Application of Grey Relation Analysis Theory to Choose High Reliability of the Network Node

Xuelong Wang
School of computer science, Xi’an Shiyou University, Shaanxi,710065, China
Email: wxl3029@126.com

Abstract. The research on resource sharing network safety problem mainly refers to the concept of trust management in distributed systems, and uses trust management method to realize secure access to shared services and data, etc. This paper describes the method of the grey correlation analysis theory that is used to calculate a reliable resource node trust value, and applies it in the access nodes feedback recommendation algorithm to adjust the recommended resource node trust value. The simulation results show that the method can obviously improve the success rate of resource searching.

1. Introduction
Grey relational analysis is a method of calculating grey relational degree and determining the contribution measure of the main behavior of the system or the influence degree between the system factors[1]. The measure of correlation between two factors or between two systems is called grey correlation degree. The change trend, size and speed of grey correlation degree reflect the relative change of factors in the process of system development. In the process of development, when the relative changes of two factors or systems have basically the same trend of change, the two factors have a greater degree of grey correlation; otherwise, they have a smaller degree of grey correlation [2]. In this paper, many factors affecting the application of resource sharing are related to the development and change of the system. Fifteen variables are used to describe the characteristics of the system and to solve the change law of the system. The local trust degree of the node is calculated by the comprehensive evaluation method of grey correlation analysis. The trust value of the node is dynamically adjusted according to the similarity of interest of the node. The trust list of the target node is maintained and reliable shared resource trusted nodes are obtained.

2. The calculating process of grey relation analysis application
According to relevant references [3][4][5], grey relational analysis generally includes the following calculation and steps:

Step 1: Determine the evaluated data and convert the original data. First, we need to eliminate the different dimensions of the original data and convert them into data that can be compared with each other.

Step 2: Determine the data sequence for reference. The reference sequence is selected according to the specific application.

Step 3: Calculate the absolute difference and the minimum and maximum values of the corresponding elements between the data sequence and the reference data sequence of each evaluated object one by one, and then calculate the correlation coefficients of the two sequences at the
corresponding element positions.

Step 4: Calculate the grey correlation degree. The arithmetic average of the correlation coefficient between the data index of each location and the corresponding elements of the reference sequence is calculated as the grey correlation degree of the two sequences to reflect the relationship between the evaluation objects and the reference sequence.

Step 5: Arrange all grey correlation degrees in the corresponding order from large to small or from small to large.

Step 6: Analyse the conclusions. If the selection of reference sequence is the optimal value of each index, the sequence with large correlation degree is better than the sequence with small correlation degree. Otherwise, the conclusion is contrary.

3. Based on the grey relation theory calculation node trust value

3.1 Application modeling

This paper takes the document resources in resources as an example to illustrate the calculation of node trust value. The main documents include: design drawings, contracts, specifications and standards, specifications and other resources stored in the form of files. Grey relational analysis is used to evaluate the trust value of the transaction nodes in the network.

Let X is the system factor set of networked resource sharing system, also called X as grey correlation factor set. Among them, Xi∈ X (i = 1,2,... n) is a systematic factor. Its observation data on the kth measurement index is Xi (k), if K is the index number, k = 1,2,... M is called Xi= (Xi (1), Xi (2),..., Xi (m)) is a sequence of behavioral indicators of factor Xi, representing the state abstraction of a system. This paper assumes that the value of m is 15. Indicators are defined as: Xi (1) denotes the number of shared resource files. Xi (2) denotes the number of DXF files shared by nodes. Xi (3) denotes the number of WMF files shared on the node. Xi (4) denotes the number of DWG files shared by nodes. Xi (5) denotes the number of PDF files shared by node. Xi (6) denotes the number of Word files shared by nodes. Xi (7) denotes the size of shared files shared by nodes. Xi (8) denotes the number of resource files accessed by a node. Xi (9) denotes the number of the resource files uploaded by the node. Xi (10) represents the size of the resource file uploaded by the node. Xi (11) denotes the number of resource files downloaded by the node. Xi (12) denotes the size of the resource file downloaded by the node. Xi (13) represents the online time of the node. Xi (14) represents the upload bandwidth of the node. Xi (15) represents the download bandwidth of the node.

3.2 The calculation steps

The calculation steps are as follows:

Step 1: Determine the evaluation index system according to the evaluation purpose, and collect the evaluation data.

Step 2: Dimensionless pretreatment of the index data is carried out to obtain the initial values of each evaluation sequence.

Because the numbers of files, file size, online time, and bandwidth of these data have different dimensions, in order to make these data comparable, dimensionless transformation of data is needed. The commonly used methods are mean value method, initial value method, normalization method, interval value method and maximum range method. In this paper, the normalization method is used to pre-process the index data in various situations without dimension. The Normalization method is:

\[
x'_i(k) = \frac{x_i(k)}{x_0}, \quad x_0 \text{ represents a real number greater than zero, } \quad i = 1,2, \ldots, n; \quad k = 1,2, \ldots, m
\]

The dimensionless data sequence can be expressed as the set of vectors X= (X1.X2,... Xn), each Xi contains M indicators. The matrix is expressed as:
Step 3: Determine the reference data sequence.
Reference data sequence can select a relatively ideal data sequence. Usually, the worst or best values of each index constitute a reference data column, and other reference values can be selected according to the evaluation items. Notes:

\[
X_0 = (x_{0\,1}, x_{0\,2}, \ldots, x_{0\,m})
\]  

(3)

Step 4: Calculate the distance \(\Delta_i(k)\) between the data sequence and the reference sequence at the corresponding points to form the difference sequence \(\Delta_i\). Notes:

\[
\Delta_i(k) = |x'_i(k) - x'_i(k)|
\]

