The George Washington University
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SEAS
School of Engineering and Applied Science

Intrusion Detection

Issues and Technologies

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Detecting Intrusions

- Detection is one phase of security engineering
  - Protect --- Detect --- React/Correct
  - Important to detect problems in environment
    - Rarely do problems exist in only one domain
  - Detection plan must include all security domains
    - Including but not limited to networks
- Things to detect
  - Occurrence of problems
    - Both those that you protected against and those you didn’t protect against
  - Failure of protection mechanisms
  - Use of counter-detection methods or techniques by adversaries

Intrusion Detection Systems

- Critical tool for detecting intruders in networks and systems
- Key things to consider:
  - What isn't a network today?
  - How much data is processed over networks?
  - If you tracked every single action in a computer system:
    - How much data would you collect?
    - How much processing overhead would you incur?
    - How would you analyze the data that you did collect?
  - If you decided not to track every single action:
    - Which ones would you track?
    - How would you protect the collection & storage processes?
    - How would you protect the analysis & reporting processes?

Types of IDSs

- Basically two types:
  - Manual
  - Automatic
- Manual
  - Someone sitting at a terminal monitoring the activities that are going on
  - Chances of success predicated on looking in the right place at the right time
  - Usually as a result of some sort of suspicion or tip
- Automatic
  - Collecting data on everything and running it through analysis tool

Manual Examples

- Cliff Stohl
  - "Cuckoo's Egg"
  - Used printers, beepers, and manual analysis
- Bellovin and Cheswick
  - "Firewalls and Internet Security"
  - Used manual traps, tricks and analysis
- Tsutomo Shimomura
  - "Takedown"
  - Used manual traps, tricks, and analysis augmented by specially designed technologies
- What's an ordinary net admin to do?

Essential Elements of IDS

- Success intrusion detection can be based on 1 or more of:
  - Audit trail processing
    - What data can be derived from an audit log of system activity to detect intrusions or access violations?
  - On-the-fly processing
    - What data is available right now to provide clues to behavior?
  - Profiles of normality
    - What's okay behavior, anyway? What predictive descriptions can be used to help identify abnormal behavior patterns?
  - Signatures of abnormal behavior
    - What's not okay behavior? How can it be spotted? Patterns?
  - Parameter pattern matching
    - Can patterns be derived that identify intrusions?

Audit Trail Processing

- System operators identify security critical events
  - When one of these events occurs, a record of that event is stored
    - Who, when, what, where, etc
  - Examples of candidate auditable events:
    - File open, file read, file write, file delete, file privilege modification
    - File creation, file removal, failed executions
    - Login attempts, unsuccessful logins, change of password
    - Adding a user, removing a user, changing a user's privileges
    - Adding a group, changing a group, deleting a group, changing a group's privileges
- Problem:
  - The more events are audited, the more data is generated
  - The more data is generated, the more data needs to be analyzed

Audit Log Analysis

- When looking at audit logs from a system, look for:
  - Users logging on at strange hours
    - Assuming you have some clue as to what normal is, and what time zone the user is currently in
  - Unexplained reboots
  - Changes to system clocks
  - Unusual error messages from mailers, daemons, or servers
  - Failed logins based on bad passwords
    - Especially multiple attempts
  - If Unix, unauthorized use of *su* command
  - Users logging in from unfamiliar sites

On-the-fly processing

- Fastest analysis of data collected in real time
  - What data is available right now to provide clues to behavior?
  - Data collected of security events is analyzed immediately
    - Limiting functions include processing speed and memory
- Attributes
  - Provides indications and warning of potentially harmful events, giving system time to protect against real harm or damage
  - Analysis is simplistic in nature in order to maximize speed
    - Complicated analyses can’t be performed because they require too much data and take too long to run
  - Some data may be lost in rush to process
  - Capacity is much smaller than off-line analysis functions

