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SISTEM REKOMENDASI WISATA TERBAIK DI KOTA YOGYAKARTA DENGAN INTEGRASI METODE MFEP DAN K-MEANS CLUSTERING

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Abstract

Yogyakarta is one of the leading tourist destinations in Indonesia with diverse attractions, ranging from cultural, historical, to natural attrac-tions, which often pose challenges for tourists in determining tourist destinations according to their preferences. This study aims to develop a recommendation system for the best tourist destinations in Yogya-karta City through the integration of the Multifactor Evaluation Pro-cess (MFEP) and K-Means Clustering methods. MFEP is used to rank destinations based on five main criteria, namely location, accessibility, facilities, cost, and uniqueness, with weights obtained from the results of tourist preference surveys. The ranking results are then analyzed using K-Means Clustering to group destinations into three categories of tourism potential, namely high, medium, and low, based on addi-tional parameters such as strategic location, number of attractions, and number of visitors. The results of this study prove that the integration of MFEP and K-Means is able to produce fast, accurate, and informa-tive recommendations, and can be used by tourists and tourism manag-ers in strategic planning and decision-making. System functionality testing using the black box method shows that all features run as need-ed, while clustering quality testing using the Silhouette Coefficient method produces very good clustering quality with an average score of 0.9552.

Keywords: K-Means Clustering; MFEP; Recommenda-tion System; Tourism; Yogyakarta

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INTRODUCTION

The city of Yogyakarta has long been known as one of the leading tourism centers in Indonesia. The city combines its identity as a cultural area as well as a student city, thus offering a rich experience for visitors [1]. The beauty of the architecture and historical value of the Yogyakarta Palace, the bustle of Malioboro Street, the magnificence of Prambanan Temple, the charm of Taman Sari, the exoticism of Parangtritis

Beach, and the panorama of Mount Merapi make this area always crowded with tourists, both from within the country and abroad [2]-[3]. This diversity not only raises the image of Yogyakarta in the national arena, but also plays an important role in the region's economic growth. However, the abundance of destination choices actually raises its own dilemma for tourists. The large number of tourist alternatives with scattered and poorly structured information makes the selection process complicated. It is not uncommon for visitors to take a long time to weigh the existing options, especially when the criteria they want are not easy to compare. As information technology develops and advances in the field of artificial intelligence, the opportunity to optimize decision-making processes through data analysis is increasingly wide open [4].

Several previous studies have contributed to the development of a recommendation system and analysis of tourism potential. A study in the Beira Baixa region of Portugal, for example, used a GIS-based Spatial Decision Support System to assess the feasibility of ecotourism using the AHP method against nine criteria, including landscape diversity and natural resource conservation. The results show a high potential for sustainable ecotourism development [5]. Another study combined Genetic Algorithm with K-Means for travel recommendation routes, which proved to be faster and more accurate than traditional K-Means [6]. A literature review by another researcher explores the application of recommender systems in the tourism industry by highlighting the role of deep learning technology in improving accuracy, but still faces the challenge of data scarcity for new destinations [7]. Meanwhile, research in Madura uses K-Means to cluster tourist attractions based on visitor characteristics, which helps in the management of tourist destinations more effectively [8].

Based on the study, it can be seen that there are similarities in themes related to tourism recommendations, but this research has novelty in the model used. The focus of this research is to develop the best tourism recommendation system in Yogyakarta City by integrating Multifactor Evaluation Process (MFEP) and K-Means Clustering. The integration of these two algorithms has never been applied before in the context of tourist destinations in Yogyakarta. MFEP is used to determine destination rankings based on criteria relevant to travelers' preferences, such as location, accessibility, amenities, cost, and uniqueness. Furthermore, the results of the ranking were analyzed using K-Means Clustering to group destinations into high, medium, and low potential categories based on strategic location parameters, number of attractions, and number of visitors [9]. Thus, this research is expected to produce an accurate recommendation system while being able to provide informative segmentation of tourism potential.

The urgency of this research lies in the need for a system that is able to overcome the complexity of destination selection, especially when consideration based on the potential of a particular area is needed [10]. With the existence of a recommendation system based on MFEP and K-Means Clustering integration, tourists can get fast, precise, and preferential guidance, as well as help tourism managers in optimizing promotion strategies and destination development in Yogyakarta City.

