Coordinating Architecture-Based Self-Protecting Systems

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Project Introduction – Problem

Do more for less—budgets are coming under increasing pressure

- Reuse: software architectures and components (off-the-shelf and otherwise)
- Open and common interfaces: better integration between systems

Intent is to achieve economies of scale for producing software

However, cyber attackers also achieve economies of scale for attacking software

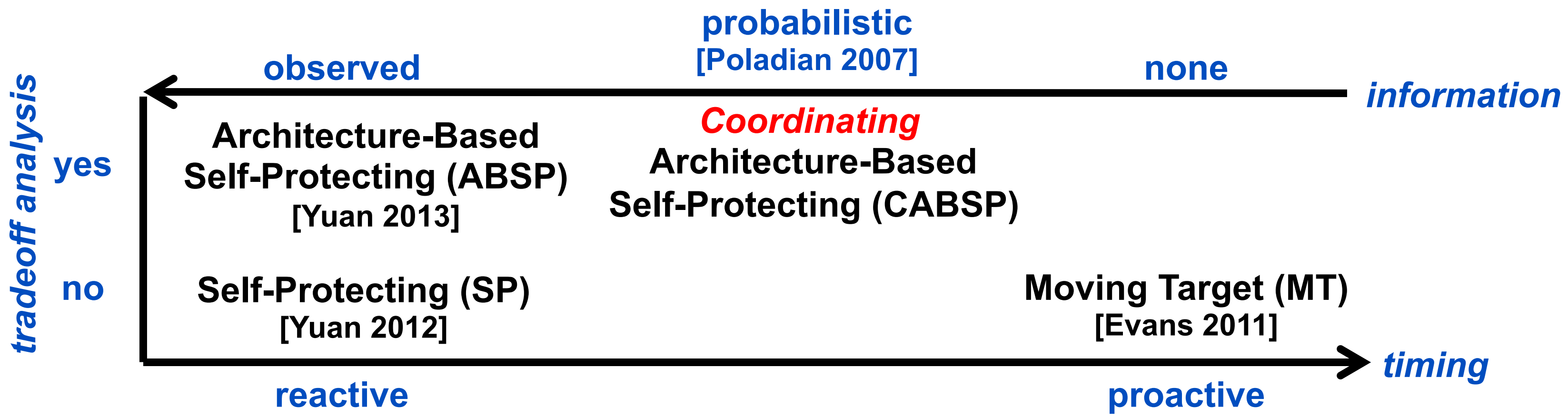
- Increases the pool of potential targets of like systems

Economic disparity

- Producers need to defend against all attacks, *a priori*, for that which is presently known
- Attackers need only to find one exploit in a common part to inflict wide-spread damage

Project Introduction – Solution

Improve the ability to resist attacks on systems with common architectures by sharing threat information and using coordinated architecture-based self-adaptation.



information: observed — probabilistic [Poladian 2007] — none

timing: reactive — proactive

tradeoff analysis: yes — no

Architecture-Based Self-Protecting (ABSP) [Yuan 2013]

Coordinating Architecture-Based Self-Protecting (CABSP)

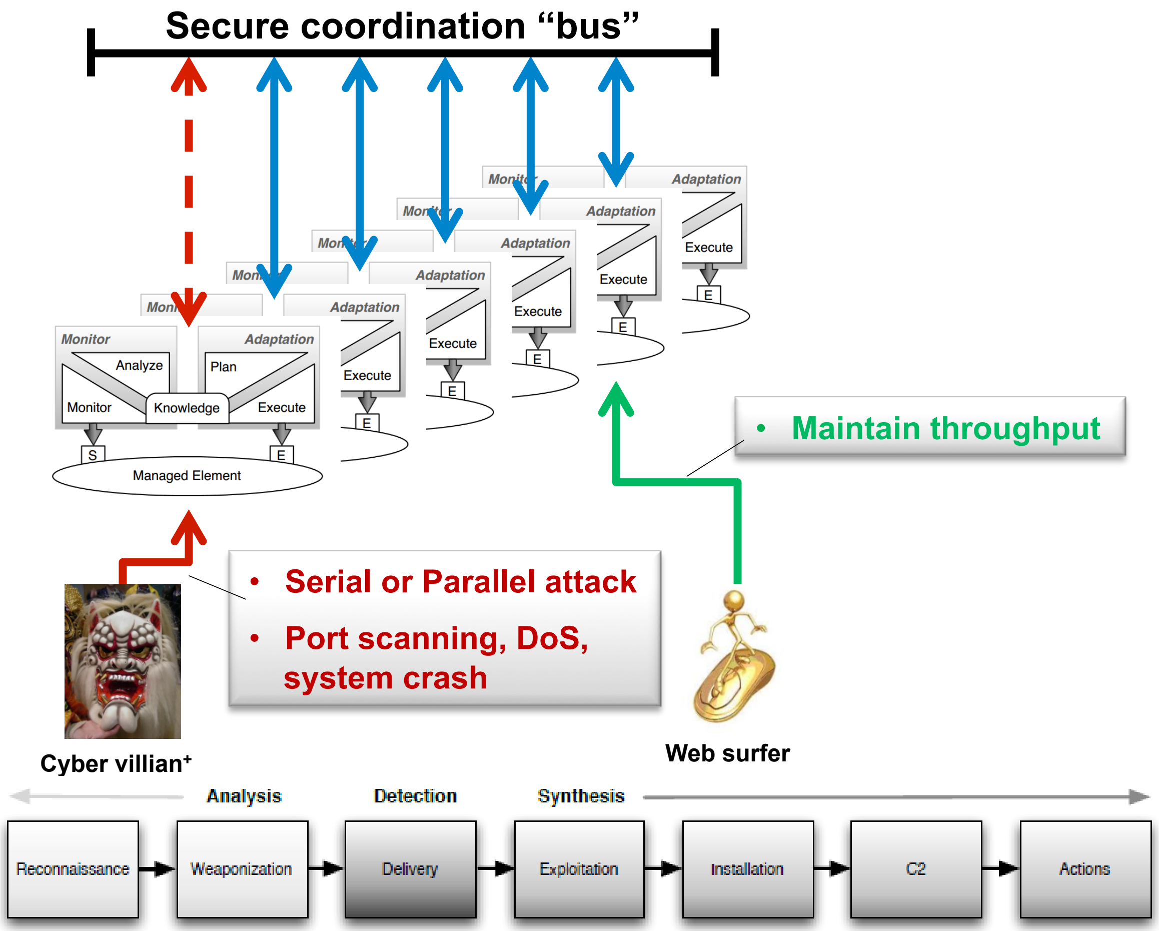
Self-Protecting (SP) [Yuan 2012]

