

Cybersecurity via Signaling Games

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This material is based upon work funded and supported by the Department of Defense under Contract No. FA8721-05-C-0003 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

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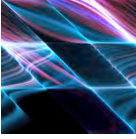
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Problem: Cybersecurity



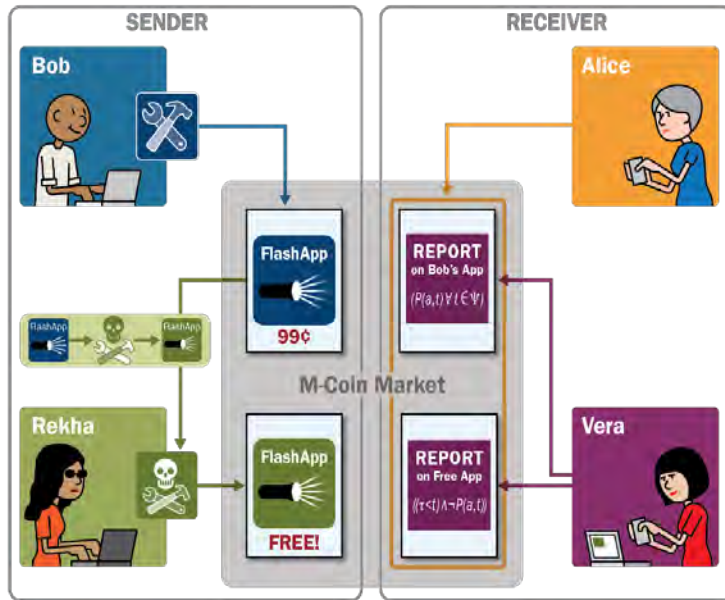
How can we establish trust, manage risk, and mitigate deceptive cyber attacks when our decision-making is constrained to partial information concerning unknown vulnerabilities, system properties, and threats?

Our approach: A fundamental model of human actions and the safety properties they affect.

- **Game-theoretical** model to simultaneously study human and system properties within a social technological systems:
 - Deceptions are definable, allowing risk estimation and policy optimization.
 - Mathematical (and virtual) means to create, explore and design a wide range of mechanisms, including agent based models, simulation, evolutionary games, and analytic calculation of equilibria.

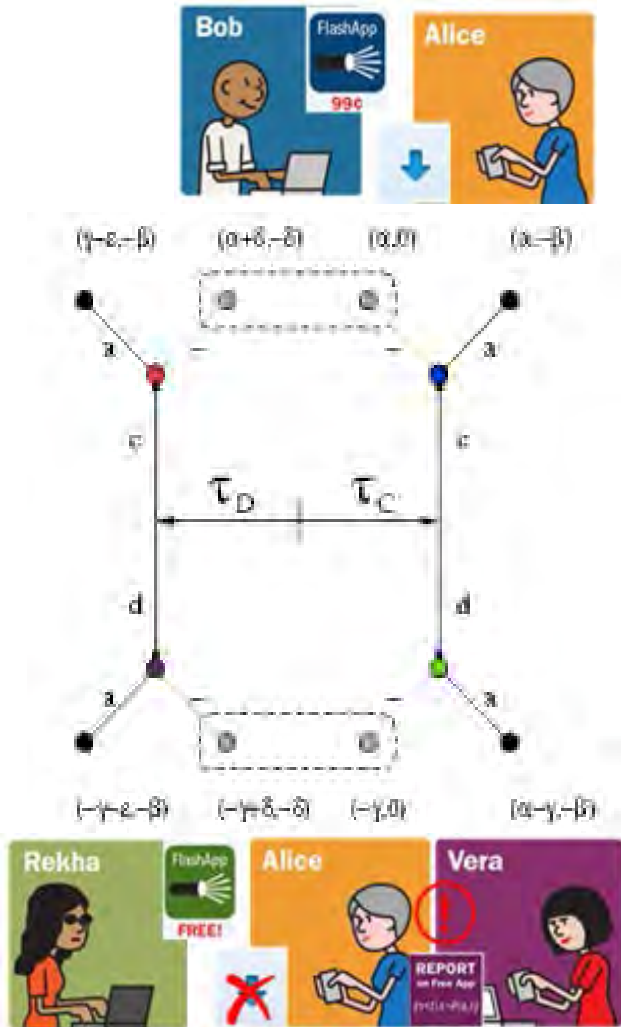


Cybersecurity and the Actions of People



- Information is incomplete.
- Decisions rely on signals (info) available at the time actions are needed.
- Deceptive strategies which leverage information asymmetries arise naturally.
- Many ways to minimize information asymmetries with respect to the desired properties of a system.
- We organizing these into agent types:
 - Recommenders for liveness.
 - Verifiers for safety.

