Securing Mobile CPSs against Stealthy Attacks

PI: Mina Guirguis – Texas State University

http://cs.txstate.edu/~mg65/mcps

Motivation:

– Mobile Cyber-Physical Systems (Mobile CPSs) will be pervasively integrated into our physical world

– How to ensure the security and safety of Mobile CPSs?

Challenges:

– Reliance on wireless technology
  - Easy to jam and interfere with

– Complexity with real-time, energy and mobility constraints
  - Widens the malicious opportunities

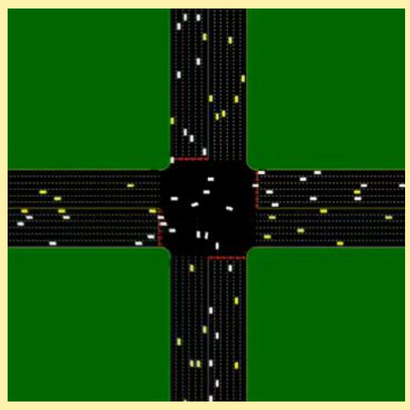
– Attacks are not “random noise”, but are well orchestrated
  - Studies that focus on random noise and disturbance do not apply

Scope of work:

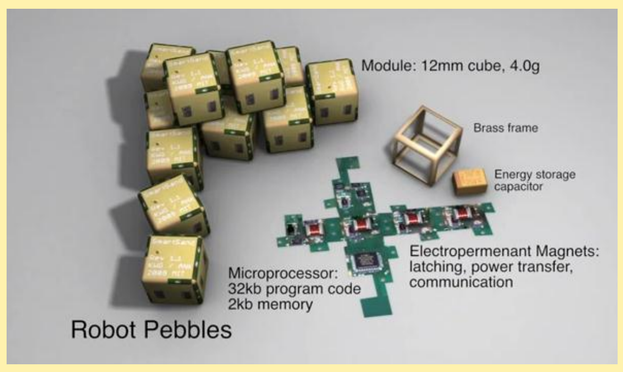
– Identifying stealthy attacks

– Developing defense mechanisms

[European Commission- *swarmanoid*]



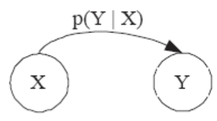
[UT- Multi-agent systems]



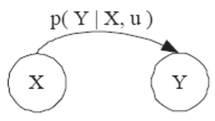
[MIT- Smart Sand]

Methodology: Identifying Stealthy Attacks

- Markov Decision Process
  – State of the system
  – Transitions

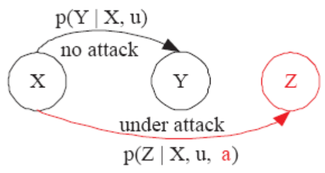


[independent]



[controlled]

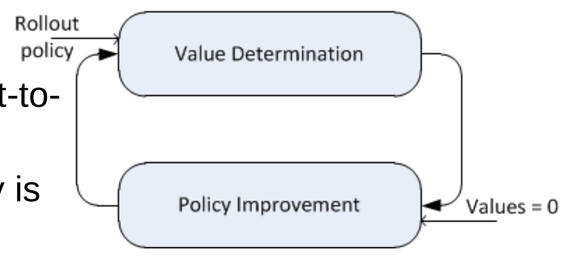
- Offense strategy
  – Aims to evolve the system into “bad” states (Z)
  – Pays a price when attacks
  – Gains a reward when inflicts damage
  – Identifies polices that maximize the cumulative rewards



[under attack]

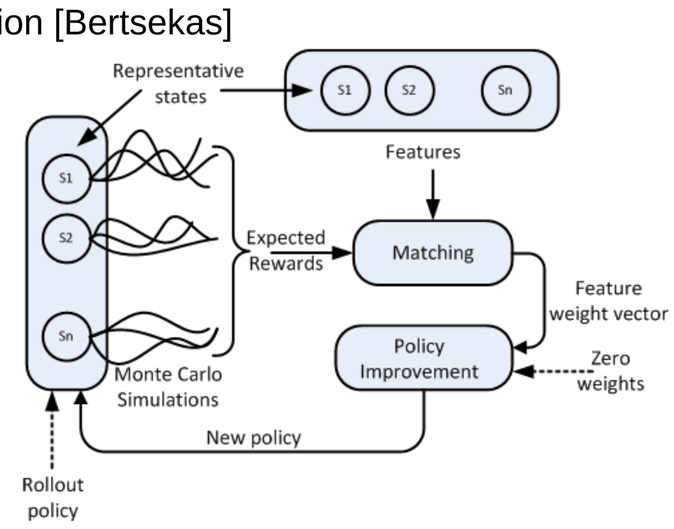
$$\max_{\mu_1,\mu_2,\cdots} E\left[\sum_{k=1}^{T} R(k)|I_k\right]$$

