CS 356 – Lecture 17 and 18
Intrusion Detection

Spring 2013

Review

- Chapter 1: Basic Concepts and Terminology
- Chapter 2: Basic Cryptographic Tools
- Chapter 3 – User Authentication
- Chapter 4 – Access Control Lists
- Chapter 5 – Database Security (skipped)
- Chapter 6 – Malicious Software
- Networking Basics (not in book)
- Chapter 7 – Denial of Service
- Chapter 8 – Intrusion Detection

Chapter 8

Intrusion Detection

Intruders

- **two most publicized threats to security are malware and intruders**
- **generally referred to as a *hacker* or *cracker***

- classes:

masquerader	misfeasor	clandestine user
• likely to be an outsider • an unauthorized individual who penetrates a system to exploit a legitimate user account	• generally an insider • legitimate user who misuses privileges	• can be either insider or outsider • individual who seizes supervisory control to evade auditing and access controls or to suppress audit collection

Examples of Intrusion

- remote root compromise
- web server defacement
- guessing / cracking passwords
- copying databases containing credit card numbers
- viewing sensitive data without authorization
- running a packet sniffer
- distributing pirated software
- using an unsecured modem to access internal network
- impersonating an executive to get information
- using an unattended workstation

Hackers

- motivated by thrill of access and/or status
  - hacking community is a strong meritocracy
  - status is determined by level of competence
- benign intruders consume resources and slow performance for legitimate users
- intrusion detection systems (IDSs) and intrusion prevention systems (IPSs) are designed to help counter hacker threats
  - can restrict remote logons to specific IP addresses
  - can use virtual private network technology (VPN)
- intruder problem led to establishment of computer emergency response teams (CERTs)