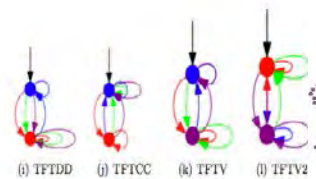
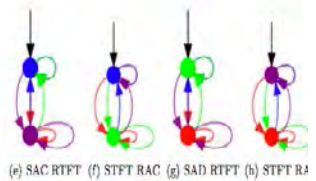
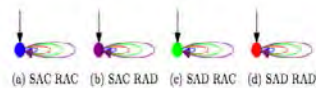
Information Asymmetric Signaling Games



- A signaling game describes a scenario with two players:
 - A 'sender' has a type determined by nature and transmits a signal (information) to a 'receiver.'
 - The 'receiver' having interpreted the signal selects an action with various equity outcomes – result will depend on the sender's type (unknown), their signal, and the receiver action.
- We have specialized signaling game models to:
 - App malware.
 - Multiple vulnerabilities and deceptive exploits.
 - Managing and estimating risks from non-compliance.

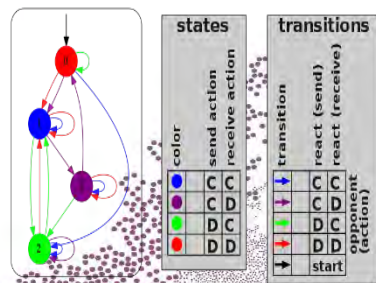
Modeling Cyber and Social Technological Systems

Signaling games are played repetitively in social technological systems. The **deception** or *gap between what ones says and does* is an increasingly important risk factor. We build upon evolutionary game theory (EGT) to describe systems of non-cooperative agents which explore and exploit utilities in cyber.

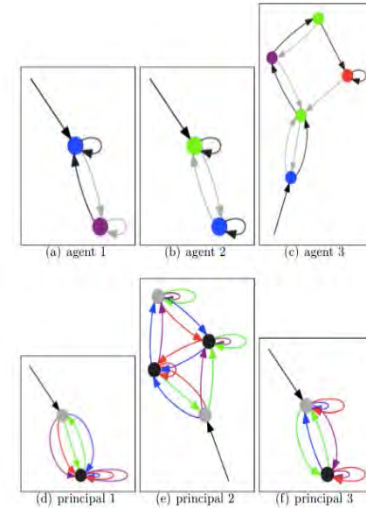
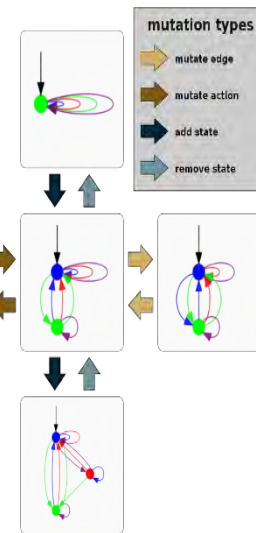


signaling game strategies

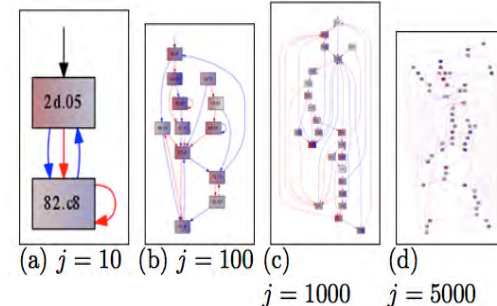
strategy encoded as finite state automata