RESEARCH METHOD

2.2 Research Tools and Materials

The research tools used include a set of computers equipped with Rapid Miner and Matlab software for data processing, XAMPP Server for database management, Adobe Dreamweaver for system interface development, and domain and hosting services for online system implementation. The research material is in the form of data on tourist destinations in Yogyakarta City and data on the results of tourist questionnaires which contain factors that determine the best tourism recommendations and clustering.

2.2 Research location

This research was conducted at the Yogyakarta City Tourism Office located on Jl. Suroto No.11, Kotabaru, Gondokusuman District, Yogyakarta City, Special Region of Yogyakarta 55224. This location was chosen because it is the center for tourism information management in the Yogyakarta area, so it is relevant to obtain accurate and comprehensive data.

2.3 Research Data

21 The data used in this study consisted of primary data and secondary data. Primary data was obtained through direct interviews with the Yogyakarta City Tourism Office and the distribution of questionnaires to tourists in a number of leading destinations. This data includes information about tourist preferences and actual destination conditions. Meanwhile, 53 secondary data were collected from literature studies, official documentation, and scientific publications relevant to the research topic.

The main source of data comes from the Yogyakarta City Tourism Office through the cooperation of research partners. The primary data obtained provide a direct picture of the factors that influence the selection of tourist destinations, while the secondary data is used to strengthen the theoretical foundation, compare the results of the research, and provide a broader context to the findings obtained [11].

20 2.4 Data Collection Methods

Data collection is carried out through three main approaches. First, an in-depth interview with the tourism information center section at the Yogyakarta City Tourism Office to obtain data on tourist destinations, assessment criteria, and the weight of tourist preferences. Second, direct observation in the field by recording the conditions of the destination, potential areas, and the number of visitors to complete the data on the interview results. Third, a literature study was conducted by examining official literature, scientific journals, proceedings, and documents related to the tourism recommendation system, MFEP method, and K-Means Clustering method [12].

8 2.5 Multifactor Evaluation Process (MFEP)

The Multifactor Evaluation Process (MFEP) method is a multicriteria decision support technique that combines various important factors with weights that reflect their level of importance [13]. Each alternative is 56 assessed based on the specified criteria, then the scoring score is multiplied by the corresponding weight, and the results are summed to produce a total preference value. This method is widely applied to the recommendation system and also to selection such as in determining the eligibility of prospective recipients of small and medium business assistance [14].

A study presented in the Journal of Physics: Conference Series (2020) demonstrates the application of MFEP to choose the right learning model by providing a subjective and intuitive assessment of a number of factors, and then determining the best alternative based on the highest score [15]. In addition, the implementation of MFEP in the context of the selection of recipients of small and medium enterprise capital assistance

has also been proven to be able to simplify decision-making objectively and efficiently based on the criteria that have been set [16].
In this study, MFEP was used to evaluate and determine the order of the best tourist destinations in Yogyakarta City based on five main criteria, namely Location, Accessibility, Facilities, Cost, and Uniqueness. The weights and properties of each criterion are set as shown in Table 1.

The stages of MFEP implementation in this study are as follows:
Determination of Criteria and Weights
Establish the five evaluation criteria that have been mentioned, then determine the weight of each criterion based on its level of importance.
Scoring on Alternatives
Assign a score to each tourist destination for each criterion, using a predetermined assessment scale (e.g. scale 1-5 or 1-10).
Final Value Calculation
Calculate the final value of each tourist destination using the equation:
MFEP Score=i=1n(boboti*scorei)

