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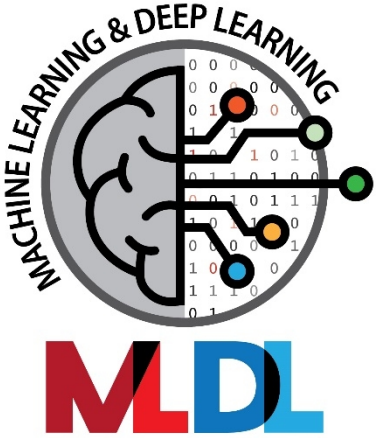

MLDL

Machine Learning and Deep Learning Conference 2021

Cyber Decision Support System for Industrial Control Systems

Robert Cole/SNL-NM, Dept. 05682

Team: Tyson Bailey, Logan Carpenter, Robert Cole, Jerry Cruz, Scottie-Beth Fleming, Trevor Hutchins, Deepu Jose, Ahmad Jrad, Nicole Murchison, Megan Nyre-Yu, Sasha Outkin, Meghan Sahakian and Tu-Thach Quach

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Abstract

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Active areas of investigation include:

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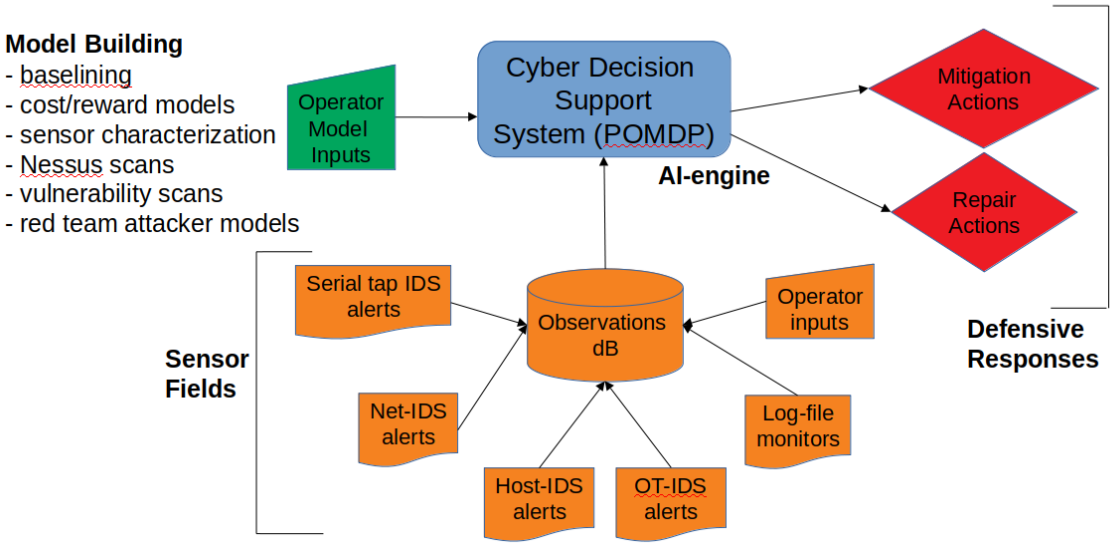
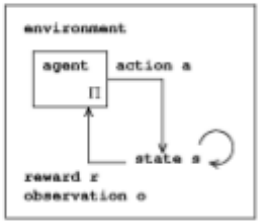
The Problem

- We are developing a Cyber Decision Support System to aid in the cyber defense of Industrial Control Systems (ICSs).
- Trained and experienced Cyber Defenders are hard to find.
- We want to improve this situation with the development of decision support systems.



Algorithmic approach

POMDP Formal Definitions



So we can more formally define a POMDP as follows:

Definition: a Partially Observable Markov Decision Process (MDP) is defined by the tuple $\langle S, A, \Omega, T, O, R \rangle$ where S is a finite set of states, A is a finite set of actions, Ω is a finite set of observations, T is a transition function defined as $T : S \times A \times S \to [0, 1]$, O is an observation function defined as $O : S \times A \times \Omega \to [0, 1]$, and R is a rewards function defined as $R : S \times A \times S \to \mathbb{R}$.

