review of PROMETHEE method in transportation," *Production Engineering Archives*, vol. 27, no. 1, pp. 69–74, Mar. 2021, doi: 10.30657/pea.2021.27.9.

[9] H. Bouayad, L. Benabbou, and A. Berrado, "An Analytic Hierarchy Process based approach for Information technology governance framework selection," in *Proceedings of the 12th International Conference on Intelligent Systems: Theories and Applications*, Oct. 2018, pp. 1–6. doi: 10.1145/3289402.3289515.

[10] I. Ajripour, M. Asadpour, and L. Tabatabaie, "A model for organization performance management applying MCDM and BSC: a case study," *Journal of Applied Research on Industrial Engineering*, vol. 6, no. 1, pp. 52–70, 2019.

[11] N. S. Parihar and P. Bhargava, "Multi Attribute Utility Theory (MAUT) Driven New Product Development Using Multi Criteria Decision Making (MCDM)," *International Journal of Engineering Trends and Technology*, vol. 67, no. 5, pp. 27–30, May 2019, doi: 10.14445/22315381/IJETT-V67I5P205.

[12] X. Wu, Z. Huang, and S. Shen, "Comprehensive Evaluation of Medical Service Ability of TCM Hospitals in 30 Provinces, Autonomous Regions and Municipalities of China in 2017 Based on Entropy Weight TOPSIS Method and RSR Method," in *Proceedings of the 2019 The World Symposium on Software Engineering - WSSE 2019*, 2019, pp. 108–112. doi: 10.1145/3362125.3362149.

[13] S. A. S. A. Mary and G. Suganya, "Multi-Criteria Decision Making Using ELECTRE," *Circuits and Systems*, vol. 07, no. 06, pp. 1008–1020, 2016, doi: 10.4236/cs.2016.76085.

[14] T. L. Saaty, "Decision-making with the AHP: Why is the principal eigenvector necessary," *Eur J Oper Res*, vol. 145, no. 1, pp. 85–91, Feb. 2003, doi: 10.1016/S0377-2217(02)00227-8.