(1)
Where:
boboti is the weight of criterion i
scorei is the score of tourist destinations in criterion iii
58 n is the number of criteria (in this study, n=5)
Alternative Ratings
Sorting tourist destinations based on final values from highest to lowest to produce a list of recommendations for the best tourist destinations.
The MFEP method was chosen because of its ability to produce an objective ranking by considering the relative influence of each criterion, so that the resulting recommendations are more relevant to the preferences of tourists.
6 2.6 K-Means Clustering
K-Means Clustering is an unsupervised learning algorithm that is used to group data into a number of groups (clusters) based on their similarity in characteristics. Each group is represented by a central point (centroid) that is updated iteratively until an optimal configuration is obtained. 6 The goal of this algorithm is to minimize the distance between 29 data in the same cluster and maximize the difference between clusters (minimum within-cluster variance and maximum between-cluster variance) 52 [17]. The K-Means work process begins by determining the desired number 35 of clusters (k), selecting the initial centroid, and then calculating the distance of each data to the centroid using a specific distance measure, such as Euclidean Distance. The data were grouped into clusters with the closest distances, then the position of the centroids was updated until there was no significant change in the grouping results [18].
3 In this study, K-Means was used to group tourist destinations in Yogyakarta City into three potential categories, namely high, medium, and low, with strategic location parameters, number of attractions, and number of visitors. The selection of this method is based on the simplicity of the process, computational efficiency, and its ability to handle large data effectively [19].
1 Determining the number of clusters (k) - in this study the k-value was set 3 to represent the high, medium, and low potential categories.
Determine the initial centroid - the initial central point is selected from the available tourist destination data.

29 Calculating the distance of each data to the centroid - the distance is calculated using the Euclidean formula:

45 d(x,y)=i=1n(xi-yi)2

(2)

Grouping data into nearby clusters - data is placed on the cluster with the shortest distance to the centroid.

Calculates new centroids - centroid positions are updated based on the average attribute values of all data in the cluster.

Repeat the process until it converges - the centroid distance calculation and update is repeated until no significant changes occur or the iteration limit is reached.

Obtaining the final result of clustering - the data is divided into three groups of potential tourist destinations.

2.7 Data Analysis

Data analysis was carried out through a series of stages starting from literature study, data collection, analysis of tourist preference factors, application of the MFEP method to determine destination rankings, application of K-Means Clustering to perform potential grouping, to system design and development [20]. System testing was conducted to evaluate feasibility, function, and accuracy, including
3 validity tests and silhouette score calculations to assess the quality of clustering [21] [22] [23].

2.8 Research Flow

This research begins with the preparation of the necessary tools and materials. The next stage is literature study to build a theoretical framework and understand the problems to be solved. Data collection was carried out through Focus Group Discussions (FGDs), interviews, observations, and literature studies [24]-[25].

The collected data is analyzed to identify factors that influence travelers' preferences. The MFEP method is then used to determine the ranking of tourist destinations based on the weight of the criteria,
13 while the K-Means Clustering method is applied to group the results of the ranking into high, medium, and low potential categories. The results of the analysis are implemented into PHP and MySQL-based systems. The final process is the testing of the system to ensure its performance, accuracy, and functionality.

RESULT AND DISCUSSION

3.1 System Implementation

The implementation of the system is carried out according to the results of the design that has been made. The user interface is designed to be simple and easy to use, with a clear division of functions on each page.

Main Page View

Displays the main navigation menu, a brief description of the system, and general information about the tourist destination. The appearance of the starting page of the application program as presented in figure 1.

Figure 1. Main Page View

MFEP Recommendation Page View
Displays a map of the location of tourist attractions that have been ranked using the MFEP algorithm. This Application Program is also equipped with the address of the location of the map of tourist recommendations as presented in figure 2.

Figure 2. MFEP Recommendation Page View

K-Means Recommendation Page View
Displays a map of the location of tourist attractions that have been ranked using the kmeans algorithm, as presented in figure 3.

Figure 3. Kmeans Recommendations Page Display

Login Page View
The user authentication page before accessing the admin page. On this page it is useful to enter the Application program as presented in figure 4.

Figure 4. Login Page View

Criteria Input Page
On the input page, this criterion is used to enter the value of the criteria into the application program as an attribute in the algorithm calculation of each. The display of the criteria attribute setting is as presented in figure 5.

Figure 5. Criteria Page View

Travel Data Input Page
On the Tourism Data Input page, it is used to enter or update information on tourist destinations. The results are as presented in figure 6.

Figure 6. Tour Page View

Assessment Data Input Page
On the input page, this assessment data is used to provide the value of each tourism alternative and its attributes. The process of adding attribute values can only be done after entering data and tourism information. the appearance is as in figure 7.

Figure 7. Rating Page View

MFEP Calculation Page
42 Displays the process and results of the calculation of preference values using the MFEP method. The display of the calculation process of the MFEP Algorithm as presented in figure 8.