Algorithmic approach

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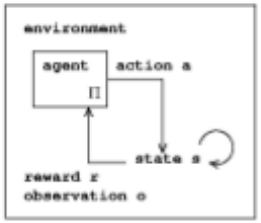

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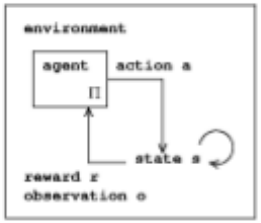
System Security State

Algorithmic approach

POMDP Formal Definitions



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Mitigation and Repair

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Algorithmic approach

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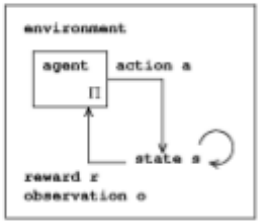

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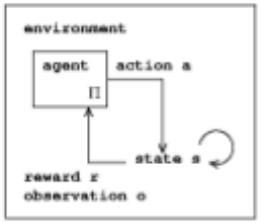
Alerts and Logs

Algorithmic approach

POMDP Formal Definitions



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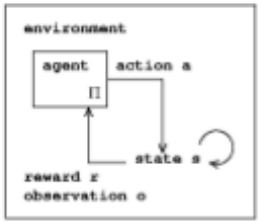
Attacker modeling and Action effects

Algorithmic approach

POMDP Formal Definitions



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Alert likelihood based on Actions

Algorithmic approach

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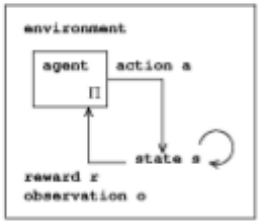

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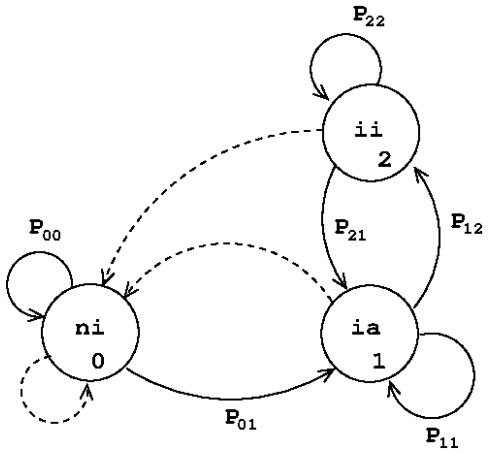
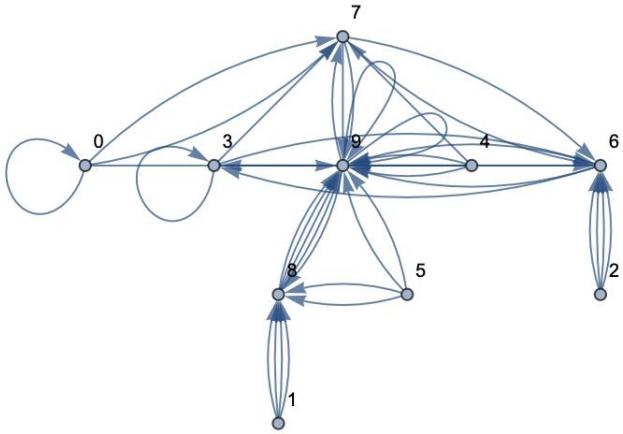
Rewards and costs for Actions

Algorithmic approach

- The Artificial Intelligence being designed within the Cyber Decision Support System is based upon Partial Observable Markov Decision Process (POMDP) modeling.
- We have developed POMDP models for the cyber defense of Enterprise Technology (ET) and Supervisory Control And Data Aquisition (SCADA) and ICS systems.
- We have developed the AI-Engine based upon POMDP forming the basis of the Decision Support System.



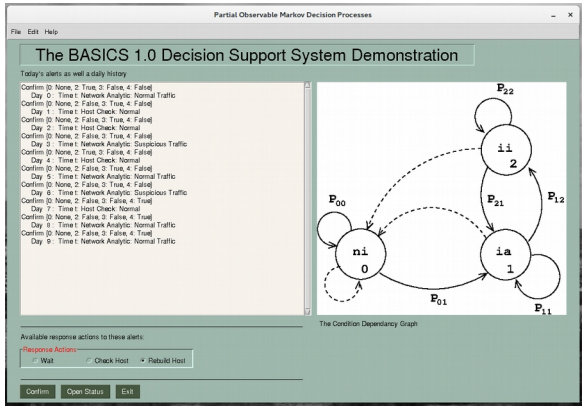
POMDP Modeling



Policy Graph Solutions

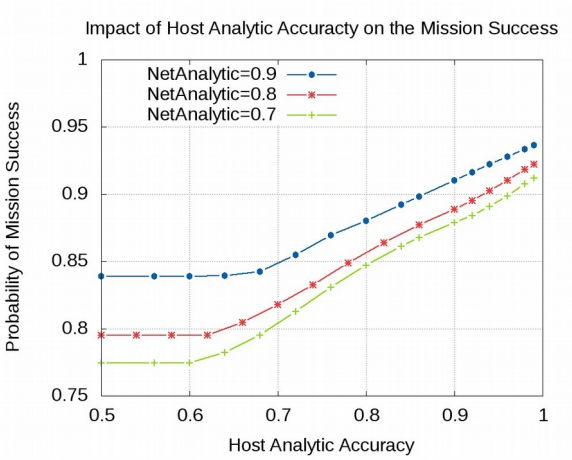
Early Results

- On an early prototype system we have explored the POMDP modeling and results.

