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Abstract: After researching various factors that influence the management and decisions on risk management of virtual organization, CBR based risk management for virtual organization is proposed in this paper. Relevant theories of fuzzy mathematics are utilized in the process of modifying the corresponding similar cases. Correct application of the new method is demonstrated substantially through instance simulation.

Keywords: Virtual Organization Management, risk man agement, case-based reasoning.

I. Introduction

Virtual Organization emerges recently as a new organization mode of enterprises. This mode has the properties of forming an interim economy of unified command of all enterprises of new product. It helps the enterprises to catch market opportunity and respond rapidly to certain market demand. Simultaneously, studies on strategies of risk management of virtual organization become popular. Successful virtual organization depends a lot on mutual cooperation and communication among enterprises of each partner, which increases greatly the number of factors affecting the risk management of enterprises. Of course, potential risk factors step up quickly as the institutional framework of the enterprises grows and the organization of virtual organizations becomes more complicated. The traditional risk management that works on the basis of regular procedures cannot cope with the new situation. Now, the new method Case-Based Reasoning (CBR) has evaded the bottleneck and solves the problem directly by making use of all existing case experiences for references. It offers an innovative direction in administrative decision of risk management.

II. Problem Description

In order to perform the enterprise's risk management harmoniously, scientific procedures are employed. The complete successive courses of risk management are risk identification, risk assessment, risk evaluation, corresponding measure and effective risk control based on the risk evaluation, and appropriate handling of unfavorable consequence caused by the risk. In the first process of risk identification, the enterprise's overall goal and sub-goals that have to be accomplished for successful overall target should be clarified. That leads to the necessity of detecting out all risk factors that hinder the achievements of the goals, analyzing the influences of the risk factors, and identifying the existing risks of the enterprise [1]. It is then followed by the implementation of the corresponding measures on effective risk control after assessment and evaluation of the enterprise's risk. Thus the complete process of risk management is finished [2,3].

However, with constantly increasing potential factors that affect an enterprise's risk, the feasibility of the above-mentioned risk management has been queried due to its limitation to analyze and evaluation all risk factors. This paper suggests a new management decision method – CBR based risk management for virtual organization. In this method, every previous case of risk management is regarded as a study case. Through analyzing and comparing the data that correlate with risk factors, a case that is most similar to the present case of risk management is chosen.

Then the chosen case has to be modified under the risk control measures so that it can be utilized for the present one[4].

III. Case-Based Reasoning

The theory behind CBR comes from cognitive science, which states that mankind can retain and memorize information they have perceived. This retained information can be retrieved when similar scenarios appear and are lessons and references for problem solving. The basic thought of CBR is to imitate this human mode of thinking. It deals with present problem by directly retrieving the accumulated experiences and knowledge. Under the enlightenment of cognitive science, Roger Shank of American Yale University proposed the cognitive model and outlines of CBR theory for the first time in 1982, and began to work on the research and application of the field in artificial intelligence [5].

A working course of CBR system is shown in Fig. 1, It includes main steps like case representation, case retrieve, case organization, case revise, case reuse, case retain.

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Existing research shows that the CBR is a kind of incremental type of problem-solving method. With the increase of cases and accumulation of experiences, ability of the system in solving problem is increasing constantly. Meanwhile, the continuous development in the technology of computer and artificial intelligence theory impels this method to maturity.

IV. Design of Case-Based Reasoning

Some key technologies that determine the efficacy of the CBR system are included when the system is applied. At present, these are the technologies that develop from the system, like the representation of the case, organization of case retain, retrieve of cases, and strategies of case revision. How to give a rational representation to the case is not a problem. Different ways of representation are designed for cases of different applicable areas. The main reference factors of the representation are integrity, rationality and good expansion performance. An effective case representation usually includes three parts of content: reason or background of the case, its characteristic details, solution and result. The multi-knowledge representation in the field of artificial intelligence is one of the usable examples. More ways of representation that gears at different areas are