Moving Target (MT) [Evans 2011]

Key idea: exploit commonality to gain a defense advantage

- Coordination based on threat information exchange to enable proactive defense.
- Proactive adaptation allows changes to be done in time to resist the attack.
- Architecture-based adaptation makes explicit quality attribute tradeoffs.

CABSP Proof of Concept



- Serial or Parallel attack
- Port scanning, DoS, system crash

- Maintain throughput

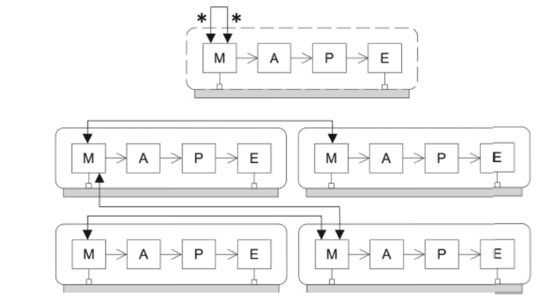


Fig. 5. Top: information sharing pattern. Bottom: concrete instance of the pattern.

MAPE Information Sharing Pattern*

*Weyns, D., Schmerl, B., Grassi, V., Malek, S., Mirandola, R., Prehofer, C.,Wuttke, J., Andersson, J., Giese, H., Goschka, K., On Patterns for Decentralized Control in Self-Adaptive Systems, Software Engineering for Self-Adaptive Systems II, Lecture Notes in Computer Science, Vol 7475, pp 76-107, 2013

legend

→	attack
→	normal use
← - →	published threat
↔	subscribed threat event

Hutchins, E., Clopperty, M., Amin, R., "Intelligence-Driven Computer Network Defense Informed by Analysis of Adversary Campaigns and Intrusion Kill Chains", 6th Annual International Conference on Information Warfare and Security, Washington, DC, 2011.

⁺Image of the Kagura Villain is licensed under the Creative Commons Attribution 3.0 Unported license with attribution to Davmandy at en.wikipedia

Intended results

Goal: Deny the possibility of reusing attacks on systems that use common architectures.

Success evaluation:

- In our CABSP proof of concept consisting of a collection of similar systems:
  - No threat: instances’ and aggregate throughput is higher than with MT.
  - Threat: instances’ and aggregate throughput is higher than with SP.

Produce the following:

- Algorithm for proactive adaptation
  - promoting diversity, and avoiding vulnerable variant when attacked
- Architecture for coordinated adaptation
  - what information and how to exchange it to guide adaptation
- Proof of concept
  - based on Rainbow’s ZNN.com (revised as needed)
  - different defense approaches: MT, SP, CABSP

Team: Coordinating Architecture-Based Self-Protecting Systems

Members

- Javier Camara
- David Garlan
- Jeffrey Gennari
- Scott Hissam
- Mark Klein
- Gabriel Moreno
- Linda Northrop
- Bradley Schmerl
- Greg Shannon

Contributing Work

- CMU's Rainbow (self-adaptation framework)
- SEI's Architecture Tradeoff Analysis
- SEI's Software Architecture Modeling
- SEI's Software Product Lines

Questions

Plan of research

Primary goal: Use CABSP to improve the ability of systems with common architectures to proactively resist attacks.

Hypothesis: CABSP-based systems will maintain higher throughput than systems that use other defenses (e.g. MT and SP).

- Key questions:
  - How and what do we communicate to coordinate adaptation?
  - How do we determine and quantify whether and when an adaptation will be effective in other, similar systems?

Experiments:

- Scenario based
  - Implement proof of concept with specific attack scenarios and different defensive approaches
    - Defense: CABSP, MT, and SP.
    - Attacks: port scanning, DoS, system crash (in series or parallel).
  - Metric: throughput of the collection of systems
    - To maintain high throughput constituent systems must remain alive, and performance overhead must be kept low.