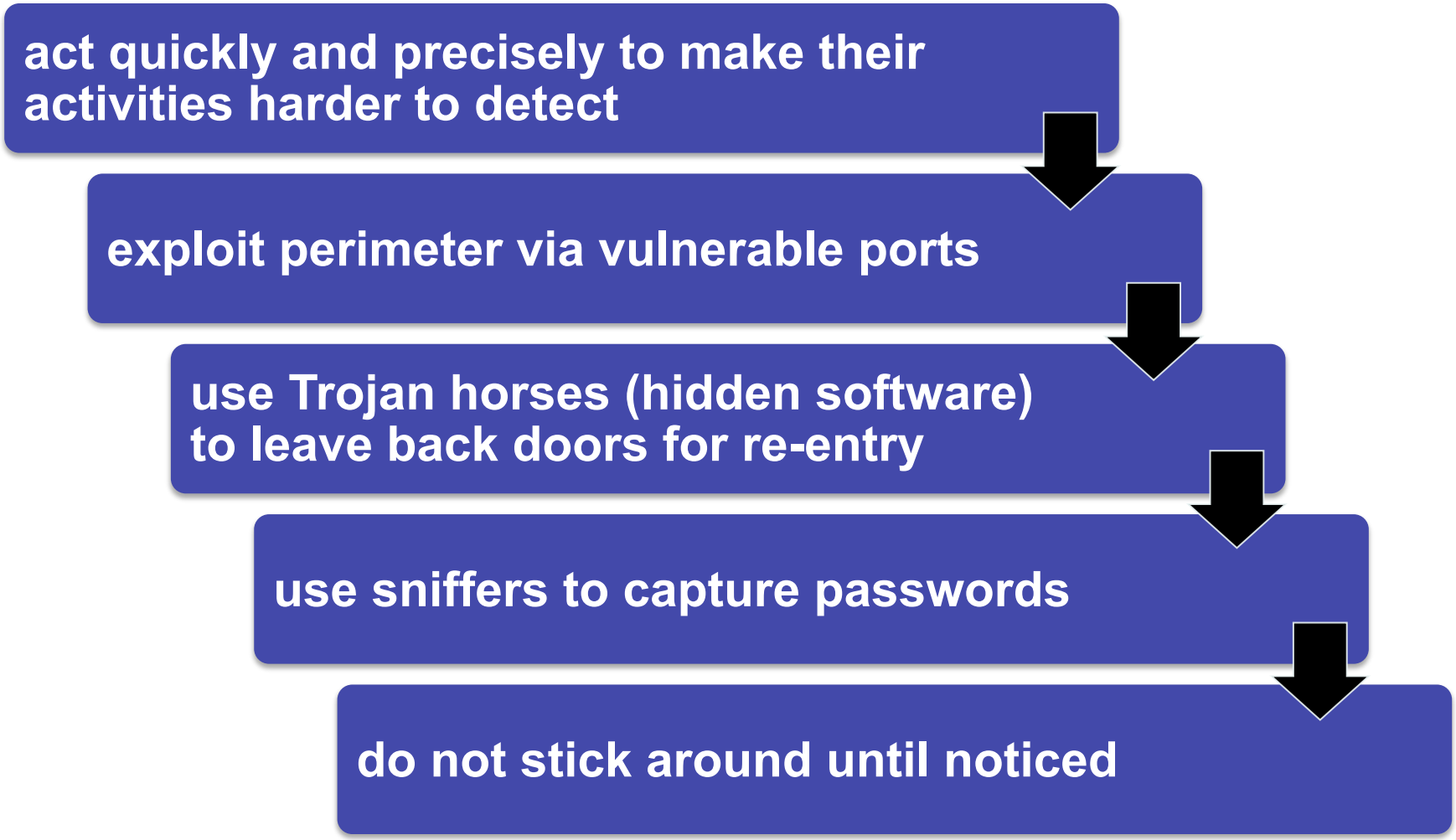
Hacker Patterns of Behavior

1. select the target using IP lookup tools such as NSLookup, Dig, and others
2. map network for accessible services using tools such as NMAP
3. identify potentially vulnerable services (in this case, pcAnywhere)
4. brute force (guess) pcAnywhere password
5. install remote administration tool called DameWare
6. wait for administrator to log on and capture his password
7. use that password to access remainder of network

