Exposing Trust Assumptions in Distributed Policy Enforcement

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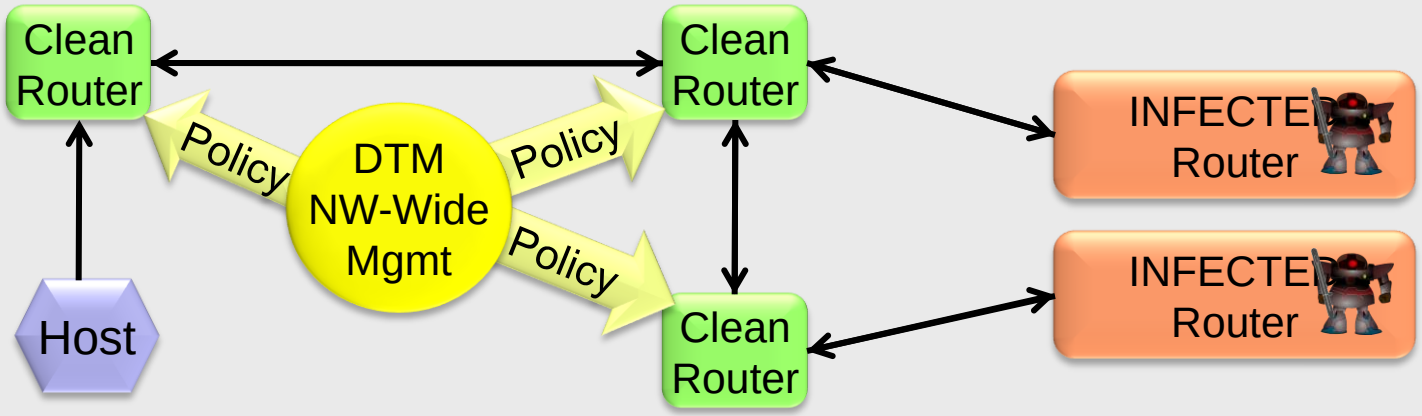
DTM – Motivation

- Distributed system defenses built as “islands”
  - Forced to make assumptions re: topology, other defenses …
    - Locally correct, globally incorrect security enforcement
  - Assumptions fail or are exploited by attackers!
- Our work is motivated by real security incidents experienced first hand
  - **“Pushing Boulders Uphill: The Difficulty of Network Intrusion Recovery” Michael E. Locasto, Matthew Burnside, and Darrell Bethea. In Proceedings of the 23rd Large Installation System Administration (LISA) Conference. November 2009, Baltimore, MD.**
- DTM forces these assumptions in the open, allowing systems to verify them continuously

Dynamic Trust Management

- A COOPERATIVE and DYNAMIC policy evaluation infrastructure that will enable such critical capabilities as:
  - Adaptation to dynamic service availability
  - Complex situational dynamics (e.g., differentiating between bot-net and physical attacks on infrastructure).
- BENEFITS of a Dynamic Trust Management approach
  - Flexible and robust control of authorizations in complex distributed systems such as the DoD/IC GIG
  - The ability to define policies for scalable decentralized defense against emergent cyber-threats by rapid adaptation of resource access limits.



Specific Tasks (Years 1-3)

- Develop language for expressing DTM policies
  - *"Arachne: Integrated Enterprise Security Management"*
    Matthew Burnside and Angelos D. Keromytis. In Proceedings of the *8th Annual IEEE SMC Information Assurance Workshop (IAW),* pp. 214 - 220. June 2007, West Point, NY.
- Design DTM architecture
  - *"Asynchronous Policy Evaluation and Enforcement"*
    Matthew Burnside and Angelos D. Keromytis. In Proceedings of the *2nd Computer Security Architecture Workshop (CSAW),* pp. 45 - 50. October 2008, Fairfax, VA.
- Collaborative/Distributed policy enforcement
  - *"F3ildCrypt: End-to-End Protection of Sensitive Information in Web Services"*
    Matthew Burnside and Angelos D. Keromytis. In Proceedings of the *12th Information Security Conference (ISC),* pp. 491 - 506. September 2009, Pisa, Italy.
  - *"Path-based Access Control for Enterprise Networks"*
    Matthew Burnside and Angelos D. Keromytis. In Proceedings of the *11th Information Security Conference (ISC),* pp. 191 - 203. Taipei, Taiwan, September 2008.
- Medium-size case study
  - In progress at Columbia CS Department

