Proceedings of the 2020 Winter Simulation Conference
K.-H. Bae, B. Feng, S. Kim, S. Lazarova-Molnar, Z. Zheng, T. Roeder, and R. Thiesing, eds.

SIMULATION OPTIMIZATION APPROACH FOR RECONFIGURATION OF THE PERISHABLE FOOD SUPPLY CHAIN DURING DISEASE OUTBREAK

Anchal Patil
Vipulesh Shardeo
Ashish Dwivedi
Jitender Madaan

Department of Management Studies
Indian Institute of Technology Delhi
Hauz Khas, New Delhi
Delhi 110016 INDIA

ABSTRACT

Considering the impact of COVID-19 prevention policies on the perishable food supply chain, this work explores the effect of network reconfiguration to reduce the risk of spread. The Indian capital, Delhi have seven big aggregator markets responsible for the redistribution of perishable food. These markets may have acted as a hotspot for the disease. Thus, we adopted agent-based modelling to examine the potential locations for the ad-hoc markets. Next, we propose to optimize the reconfigured network considering the travel time and cost, product quantity and quality and establishment cost of the new market.

1 INTRODUCTION

A significant portion of the Indian diet is made up of perishable food. Supply chain network of Perishable food provides employment to a significant section of society. Farmers, distributors, vendors, transporter, aggregators, street hawkers and consumers are interwind in a daily transaction for the smooth functioning of the perishable food supply chain (PFSC). The critical activity of PFSC such as food production, supply and distribution are governed by several risks emerging from price and demand volatility, absenteeism, supply chain (SC) disruptions, and volatility. These issues further magnified by material hoarding, risk of infections and production demand mismatch during a disease outbreak. In India, everchanging regulations during the lockdown period magnified the crisis of the PFSC. For the capital city Delhi, PFSC composed of 7 big wholesale market and several small markets serving approximately 1.9 crore population. Traders reach customers through various channels – street hawkers, shops, and direct delivery. On 29th April traders at Delhi biggest wholesale market, Azadpur requested the government to close the market on account of becoming a potential COVID hotpot.

It became apparent that COIVD-19 world cannot use the existing supply chain until the vaccine is found. Multiple cases have been found where infection spread and rippled, along with the supply chain personnel. To mitigate these challenges, the configuration of the PFSC needs to be modified. The modified PFSC need to assure the performance of existing SC, meanwhile supporting the social distancing measures. Further modified PFSC can be improved by minimizing the need for interactions and reducing the probability of infection. This study proposes a hybrid simulation-optimization model to reconfigure the existing PFSC of New Delhi metropolis. We propose to develop an agent-based model (ABM) to experiment with different PFSC configuration. The ABM is sought to map the contact pattern of several agents of the PFSC network using spatial agent-based simulation modelling. Contact patterns can provide insight into the infection risk of that particulate PFSC configuration. Thus, enabling the evaluation and design of modified PFSC. Next, we propose to optimize the PFSC network configuration.

This study intends to achieve the following two objectives:

- Evaluate and identify the PFSC network configuration with minimum infection risk.
- Optimize the perishable food supply chain, (minimize COVID hazard, minimize delivery time, minimize cost, minimize reconfiguration cost).

2 METHODOLOGY

The study is being undertaken in the three phases. Figure 1 shows the research methodology.

A. Agent-based simulation of food supply chain and disease spread:

In the first phase, we are developing a spatial ABM of PFSC in NCT of Delhi. This phase intends to access the demand and production of food in the target area. Then the supply chain will be mapped to evaluate the contact pattern of peoples. A limited no of the initial infected people will be inserted to COVID risk in different configurations. The ABM will consist of a PFSC transportation network and its different agents, interaction module of these agents and disease spread module.

B. Exploration of parameter space using Genetic algorithm (GA):

In the 2nd phase, Wholesale market location will be optimized using GA. The GA encodes chromosome from the list of potential locations where ad-hoc markets can be deployed. Fitness functions evaluate the no of person that will be infected under different configuration.

C. Mixed-integer programming model for optimizing ad-hoc wholesaler location:

We propose to solve the location-allocation problem as a multi-objective mixed-integer linear program. The model will optimize the transportation cost, travel time, establishment cost, quantity and quality of food. The model also incorporates the minimization of infection spread risk.

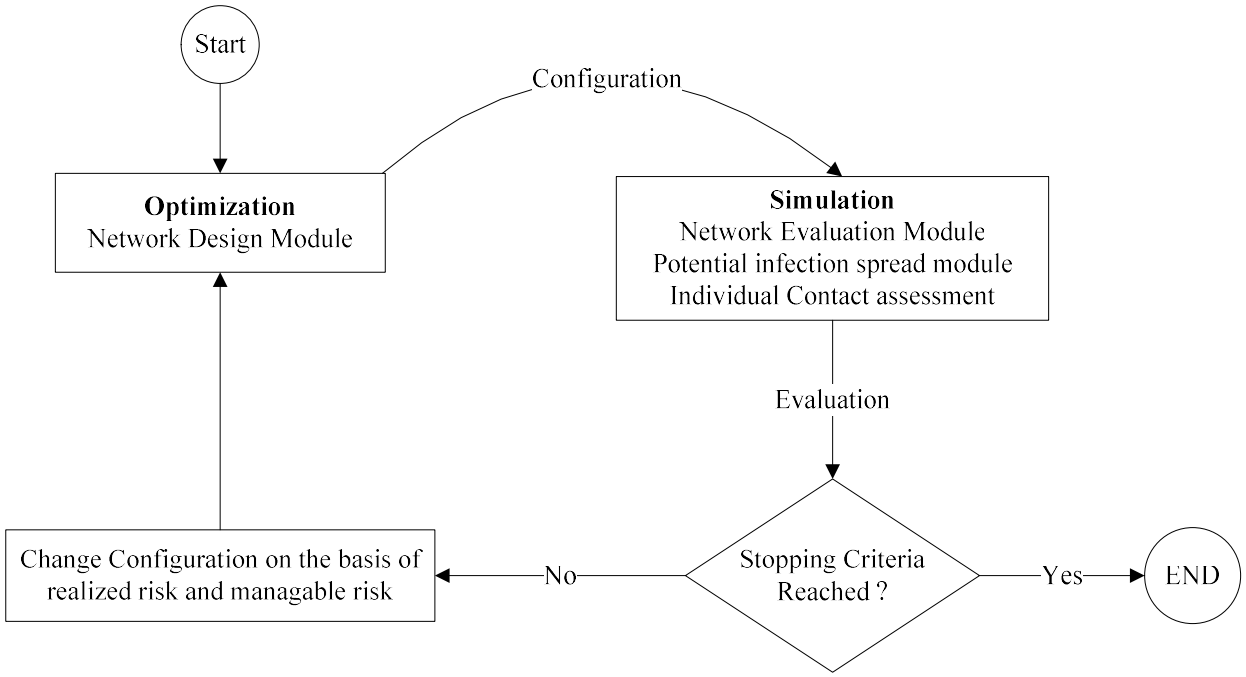

Figure 1: Research methodology.