Real Time Processing

- Data has to be gathered
  - Packet diversion to analysis function
    - By firewalls, routers, gateways, etc
    - Based on headers, routing tables, access lists, or other applications
  - Network sniffing
    - Tap the network by listening in promiscuous mode
      - Accepts all traffic along a certain pathway
    - Legal restrictions apply in some circumstances (like at an ISP)
- Data has to be analyzed, fast
  - Limited to looking for actual actions in real time
  - Can’t detect subtle long term attacks that are in the noise

Profiles of normality

- Based on understanding how users operate normally
  - What's okay behavior, anyway?
  - What predictive descriptions can be used to help identify abnormal behavior patterns?
- Implies
  - Database of user profiles
    - Which must be protected from modification
    - Which is resistant to "training"
  - Comparison of expected activity to actual activity
    - Some time delay in this analysis
    - The allowable deviance must be understood ahead of time

The IDES Model

- Published in mid 1980s by Dr. Denning
- An intrusion detection system is comprised of a six-tuple mathematical object
  - Subjects, objects, profiles, audit records, anomaly records, alarms
  - What these are
    - Subjects and objects are the initiators and targets of activity
    - Profiles are the models of behavior
      - Often based on statistical models of past behavior -- ‘training’
    - Audit records are captured security events or observed behavior
    - Anomaly records are programmed decisions based on intrusion analysis
    - Alarms are how the potential problems are reported
- Example: detecting toll fraud

Detecting Toll Fraud

- Subjects and Objects
  - Caller and callee (be it a person, PBX, or other end process)
- Profiles of normal usage
  - Based on past behavior patterns, expected behavior patterns
  - Some calling patterns would be abnormal no matter what
    - Late night calls to certain numbers
- Audited activities
  - Calls
    - From, when, where, to
- Automated response patterns based on previous decisions
  - Reconfiguration of service, including outbound access

Signatures of abnormal behavior

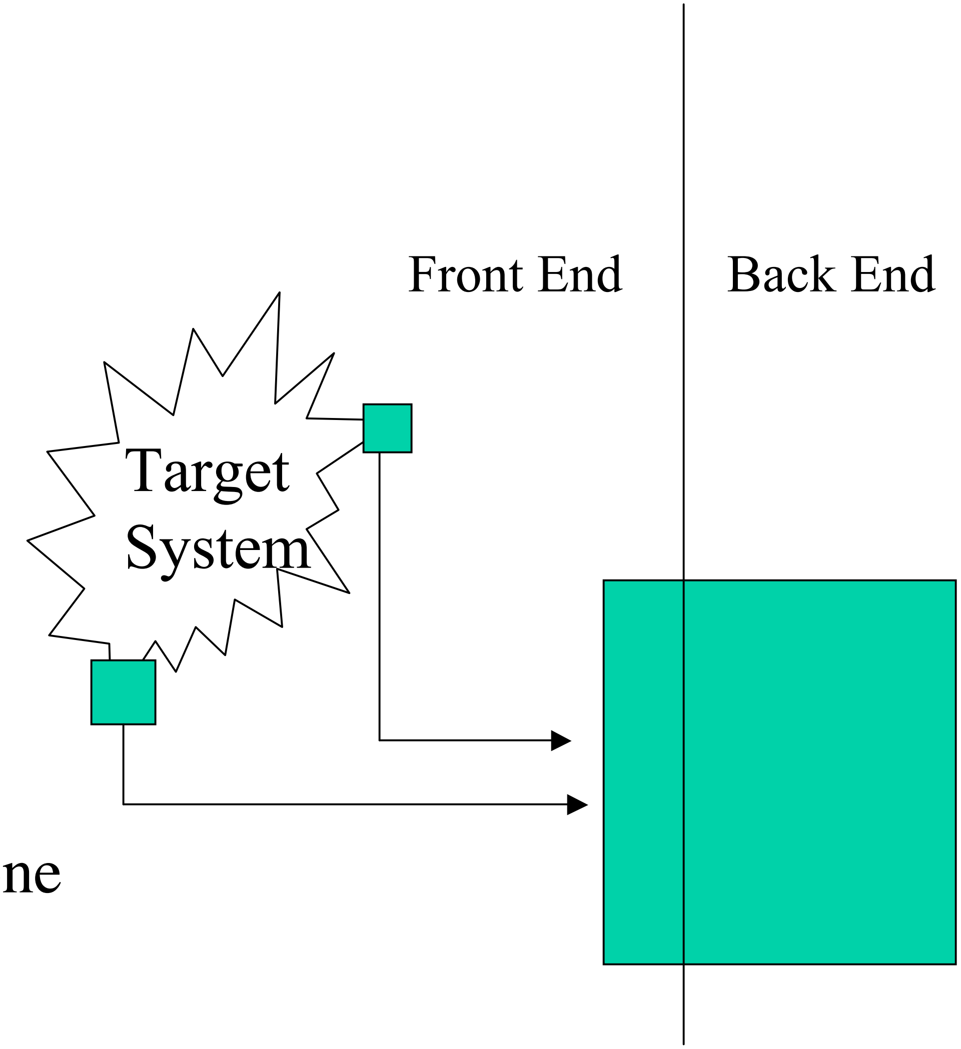
- A method of detecting attacks rather than deviations from expected behaviors
  - What's not okay behavior? How can it be spotted? Patterns?
- Two variations
  - Attack signatures
    - A known set of activities that are highly correlated with attack activity
    - Usually a set of behaviors related in time sequence
    - Good source of these are hacking sites on the 'net
  - Select character strings
    - Anti-viral software makes use of these strings to detect viruses
    - Also includes certain activities that require a set of commands in a specific order
      - Firewalls use this to detect hostile intrusion attempts