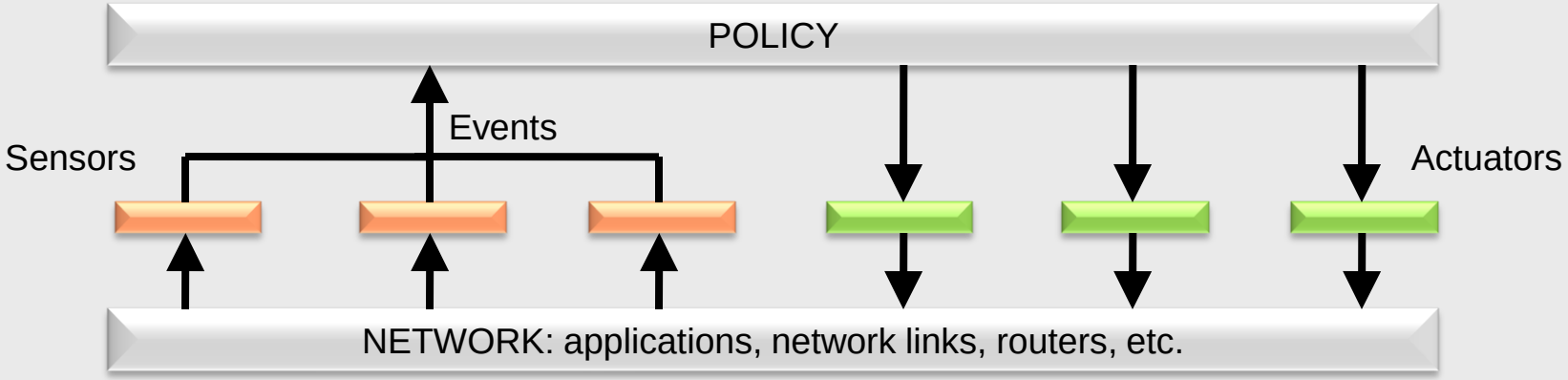
Contributions

- Framework for integrating all types of defenses
- Proof of feasibility
  - Prototype, preliminary performance, security analysis
- Initial exploration of design options
- Education (GRA training, coursework integration)
- Outreach (collaboration with Symantec)

Overall Approach

- Define policies that take into consideration system-wide context
  - Extend security mechanisms to emit contextual information (continuous or event-based)
  - Distribute information to interested components
- Integrate IDS/ADS, access control, reaction
- Challenges:
  - Accuracy (extracting data from noise)
  - Complexity (defining policies)
  - Performance (scale with users, system, events)

