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Research Paper

A Combined Approach of AHP and TOPSIS for Fault-Tolerance

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Abstract— Fault tolerance has become more crucial because almost every corporate sector uses internet services to transmit critical information over the internet. The relationship between fault categories and their characteristics is convoluted as a result of the fuzziness of faults. Therefore, a difficult aspect of diagnosis using the conventional method is identifying the defect type. Over the past two decades, several ways have been developed to address the high dependability of systems, however, the bulk of these methodologies are either theoretical or unworkable. Examining the validity and plausibility of the model using AHP & TOPSIS was the review's driving force. Here, we used the Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for fault-tolerance, two specific multi-criteria decision-making techniques. Here we will see the combined results of AHP and the TOPSIS for fault tolerance.

Keywords—AHP methods, TOPSIS, Fault-tolerance, SOA.

I. Introduction

A blunder is a human activity that creates an erroneous outcome, while, disappointment is the powerlessness of a framework or a part to achieve its necessary capacities inside determined execution prerequisites. Assuming an issue or fault isn't handled as expected, it builds the framework's disappointment rate. Little changes in nuclear help might prompt the general disappointment of the composite assistance. Shortcoming investigation is the interaction to identify and analyze the issue in the specialized frameworks. A dynamic fault tolerance replication strategy is designed and proposed to a framework. Experiments are conducted to illustrate the advantage of the proposed framework as well as the dynamic fault tolerance replication strategy. Comparison of the effectiveness of the proposed framework and various traditional fault tolerance strategies are also used in complete research [1]. Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analysed independently. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well or poorly understood—anything at all that applies to the decision at hand [2]. A legitimate understanding of programming adaptation to internal failure requires the idea of the faults and their results in the framework. Moreover, an appropriate disappointment examination of services can assist with planning a superior issue fault tolerating framework [3-5]. Fault analysis for the most part covers kinds of faults, how faults act, the idea of faults, and so on In the SOA-based framework, programming services are communicating with one another to give and get functionalities [6-10].

II. Techniques & Tools (TOPSIS, AHP)

A. TOPSIS

It is investigated to extend the multi-quality decision-production method TOPSIS (a strategy for request execution by closeness to ideal arrangement) to a collective choice environment. TOPSIS is a practical and beneficial method for positioning and selecting uncertain choices based on distances. We provide a few options for the tasks, such as standardization, distance measurements, and mean administrators, at each of the relevant TOPSIS steps in order to gain a comprehensive understanding of the strategies employed. Furthermore, the TOPSIS system contains an accumulation of the preferences of various decision-makers. To address the issue of positioning and contrasting calculations, we suggest an elective novel strategy based on the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). In developmental calculation, calculations are run several times, and then a measurement is made to determine the mean qualities and standard deviations. It is incredibly common to deal with such issues through factual tests in order to analyse a calculation's display. Positioning calculations, such as the Friedman test, which only consider the mean value and not the standard deviation of the results, may also introduce limitations. Since the TOPSIS cannot handle this information in a straightforward manner, we develop a calculation positioning method called A-TOPSIS that is dependent on the TOPSIS. In this case, the options are based on calculations, and the benchmarks are the standards. A decision matrix conveys the evaluation of the measure-related options in terms of mean characteristics and standard deviations.

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B. AHP

In the theory of decision making, the analytic hierarchy process (AHP), also an analytical hierarchy process, is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s; AHP has particular application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education. Rather than prescribing a "correct" decision, the AHP helps decision-makers find one that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions [2].

III. MODEL FOR FAULT-TOLERANT BEHAVIOR

Here we have implemented the TOPSIS model for the analysis of Fault-tolerance which indeed is the mathematical part of this research, with the help of the AHP theory we have determined the right qualitative criteria for the various observations. The results by mathematical calculations derived from TOPSIS in tabular and graphical form are analyzed and the final evaluations are done with AHP so we applied both the mathematical and the theoretical approaches in this. Below is the step-by-step work of the research:

A. Step 1. Construct the decision matrix and determine the weight of the criteria:

In this segment, we have measured the heaviness of fault resistance boundaries to show that the TOPSIS assessment results have a high connection with the planned TOPSIS assessment results (table 1), yet they vary fundamentally according to the positioning viewpoint (table 1). The positioning contrast will be significantly more prominent for explicit boundaries. The assessment technique can't be essentially picked for a higher connection coefficient. It ought to be founded on the reason for the assessment and the guideline of the assessment technique. All things considered, the decision of assessment strategies will essentially affect the outcomes.

