What Next in Intrusion Tolerance

29 June 2009

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3rd Workshop on Recent Advances in Intrusion Tolerant Systems
DSN 2009

Outline

- Intrusion Tolerance and Survivability
- Achievements so far
- Emerging software technologies
- New challenges and issues
- Potential way forward
- A concrete example: electric grids
- Conclusion

Generations of Security Research

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No system is perfectly secure– only adequately secured with respect to the perceived threat.

Prevent Intrusions
(Access Controls, Cryptography, Trusted Computing Base)


Trusted Computing Base


Access Control & Physical Security


Cryptography

But intrusions will occur

1st Generation: Protection

Detect Intrusions, Limit Damage
(Firewalls, Intrusion Detection Systems, Virtual Private Networks, PKI)


Firewalls


Boundary Controllers


Intrusion Detection Systems


VPNs


PKI

But some attacks will succeed

2nd Generation: Detection

Tolerate Attacks
(Redundancy, Diversity, Deception, Wrappers, Proof-Carrying Code, Proactive Secret Sharing)


Intrusion Tolerance


Big Board View of Attacks
Real-Time Situation Awareness & Response


Graceful Degradation


Hardened Operating System

3rd Generation: Tolerance and Survivability

Survivability and Intrusion Tolerance

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Premise

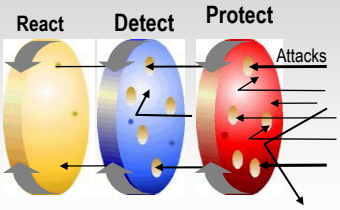
- The number & sophistication of cyber attacks is increasing – some of these attacks will succeed

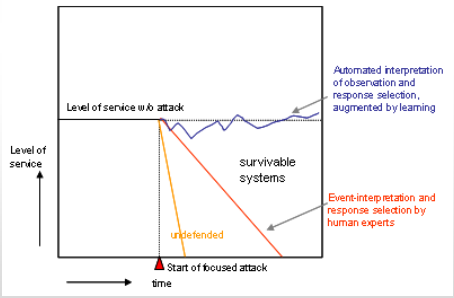
Philosophy

- *Operate through attacks* by using a layered defense-in-depth concept
  - Accept some degradation
  - Protect (C,I, A) of most valuable assets (information, services, …)
  - Move faster than the intruder

Approach

- "Defense Enabling" Distributed Applications
- Survivability architecture





- Exploring beyond degradation-- regain, recoup, regroup and even improve
- Semi-automated: Survivability architecture captures a lot of low level (and sometimes uncertain and incomplete) information – utilizes advanced reasoning and machine learning

Achievements So Far

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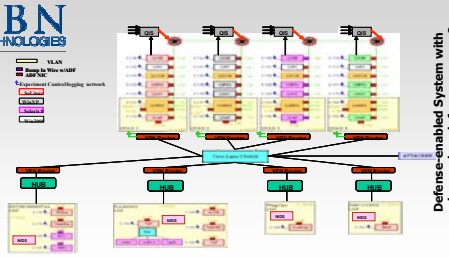

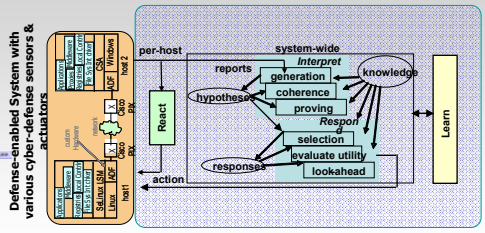

Military (USAF) Joint Battlespace Infosphere (JBI) information management system exemplar made survivable and subjected to sustained attacks over several weeks by multiple independent red teams

Results

- The system survived 75% of attacks
- Of those that succeeded,
  - Average time to failure was 45 minutes
  - Vs. immediately in the unprotected system
  - Minimum of 10 minutes to failure
  - Required combinations of attacks
- Adaptive defenses added 5-20% overhead to call latency

Challenge: Develop automated mechanism that would interpret the reports and decide the effective course of action

CSISM Approach: 3 level decision making- reactive, deliberate and learned; use theorem proving and coherence to reason about accusatory and evidentiary information contained in reported events

Results

- Possible to minimize expert involvement
- Reasoning about accusatory and evidentiary information wrt encoded knowledge
  - Made correct decision in ~75% cases in red team exercises
  - Compute intensive
- Integrating learned responses online needs additional research

