Physica A 508 (2018) 390–401

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Development of the mitigation strategy against the schedule risks of the R&D project through controlling the cascading failure of the R&D network

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HIGHLIGHTS

- Organization–task network of the R&D project.
- The cascading failure model of the R&D network based on the SIR and CA model.
- The mitigation strategy through controlling the cascading failure of the R&D network.
- Immune some firms before the occurrence of the cascading failure.

ARTICLE INFO

Article history:
Received 25 September 2017
Received in revised form 28 February 2018
Available online xxxx

Keywords:
R&D project
Organization–task network
Cascading failure
Mitigation strategy
Immunization

ABSTRACT

For R&D projects, the cascading failure among R&D firms will lead to the schedule risks of the R&D tasks, which may lead to potential severe consequences. It is necessary to develop mitigation strategies against cascading failures, so as to reduce schedule risks of R&D projects. Firstly, we propose the BBV algorithm to build the R&D network. Secondly, we build the model of the cascading failures of the R&D network based on the CA model. Thirdly, we develop the mitigation strategies against the schedule risks of the R&D project through controlling the cascading failure. Finally, we analyze different effectiveness of these mitigation strategies against the cascading failures of the R&D network under different values of some critical parameters and different attack strategies. The simulation results show that with the increase of μ and β, the schedule risk of the task network gradually decreases. With the increase of the control parameters ζ, the schedule risk of the task network gradually increases. In any case, the effectiveness of global immunization is better than local immunization, when we know the global information, HI is better than KI, and when we only know the local information, lAI is better than AI. The effectiveness of mitigation strategy under random attack strategy is the best, followed by high-degree attack strategy and high-centrality attack strategy. This provides a new useful theoretical basis on how to keep the safety of the schedule of the R&D project proactively against the cascading failure of the R&D firms in the real world.

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1. Introduction

Facing the dynamic market demands and scarcity of resources, it has been an important trend to form a network composed of many firms in the operation of R&D projects, the firms in the network can achieve complementary resources

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https://doi.org/10.1016/j.physa.2018.05.108
0378-4371/© 2018 Published by Elsevier B.V.

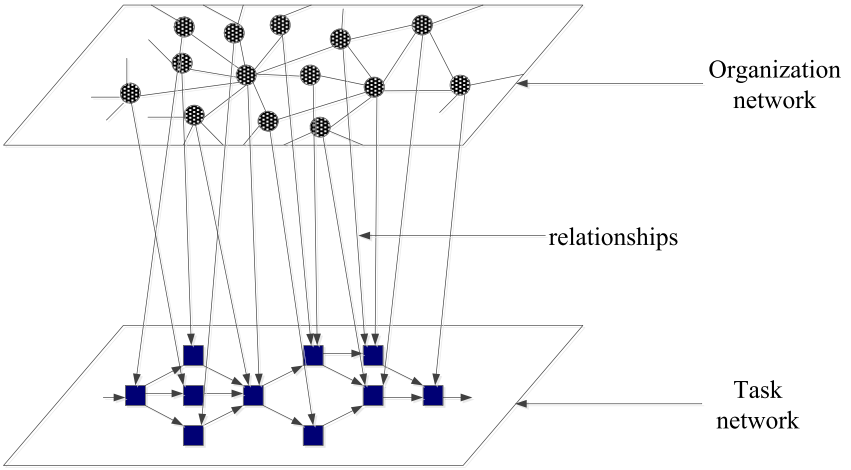

Fig. 1. Organization–task network.

and share risks [1,2]. Certainly, R&D network will help R&D firms to reduce costs and risks, however, when a firm in the network is not efficiently involved in the R&D project due to changes of the external market environment or its own poor management, this kind of event will have a negative effect on other firms that cooperate with him, which may propagate and result in paralysis of the network, this phenomenon is the cascading failure of the R&D network [3].

In addition, research studies show that schedule risk is an important cause of many risk events in the project management, and many researchers are studying on the mitigation strategy of the schedule risks in the project management [4]. Feng [5] developed a lead-time risk transfer algorithm, as well as analyzed the risk evaluating, identified the bottleneck risk units, then adjusted and optimized the schedule risks, in order to provide sufficient decision support for virtual enterprises. Li [6] proposed a risk-control approach to suppress the program schedule risk, combined with the practice of the program schedule management. However, these studies are mostly based on the uncertainty of the schedule to carry out the schedule risk control approaches, few people focus on the impact of how the schedule risks are affected by the firms that execute the tasks. As for the R&D project, many firms take part in it and execute its tasks, the cascading failure of the R&D network will probably lead to the delay of the schedule of the R&D tasks, thus forming the schedule risks of the R&D project, so it is an essential factor of the schedule risks of the R&D project.

We present an frame to represent the impact mechanism of how the schedule of tasks are affected by the firms that implement them in the organization–task network in Fig. 1, which consists of two related networks. From the perspective of system analysis, the R&D project can be regarded as a multi-level, multi-factor and multi-subsystem complex system. Its structure refers to a set of functions and relationships with a number of sub-systems, which can reflect the interaction between the elements. The R&D project can be divided into two categories: organizations and tasks, from the viewpoint of systematical analysis, and we can call them organizational network and task network in the background of network operation. The organization network refers to a set of firms who take part in the R&D project, the task network refers to a set of sub-tasks defined by the WBS of the R&D project. In the operation process of the R&D project, each sub-task must be executed by the corresponding organizations, and thus forming a set of relationships.

For the R&D project, the cascading failures of the participating firms will delay the schedule of their implementation tasks, thus forming the schedule risk of the R&D project. From this point of view, we will propose the mitigation strategy to suppress the cascading failures of the organization network, so as to reduce the schedule risk of the task network.

The main contributions of this paper are summarized as follows.

(1) We propose the cascading failure model of the R&D network, combined with the characteristics of the R&D network and the CA model. Compared with other cascading failure models, such as the Load–capacity model and the Mean-field, the model that we propose can represent the discrete spatial and temporal evolution of the cascading failure of the R&D network.
(2) We develop the mitigation strategy against the schedule risks of the R&D project through controlling the cascading failure of the R&D network. While existing studies on the mitigation strategy against the schedule risks are mostly based on the uncertainty of the schedule. Few people focus on the impact of how the schedule risks are affected by the firms that execute the tasks, which is an essential factor of the schedule risks of the R&D project.
(3) We propose the mitigation strategy against cascading failures of the R&D network on immunizing some firms in the R&D network to enhance the robustness of the R&D network before the occurrence of the cascading failure. Compared with other mitigating strategy, the mitigation strategy that we propose can mitigate the propagation of failures without

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