(4)

\[
\Delta_i = (\Delta_i(1), \Delta_i(2), \ldots, \Delta_i(m)), \quad i = 1, 2, \ldots, m
\]

(5)

Step 5: Find the maximum difference and minimum difference among all the difference sequences obtained. Notes:

\[
M = \max_{i=1}^{n} \max_{k=1}^{m} \Delta_i(k), \quad m = \min_{i=1}^{n} \min_{k=1}^{m} \Delta_i(k)
\]

(6)

Step 6: Calculate the correlation number of two or two data sequences.
The correlation coefficients of each comparison sequence and reference sequence on the corresponding elements are calculated respectively. Notes:

\[
\gamma_{0i}(k) = \frac{m + \xi \cdot M}{\Delta_i(k) + \xi \cdot M}, \quad \xi \in (0, 1), \quad k = 1, 2, \ldots, n; \quad i = 1, 2, \ldots, m
\]

(7)

Among them, \(\gamma_{0i}(k)\) represents the grey correlation coefficients of two sequences at K element.
In the formula, \(\xi\) is the resolution coefficient, \(\xi \in (0, 1)\). \(\xi\) usually takes a value of 0.5. The smaller \(\xi\) is, the greater the difference between correlation coefficients is, and the stronger the discrimination ability is. If \(\{x_{0\,i}(k)\}\) is the worst value data, the bigger the correlation coefficient \(\gamma_{0i}(k)\) is, the worse the evaluated data is; when \(\{x_{0\,i}(k)\}\) is the best value data, the bigger the correlation coefficient \(\gamma_{0i}(k)\) is, the better the evaluated data is.

Step 7: Calculate the correlation degree.
The grey correlation degree is obtained by calculating the arithmetic average of the correlation coefficients between the indexes of each comparison sequence and the corresponding elements of the reference sequence. This value indicates the degree of association between the reference sequence and the evaluation objects. Notes:

\[
\gamma_{0i} = \frac{1}{m} \sum_{k=1}^{m} \gamma_{0i}(k)
\]

(8)

When each index data has different weights in the comprehensive evaluation, it is necessary to consider the weight coefficient of the index to get the weighted average value in solving the correlation degree.
\[ \gamma_{0i} = \frac{1}{m} \sum_{k=1}^{m} w_k \cdot \gamma_{0i}(k) \]

Finally, the correlation degree between the comparison sequence and the reference sequence is sorted from large to small, and the larger the correlation degree, the more consistent the change situation between the comparison sequence and the reference sequence is, thus the comprehensive evaluation conclusion of each node of the system is obtained.

4. The experimental results and analysis

4.1 The simulation environment

The simulation environment is built on a PC with Intel Core 2 Quad 2.83 GHz CPU 4 GB memory. The system consists of 1000 network nodes, each node initiates five resource query requests per minute, and each request has a random resource type and size.

The simulation time is discretely divided into several simulation cycles, in which: (1) the initial value remains unchanged. (2) Random selection of a certain proportion of nodes in the network to initiate queries to other nodes in the network. This value is an adjustable parameter in the simulation experiment. In each current cycle, the number of requesting nodes can be set to 200, 300, 400,... 800, and each node issues five query requests. (3) At the end of the interaction, the trust value of each node is calculated by gray correlation theory. According to the calculation results, trusted nodes larger than the threshold are selected for interaction. The current threshold is set to 1.1 times the average gray value, and remains unchanged. (4) According to the evaluation of each round-robin interaction, the trust level and the corresponding list value of the node are adjusted.

In order to avoid the phenomenon of mutual elevation or depreciation in the evaluation between nodes, the highest score and lowest score in the evaluation of nodes are removed in simulation, and then the average value of the evaluation of other nodes is taken as the trust value of nodes, thus improving the accuracy of evaluation.

4.2 The results of simulation analysis

Assuming that there are no malicious nodes in the system, the initial value of the cycle remains unchanged. Each cycle lasts 10 minutes, and 1000 queries are randomly initiated in each cycle. When the cycle time increases, the simulation results are shown in Figure 1. In the initial 10 minutes of simulation, because the system nodes participate in fewer transactions and have no historical transaction records, the success rate of queries in the two cases before and after using the trust mechanism in this paper is similar. With the increase of time, the query success rate of the two systems has changed significantly. The query success rate of the no-Gray is about 33%, but the query success rate of the Gray is much higher than that of the No-Gray.

![Fig.1 The Ideal Experimental Results of The Two Methods](image1)

![Fig.2 The Comparison of The Two Query Success Rate](image2)

Figure 2 shows the trend of query success rate when the initial value of each cycle is the same and
the number of queries is constantly changing. At the beginning of the simulation, the number of queries per cycle increases by 1000, and at the end of the simulation, the number of queries per cycle increases by 500. The success rate of using this trust mechanism (Gray) increased significantly, while the success rate of not using the trust mechanism (No-Gray) remained basically balanced. After the fiftieth minute of system transaction and 18000 query requests, the query success rate of grey analysis theory tends to be stable. Because the initial values of the experiments in Fig. 1 and Fig. 2 are different, the results of the two experiments are slightly different. This experiment shows that the query success rate using the mechanism is significantly higher than that of without using the mechanism.

5. Conclusions
According to the actual requirement of virtual enterprise resource information sharing system, this paper describes a method to find reliable resources based on grey relational analysis. This method analyses and mines the dynamic changes of historical score data, establishes and maintains the trust between users, and uses the feedback of users to adjust the change of trust value of nodes, which accords with the characteristics of resource sharing. The experimental results show that before and after using this method, the query accuracy has changed significantly, and the query accuracy has improved significantly, and the query success rate has increased significantly with the increase of query times.

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