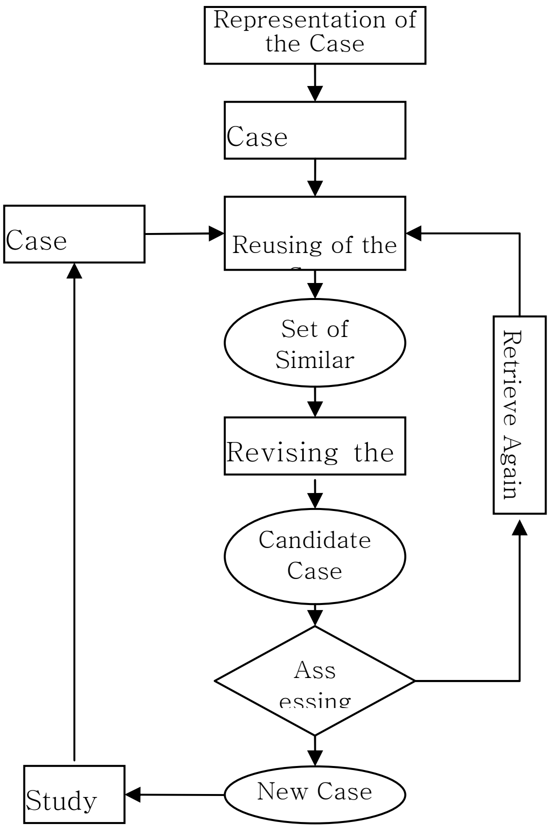

Fig. 1. The flow chart of the CBR System System

available as a result of the rapid development in information technology.

Usually the CBR system uses a special case library to retain the cases. With the ever-increasing cases, it is not enough to rely only on good search algorithms to perform case retrieve. The organization and memory structure of the case become a basic problem. It concerns with search speed and successful case search. Nowadays, most CBR systems adopt either dynamic store models or the memory model based on semantic network.

Case retrieve and matching are the keys of the CBR system. Its main purpose is to search out the best case from the cases store according to the definition and description of the new problem and becomes the guideline for solving the new problem. Result of the case search determines the quality of the whole system directly. Nowadays, the commonly used tactics of case search are proximal tactics, derived tactics, knowledge-lead tactics, and template-search tactics.

Case revision is another important step. Its main job is to make appropriate revising and adjusting of the chosen similar case so that it is more applicable for the present situation. But due to diversities of different situations, there is no common tactics for case revision. Real problem has to be solved by concrete analysis. The focus of this paper is to provide guidance on tactics of case modification in risk management of virtual enterprises, utilizing theories in fuzzy mathematics and optimal algorithms. The concrete procedures are:

1) An evaluation performance for the enterprise's risk control tactics has to be listed. It includes data on the frequency of utilization of risk measure, risk expenses, occurrence frequency of the risk, and risk loss. Efficacy of the risk control measures is reflected by its occurrence frequency and the loss. Of course, when it comes to actual application, managers can add other meaningful and measurable performances according to their experience.

2) Statistical analysis on each risk control measure of the chosen case has to be done. Frequency of utilization of the risk measures, occurrence frequency of the risk, and risk loss are calculated. Usually, expenses on risk control measures are known and the risks of the corresponding solutions of each measure are fixed too.

3) Fuzzy intervals are assigned to each measurable performance according to experiences. Usually risk manager inclines to choose control measures of high frequency utilization, low consumed expenses, low occurrence frequency and small loss. Therefore a decision maker needs to define the membership degree of four performance as $A_i(x)$, i = 1, 2, 3, 4, to four fuzzy intervals: {Frequency of utilization of risk measure is high}, {Measure expense of the risk is low}, {Occurrence frequency of the risk is low}, {Risk loss is small}.

4) Manager, based on their experiences, establish the weight value w_i, for each performance in order to reflect the partiality.

Here, $\sum \omega_i = 1$, i = 1, 2, 3, 4.

5) To get an appraisal result of each risk control measure, the assumed weight values and the calculated membership degree are worked on with the weighted sum by the formula

$$\sum_{i=1}^{4} \omega_i A_i(x)$$
.

