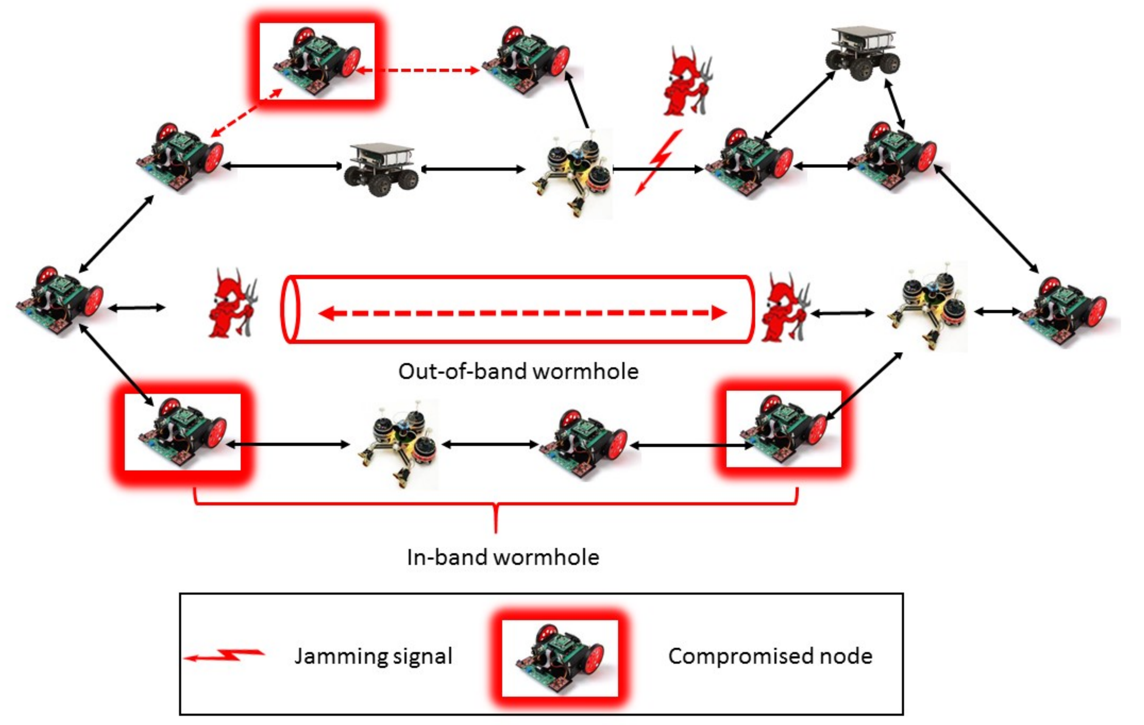
CPS: Breakthrough: Towards a Science of Attack Composition, Mitigation and Verification in Cyber Physical Systems: A Passivity Based Approach (CNS-1446866)

Principal Investigators: Radha Poovendran, Linda Bushnell
Network Security Lab, Department of Electrical Engineering
University of Washington, Seattle {rp3, lb2}@uw.edu