Emerging Trends

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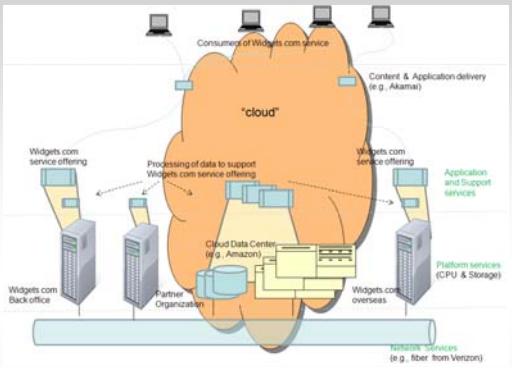
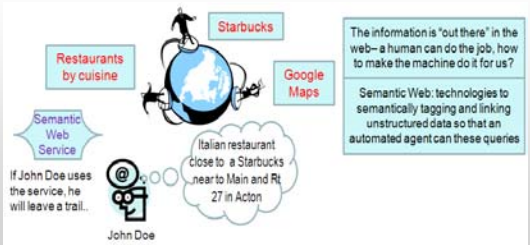
CLOUD: Somebody else's data center

Compute, storage, communication
Scale, Provisioning
Dynamism

SOA: Think information systems in terms of services: as opposed to algorithms, protocols, data structures, objects… is it really a new think?

Loose coupling
Externalization
Reuse and dynamism





Semantic Web: Automate associating or relationship discovery in available data based on semantics

Semantic tags, Linking and Link Chasing
Mash ups

Things that will improve

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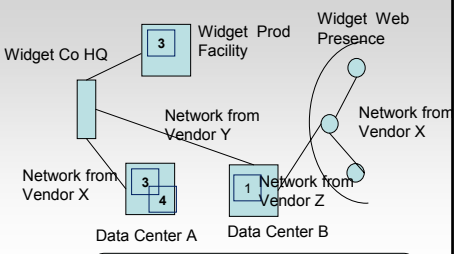
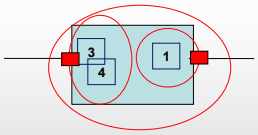
- Defense in depth
  - Buy protected, guaranteed connectivity from Verizon
  - Buy storage and servers from Amazon
  - Diversity (different cloud vendors), Dynamic, Cheap(er)



1. Svc for sales force management
2. Svc for supply chain
3. Svc for pay roll management
4. Svc for HRM

- Access control to networks, CPU, storage
  - Cloud owner's revenue depends on it



- Situation Assessment Reasoning
  - Semantic correlations and patterns

Things that will remain challenging…

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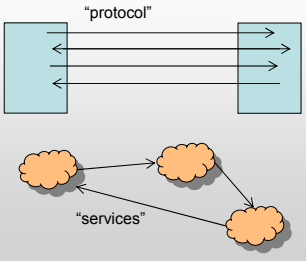
- Validation and trust
  - How to validate security and intrusion tolerance of a service offering?
  - How to judge trustworthiness of cloud?

- Accountability
  - Tasks that used to be "internal" to an organization, will now span multiple organization boundaries
    - Organizations will log and audit
    - But may be mismatched



New Challenges

- Data protection
  - Social networking model
  - Encrypt before storing
  - Data gleaned while your process executes?
  - Leakage through semantic linking?
  - What about metadata?
- Service Management
  - End to end security:
    - Orchestration, (re)provisioning of cloud resources
    - What happens when failures cannot be masked within?
    - Externalization may not always be good!
- Regulatory Issues
  - Privacy
  - Detecting, deterring bad guys while facilitating legitimate use
    - Cloud offering encrypted storage
    - Communication vendor offering encrypted guaranteed bandwidth

Potential Way Forward

- Service-oriented Security
  - What does crumple zones mean for services?
  - Service-layer VPGs
  - Service conglomerates
- MILS
  - Inside a cloud
  - VM techniques
- Online Continued Indicator of Assurance
  - Quality of assurance
- Securing Digital Objects
  - Encode access control and authentication policies as metadata
  - Leverage Service Orientation and fast networks
- Practical Privacy Preserving Schemes
  - Crowds
  - One time codes

A Concrete Case

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- Grid modernization
- Role of information systems
- Emerging software technologies
- But what about Intrusion Tolerance?

Conclusion

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- Intrusion Tolerance
  - Still important, probably more so now…
  - Going mainstream (plug for the panel)
    - Has it? Going to?
    - Impediments? Accelerators?
  - Bottom-line: need to constantly update itself
    - Arms race against the adversary
    - Advanced technology helps the attacker as well
    - Beware of bandwagons!