[15] A. Setyawan, F. Y. Arini, and I. Akhlis, "Comparative Analysis of Simple Additive Weighting Method and Weighted Product Method to New Employee Recruitment Decision Support System (DSS) at PT. Warta Media Nusantara," *Scientific Journal of Informatics*, vol. 4, no. 1, pp. 34–42, May 2017, doi: 10.15294/sji.v4i1.8458.
[16] S. Bahrami, R. Yaakob, A. Azman, and R. Atan, "An Integrated of Fuzzy Rule Base System and TOPSIS Technique for Multi-Attribute Decision Making," in *Proceedings of the 3rd International Conference on Software Engineering and Information Management*, Jan. 2020, pp. 58–62. doi: 10.1145/3378936.3378940.
[17] W. de Keyser and P. Peeters, "A note on the use of PROMETHEE multicriteria methods," *Eur J Oper Res*, vol. 89, no. 3, pp. 457–461, Mar. 1996, doi: 10.1016/0377-2217(94)00307-6.
[18] A. P. R. Pinem, "Implementation of Fuzzy ELECTRE for Assessment of Damage Due to Natural Disasters," in Indoensian "Implementasi Fuzzy ELECTRE Untuk Penilaian Kerusakan Akibat Bencana Alam," *JURNAL SISTEM INFORMASI BISNIS*, vol. 7, no. 2, p. 81, Nov. 2017, doi: 10.21456/vol7iss2pp81-87.
[19] P. Kailiponi, "Analyzing evacuation decisions using multi-attribute utility theory (MAUT)," *Procedia Eng*, vol. 3, pp. 163–174, 2010, doi: 10.1016/j.proeng.2010.07.016.
[20] S.-W. Huang, J. J. H. Liou, H.-H. Chuang, and G.-H. Tzeng, "Using a Modified VIKOR Technique for Evaluating and Improving the National Healthcare System Quality," *Mathematics*, vol. 9, no. 12, pp. 1–21, Jun. 2021, doi: 10.3390/math9121349.
[21] S. Opricovic and G.-H. Tzeng, "Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS," *Eur J Oper Res*, vol. 156, no. 2, pp. 445–455, Jul. 2004, doi: 10.1016/S0377-2217(03)00020-1.
[22] A. Ishak, Asfriyati, and B. Nainggolan, "Integration of Fuzzy AHP-VIKOR Methods in Multi Criteria Decision Making: Literature Review," *IOP Conf Ser Mater Sci Eng*, vol. 1003, no. 1, p. 012160, Dec. 2020, doi: 10.1088/1757-899X/1003/1/012160.
[23] T. L. Saaty, "Decision making with the analytic hierarchy process," *International Journal of Services Sciences*, vol. 1, no. 1, p. 83, 2008, doi: 10.1504/IJSSCI.2008.017590.
[24] P. Andrews, K. Harker, and A. Krahmer, "Applying the Analytic Hierarchy Process to an Institutional Repository Collection," in *Proceedings of the 18th ACM/IEEE on Joint Conference on Digital Libraries*, May 2018, pp. 37–40. doi: 10.1145/3197026.3197064.
[25] T. L. Saaty, "How to make a decision: The analytic hierarchy process," *Eur J Oper Res*, vol. 48, no. 1, pp. 9–26, Sep. 1990, doi: 10.1016/0377-2217(90)90057-I.
[26] K. Mukherjee, "Analytic hierarchy process and technique for order preference by similarity to ideal solution: a bibliometric analysis 'from' past, present and future of AHP and TOPSIS," *International Journal of Intelligent Engineering Informatics*, vol. 2, no. 2/3, p. 96, 2014, doi: 10.1504/IJIEI.2014.066210.
[27] L. A. Gumay, B. Purwandari, T. Raharjo, A. Wahyudi, and M. Purwaningsih, "Identifying Critical Success Factors for Information Technology Projects with an Analytic Hierarchy Process," in *Proceedings of the 2020 2nd Asia Pacific Information Technology Conference*, Jan. 2020, pp. 108–112. doi: 10.1145/3379310.3379326.
[28] H. Hu, X. Mao, and J. Li, "Study on Multimodal Transportation Route Selection based on a Simplified ELECTRE Approach considering Environmental Impacts," in *Proceedings of the 2018 1st International Conference on Internet and e-Business*, Apr. 2018, pp. 308–312. doi: 10.1145/3230348.3230432.
[29] H. G. Costa and M. B. T. Duarte, "Applying ELECTRE TRI ME for Evaluating the Quality of Services Provided by a Library," in *Proceedings of the 2019 11th International Conference on Education Technology and Computers*, Oct. 2019, pp. 278–281. doi: 10.1145/3369255.3369313.
[30] T. Wang, "The Information Security Risk Assessment Model Based on Improved ELECTRE Method," in *Proceedings of the 2019 7th International Conference on Information Technology: IoT and Smart City*, Dec. 2019, pp. 570–574. doi: 10.1145/3377170.3377181.
[31] A. Lin and M. Lu, "The site selection evaluation of photovoltaic applications using analytic hierarchy process in urban areas, China," in *Proceedings of the 8th International Conference on Informatics, Environment, Energy and Applications - IEEA '19*, 2019, pp. 119–123. doi: 10.1145/3323716.3323733.
[32] S. Abadi *et al.*, "Implementation of fuzzy analytical hierarchy process on notebook selection," *International Journal of Engineering & Technology*, vol. 7, no. 2.27, pp. 238–243, Aug. 2018, doi: 10.14419/ijet.v7i2.27.12047.

BIOGRAPHIES OF AUTHORS

Akmaludin Akmaludin graduated with an MMSI Magister degree in Information Systems from Gunadarma University, Indonesia, in 2002. His research interests include Computer Science, Decision Science, and Decision Making. He can be contacted at email: akmaludin.akm@nusamandiri.ac.id.

Erene Gernaria Sihombing graduated as an Master degree of Computer Science from High School of Information and Computer Management (STMIK) Nusa Mandiri Jakarta, Indonesia. 2015. Research field are Computer Science such as Data Mining, Decision Support Systems. He can be contacted at email: erene.egs@nusamandiri.ac.id.

Rinawati graduated as a Master Degree of Computer Science from High School of Information and Computer Management (STMIK) Nusa Mandiri Jakarta, Indonesia. In 2012. Research field are Computer Science such as Data Mining, Decision Support Systems. She can be contacted at email: rinawati.riw@nusamandiri.ac.id..

Frisma Handayanna graduated as a Master Degree of Computer Science from High School of Information and Computer Management (STMIK) Nusa Mandiri Jakarta, Indonesia. In 2012. Research field are Computer Science such as Data Mining, Decision Support Systems. She can be contacted at email: frisma.fha@nusamandiri.ac.id.

Linda Sari Dewi graduated as a Master Degree of Computer Science from High School of Information and Computer Management (STMIK) Nusa Mandiri Jakarta, Indonesia. In 2012. Research field are Computer Science such as Data Mining, Decision Support Systems. She can be contacted at email: linda.lrw@nusamandiri.ac.id.

Ester Arisawati graduated as a Master degree of Computer Science from High School of Information and Computer Management (STMIK) Nusa Mandiri Jakarta, Indonesia. In 2012. Research Field are computer science such as data mining, decision support systems. She can be contacted at email: ester.err@nusamandiri.ac.id.