Parameter pattern matching

- Very subtle
  - Can patterns be derived that identify intrusions?
  - Relies on monitoring a wide variety of system and network attributes
  - Useful when normal operational behavior cannot easily be characterized
- Most successful implementations
  - Based on humans viewing data presentations
  - Some success with data mining applications
  - Some limited success with AI in the research community

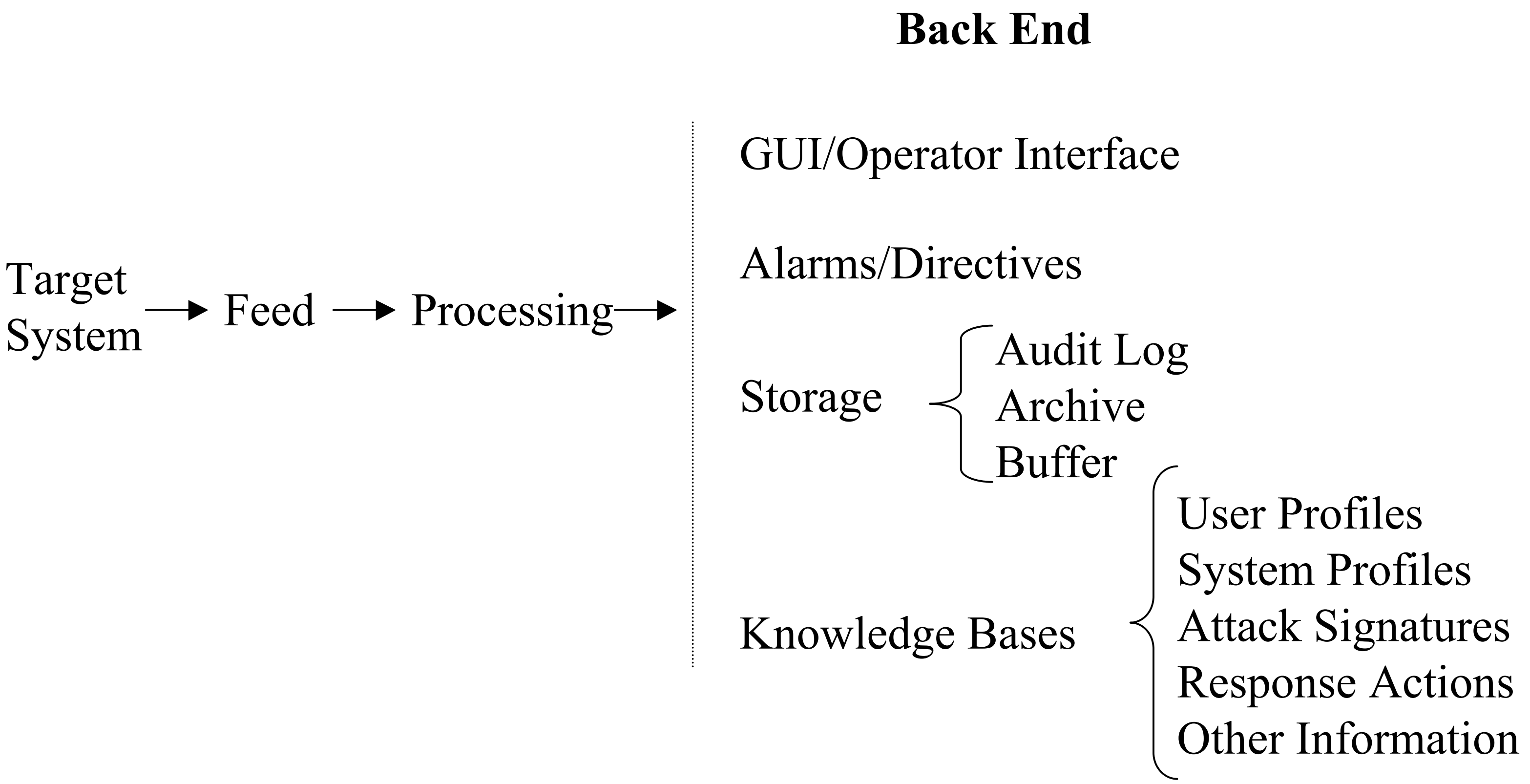
IDS Architectural Elements

- Knowledge base
  - Potential problems, etc
- Functional components