TABLE I. Decision Matrix and Weight Criteria

Weightage		Low	Mid	High
0.4730329	**Error Confinement and Detection**	1.2	2.3	5.1
0.2593492	**Error Diagnosis and Reconfiguration**	1.4	2.5	5.3
0.145644	**Recovery and Restart**	1.6	2.7	5.5
0.079525	**Repair**	1.8	2.9	5.7
0.042449	**Reintegration**	2	3.1	5.9

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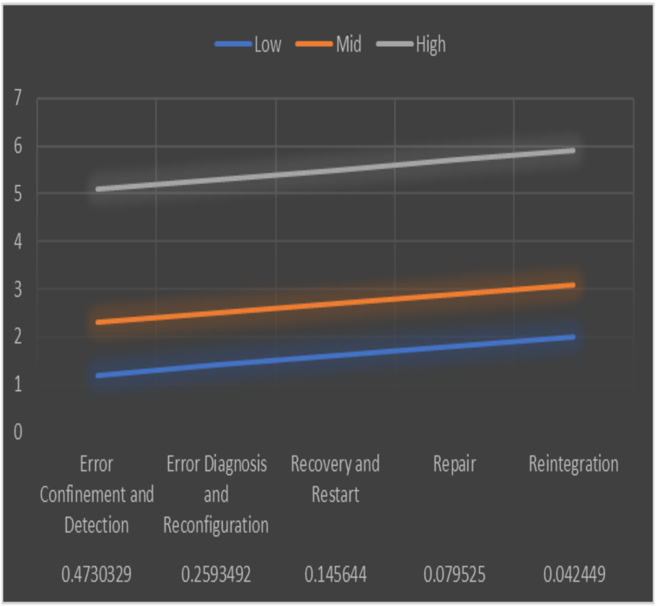

Fig. 1. Graphical-based Evaluation Decision Matrix and weight Criteria Significance

B. Step 2. Calculate the normalized decision matrix:

This progression changes different attribute(.) dimensions into non-dimensional properties which permit correlations across criteria (Low, Mid, and High). Since different rules are typically estimated in different units, the scores in the assessment matrix TABLE I have to be transformed to a normalized scale. The normalization of qualities can be done by one of the few known normalized equations (Eq 1 and 2). The absolute most as often as possible utilized techniques for working out the standardized worth nij are the accompanying

$$nij = \frac{xij}{\sqrt{\sum_{i=1}^{m} xij}} \tag{1}$$

$$nij = \frac{xij}{\max xij} \tag{2}$$

C. Step 3. Calculate the weighted normalized decision matrix:

The weighted normalized value Vij is calculated in the following way as shown in TABLE II.

$$V_{ij} = w_j \, n_{ij} \text{ for } i = 1, \ldots, m;\ j = 1, \ldots, n. \tag{3}$$

where w_j is the weight of the j-th criterion, $\sum_{j=1}^{n} w_j = 1$

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TABLE II. Calculate the Normalized Matrix

	Low	Mid	High
Error Confinement and Detection	0.209721	0.401965	0.891314
Error Diagnosis and Reconfiguration	0.232367	0.414941	0.879676
Recovery and Restart	0.252667	0.426375	0.868541
Repair	0.27093	0.436498	0.857944
Reintegration	0.28742	0.445502	0.84789