Strategy mutant network with 10K mutations



Asymmetric compliance strategies

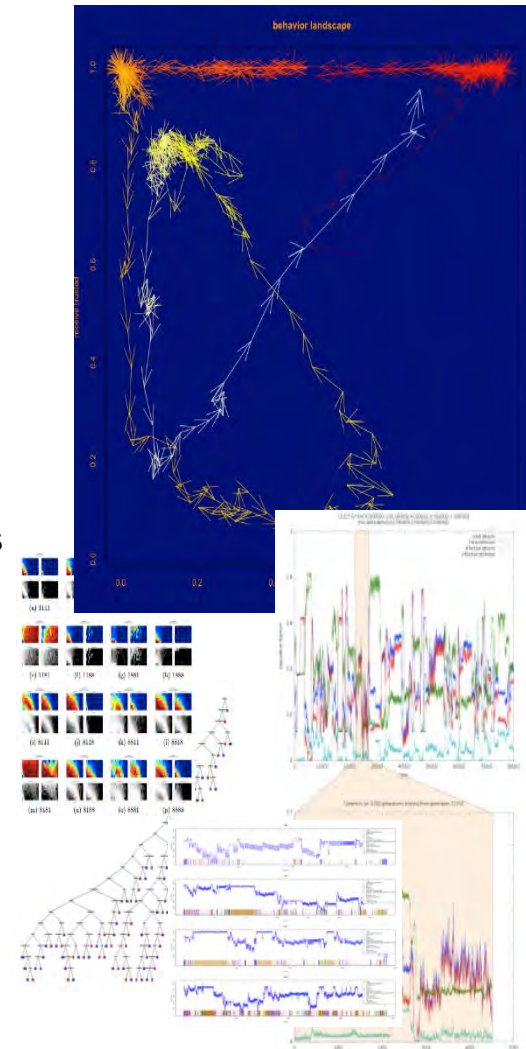


Epistatic Strategies with k-vulnerabilities

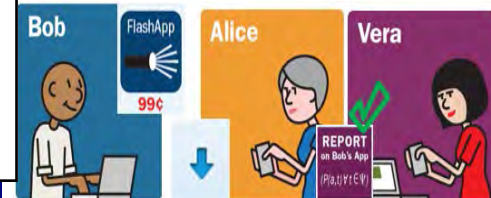
Yielding Understanding of System Dynamical Modes, Emergent Properties, Risk, and Controls



- **"Cyber Security via Signaling Games: Toward a Science of Cyber Security,"** 2014 International Conference on Distributed Computing and Internet Technology. Simulations studies reveals 'talk is cheap and costly signaling via checking market m-coin' is an effective pathway for systems recovery.
- **"Agent-Based Trace Learning in a Recommendation-Verification System for Cybersecurity,"** 2014 IEEE International Conference on Malicious and Unwanted Software. An outline of a ML defenses with a Recommendation/Verifier System that creates agent types for desired properties.
- **"Cyber Security via Minority Games with Epistatic Signaling,"** 2014 International Conference on Bio-inspired Information and Communications Technologies. Preferential early mover advantages have similar effects to maintaining strong global effectiveness measures but will be easier to do.
- **Awarded Best Paper: "Compliance Control: Managed Vulnerability Surface in Social-Technological Systems via Signaling Games,"** 2015 ACM CCS International Workshop on Managing Insider Security Threats. Consider a risk-sensitive control to actuate behavior.

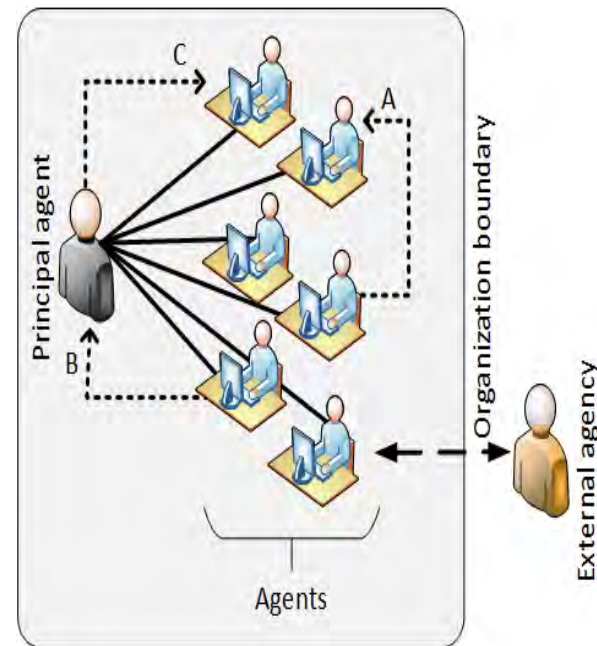
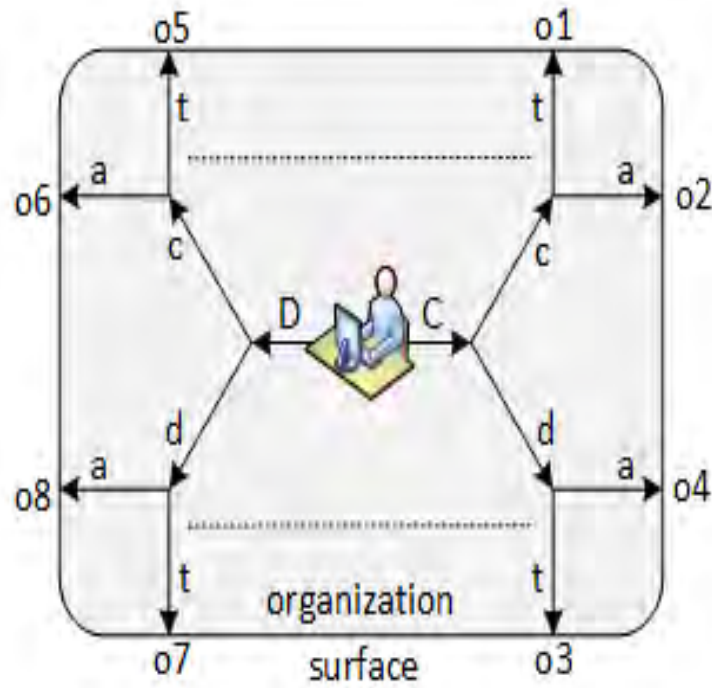