  - Target system
  - Feed
  - Processing
  - Knowledge Base
  - Storage
  - Alarms
  - Operator Interface
  - Comms infrastructure backbone



Back End Elements

- Architectural elements that support functionality
  - Knowledge base(s), Storage, Alarms, Interface, Comms Infrastructure



Back End

Target System → Feed → Processing →

GUI/Operator Interface

Alarms/Directives

Storage
- Audit Log
- Archive
- Buffer

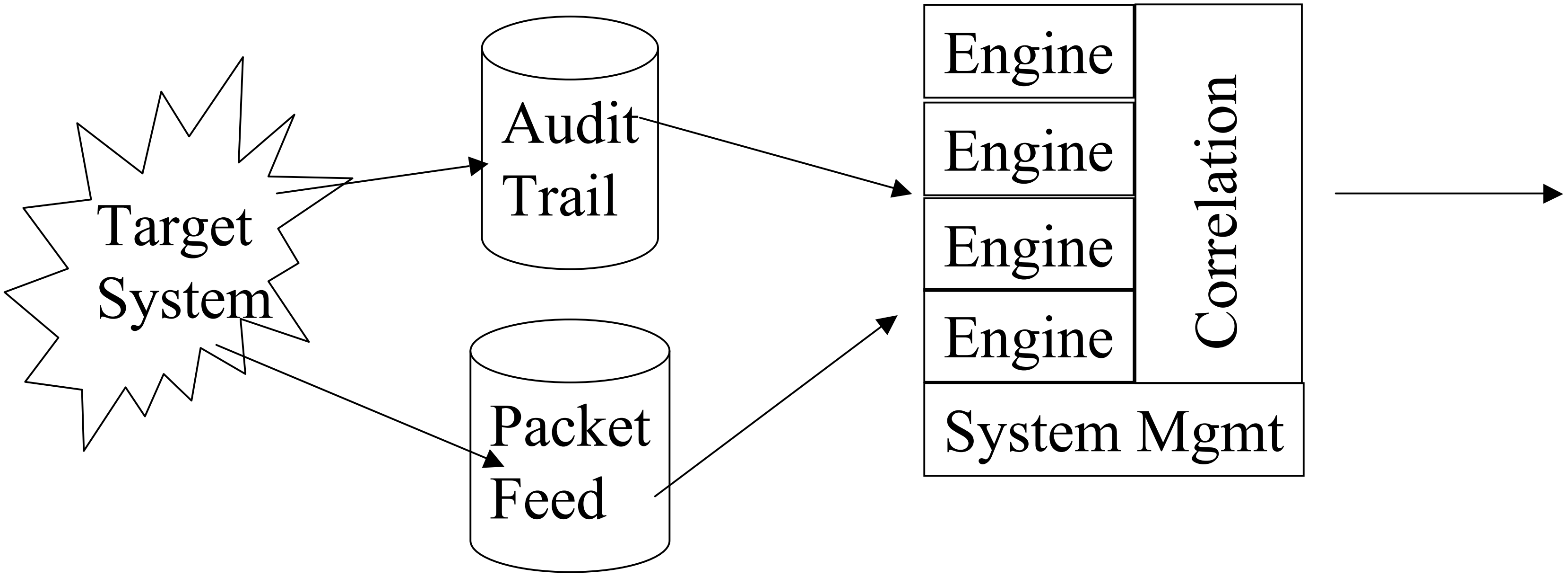
Knowledge Bases
- User Profiles
- System Profiles
- Attack Signatures
- Response Actions
- Other Information

