The Best Selection of Programmers in Generation 4.0 Using AHP and ELECTRE Elimination Methods

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Abstract. The quality of data processing in information systems in the 4.0 industrial era is expected to be in the form of paperless-based digitalization, thus a number of capable and reliable users are needed in terms of data processing in the form of digitalization, the means developed can be through the internet or via smartphone-based on Android. The need for The best programmer is certainly very needed in terms of data development and processing and information delivery. This needs to be done so that the process of sending data and information can be done simply and very high speed, because the transfer of resources has been converted into digital form. The need for programmer staff must be selected consistently so that users who are accepted as the best and reliable programmers according to job requirements, from ten programmers with collaboration AHP method and ELECTRE can provide optimal decisions with the following results, programmer code P5, P6, P7 and P10 get the biggest score with weight of 3, followed by programmer code P9 with weight of 2, and followed by programmer code P1, P2, P8 with weight of 1, and there are two programmer codes which are eliminated by the ELECTRE method, P3 and P4. The collaboration in the method of Analytic Hierarchy Process (AHP) and ELECTRE Elimination which is the crystallization of the Multi-criteria Decision Making (MCDM) can be a decision support in the selection process of the best programmers to produce optimal decisions

1. Introduction

In the current era of digitalization 4.0, all forms of documents in the form of data and information are made in electronic form [1] , so that the world of informatics such as processing and processing data is very much needed especially in the distribution of queries on information that is ready to be presented to a general audience smartly [2].

To be able to convert data into information, a reliable user is required to present data into information in the database management system, because the data must be stored in an adequate storage. Users who are able to take action like this are reliable programmers who can be said to be the best users in the world of information systems. Therefore we need a measuring tool that can assess the ability of reliable programmers who can be accepted as digital users, they are said to be able to handle all forms of document conversion into a form of digitization [2], of course there are many criteria assessments to determine the best number of programmers through the right method [3].

A number of methods can be done to measure the selection of reliable and best programmers, one of which is the Analytic Hierarchy Process (AHP) [4] which can be collaborated with elimination methods such as ELECTRE (Elimination Et ChoixTraduisant La Realite) [5],[6] . This collaboration method has a good level of accuracy, so it can be used to select programmers to get the best rating among them. AHP can be used to determine the preference magnitude of a number of criteria for determining each criterion weight, while the Elimination ELECTRE method is used to determine the alternatives for programmers in the reliable category. The collaboration of the two methods will provide the optimal solution [7] for determining the selection process for reliable programmers.

Criteria parameters used as a barometer [8]for selecting programmers include seven criteria, namely abstract depiction, conceptual design, logical data model, physical data model, codding program, cyclomatic logical, and matrices logical. While programmers who act as alternatives consist of ten people to become the best programmers in 4.0 generation era.

2. Methods

This section will explain the basic concepts of the method and will be collaborated to determine optimal decisions, namely:

2.1 Analytical Hierarchy Process(AHP)

The preference for a number of criteria used for weighting can be used the Analytic Hierarchy Process (AHP) method [9]. The AHP method can provide optimal solutions to preferences carried out with the concept of two-dimensional algebra matrices [10]. Thus the preparation of pairwise matrices as the main key of the calculation of the concept of algebra matrices, with stages and steps that are long and have a specific purpose, namely to find the eigenvector value [9], [4], [11]. The optimal eigenvector value can only be done through iterations until there is no difference in the value of the eigenvector acquisition with the previous eigenvector value.

This eigenvector can be used as a reference for optimal values [5]. The stages that must be passed to obtain the optimal eigenvector value are (1) determining pairwise matrices; (2) determine the consistency of vector quantities; (3) determine the lambda max amount; (4) determine consistency index; (5) determine the consistency ratio (CR) as a benchmark for accepting or rejecting a decision [9][12].

To determine the amount of consistency ratio (CR), random index (RI) is needed as a measure of the order quantity used in the preparation of pairwise matrices (equation 1). As for the amount of RI that can be used can be seen in (Table 1).