Need for Science of CPS Security

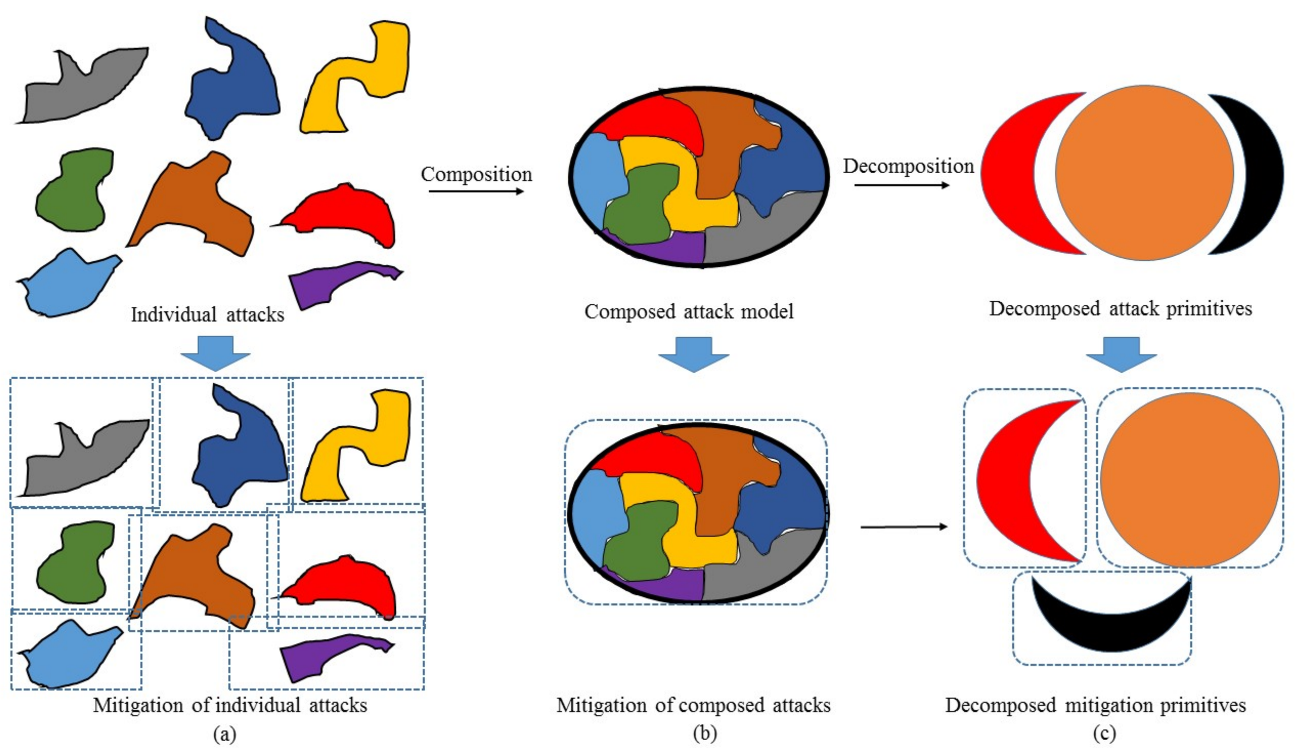


- CPS are inviting targets for intelligent, persistent attacks
- **Composition of multiple attacks** and **development of mitigation strategies** are open problems in cyber security
- Need to **provide verifiable guarantees** of CPS performance and security in the presence of cyber attacks

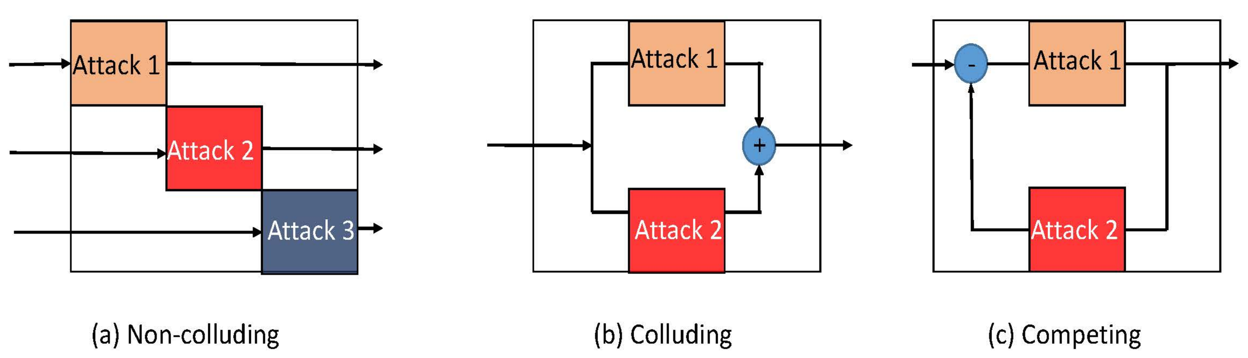
Scientific Questions Addressed

- How to **model intelligent, persistent attacks** and their impact on CPS?
- How to **compose multiple attacks** and develop efficient mitigation strategies against composed attacks?
- How to **verify the mitigation strategies** provide required performance, safety and security of CPS?

