Advanced Science and Technology Letters
Vol.94 (Networking and Communication 2015), pp.52-56
http://dx.doi.org/10.14257/astl.2015.94.12

A Hybrid Optimization Framework Considering Risks and Operation Strategies in an Enterprise Network

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Abstract. The world has been made into a global network regardless of geographic locations through transportation, information technology and etc. Risks such as earthquake, war, bad weather, fire, accident and etc. in a nation or a region are disseminated among other nations and regions quickly and they are being affected by each other immediately. An enterprise network makes many solutions to cope with the risks but the network does not provide an integrated optimization framework because the network is very complex and difficult. This paper, therefore, decomposes a network into a simulation level, a design level, and an operation level. And then it integrates the network and optimizes the system to solve the problems. The simulation level accomplishes simulation optimization. The design level and the operation level perform Particle Swarm Optimization (PSO). Also, an integrated model provides a supply chain hybrid optimization model in order to fulfill the whole optimization.

Keywords: framework, hybrid optimization, risk, simulation level, design level, operation level, network

1 Introduction

Society is being formed into a global network because of the advancement of transportation, information, and communication technologies. So, geographical distance is being meaningless. And then people and social systems are influencing on each other immediately. Humanity is being seriously challenged by the attack of Islamic State (IS), earthquakes and environment deterioration around the entire world, and etc. So, many enterprises which make product and service are distressed by the dangers. The supply chains of Ford and Toyota were severely influenced by the terrorist's attacks on September 11, 2001 [1]. The factory which manufactures around 25% of total global output of HDD was stopped due to the strongest flooding that was the first in fifty years occurred in Thailand and then computer and semiconductor industries were suffered an enormous loss from the disaster.

The economy and society has diversified and dynamically changed. The facilities and links of a supply chain, therefore, which makes products and service have been hindered due to bad weather, natural disaster, man-made disaster, and etc. [2]. A supply chain has risks of destruction (a risk that is no longer use or cannot be recovered forever in a supply chain) and disruption (a risk that has been temporarily suspended and all or a part will be recovered after certain time in a supply chain) due

ISSN: 2287-1233 ASTL

to uncertainty and external influences and the risks give consistently negative effects on business [3]. The problems occurred in a supply chain are explained by risk, destruction, and disruption. Sustainability and resilience are explained to overcome the problems [2] [4] [5] [6] [7].

The earlier studies decomposed a supply chain into design level and operation level individually and tried to solve it because the risks which are occurred in a variety of ways are not solved easily at the same time. The design level is a method which is approached in the view of new construction of an optimal supply chain and the operation level is a method which is accessed in the view of optimal operation of a supply chain that is already constructed. The previous researches did not optimize the chain because the researches tried to optimize the design level and the operation level individually in a supply chain. Also the studies did not reify risk uncertainty, risk randomness, risk possibility, and etc. and reflected risk as a single factor despite reason of the risks has many factors.

This paper, therefore, will propose a supply chain hybrid optimization framework which is self-organized, recovered, and persisted itself in order to counter destruction risk, disruption risk, dynamic property, randomness, and etc. considering the design level and operation level of a supply chain.

2 A Supply Chain Hybrid Optimization Framework

A supply chain is difficult to optimize total optimization simultaneously and is hard to present a solution to secure sustainability because the network has various risk factors and the modeling of the chain is tangled. So, this paper proposes an optimization framework which decomposes the system and integrates it to solve the problems.

A supply chain is decomposed into a simulation level, a design level, and an operation level to model and optimize the chain easily. The simulation level (Fig. 1) is a base model to evaluate an entire supply chain and optimize the network. And the level constitutes a model to reflect and evaluate uncertainty, risk possibility, risk continuity of a supply chain. Also, the level uses a stochastic simulation to reflect various risk factors which are occurred in a supply chain, the properties of an enterprise network, the uncertainties due to the possibility and continuity of risk, the destruction and the disruption of a supply chain. The simulation strategy of a simulation level includes various conditions such as the risk condition of destruction and disruption, the stopping condition of a simulation model, various operational scenarios, and etc.

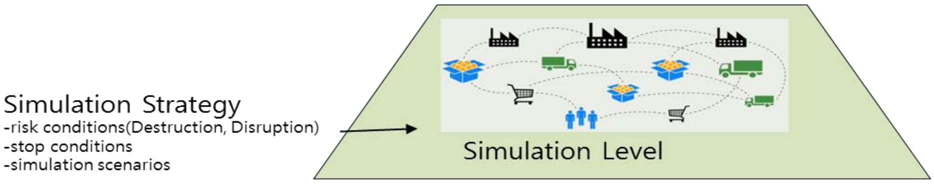

Fig. 1. A simulation level with simulation strategies.

The design level (Fig. 2) composes a model to evaluate various design factors and design an optimal supply chain network before a physical supply chain network is not built. Also, the level should corporate with an operation level and then make an optimal supply chain network because the companies should ask for outsourcing to other enterprises and constitute new facilities to fulfill customer demands if companies have a destruction and a disruption in the operation step of a supply chain. The design strategy of a design level pursues the design optimization of a supply chain using Particle Swarm Optimization (PSO) method in the light of scale conditions, tier conditions, connection or link conditions, vehicle conditions, recovery conditions, and etc.