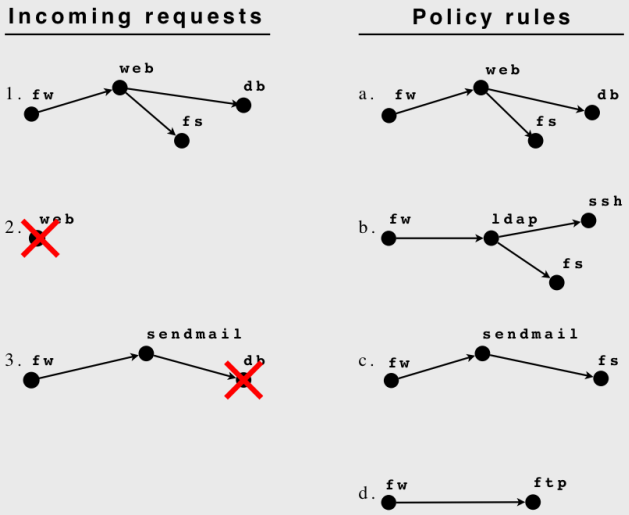
Arachne

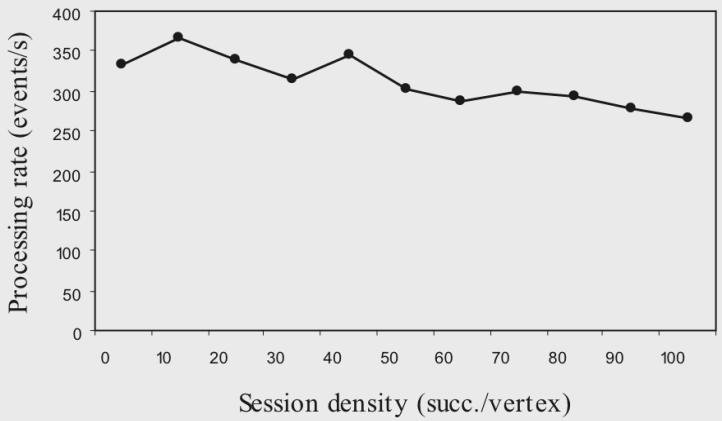


- ARACHNE is a system for the coordinated distribution and evaluation of a system-wide policy on different nodes
  - Several prototype systems for enterprise-level security have been developed
- GOAL: Integrate a variety of different, diverse security mechanisms and policy expression methods
  - Achieve enhanced protection over any individual method
  - Allow exchange of information between different mechanisms (Eliminate the possibility of “locally correct” but globally wrong decisions
  - Capture trade-offs between amount of global context, scalability, etc.

Arachne

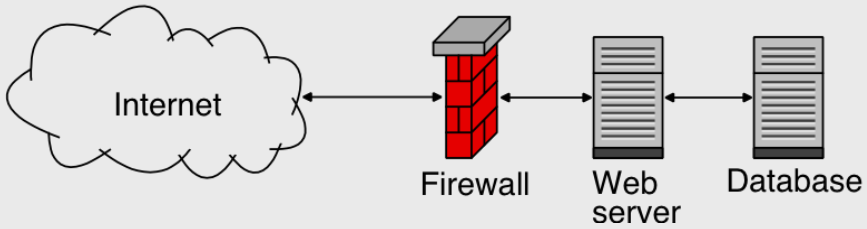
- Simple publish-subscribe backend
  - Policies consume and produce events, may revisit decisions based on new information
  - "Sessions" group related components
  - Graph-based policies, can be learned and refined





Other work

- Path-based policy enforcement
  - Simplification of Arachne (weaker properties, higher performance), well suited for web SOAs



- Selective data protection in web SOAs
  - Limit data theft/leakage risks by using web client as vantage point that encrypts data to specific SOA components
- Study of Rogue Antivirus sites (with Symantec)

Lessons Learned

- Coordinated defenses appear to be feasible
- Writing policies from scratch is hard
  - Exposing assumptions requires people to think about what assumptions they are making
    - Not always obvious!
- Learning interaction policies is promising
  - Someone still needs to define component policies
- Performance does not appear to be show-stopper
- Accuracy remains to be seen (current focus)

Outreach and Education

- Integrated material into COMS W4180 course
- 2 invited talks (beyond conference talks) and 1 panel
- Main Ph.D. GRA now working for NSA
- Working with Symantec to determine modus operandi of rogue AV sites (and why users trust them)
  - Preliminary results published in the October 2009 Interim Symantec Threat Report (ISTR)

"Gone Rogue: An Analysis of Rogue Security Software Campaigns" Marc Cova, Corrado Leita, Olivier Thonnard, Marc Dacier, and Angelos D. Keromytis. To appear in the Proceedings of the *5th European Conference on Computer Network Defense (EC2ND).* November 2009, Milan, Italy. *(Invited paper)*

Future Directions

- Continue work on refining architecture and system
  - Explore performance/scalability, effectiveness, overhead tradeoffs
- Integrate with QTM
  - Particularly important in federated systems (e.g., dynamically composable SOAs)
- Large-scale case study

Future Directions

- Investigate the use of reactive mechanisms
  - Global coordination of dynamic defenses

- Investigate the use of active deception
  - Possible integration into NCR

Expected Contributions in Years 4 & 5

- Proof of feasibility
  - Experimentation in real environment
- Exploration of design and implementation space
- Use of active defenses and deceit
  - Can we challenge attackers' (trust) assumptions?

Summary

- Exploring systems that allow (and require) explicit assumption (trust) declarations
- All deliverables on track (or done) for Years 1-3
- Interesting new directions and capabilities to be explored in Years 4-5