Study on the Reliability of Hierarchical Supplier System

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Abstract: This paper applies reliability theory to the study of material supply in supplier system, proposes the conception of single supplier reliability and the flow of reliability calculate, then analyzes the reliability of hierarchical supplier system and taken the factor of cost into account.

Introduction

Due to the global expansion of companies, competition all over the world is becoming stronger. Many companies implement the integrated supply chain management (ISCM) to coordinate and control the material flow, information flow and fund flow. Integrated supply chain management is a seamless process, in order to achieve the overall goal of integrated supply chain[1].

The reliability of hierarchical supplier system is related to the effective operation of supply chain, has a major influence on the achieve the goal of materials supply[2]. This paper establishes the conception of single supplier reliability based on supplier evaluation theory, then analyzes the reliability of hierarchical supplier system.

Reliability of single supplier

Reliability of single supplier is sometimes simple defined as the probability of materials supply process performing its intended or specified function[3]. This definition emphasizes that the reliability is a function positive correlation with the time limit. Therefore, set the task parameter (a) and environmental parameter (e) as a constant. The reliability of single supplier can be written as follows.

$$R_{SV}(t) = R_{SV}(t,e,a) = P(T < t)$$

Then, the distribution function of instability can be expressed as follows.

$$F_{SV}(t) = F_{SV}(t,e,a) = P(T \geq t)$$

Assumption $F_{SV}(t)$ can be differential, the distribution density of instability defined as

$$f_{SV}(t) = \frac{dF_{SV}(t,e,a)}{dt} = -\frac{dR_{SV}(t,e,a)}{dt}$$

The instability probability of single supplier means that single supplier completes the materials supply task within the time (t) requirements, while can't completes the task within the time ($t-dt$) . It can be calculated from the following expression.

$$\lambda_{SV}(t) = -\frac{f_{SV}(t)}{R_{SV}(t)}$$

Therefore, the paper established the reliability concept of single supplier in hierarchical supplier system.

Take the task parameter (a) as a variable into consider, the reliability of single supplier can be given as follows.

$$R_{SV}(t,e,a) = P(T < t \mid A \geq a)$$

Reliability calculation method of hierarchical supplier system

The functions of supplier management agent can be divided into data mining, information transmission and information collection. The reliability can be predict and calculate by black box theory[4]. Application of analogue simulation is confirmed the function sequence relationship and sequence parallel relationship of materials supply task.

Relevant reliability changes can be calculated according to the change of time limit index in simulation process. UML model of reliability simulation process of single supplier is as shown in Fig 1.

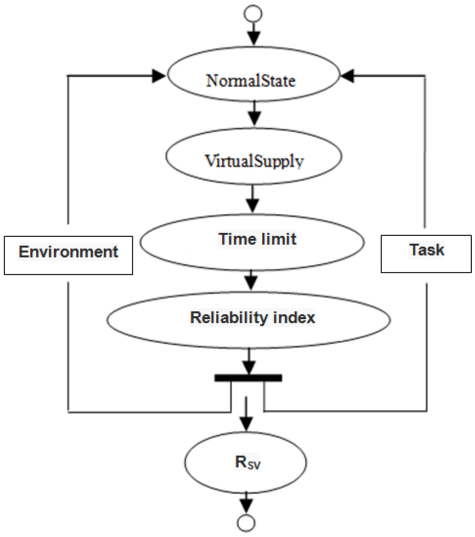

Fig 1. UML diagram of reliability simulation process of single supplier

Actual hierarchical supplier system is a complicated network system, after learning about operational connections among suppliers of all levels and calculating reliability of suppliers through simulation, a reliability diagram of hierarchical supplier system is formed, the transformation from physical level structure to functional level structure is realized.

Simplification of the complicated network system can be conducted with Boolean truth table, probability graph, non intersection algorithm and etc., furthermore, calculation of reliability of hierarchical supplier system can be realized.

Hierarchical supplier system based on cost considerations

The impact of cost was not considered in above analysis, but for reliability evaluation of hierarchical supplier system, it is necessary to analyze single supplier's cost after cost control and adjustment are carried out.

Set reliability of single supplier before adding cost control and adjustment as $R_{SV}=p$ and operation cost as C_{SV}. After cost control and adjustment are added, expressions of reliability of single supplier and of total cost respectively are:

$$R_{SV}^{'} = p \cdot p_{\mathrm{N}} + p \cdot (1-p_N) \cdot p_F + (1-p) \cdot p_E \cdot p_T$$

$$C_{SV}^{'} = C_C + (1-R_{SV}^{'}) \cdot C_{\mathrm{A}} + [p \cdot (1-p_N) + (1-p) \cdot p_E] \cdot C_I$$

Caused reliability and cost improvement respectively are:

$$\Delta R = R_{SV}^{'} - R_{SV} \qquad \Delta C = C_{SV}^{'} - C_{SV}$$

If reliability of hierarchical supplier system is R_S, reliability of single supplier is R_i, and cost of improving reliability is C_i, then sensitivity analysis after cost is considered can be expressed as $\frac{\partial R_S}{C_i \partial R_i}$, $(i = 1,2,\cdots,n)$.

Related symbols in above expressions provide following assumptions:

P —accurate supply rate before cost control and adjustment measures are implemented;

P_E —under the precondition of supply deviation's existing, deviation probability which can be found in control stage;

P_T —when supply deviation exists and is found, probability of adjustment being conducted in adjustment stage;

P_N —under the precondition of supply deviation’s not existing, deviation probability which can be found in control stage;

P_F —under the precondition of supply deviation’s not existing, probability of deviation being found but not being adjusted in control stage;

C_C —cost of every implementation of control stage;

C_I —when supply deviation is found, cost of checking if any problem exists and of conducting adjustment;

C_A —average cost when adjustment is not conducted.

Conclusion

Rationality of reliability calculation theory of hierarchical supplier system and simulation calculation strategy can be proved through case analysis.

It needs to be pointed out that, the research results of this essay is preliminary, reliability of hierarchical supplier system should be further analyzed combining reliability and cost, with high time limit demands, bigger material supplying tasks and faster changing environments.

References

[1] Huo Jia-zhen, Ma Xiu-bo, Zhu Lin-jie. Integrated supply chain performance evaluation system and its application[M]. Tsinghua university press, 2005.

[2] Ma Li-juan. Supply chain management-based supplier selection: A tentative exploration[J]. Industrial engineering and management, 2002.7(6): 23-25.

[3] Han Jing-ti. Emergent situation logistics supply chain integrated pattern-ELS3 Analysis[J]. Journal of air force engineering university, 2005.6(2): 18-21.

[4] Wang Li-yong, Shi Zhu-xian. Mathematical model for quantitative analysis of internal control evaluation[J]. Systems engineering-theory & practice, 2005.25(8):10-17.