6) Usually, an enterprise's risk management is constrained by the expenses of the risk measures. At this moment, not every risk is controllable. Therefore, under the condition of expense constraint, the best combination of risk control measure is selected. This is a typical kind of 0-1-knapsack problem. The method of optimizing can be applied to obtain the final combination of control measures.

V. Simulation Analysis

About 5,800 cases are stocked in the case library of the CBR system as emulation cases. Each case mainly includes contents of three parts. The first part lists 30 attributes that are ascribed to the characteristics of cases which are the data index that are related to the potential risk factors of the enterprise. Through comparison among these characteristic attributes, the case that is most similar to the present case is chosen as guidelines for decision-making. The second part is 8 attributes ascribed to risk control measure, with recorded solutions adopted for the cases. The last part is 10 slots for recording the risks that have occurred and the subsequent loss in each course of risk management. These data reflect the efficacy of the adopted combination of risk control tactics.

As for the tactics of case retrieve, formula (1) is applied to choose a similar case:

$$sim(c_i, c_r) = \sum_{j=1}^{n} \varpi_j \times \frac{\left| c_i^j - c_r^j \right|}{c_i^j} \quad (1)$$

Among them, c_i and c_r express cases i and r respectively. ϖ_j shows the weight of the jth attribute. The degree of resemblance between the present case and the case in the case store is calculated through formula (1). A threshold value δ is the established. The degree of resemblance that is lower than δ will be elected and will be regarded as a guideline for present decision making.

Then the following modification method is carried out in order to confirm which risk control measure should be taken in the new case. The chosen case is examined under statistical analysis to confirm the following: frequency of utilization of the risk measure, measure expenses, occurrence frequency of the risk, and the corresponding risk loss. Usually, expenses of each risk control measure do not change. Statistical result is shown in table 1.

Table 1. Statistics of Cases

Control measure of the Risk	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7		Measure 8		
Frequency of utilization of the measure	0.51	0.52	0.5	0.44	0.47	0.46	0.43		0.49		
Measure expenses	5	3.7	2.5	1.7	1.9	0.7	2		3		
Risk	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7	Risk 8	Risk 1	Risk 9	Risk 10
Occurrence frequency of the risk	0.52	0.45	0.41	0.47	0.5	0.48	0.52	0.51	0.52	0.53	0.52
Risk loss	2.9	3.28	2.1	1.8	8.9	6.71	2.93	7.56	2.9	2.52	3.5

As shown in Table 1, measures 7 and 8 are effective for two and three kinds of risks respectively. Other risk control measures address to only one kind of risk. In order to appraise each control measure of risk, a fuzzy set is formed to calculate the membership degree of the statistical results in Table 1. It includes the frequency of utilization of the measure, measure expenses, occurrence frequency of the corresponding risk and risk loss. In the fuzzy sets, only the four significant elements are taken: frequency of utilization of measure is high, measure expenses are low, occurrence frequency of the risk is low and risk loss is small. Table 2 illustrates the membership functions.

Here, the trapezoid membership functions are chosen. Of course, other types can be selected according to the concrete problem. From the definition of the fuzzy set in Table 2, the membership degree of the fuzzy sets can be calculated from the statistical data of Table 1. The result is displayed in Table 3.

Then, weight values are assigned to each elements of the set according to the different degree of emphasis. The four elements are: frequency of utilization of the measure, measure expenses, occurrence frequency of the risk and risk loss. The maximum value to each element is 1 and they are illustrated in Table 4.

Table 2. The Membership Function of the Fuzzy Sets

Fuzzy set	Membership function
Frequency of utilization of m easure is high	$A(x)=\begin{cases}0 & x<0.2\\ \frac{x-0.2}{0.4} & 0.2\le x\le 0.6\\ 1 & 0.6<x\end{cases}$
Measure e xpenses are low	$A(x)=\begin{cases}0 & x<2\\ \frac{6-x}{4} & 2\le x\le 6\\ 1 & 6<x\end{cases}$
Occurrence frequency of the risk is low	$A(x)=\begin{cases}0 & x<0.3\\ \frac{0.5-x}{0.2} & 0.3\le x\le 0.5\\ 1 & 0.5<x\end{cases}$
Risk loss is small	$A(x)=\begin{cases}0 & x<3\\ \frac{9-x}{6} & 3\le x\le 9\\ 1 & 9<x\end{cases}$