Back End Considerations

- Design Considerations
  - Knowledge Bases
    - Potentially contain normal and abnormal descriptions of user and/or system operational patterns
  - Alarms
    - Human Terminating Alarm
    - Automated Process Terminating Alarm
    - Hybrid
  - GUI/Operator Interface
    - Enable rapid operator response, present information clearly and unambiguously, avoid clutter, simple and easy response initiation
  - Comms Infrastructure
    - Reliable and secure both within the system and between components

Front End Elements

- Feeds and Processing Engines
  - Feeds transfer collected information to the processing component of the IDS
  - Processing suite contains the engines/filters, the system management, and the correlation elements



Front End Architecture

- Feed Considerations
  - Type(s) of target system
  - any real time response requirement
  - network capacity
  - target system activity
- Engines/Filters
  - Viewed as modular tasks
  - Enhances speed, enables complexity avoidance
  - Execute the philosophies of IDS discussed previously
    - Audit trail processing, On-the-fly processing, Profiles of normality, Signatures of abnormal behavior, Parameter pattern matching

Where to Put It?

- Network IDS
  - Principle activity to detect network activity that indicates unauthorized or malicious activity
  - Does nothing to detect issues that are not network oriented
- Host-based IDS
  - Principle activity is to detect actions on computers that indicate unauthorized or malicious activity
  - Does nothing to detect issues that are network oriented
- Enterprise IDS
  - An attempt to integrate intrusion detection efforts across host and network based activities to see the larger picture

Research Influences

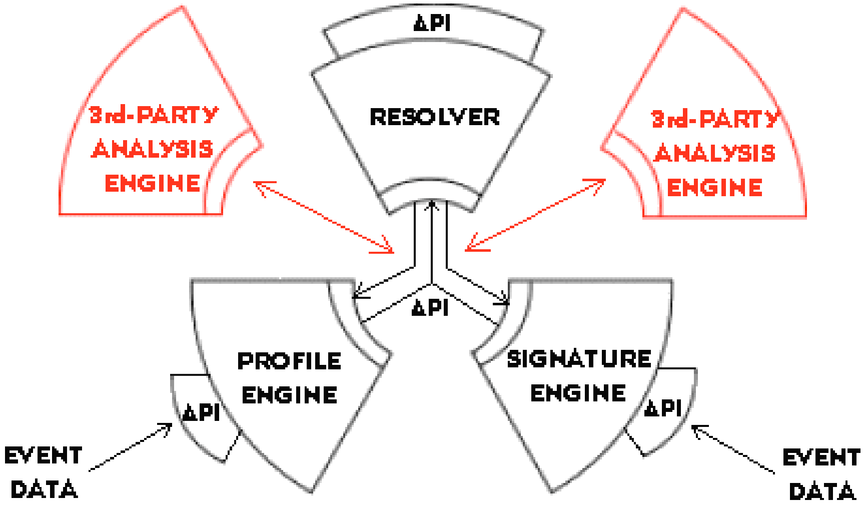
- EMERALD Generic Monitor Architecture
  - – Culmination of years of research by SRI, funded by DARPA
  - – Heirarchically layered network surveillance in 3 layers
    - Lowest: Service specific analysis monitoring
    - Middle: Domain wide analysis monitoring
    - Highest: Enterprise wide analysis monitoring
  - – Enables analysis that overarches implementation details
  - – Features target specific optimization:
    - Configurable event structures
    - Engine configurations
    - ‘Subscription’ list