Table 1. Random Index

Ordo	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.48

Some formulations that can be done in the use of the AHP method and become a reference [13], [7] in the process of determining the optimal eigenvector value, the first time that is done is to arrange pairwise matrices as the initial mathematical calculation of algebra matrices (equation 2). It is possible with the Multi-criteria Decision Making (MCDM) [13] method that iterations will occur in order to find the loss of certain eigenvector differences with the previous eigenvector [14], this is what is called the optimal eigenvector value.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ x_{31} & x_{32} & \cdots & x_{3n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Thus it can determine the value of consistency vector value, which is the result of multiplication of pairwise matrices with optimal eigenvector [15], from this it can be obtained optimal vector length where vectors are arranged in layers to determine the magnitude of the averaged. Then determine the consistency ratio (CI) that appears in (equation-2) and test the consistency ratio (CR) on the feasibility of the value provided that <= 0.1 or vice versa if more than 10% then the decision must be checked again the possibility of pairwise matrices placement has the wrong input [16] , pay attention (equation-3). The results of this optimal eigenvector can be used as a preference for the assessment of each criterion.

$$CI = \frac{\lambda\, max - n}{n-1} \quad (2)$$

$$CR = \frac{CI}{RI} \quad (3)$$

2.2. ELECTRE

The selection system with the elimanasi concept is a method that can be done with ELECTRE (Elomination Et Choix Taduisant La Realite), this method requires a long step in preparing expanded data through a comparison of each dataset row of each criterion element [17]. The steps that can be done through the ELECTRE method are (1) initializing the dataset; (2) normalization of datasets; (3) compare each dataset row with the other lines; (4) determine the amount of concordance and discordance; (5) determine the threshold value; (6) determine the aggregate dominant matrices; (7) Determine alternative ratings [6]. Thus ranking is done by elimination to determine the number of alternatives chosen. ELECTRE which is used in the case of selecting the best programmers will need a supporting formulation that helps in every step of the calculation of the best programmer selection. Alternative datasets and criteria that have been arranged so that they can be processed mathematically, must go through the stages of normalization that can be done using (equation-4) [3].

$$\mathrm{R}_{(\mathrm{i,j})} = \frac{\mathrm{X}_{(\mathrm{i,j})}}{\sqrt{\sum_{\mathrm{i=1}}^{\mathrm{m}} (\mathrm{X}_{(\mathrm{i,j})})^2}}, \text{ where i=1,2,3, ... m; j=1,2,3, ... n} \quad (4)$$

The normalized data has the strength to be weighted after being operated with the preference magnitude that has been obtained by the AHP method [18], so that each weighted data will be known as weight normalization which has the position of the row and column arrangement with the range that has been calculated. Next determine the set value of concordance, note (equation-5) and the discordance set, note (equation-6), this is done to determine the stages of grouping each value in the set of concordance and discordance categories.

$$C_{(k,l)} = \{j, y_{(k,j)} > y_{(i,j)}\} \qquad \text{, where j=1,2,3,……,n} \quad (5)$$

$$D_{(k,l)} = \{j, y_{(k,j)} < y_{(i,j)}\} \qquad \text{,where j=1,2,3,……,n} \quad (6)$$

With the basis of the set of concordance and discordance, the arrangement of matrices concordance will be known, note (equation-7) and the arrangement of matrices discordance [17], note (equation-8), the elimination process with the ELECTRE method will be more clearly illustrated in the matrix arrangement through a standard threshold as dominant matrices concordance of attention (equation-9) [19] and threshold as dominant discordance discordance note (equation-10), dose of threshold is done naturally on matrices element data in matrices dominant concordance and dominant matrices discordance.

$$C_{(k,l)} = \sum_{j \in C_{(k,l)}} W_j \;\;, \text{ where } \;\; C_{(k,l)} \geq j_{(i,j)}, \;\; \text{for } j = 1,2,3, \ldots n \tag{7}$$

$$D_{(k,l)} = \frac{\max\{|v_{(k,j)} - v_{(i,j)}|\}_{j \in D_{(k,l)}}}{\max\{|v_{(k,j)} - v_{(i,j)}|\}_{\forall j}} \;, \text{ where } \; D_{(k,l)} = \{j,\ y_{(k,j)} < y_{(i,j)}\} \text{ for } j = 1,2,3, \ldots,\ n \tag{8}$$

$$\sqsubseteq = \frac{\sum_{k=1}^{m} \sum_{l=1}^{m} C_{(k,l)}}{m(m-1)} \;, \text{where } f_{(k,l)} = \left\{\frac{1, \text{ jika } c_{(k,l)} \geq \sqsubseteq}{0, \text{ jika } c_{(k,l)} < \sqsubseteq}\right\} \tag{9}$$

$$\sqsupseteq = \frac{\sum_{k=1}^{m} \sum_{l=1}^{m} C_{(k,l)}}{m(m-1)} ,\; \text{where } g_{(k,l)} = \left\{\frac{1, \text{ jika } c_{(k,l)} \geq \sqsupseteq}{0, \text{ jika } c_{(k,l)} < \sqsupseteq}\right\} \tag{10}$$

Determining aggregate matrices is the purpose of determining the multiplication value of both matrices, concordance and discordance, of course, calculation of the formula in (equation-11) can be done. Matrices Aggregate can be used as a basis for determining the rank of each alternative [20], the highest rank is given to the score with the largest accumulative number of results of multiplication concordance and dominant discordance matrices.