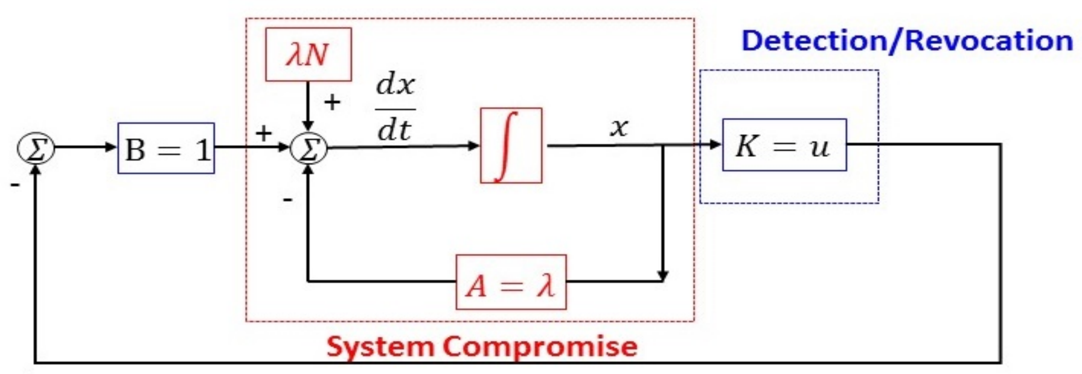
Our Passivity Based Approach



- Provides **composition rules** of multiple adversary models
- Enables **identification of new attack primitives** via decomposition of composed attacks
- Leads to **seamless integration** into dynamical models of CPS
- Adaptive **incorporation of newly-discovered attacks** into composed adversary mode
- Develop techniques for **verification** of passivity-based adversary models and mitigation via **approximate bisimulation**