Criminals

- organized groups of hackers now a threat
  - corporation / government / loosely affiliated gangs
  - meet in underground forums
  - common target is credit card files on e-commerce servers
- criminal hackers usually have specific targets
  - once penetrated act quickly and get out
- IDS / IPS can be used but less effective
- sensitive data should be encrypted

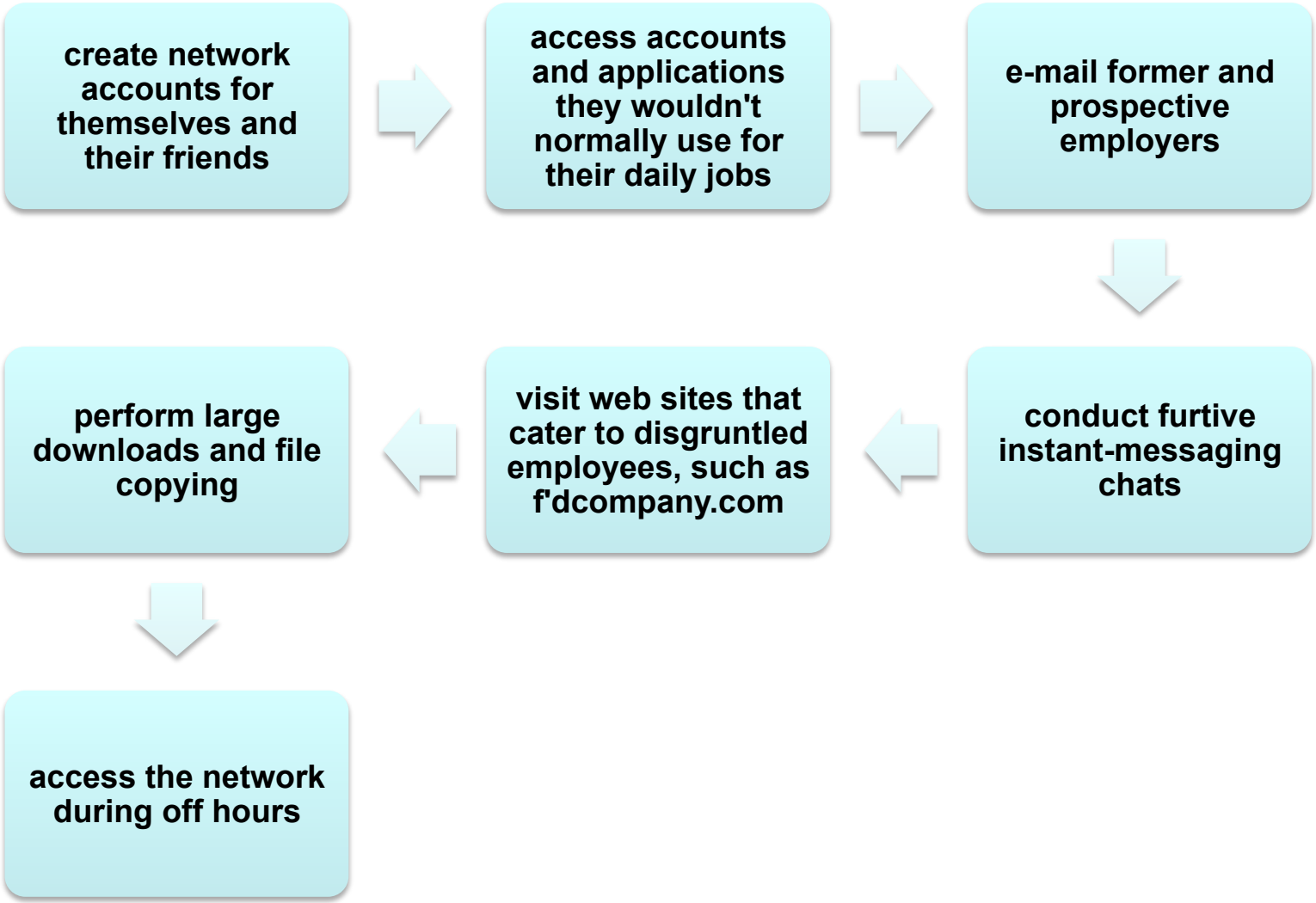
Criminal Enterprise Patterns of Behavior