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

3. Implementation and Result

To determine preference for a number of criteria, it should not be self-determined but must go through research with the help of questionnaire instrumentation from experts who already know the programmer's work such as an analyst's level, of course with the snowball sampling method. So the results obtained from preference values can be objective. Questionnaire input data can be processed with the concept of algebra matrices and can be tested with the help of the expert choice application as a logical comparison. The accumulation of data is expressed in the form of a pairwise matrices which contains points consisting of seven criteria which can be seen in (table 2) and (figure 2).

Table 2. Eigenvector using Algebra matrices

Criteria	AD	CD	LD	PD	CP	CL	ML	**Eigenvector**
Abstract Depiction (AD)	1.000	2.099	2.955	2.042	1.977	2.021	1.077	0.242
Conceptual Design (CD)	0.476	1.000	2.046	2.003	2.061	2.097	2.097	0.196
Logical Data Model (LD)	0.338	0.489	1.000	1.163	1.163	2.057	1.039	0.118
Physical Data Model (PD)	0.490	0.499	0.860	1.000	1.056	2.129	2.034	0.130
Codding Program (CP)	0.506	0.485	0.860	0.947	1.000	2.316	2.104	0.131
Cyclomatic Logical (CL)	0.495	0.477	0.486	0.470	0.432	1.000	2.073	0.090
Matrices Logical (ML)	0.928	0.477	0.962	0.492	0.475	0.482	1.000	0.093
Lamda=	7.463							
Consistency Index=	0.077							
Consistency Ratio=	0.059							

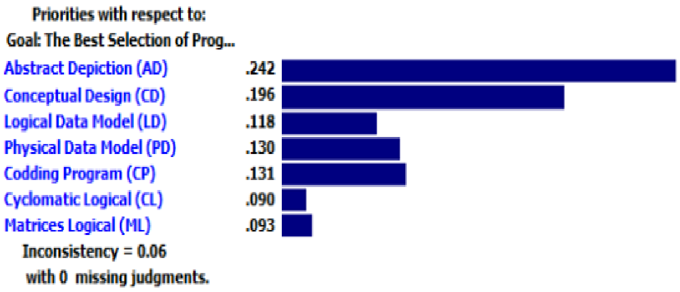

Figure 1. Eigenvector using expert choice

Decisions that can be taken as preferences for seven criteria are done through an iteration process that has taken place five times, it turns out that it is able to provide optimal eigenvector values, things can be known through the difference in eigenvector values obtained with the previous eigenvector value of zero at the decimal value position.

The optimal eigenvector can be used as a preference in the ELECTRE method. So it is necessary to know the dataset to be processed by the ELECTRE Elimination method, note (table 3a) which consists of ten programmers and seven criteria used as measurements. The value of the interval value as an assessment has a range of one to five. This dataset will be processed to be normalized and the results will be multiplied by the preference obtained through the optimal eigenvector, so having a list as weight normalization, pay attention (Table 3b).

Table 3a. Dataset

Alt	K1	K2	K3	K4	K5	K6	K7	Total
P1	2	4	4	5	3	2	3	23
P2	4	4	3	4	2	2	4	23
P3	4	5	3	2	2	4	3	23
P4	2	2	5	4	5	3	2	23
P5	3	2	4	5	3	2	4	23
P6	3	3	5	4	2	3	3	23
P7	5	2	4	2	5	2	3	23
P8	4	5	2	2	4	3	3	23
P9	2	5	2	3	4	3	4	23
P10	3	3	3	4	4	2	4	23

Table 3b. Weight normalization

Alt	K1	K2	K3	K4	K5	K6	K7
P1	0.048	0.069	0.042	0.059	0.037	0.022	0.028
P2	0.095	0.069	0.032	0.047	0.025	0.022	0.038
P3	0.095	0.087	0.032	0.024	0.025	0.044	0.028
P4	0.048	0.035	0.053	0.047	0.062	0.033	0.019
P5	0.072	0.035	0.042	0.059	0.037	0.022	0.038
P6	0.072	0.052	0.053	0.047	0.025	0.033	0.028
P7	0.119	0.035	0.042	0.024	0.062	0.022	0.028
P8	0.095	0.087	0.021	0.024	0.049	0.033	0.028
P9	0.048	0.087	0.021	0.036	0.049	0.033	0.038
P10	0.072	0.052	0.032	0.047	0.049	0.022	0.038

The basic findings of weight normalization are the benchmarks for producing appropriate matrices concordance and discordance (equations 5 and 6). The results can be seen in (Table 4a and 4b).