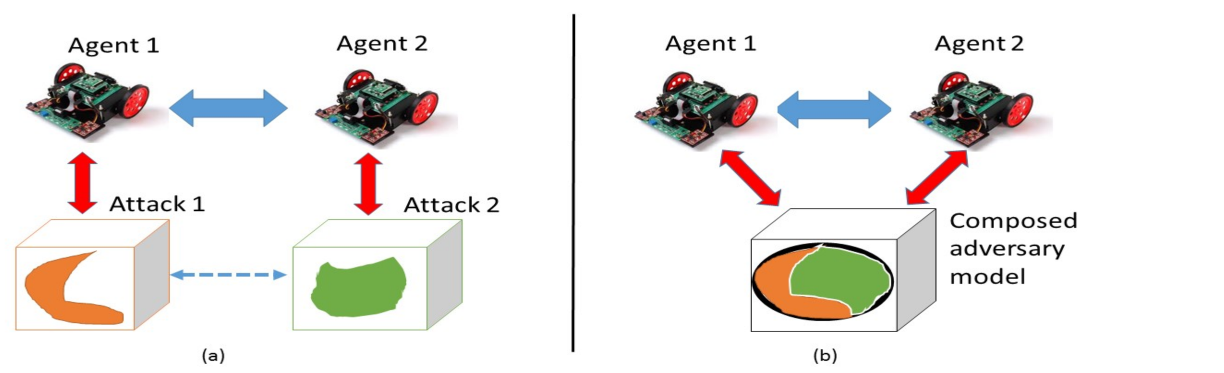


Passivity Modeling of Individual Attacks and Mitigation



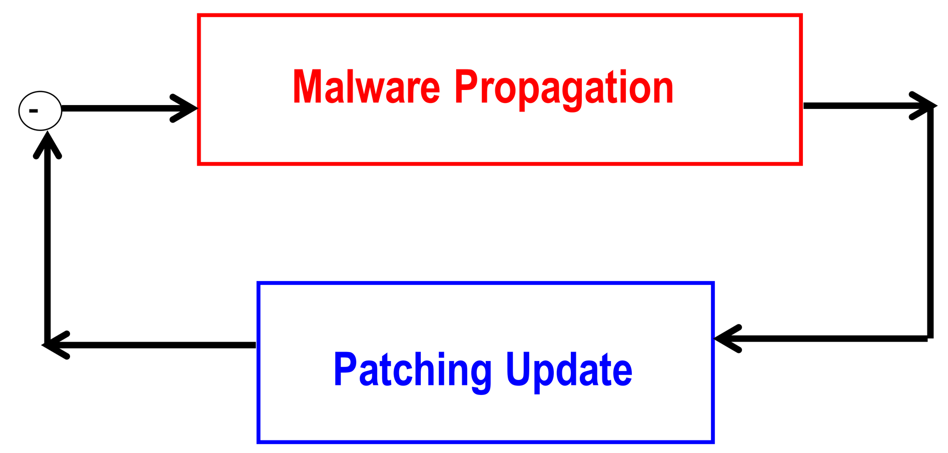
- Formulate **passive dynamical models** representing impact of attack on CPS
- **Identify class of cyber-attacks** that admit passive dynamical representation
- Model the **time-varying mitigation strategy** as passivity dynamical system
- Design mitigation strategy to **guarantee security properties** of CPS

Passivity-Based Composition of Adversary Models and Mitigation



- **Compose attacks** by non-colluding, colluding, and competing adversaries
- Compose attacks targeting distinct, interdependent CPS components
- **Decompose a composed adversary** model into attack primitives
- **Develop efficient mitigation strategies** against composed adversary model

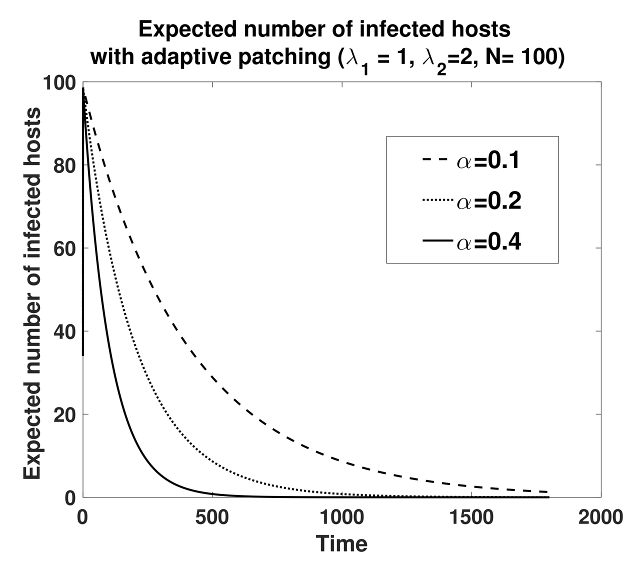
Adaptive Patching Strategy Against Malware Propagation



Propagation rate is assumed to be unknown to the defender

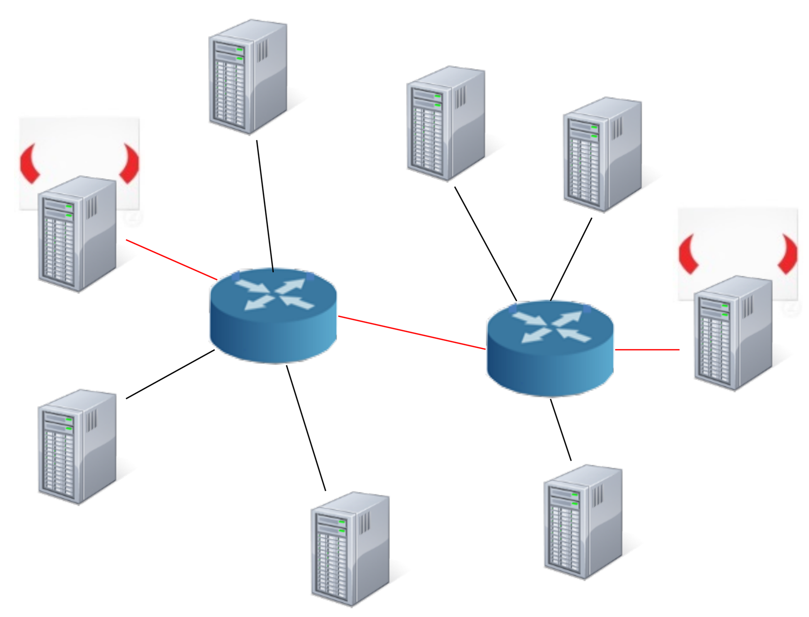
Main idea:

