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Nodal interdiction

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ABSTRACT

This study extends network interdiction to directly include node interdiction. Current interdiction literature focuses primarily on arcs/edges. Traditional network interdiction generally incorporates nodes by replacing each node with two artificial nodes and an artificial link; this is followed by a links interdiction approach. However, this increases the size of the network, and in some cases may not be intuitive to the decision maker. To more directly represent nodes to target/protect, a formulation that explicitly considers nodes is proposed and discussed.

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1. Background

The Department of Defense Joint Publication 3-03 states:

> Interdiction operations are actions to divert, disrupt, delay, or destroy an enemies' surface capabilities before they can be used effectively against friendly forces, or to otherwise achieve objectives [1, pp. I-1].

Two of the most common types of interdiction used are disruption and destruction. Disruption involves "upsetting the flow of information, operational tempo, effective interaction, or cohesion of the enemy force or those systems" [1, pp. I-1], while destruction means "damage the structure, function, or condition of a target so that it can neither perform as intended nor be restored to a usable condition, rendering it ineffective or useless" [1, pp. I-4].

To apply general interdiction in a mathematical framework, bilevel programming models (see [2,3]) with diametrically opposing objective functions have been proposed. This branch of study can be further specialized to focus on those problems which have a network structure as their foundation. For example, a commonly used network example is maximum flow interdiction. In this case, the problem is to consider a "defender" who attempts to maximize flow through a capacitated network while an "attacker" tries to minimize this maximum flow. The "attacker" has limited resources to stop flow on targeted elements and, therefore, cannot stop all flow by targeting the minimum cost cut set. Wood has proven that this problem is NP-complete even when the interdiction of an arc requires exactly one unit of resource [4]. However, advancements made by Wood and others show that these specialized subsets of bilevel programming can be solved for realistic networks in reasonable timeframes [5]. To extend these methods, the maximum flow problem and its interdiction model must first be discussed.

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