SaTC: CORE: Medium: An Optimization Framework for Identifying Dynamic Risk Management Practices
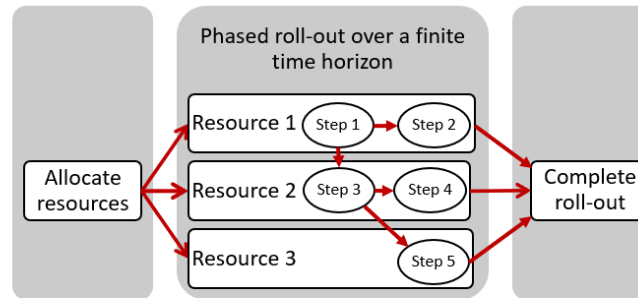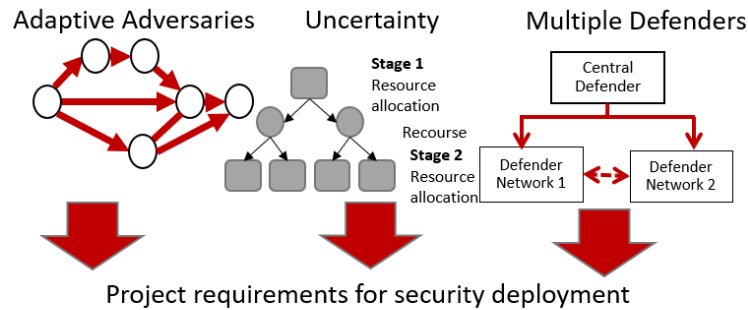
WISCONSIN
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Challenge:

- Protecting IT systems requires deploying security mitigations under uncertainty in a resource-constrained environment.
- Decisions of which mitigations to deploy and when are interrelated due co-coverage of vulnerabilities, use of shared resources, and precedence relations.
- Effectiveness of mitigations is uncertain and may depend on decisions of adaptive adversaries

Solution:

- This project advances our understanding of how to cost-effectively reduce risk by using optimization to make these interdependent planning and security resource allocation decisions
- Innovations include new integer programming models, multi-stage stochastic programming models, and network game models
- Models with adaptive adversaries and coordination between defenders are major focus areas.

Adaptive Adversaries · Uncertainty · Multiple Defenders

Stage 1 Resource allocation
Recourse
Stage 2 Resource allocation

Central Defender
Defender Network 1 ↔ Defender Network 2

Project requirements for security deployment

Phased roll-out over a finite time horizon

Allocate resources → Resource 1 (Step 1 → Step 2) → Resource 2 (Step 3 → Step 4) → Resource 3 (Step 5) → Complete roll-out

Optimization models and algorithms
- Integer programming
- Multi-stage stochastic programming
- Game theory

Optimization/ Decision Support

Scientific Impact:

- This project supports dynamic defensive strategies with the potential to achieve high levels of security without a corresponding increase in cost.
- New algorithmic techniques will identify optimal and near-optimal solutions to practical-sized problem instances quickly.
- Algorithmic advances may have applicability in other domains
- Project seeks to "bend the cost curve" by providing tools to manage risk in cost-effective manner, supporting choice of mitigations to implement along with implementation plans

Broader Impact and Broader Participation:

- Mentoring graduate and undergraduate students on research
- "Lab open house" event for undergraduates interested in research (March 2021)
- Doctoral development seminar to retain female and underrepresented minority (URM) graduate students
- Outreach talks to the public and YouTube videos planned
- Science blogging