

A Successive Refinement Algorithm for Tri-Level Stochastic Defender-Attacker Problems with Decision-Dependent Probability Distributions

Tri-level defender-attacker game models are a well-studied method for determining how best to protect a system (e.g., a transportation network) from attacks. Existing models assume that defender and attacker actions have a perfect effect, i.e., system components hardened by a defender cannot be destroyed by the attacker, and attacked components always fail. Because of these assumptions, these models produce solutions in which defended components are never attacked, a result that may not be realistic in some contexts. This paper considers an imperfect defender-attacker problem in which defender decisions (e.g., hardening) and attacker decisions (e.g., interdiction) have an imperfect effect such that the probability distribution of a component's capacity depends on the amount of defense and attack resource allocated to the component. Thus, this problem is a stochastic optimization problem with decision-dependent probabilities and is challenging to solve because the deterministic equivalent formulation has many high-degree multilinear terms. To address the challenges in solving this problem, we propose a successive refinement algorithm that dynamically refines the support of the random variables as needed, leveraging the fact that a less-refined support has fewer scenarios and multilinear terms and is, therefore, easier to solve. A comparison of the successive refinement algorithm versus the deterministic equivalent formulation on a tri-level stochastic maximum flow problem indicates that the proposed method solves many more problem instances and is up to 66 times faster. These results indicate that it is now possible to solve tri-level problems with imperfect hardening and attacks.

Authors: Dr MEDAL, Hugh (University of Tennessee, Knoxville); AFFAR, Samuel (University of Tennessee, Knoxville)

Orateur: AFFAR, Samuel (University of Tennessee, Knoxville)

Classification de Session: Sequential decision-making under uncertainty

Classification de thématique: Sequential decision making under uncertainty