Type Test
Test Model
Skenario
Expected results
Test Result
Normal Test
Login
Enter the username password correctly and completely
Log in to the dashboard page
Normal
False Test
Login
Enter the wrong username password
Error notification appears
Normal
Normal Test
Travel data input
Enter complete tourist attraction data
Data successfully saved and Return to the travel page
Normal
False Test
Travel data input
Enter incomplete tourist attraction data
Error notification appears
Normal
Normal Test
Criterion data input
Enter the complete criteria data
Data is saved and returns to the criteria page
Normal
False Test
Criterion data input
Enter the complete criteria data
Error notification appears
Normal

Figure 8. Kmeans Calculation Page View

K-Means Calculation Page

After the MFEP Algorithm calculation process is completed, then the
13 results become one of the calculation attributes in the K-Menas
Clustering Algorithm Integration. The appearance of the calculation
59 process of the K-Means Clustering Algorithm is as presented in figure 9.

Figure 9. Kmeans Calculation Page View

3.2 System Testing

48 Testing is carried out to ensure that the system has worked as needed.

Functionality Test

Testing is carried out using the black box testing method to check each system function, such as data input, calculation processes, and display of recommendation results. recapitulation of functional testing as presented in table 2.

Table 2. Summary of Functionality Testing

Validity Testing

In the Validity Test, a comparison was made between the results of manual calculations and the results of the Application program. In manual calculations starting from the calculation of the MFEP algorithm as follows:

MFEP Calculation Stages

The MFEP calculation stages are as follows:

a. Criteria and Weighting

This study uses five basic criteria in calculating the MFEP Algorithm, as presented in table 3.

Table 3. Weight and Criteria

Criterion
Weight
Quality
Location
0.25
Benefit
Accessibility
0.20

Benefit
Facilities
0.20
Benefit
Cost
0.15
Cost
Uniqueness
0.20
Benefit

b. Tourism Data Value
After the value of the criterion attributes is determined for the weight value, the next stage is to provide the value of each tourism alternative, as presented in table 4.

Table 4. Tourism Data Values
Tour
C1
C2
C3
C4
C5
Candi Prambanan
5
5
5
2
5
Malioboro
5
5
5
5
4
Keraton Yogyakarta
5
5
4
3
5
Taman Sari
5
4
4
3
4
Pantai Parangtritis
4
4
4
4
4
Hutan Pinus Mangunan

3
3
3
4
4
Gunung Merapi (Bunker Kaliadem)
3
3
3
4
5
Goa Pindul
3
3
4
2
5
Tebing Breksi
4
4
4
4
4
Bukit Bintang
4
4
3
5
4

Normalization (Min and Max)
The min and max values in normalization are used as shown in table 5.

Table 5. Min and Max Values

C1
C2
C3
C4
C5
MIN
3
3
3
2
4
MAX
5
5
5
5
5

The following is the calculation of normalization of Min and Max for Prambanan Temple

37 C1 = 5/5 = 1 C3 = 5/5 = 1 C5 = 5/5 = 1
C2 = 5/5 = 1 C4 = 2/2 = 2

The normalization results from the calculation of tourism data are as presented in table 6.

Table 6. Results of Normalization of Tourism Data
Tour
38 C1
C2
C3
C4
C5
Candi Prambanan
1
1
1
1
1
Malioboro
1
1
1
0.4
0.8
Keraton Yogyakarta
1
1
0.8
0.67
1
Taman Sari
1
0.8
0.8
0.67
0.8
Pantai Parangtritis
0.8
0.8
0.8
0.5
0.8
Hutan Pinus Mangunan
0.6
0.6
0.6

0.5
0.8
Gunung Merapi (Bunker Kaliadem)
0.6
0.6
0.6
0.5
1
Goa Pindul
0.6
0.6
0.8
1
1
Tebing Breksi
0.8
0.8
0.8
0.5
0.8
Bukit Bintang
0.8
0.8
0.6
0.4
0.8

d. MFEP Score Value
The following is an example of calculating the score of MFEP Prambanan Temple.