      Event collection methods

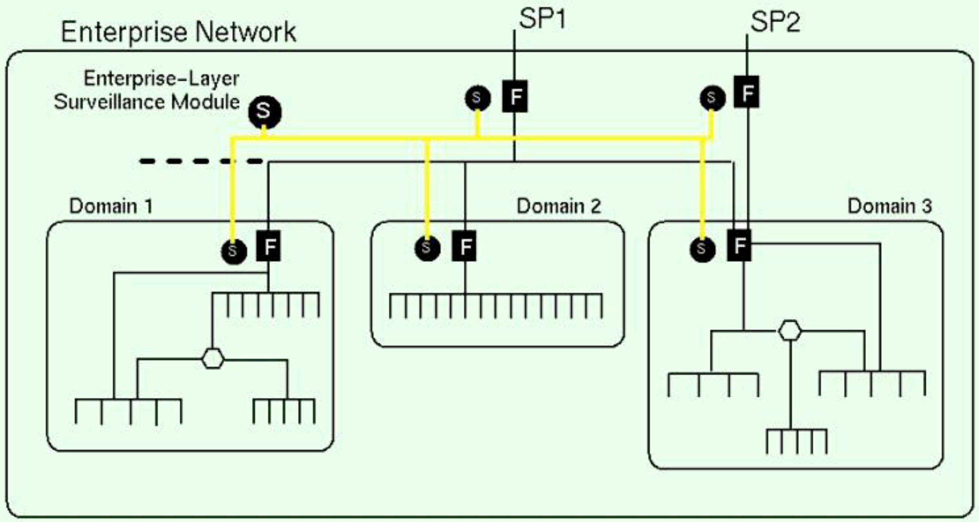
      Analysis unit configurations

      Variable response methods
  - – Lots of details available on the SRI web site
    - including technical publications

EMERALD Architecture



Source: http://www.sdl.sri.com/emerald/concepts.html, 22 May 2000



Source: http://www.sdl.sri.com/emerald/live-traffic.html, 22 May 2000

Common Intrusion Detection Framework

- CIDF began in 1997; government sponsored effort
- Includes:
  - Set of architectural conventions for how IDSs can be modeled
    - Event generators, analysis engines, storage mechanisms, response components
  - Specification for messaging
    - Generalized Intrusion Detection Objects (GIDO)
  - Specification for how to move GIDOs through system components
  - Interoperability protocols
- Enables
  - Multi-vendor solutions
  - Distributed IDS architectures

Challenges in IDS

- Correlating data from many types of targets
  - Personnel security systems (badges, etc)
  - Physical security systems (door alarms, etc)
  - Help desk
  - Network security systems (firewalls, etc)
- Distributed enterprises with integrated IT
  - Correlating data from many different physical locations
- Maintaining security attributes of IDS elements and data
  - C, I, A
  - Auditing to ensure correct operations
  - Support to forensics processes

Caveats

- This subject matter is incredibly complex
  - This presentation has been a very high level look
- A couple of good texts on the subject include:
  - Edward Amoroso’s “Intrusion Detection Systems”
  - Paul Proctor’s “Practical Intrusion Detection Handbook”
- The technology is not mature and research is on-going
- Understanding how to integrate an IDS into a security architecture requires both technical and business process analysis skills

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