Adaptively update the patching rate when an infection is detected



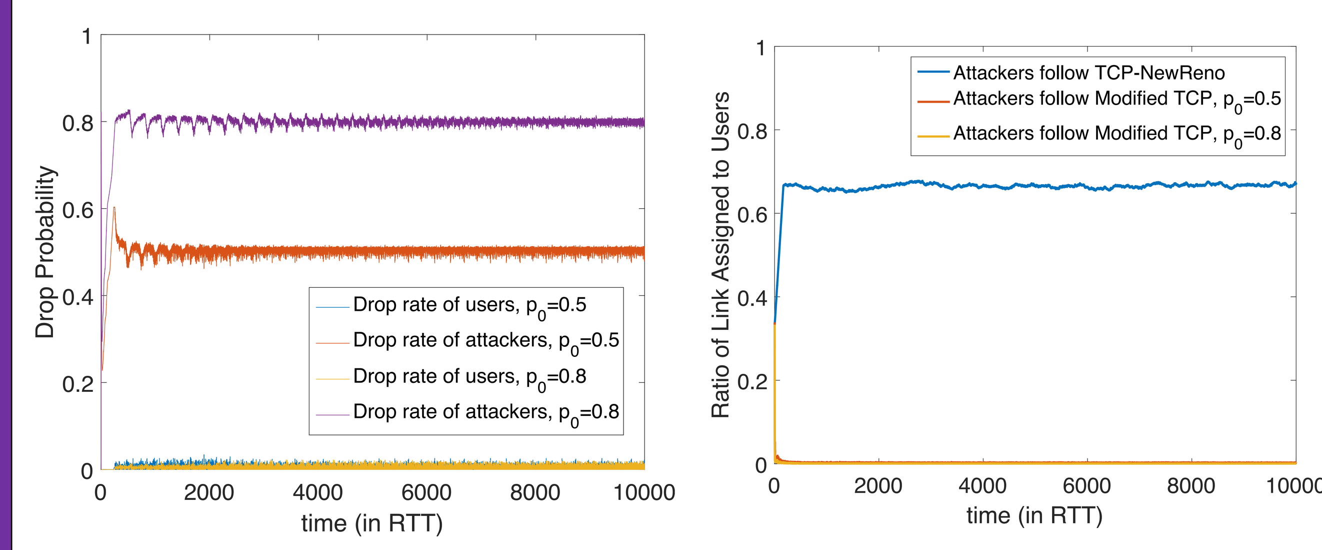
- Proposed **adaptive patching strategies** when propagation rate is **unknown**
- Proved **asymptotic convergence** to the computed equilibrium using passivity-based analysis

CoreMelt Attack



- Attacker sends high volume of data from compromised clients to compromised servers
- Overloads backbone Internet routers, resulting in denial of service for other network nodes

Passivity-Based Approach to CoreMelt



- Developed a Lyapunov-based framework for analyzing the adversary's attack strategy
- Characterized the optimal attack strategy for achieving a desired congestion level for the targeted link
- Proposed mitigation strategies for increasing the bandwidth allocated to legitimate users

References

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[8] G. Yang, H. Hosseini, D. Sahabandu, A. Clark, L. Bushnell, and R. Poovendran, "Modeling and Mitigating the CoreMelt Attack." Submitted to American Control Conference, 2018.