Through calculations of weighted sum on the data in Table 3 and 4, appraisals on each risk control measures are obtained and shown in Table 5. Here comes a typical solution of 0-1-knapsack problem. The best combination of risk control measure has to be selected under the constraints that the measure expenses should not exceed the expenses of the new case, which is 9. {Measure 4, Measure 6, Measure 7, Measure 8} should be the best combination since it has achieved the goal of highest control efficacy. It is the solution of the new case.

Table 3. The Membership Degree of Statistical Data

Control measure of the risk	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7		Measure 8		
Frequency of utilization of measure (high)	0.76	0.79	0.75	0.6	0.67	0.66	0.58		0.72		
Measure expenses (low)	0.25	0.575	0.875	1	1	1	1		0.75		
Risk	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7	Risk 8	Risk 1	Risk 9	Risk 10
Occurrence fre quency of the r isk (low)	0	0.27	0.45	0.13	0	0.11	0	0	0	0	0
Risk loss (small)	1	0.95	1	1	0.015	0.38	1	0.239	1	1	0.92

Table 4. Appraisal Weight Value of Each Performance

Control measure of the risk	Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6	Measure 7	Measure 8
Frequency of utilization of measure (high)	0.3	0.2	0.58	0.39	0.45	0.3	0.5	0.4
Measure expenses	0.3	0.3	0.22	0.17	0.25	0.2	0.1	0.05

(low)											
Risk	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7	Risk 8	Risk 1	Risk 9	Risk 10
Occurrence f requency of the risk (low)	0.1	0.1	0.1	0.21	0.1	0.2	0.1	0.1	0.1	0.1	0.05
Risk loss (small)	0.3	0.4	0.1	0.23	0.2	0.3	0.1	0.1	0.1	0.1	0.5

Table 5. Appraisal Results of Risk Control Measures

Control measure of the risk	1	2	3	4	5	6	7	8
Appraisal result	0.66	0.564	0.54	0.72	0.49	0.7	0.82	0.717
Measure expenses	5	3.7	2.5	1.7	1.9	0.7	2	3

The ten new cases, being chosen according to the above case selection and strategy modification, are tested. The final comparison between the derived risk control measure and the pragmatic risk control measure are listed in Table 6. Moreover, the unanimous rates of the two combinations – measures of pragmatic case and measures based on CBR are statistically calculated. The average of unanimous rate of the ten cases is 72%.

Table 6. Comparison of Solutions

Case	Combination of pragmatic risk control measures	Combination of derived risk control measures	Unanimous number of measure	Number of actual measure	Unanimous rate
1	1, 6, 7, 8	4, 5, 7, 8	2	4	50%
2	2, 5, 6, 7, 8	1, 4, 6, 7	2	5	40%
3	1, 4, 5, 6, 7	1, 3, 4, 5, 6	4	5	80%
4	2, 3, 4, 8	2, 3, 4, 6, 8	4	4	100%
5	2, 3, 4, 7, 8	2, 3, 5, 6, 8	3	5	60%
6	2, 3, 4, 7, 8	2, 3, 5, 6, 7	3	5	60%
7	4, 5, 7, 8	4, 5, 7, 8	4	4	100%
8	3, 4, 5, 6	2, 3, 4, 6, 8	3	4	75%
9	2, 4, 5, 6, 8	4, 5, 6, 8	4	5	80%
10	3, 4, 5, 6	2, 3, 4, 6, 8	3	4	75%

VI. Conclusions

This article has proposed a CBR-based management decision method for virtual organization risk management. It uses the knowledge of fuzzy mathematics for the strategy of case modification, and develops a tactics of revising the case so that it becomes more applicable for the present situation. The new strategy integrates all considerations of the applications of risk control measures and appraisals on its control efficacy, so that the accuracy of getting the appropriate solution is enhanced. The method is elaborated in details through the emulation analysis.

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