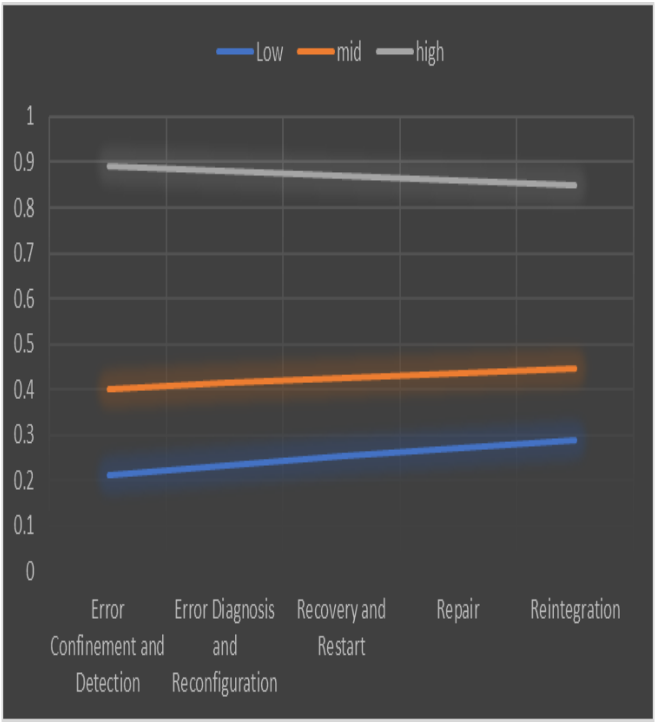

Fig. 2. Graphical-based Evaluation Calculate Normalized Matrix Significance

D. Step 4. Determine the positive ideal and negative ideal solutions:

Distinguish the positive ideal alternative (outrageous execution on every basis) and recognize the negative ideal alternative (turn around outrageous execution on every rule). The ideal positive solution is the solution that boosts the advantage measures and limits the expense rules while the negative ideal solution augments the expense standards and limits the advantage models. Positive ideal solution Si+ has the structure, shown in TABLE III.

$$v_i^+ = ((v_1)^+, (v_2)^+, (v_2)^+ \ldots\ldots \ldots(v_n)^+) = \{(\max_i (v_{ij} \mid j \in I)), (\min_i (v_{ij} \mid j \in J)) \quad (4)$$

$$v_i^- = ((v_1)^-, (v_2)^-, (v_2)^- \ldots\ldots \ldots(v_n)^-) = \{(\min_i (v_{ij} \mid j \in I)), (\max_i (v_{ij} \mid j \in J))\} \quad (5)$$

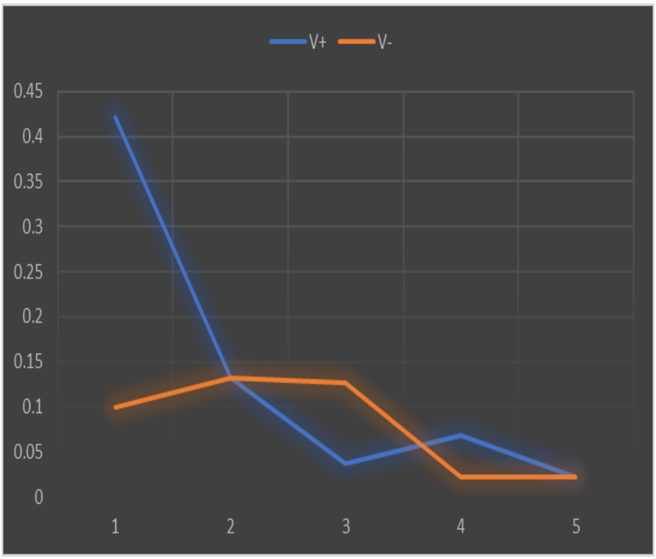

Fig. 3. Graphical-based Evaluation V^+ and V^- Significance

TABLE III. Calculate the Ideal Best and Ideal Worst Value

V^+	V^-
0.421621	0.099205
0.132007	0.132007
0.036799	0.021546
0.068228	0.21546
0.022368	0.022368

E. Step 5. Calculate the separation measures between the positive and negative ideal solution:

A variety of distance measures can be used in the TOPSIS approach. TABLE IV shows the separation of each alternative from the positive ideal solution, below is the formula for positive separation:

$$s_i^+ = \left(\sum_{j=1}^{n}\left(s_{ij} - s_j^+\right)^p\right)^{1/p}, i = 1, 2, \ldots, m \qquad (6)$$

The separation of each alternative from the negative ideal solution is given as

$$s_i^- = \left(\sum_{j=1}^{n}\left(s_{ij} - s_j^-\right)^p\right)^{1/p}, i = 1, 2, \ldots, m \qquad (7)$$

Where p ≥1. For p= 2 we have the most used traditional n-dimensional Euclidean metric shown in TABLE IV.