Signaling Game Systems and Behavior Dynamics



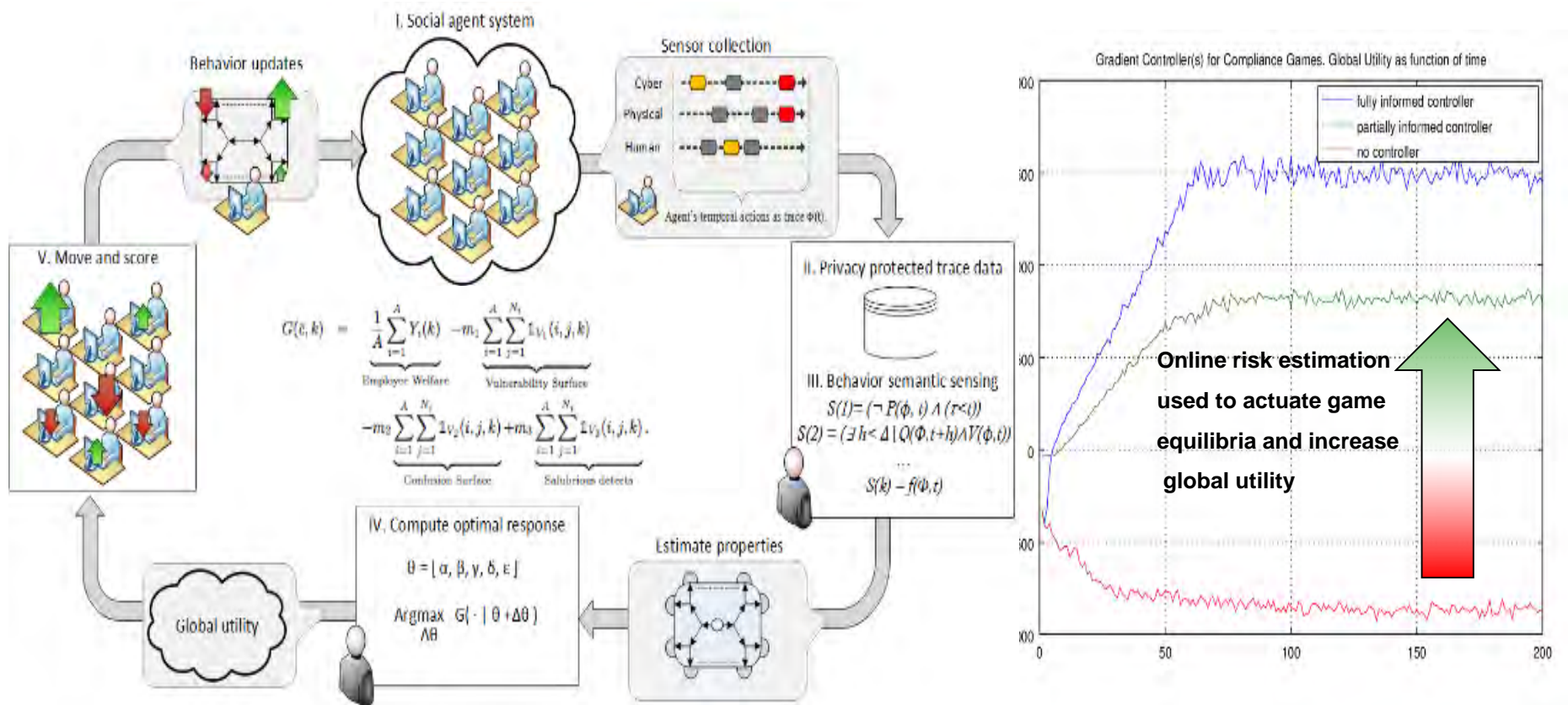
Compliance Control and Managing a Vulnerability Surface

- Game focuses on organizational policies, compliance, and behavioral patterns arising from atomic actions within an organization.
- A deceptive type may optimize a local utility with a non-compliant action. Non-compliance creates vulnerability and confounds risk estimation for a principal.



Compliance Control: Managed Vulnerability Surface

- We suggest a counter-strategy: observable risk measures with a 'honey surface.'
- And create a closed control loop to optimize utility by forming risk estimators from observables and show that in principle: deception is a controllable.



The end, thank you for your interest.

Question?

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