Candi Prambanan = (1*0.25)+(1*0.20)+(1*0.20)+(1*0.15)+(1*0.20)=1

Bukit Bintan = (0.8*0.25)+(0.8*0.20)+(0.6*0.20)+(0.4*0.15)+(0.8*0.20)=0.7
47 The results of the MFEP score are as presented in table 6.
Table 7. MFEP Score Results
Tour

MFEP
Candi Prambanan

1
Malioboro

0.87
Keraton Yogyakarta

0.91
Taman Sari

0.83
Pantai Parangtritis

0.755

Hutan Pinus Mangunan

0.625
Gunung Merapi (Bunker Kaliadem)

0.665
Goa Pindul

0.78
Tebing Breksi

0.755
Bukit Bintang

0.7

Stages of K-Means Calculation
32 The calculation stages of the Kmeans algorithm are as follows:
51 At the initial stage in the calculation of the K-Means Clustering Algorithm, the initial centroid value was determined which was useful as a basis for the clustering process. The Initial Centroid values are randomly generated in this case the researcher randomly takes the values from the initial centroids as presented in table 8.

Table 8. Early Centroid Values
TOUR
C1
C2
C3
C4
C5
MFEP Score
Candi Prambanan
5
5
5
2
5
1
Taman Sari
5
4
4
3
4
0.83
Pantai Parangtritis
4
4
4
4
4
0.755

b. Counting iterations 1

Iteration 1 is calculated based on the centroid value in table 9 and the value of tourism data that can be seen in table 10. The following is an example of the calculation formula for iteration 1 facing malioboro:

Table 9. Iteration Calculation Results 1

Wisata	Cluster 1	Cluster 2	Cluster 3	Cluster Position	Closest Distance
Candi Prambanan	0.0000	2.007	2.839	1	0.000
Malioboro	3.1649	2.450	2.003	3	2.003
Keraton Yogyakarta	1.4171	1.416	2.006	2	1.416
Taman Sari	2.0072	0.000	1.416	2	0.000
Pantai Parangtritis	2.8390	1.416	0.000	3	0.000
Hutan Pinus Mangunan	4.1401	2.654	1.737	3	1.737
Gunung Merapi (Bunker Kaliadem)	4.0140				

2.833
2.002
3
2.002
Goa Pindul
3.0081
2.646
2.646
3
2.646
Tebing Breksi
2.8390
1.416
0.000
3
0.000
Bukit Bintang
4.0112
2.453
1.415
3
1.415

c. Defining a new centroid
From the results of the calculation of Iteration 1, so that with the centroid formula, a new centroid value is obtained as presented in table 10.

Table 10. New Centroid Values
Tour
C1
C2
C3
C4
C5
MFEP Score
Candi Prambanan
5
5
5
2
5
1
Taman Sari
5
4.5
4
3
4.5
0.87
Pantai Parangtritis
3.7143
3.7143
3.7143

4.00
4.2857
0.7357

d. Calculating Iteration 2
Iteration 2 is calculated based on the new centroid values in table 11 and the tourism data values shown in Table 5. The results of iteration 2
55 can be seen in Table 11.

Table 11. Calculation Results of Iteration 2
Wisata
Cluster 1
Cluster 2
Cluster 3
Cluster Position
Closest Distance
Candi Prambanan
0.000
1.586
3.089
1
0.000
Malioboro
3.165
2.345
2.461
2
2.345
Keraton Yogyakarta
1.417
0.708
2.220
2
0.708
Taman Sari
2.007
0.708
1.705
2
0.708
Pantai Parangtritis
2.839
1.585
0.572
3
0.572
Hutan Pinus Mangunan
4.140
2.926
1.275
3
1.275
Gunung Merapi (Bunker Kaliadem)
4.014

2.923
1.430
3
1.430
Goa Pindul
3.008
2.740
2.369
3
2.369
Tebing Breksi
2.839
1.585
0.572
3
0.572
Bukit Bintang
4.011
2.555
1.325
3
1.325

e. Determining the New Centroid
Based on the calculation process from iteration 2, a new centroid was obtained as presented in table 12.

Table 12. New Centroid Values
Tour
C1
C2
C3
C4
C5
MFEP Score
Candi Prambanan
5
5
5
2
5
1
Taman Sari
5
4.666667
4.3333333
3.6667
4.33333
0.87

Pantai Parangtritis
3.5
3.5
3.5
3.8333
4.33333
0.7133333

f. Counting Iterations 3
After getting a new centroid, it continues to look for the 3rd iteration.
25 The results can be seen in table 13.