Table 4a. Concordance matrices

Alt	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
P1	0.000	0.378	0.378	0.419	0.196	0.457	0.326	0.247	0.247	0.444
P2	0.335	0.000	0.223	0.532	0.439	0.532	0.419	0.341	0.490	0.439
P3	0.529	0.286	0.000	0.622	0.529	0.529	0.286	0.208	0.450	0.529
P4	0.339	0.339	0.378	0.000	0.339	0.131	0.337	0.378	0.378	0.339
P5	0.335	0.378	0.471	0.465	0.000	0.353	0.223	0.341	0.490	0.247
P6	0.450	0.208	0.247	0.532	0.404	0.000	0.534	0.247	0.490	0.208
P7	0.373	0.491	0.491	0.335	0.373	0.373	0.000	0.491	0.491	0.491
P8	0.659	0.417	0.131	0.532	0.659	0.570	0.286	0.000	6.000	0.529
P9	0.510	0.417	0.353	0.289	0.417	0.420	0.509	0.223	0.000	0.286
P10	0.466	0.373	0.353	0.532	0.327	0.224	0.419	0.341	0.490	0.000

Table 4b. Discrordance matrices

Alt	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
P1	0.000	1.000	1.000	0.712	0.688	1.000	1.000	1.000	0.731	1.000
P2	0.259	0.000	0.918	0.777	0.356	0.887	1.000	1.000	0.518	1.000
P3	0.746	1.000	0.000	0.712	0.684	0.684	0.712	1.000	0.518	0.712
P4	1.000	1.000	1.000	0.000	0.965	0.643	1.000	1.000	1.000	1.000
P5	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000
P6	0.727	1.000	1.000	1.000	0.712	0.000	1.000	1.000	1.000	1.000
P7	0.497	0.936	1.000	0.332	0.746	0.497	0.000	1.000	0.727	0.497
P8	0.746	0.960	0.441	0.610	0.684	0.915	0.458	0.000	0.249	0.684
P9	1.000	1.000	1.000	0.610	0.458	0.915	1.000	1.000	0.000	0.688
P10	1.000	0.727	1.000	0.887	0.970	0.857	1.000	1.000	1.000	0.000

Thus the stages of elimination with the ELECTRE method, began to be clearly seen at the stage of finding matrices concordance and discordance, by looking for the magnitude of the threshold value of each of them. The value of the threshold magnitude can be searched using (equations 9 and 10), this can be done to determine the dominant concordance matrices and dominant discordance matrices. Where the value of the requirements determined based on the threshold acquisition value is a definite reference and must be valued above the threshold value. This means that if the value is above the threshold it will be worth one and vice versa if the value below the threshold value will be zero in the sense that it is eliminated. After obtaining each value for the dominant matrices, you will carefully find the aggregate dominant matrices. Aggregate dominant matrices can also occur in the second phase of elimination, where the results of multiplication using (equation 11) form the basis of ranking through the acquisition of the number of weights obtained from the seven criteria used, pay attention in (table 5).

Table 5. The Result in Aggregate Dominant Matrices

Alt	Aggregate Dominant Matrices										Rank
P1	0	0	0	0	0	1	0	0	0	0	3
P2	0	0	0	0	0	1	0	0	0	0	3
P3	0	0	0	0	0	0	0	0	0	0	4
P4	0	0	0	0	0	0	0	0	0	0	4
P5	0	0	1	1	0	0	0	0	1	0	1
P6	0	0	0	1	0	0	1	0	1	0	1
P7	0	1	1	0	0	0	0	1	0	0	1
P8	0	0	0	0	0	1	0	0	0	0	3
P9	1	0	0	0	0	0	1	0	0	0	2
P10	1	0	0	1	0	0	0	0	1	0	1

4. Conclusion

The use of the Multi-criteria collaboration method between AHP and ELECTRE has proven the optimal results of the selection process of a number of programmers displayed in the Aggregate Dominant Matrices, from ten programmers who fall into the category of having a total ranking of all criteria. from the process carried out through AHP to the acquisition of eigenvector values that elevates the rating system to suit the needs of the relevant programmers. The results obtained were programmers with codes P5, P6, P7, and P10 which ranked first with the highest weight worth 3 and followed by programmers with code P9 with a weight of 2 ranked second, then rated 3 with a weight of 1 namely programmers with code P1, P2, and P8, while programmers who are eliminated are coded P3, P4 because they have no weight at all. Thus the collaboration between the two methods AHP and ELECTRE Elimination can be a reference in terms of selection and evaluation for the best selection of programmers in generation 4.0 industrial era.

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