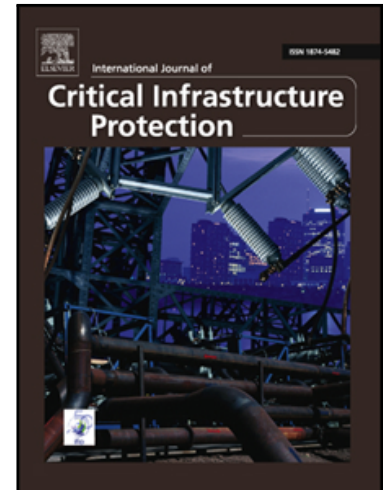


Accepted Manuscript

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PII: S1874-5482(17)30114-2
DOI: [10.1016/j.ijcip.2018.06.002](https://doi.org/10.1016/j.ijcip.2018.06.002)
Reference: IJCIP 255



To appear in: *International Journal of Critical Infrastructure Protection*

Received date: 21 July 2017
Revised date: 7 June 2018
Accepted date: 8 June 2018

Please cite this article as: Chen Zhao , Nan Li , Dongping Fang , Criticality assessment of urban interdependent lifeline systems using a biased PageRank algorithm and a multilayer weighted directed network model, *International Journal of Critical Infrastructure Protection* (2018), doi: [10.1016/j.ijcip.2018.06.002](https://doi.org/10.1016/j.ijcip.2018.06.002)

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Criticality assessment of urban interdependent lifeline systems using a biased PageRank algorithm and a multilayer weighted directed network model

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ABSTRACT: Urban lifeline systems play vital roles in sustaining fundamental functionalities in urban areas. These systems, working collaboratively and synergistically, form a complex system of systems, in which disruptions in one system can rapidly propagate to others, posing a great challenge for the identification and protection of critical infrastructure facilities. This study introduces a new criticality assessment approach of interdependent lifeline systems. Given a weighted directed network of infrastructure systems, the proposed approach calculates vertex criticality through the biased PageRank algorithm: compared with the original PageRank algorithm, the biased one utilizes a personalization vector (in this context, vertex functional importance) in the process of criticality measurement. This algorithm design fulfils an integration of both network topology and function, and can comprehensively measure vertex criticality. To consider the impact of cascading failure, this criticality assessment method also adopts a linear combination form to take into account the criticality of child vertices using conditional probabilities as parameters. A case study is conducted on five real lifeline systems in a middle-sized county in China with over 300,000 inhabitants. Based on the case study model, targeted vertex attacks are carried out to illustrate the validity and effectiveness of this criticality measurement. Examining both network topological and function response, resulting curves show that the criticality ranking calculated with the proposed approach is better to reflect component topological and functional importance compared to other commonly used metrics. The main contribution of this study to the body of knowledge is the proposition of a new approach for criticality assessment of facilities in interdependent infrastructure systems under disaster scenarios, which provides a useful and intuitive guide for decision making process with regards to pre-disaster infrastructure protection.

KEYWORDS: lifeline system, interdependency, network model, weighted directed network, criticality assessment

1. Introduction

Critical Infrastructures (CIs) underpin every aspect of urban life by providing essential services [1, 2]. According to the President's Commission on Critical Infrastructure Protection (PCCIP), CI is defined as 'a network of independent, mostly privately-owned, manmade systems and processes that function collaboratively and synergistically to produce and distribute a continuous flow of essential goods and services'

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