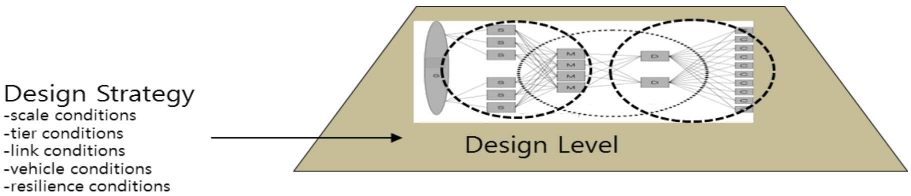

Fig. 2. A design level with design strategies.

The operation level (Fig. 3) controls various factors which are occurred in operational process after a supply chain network was already built and proposes optimal operation alternatives. The level should collaborate with a design level to give solution if there is physical change and additional request to efficiently manage a supply chain. The operation strategy of an operation level seeks the operational optimization of a supply chain using PSO method in the light of demand conditions, supply conditions, alternative route conditions, buffer conditions, inventory conditions, and etc.

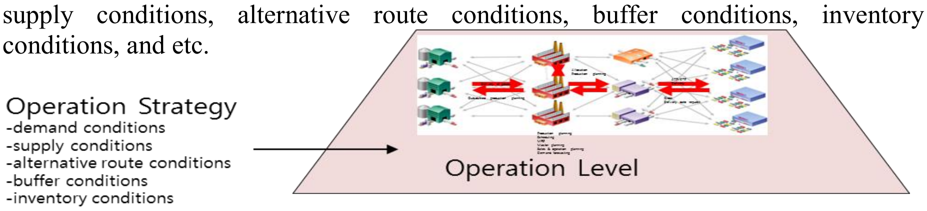

Fig. 3. An operation level with operation strategies.

The risks of a supply chain, which are importantly considered in this paper, can be classified in a variety of sources. Zsidisin & Ritchie [8] defined risk as “uncertainty based on a well grounded (quantitative) probability” and marked it as (the probability that some event will occur) × (the consequences if it does occur). Also, the paper classified the risk of a supply chain as internal to the firm: Process, Control, external to the firm but internal to the supply network: Demand, Supply, and external to the network: Environmental. Chopra & Sodhi [9] categorized it as system risk, forecast risk, intellectual property risk, procurement risk, receivables risk, inventory risk, and capacity risk. Tang & Musa [10] divided risk as material flow risk, financial flow risk, and information flow risk and evaluated it.

Even if the risks which are occurred in a supply chain are classified in a variety of settings, this paper supposes only the cases that the risks have a real influence on a supply chain. So, this study reflects within the framework of destruction and disruption and evaluates only the cases.

A supply chain optimization framework needs a self-organization in order to propose for itself solution in response to various risks and situations of a supply chain. To do that, the performance measures and the evaluation of a supply chain are needed because the system should give an optimal result which is satisfied to required conditions and environment. This paper evaluates the performance measures in the customer’s perspective and enterprise’s perspective [11]. The performance measures in the customer’s view consider product service/quality, delivery effect in timeliness, customer processing time in flexibility, customer loyalty, innovation of product process, response time of a supply chain, information flow, resource management, treatment of risk factors, and etc. The performance measures in the company’s perspective consider total supply chain cost, quality improvement of process, value-added labor productivity, unit cost savings, profitability, cash cycle time, asset management efficiency, stability of financial structure, and etc.

3 Conclusions and Future Works

The risks which affect a supply chain are various and give the severe effect to the network. They, therefore, must be overcome to ensure enterprise’s sustainability. But, the previous studies do not specifically consider the various risks which are occurred in an enterprise network but mainly consider only one factor. So, the risks which are actually occurred in the network are difficult to express causes exactly. This paper, therefore, clearly classified the risks into destruction and disruption risk. Also the study proposed a framework that the destruction is considered in a design level and the disruption is considered in an operation level. That is, a supply chain hybrid optimization framework was proposed to optimize whole supply chain considering the risks of destruction and disruption which are occurred in a supply chain.

It was difficult to accomplish the total optimization considering a design level and an operation level at the same time because a supply chain has complex and various risks and the risks have the stochastic characteristics such as possibility, continuity, and etc. The study included uncertainty to reflect the real world as much as possible, which has many various factors which are occurred in a supply chain and proposed a simulation optimization to evaluate diverse strategies of a supply chain in a simulation level. The optimization of a design level and an operation level is solved by PSO method and the whole model proposed the integrated framework to support hybrid optimization.

The hybrid optimization framework of a supply chain proposed a self-organized network to solve the internal and external problems which are occurred in an enterprise network. The measurement of performance was organized to solve the problems which are occurred in customer satisfaction, quality, time, cost, finance, and etc. and seek the whole optimization of a supply chain.

This paper decomposed a supply chain into a simulation level, a design level, and an operation. A simulation level pursued a simulation optimization considering risk factors, a design and an operation level a hybrid optimization framework which conducts PSO optimization. In further research, this paper needs to make the independent models (a simulation model, a design model, and an operation model) and test it separately. Also this study needs to integrate it as the integrated model (hybrid optimization model) and run it to verify the proposed integration framework.

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