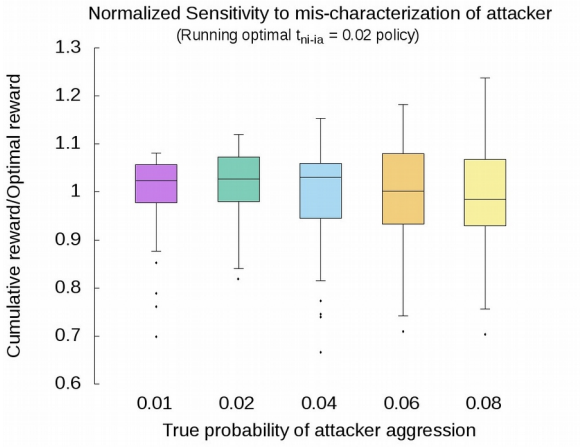


POMDP Simulation and Operator Interface for gaming.

Analytics Assessments

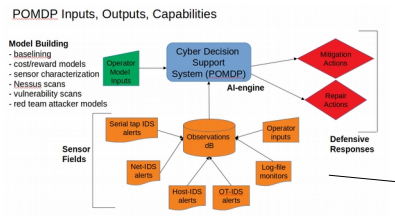


Sensitivity Analysis

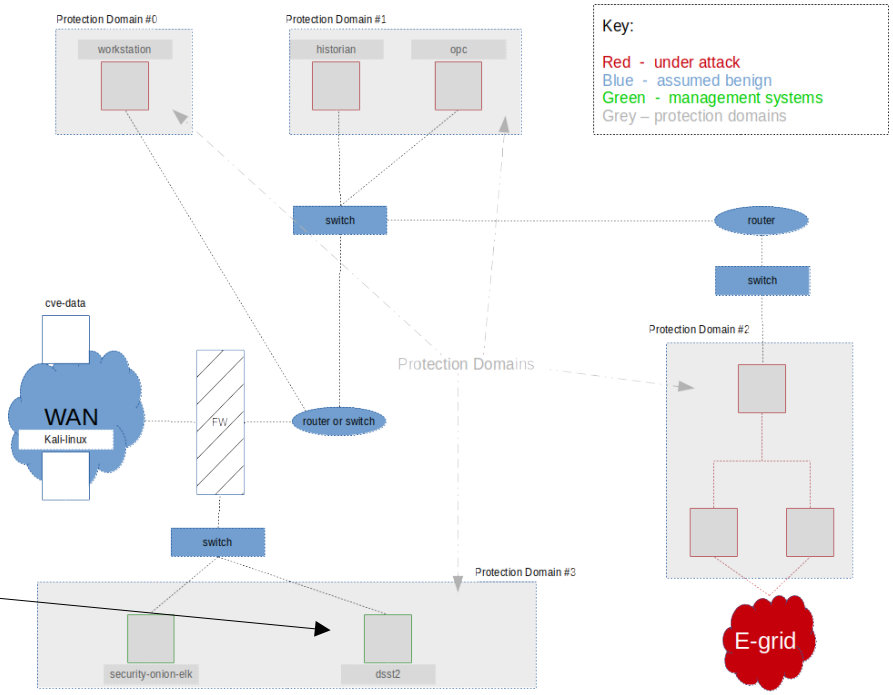


Description of More Data

- We have developed a SCEPTRE emulation model of a slimmed down version of a Department of Defense (DoD) ICS system.
- We have embedded the AI-Engine into our SCEPTRE model for test and demonstration.



Embedded AI-Engine



SCEPTRE ICS Model

Conclusions

- Developing POMDP models for cyber defense is a way to incorporate domain expertise into the AI.
- Need to perform more varied performance studies of the POMDP models in the protection of other ICS domains (electrical, water, pipeline).
- Need to figure out how to incorporate learning into these systems.
- Need to simplify POMDP model building.
- Need to perform human factors studies to determine optimal functional allocation between human and machine.