Table 13. Calculation Results of Iteration 3
Tour
Cluster 1
Cluster 2
Cluster 3
Cluster Position
Closest Distance
Candi Prambanan
0.000
1.948
3.262
1
0.000
Malioboro
3.165
1.563
2.872
2
1.563
Keraton Yogyakarta
1.417
1.055
2.435
2
1.055
Taman Sari
2.007
1.055
1.889
2
1.055
Pantai Parangtritis
2.839
1.338
0.944
3
0.944
Hutan Pinus Mangunan
4.140
2.973
0.947
3

0.947
Gunung Merapi (Bunker Kaliadem)
4.014
3.025
1.107
3
1.107
Goa Pindul
3.008
3.181
2.135
3
2.135
Tebing Breksi
2.839
1.338
0.944
3
0.944
Bukit Bintang
4.011
2.267
1.491
3
1.491

g. Determining the New Centroid
After counting the 3rd iteration, proceed to count the new centroids, as for the results of the new centroids can be seen in table 14.

Table 14. New Centroid Values
Wisata
C1
C2
C3
C4
C5
MFEP Score
Candi Prambanan
5
5
5
2
5
1
Taman Sari
5
4.666667
4.3333333
3.6667
4.33333
0.87
Pantai Parangtritis
3.5

3.5
3.5
3.8333
4.33333
0.71333

After calculating the new centroid, then compare the new centroid of table 14 with the previous centroid of table 12. If it is the same then the iteration will stop. If it is different, it is continued by calculating the next iteration.

Silhouette Coefficient Testing
13 It was carried out to measure the quality of clustering produced by the K-Means method. The Silhouette Coefficient value is used to assess whether the cluster division is optimal. The test results can be seen in table 15.

Table 15. Silhouette Coefficient Test Results
No
41 Cluster 1
Cluster 2
Cluster 3
A(I)
b(i)
s(i)
1
0
1.947993269
3.261553822
1.55834641
1.736515697
0.821830713
2
3.164948657
1.56347192
2.871718417
2.657209822
2.533379665
1.123830157
3
1.417074451
1.054851227
2.434659456
1.44843233
1.635528378
0.812903952
4
2.007211997
1.054851227
1.889223827
1.473465875
1.650429017
0.823036858
5

2.839018316
1.338283519
0.943729304
1.665362556
1.70701038
0.958352176
6
4.14012379
2.972844224
0.946938048
2.780145193
2.686635354
1.093509839
7
4.014003612
3.025415031
1.106597638
2.788999479
2.715338761
1.073660719
8
3.008055851
3.181070749
2.13541565
2.705859564
2.774847417
0.931012148
9
2.839018316
1.338283519
0.943729304
1.665362556
1.70701038
0.958352176
10
0
1.947993269
3.261553822
1.55834641
1.736515697
0.821830713

SC average value

0.955165415

Based on table 15 above, the average value of the Silhouette Coefficient is 0.9551, this means that the quality of the dataset structure in this clustering is very strong because it is close to a score of 1.

CONCLUSION

This research has produced a recommendation system for the best tourist destinations in Yogyakarta City through the integration of the Multifactor Evaluation Process (MFEP) and K-Means Clustering methods. The MFEP method is used to rank destinations based on five main criteria, namely location, accessibility, facilities, cost, and uniqueness, with weights determined based on tourist preferences. This process produces objective and measurable preference values. The obtained preference values are then processed using the K-Means Clustering method to group tourist destinations into three potential categories, namely high, medium, and low. The grouping is carried out by considering additional parameters such as strategic location, number of attractions, and number of visitors. The algorithm iteration process stops at the third iteration with a stable cluster division. Testing the quality of clustering using the Silhouette Coefficient method produces an average value of 0.9552, which indicates that the quality of the clustering is in the very good category, with a high level of uniformity within the cluster and clear differences between clusters. System functionality testing using the black box method also demonstrated that all features, from data input and calculation to visualization of recommendation results, met user needs. Overall, the integration of the MFEP and K-Means methods within this system has proven to be capable of providing fast, accurate, and informative destination recommendations, thus benefiting tourists in determining their destinations and tourism managers in formulating promotional and development strategies.

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