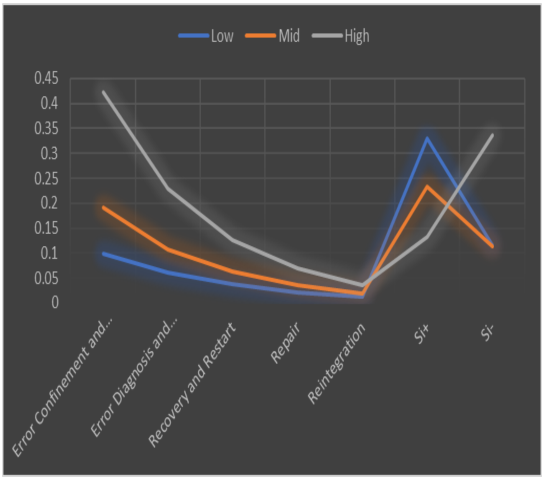

Fig. 4. Graphical-based Evaluation Euclidean Matrix Significance

	Low	Mid	High
Error Confinement and Detection	0.099205	0.190143	0.421621
Error Diagnosis and Reconfiguration	0.060264	0.107615	0.228143
Recovery and Restart	0.036799	0.062099	0.126498
Repair	0.021546	0.034712	0.068228
Reintegration	0.012201	0.018911	0.035992
Si^+	0.330302	0.234131	0.131484
Si^-	0.11486	0.11407	0.336443

TABLE IV. Calculate the Normalized Matrix

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F. Step 6. Rank the preference order or select the alternative closest to 1

The descending order of the value of Ri can now be used to rate a collection of options. TABLE V is shown.

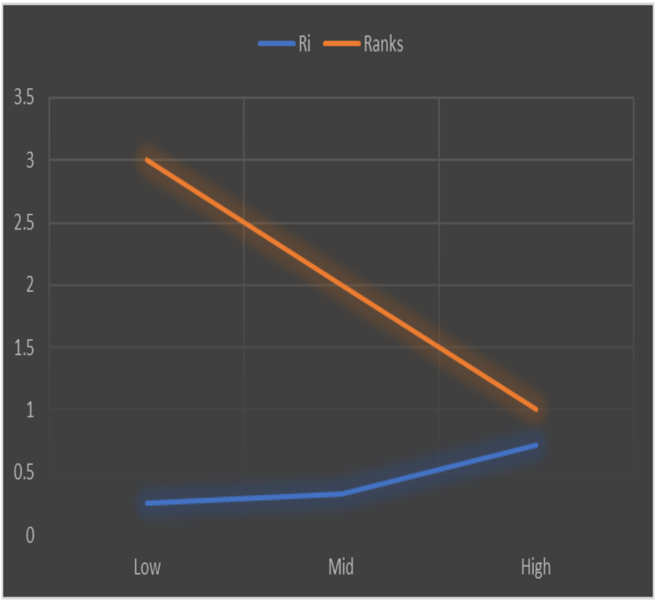

Fig. 5. Graphical-based Evaluation Ri and Rank Evaluation Significance

Alternatives	Ri	Ranks
Low	0.258019	3
Mid	0.327598	2
High	0.719008	1

TABLE V. Ri and Rank

IV. CONCLUSION

In the present work methodology of the AHP has been implemented to solve the problem of best model selection. The present work proposes an AHP approach and validates to approach using TOPSIS for the selection of methods. The significant benefits of this examination are that it very well may be utilized for both subjective and quantitative models. In this portion, we have a comparison utilized in this work that diminishes the reliance of the model on fault factors. In above table 5 based on the comparison of alternatives (low, mid, and high) the method applied can be seen that high 1 is preferred with a value (0.719008).

Since to has the highest weight of (0.719008) among the three alternatives. Mid 2 is the second choice (0.327598) and Low is the last choice (0.258019). The outcome demonstrates that the model has the ability to be adaptable and apply to various kinds of decreasing to blame variables. The last need weight of every option at the last level of the pecking order will prompt a suggested most ideal choice. It tends to be reasoned that the model is awesome and each factor is best in the decrease of issue factors.

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