- Exact Policy Iteration
  – Optimal policies can be obtained
  – Value determination: expected cost-to-go values are computed
  – Policy improvement: a better policy is generated



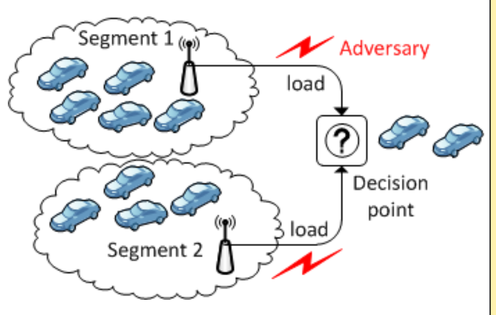
- The curse of dimensionality:
  – Large state space makes it computationally infeasible to obtain exact solutions [Bellman]

- Approximate Policy Iteration
  – Relies on Monte Carlo simulations
  – Characterizes states based on a set of feature
  – Uses a parametric cost-to-go approximation for the value function [Bertsekas]



Stuck in Traffic (Sit) Attacks on Intelligent Transportation Systems

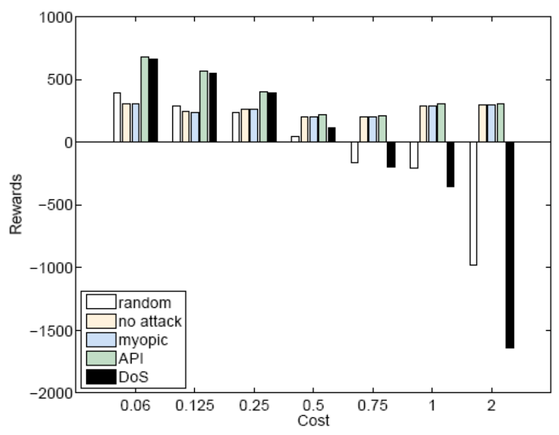
- The setup
  – Decision points reflect loads on segments
  – Drivers make informed decisions
  – Attackers aims to cause congestion



- Scenarios
  – Traffic optimization

- Damage
  – Degree of imbalance

- Cost
  – Number of vehicles affected

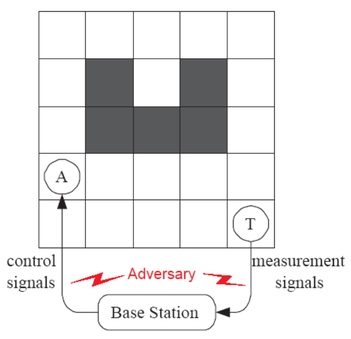


http://arxiv.org/abs/1210.5454

Stealthy Attacks on Target Tracking Applications

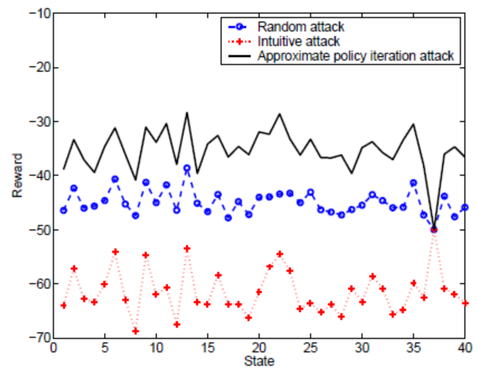
- The setup
  – Target moves randomly
  – Agent seeks to find the target
  – Attacker aims to hinder tracking

- Scenarios
  – Search and rescue
  – Border control



- Damage
  – Distance between the agent and the target
  – Negative if target is found

- Cost
  – Different values for control and measurement signals



Collaborators: George Atia (UCF), Vu Nguyen (Texas State), Janiece Kelly (Texas State) and Seth Richter (LeTourneau)

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NSF Secure and Trustworthy Cyberspace Inaugural Principal Investigator Meeting
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