Insider Attacks

- among most difficult to detect and prevent
- employees have access and systems knowledge
- may be motivated by revenge/entitlement
  - employment was terminated
  - taking customer data when moving to a competitor
- IDS / IPS can be useful but also need:
  - enforcement of least privilege, monitor logs, strong authentication, termination process

Internal Threat
Patterns of Behavior



The following definitions from RFC 2828 (Internet Security Glossary)

•**Security Intrusion:** A security event, or a combination of multiple security events, that constitutes a security incident in which an intruder gains, or attempts to gain, access to a system (or system resource) without having authorization to do so.

•**Intrusion Detection :** A security service that monitors and analyzes system events for the purpose of finding, and providing real-time or near real-time warning of, attempts to access system resources in an unauthorized manner.

Intrusion Detection Systems (IDSs)

- host-based IDS
  - monitors the characteristics of a single host for suspicious activity
- network-based IDS
  - monitors network traffic and analyzes network, transport, and application protocols to identify suspicious activity

comprises three logical components:

- **sensors - collect data**
- **analyzers - determine if intrusion has occurred**
- **user interface - view output or control system behavior**

IDS Principles

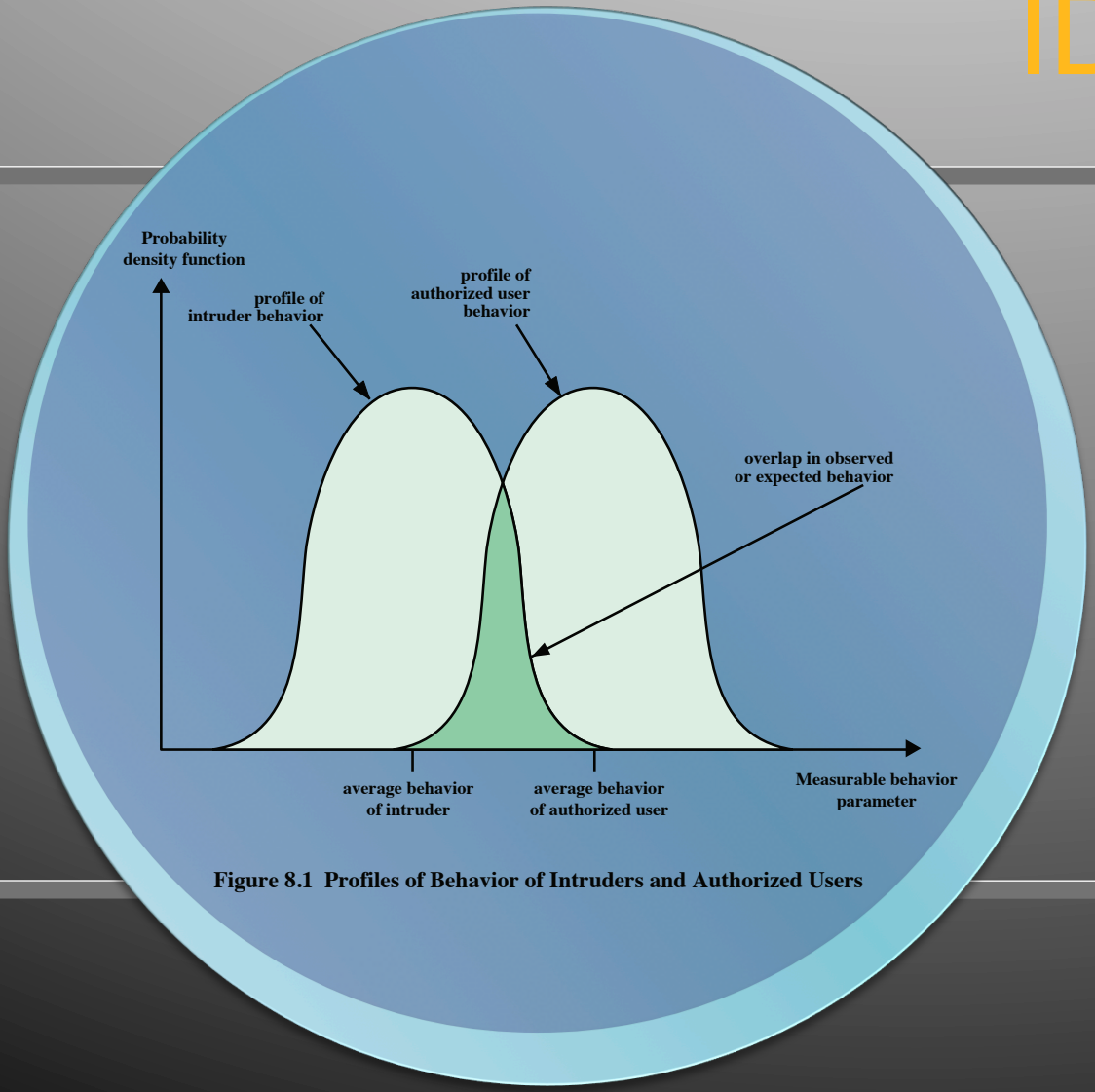


Figure 8.1 Profiles of Behavior of Intruders and Authorized Users

- assume intruder behavior differs from legitimate users
- overlap in behaviors causes problems
  - false positives
  - false negatives

IDS Requirements

run continually	be fault tolerant	resist subversion
impose a minimal overhead on system	configured according to system security policies	adapt to changes in systems and users
scale to monitor large numbers of systems	provide graceful degradation of service	allow dynamic reconfiguration

Host-Based IDS

- adds a specialized layer of security software to vulnerable or sensitive systems
- monitors activity to detect suspicious behavior
  - primary purpose is to detect intrusions, log suspicious events, and send alerts
  - can detect both external and internal intrusions

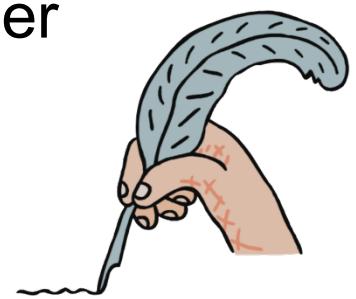
Host-Based IDS Approaches to Intrusion Detection

anomaly detection

- threshold detection
  - involves counting the number of occurrences of a specific event type over an interval of time
- profile based
  - profile of the activity of each user is developed and used to detect changes in the behavior of individual accounts

signature detection

- involves an attempt to define a set of rules or attack patterns that can be used to decide that a given behavior is that of an intruder



Audit Records

native audit records

- multiuser operating systems include accounting software that collects information on user activity
- advantage is that no additional collection software is needed
- disadvantage is that records may not contain the needed information or in a convenient form

detection-specific audit record

- collection facility that generates records containing only information required by the IDS
- advantage is that it could be made vendor independent and ported to a variety of systems
- disadvantage is the extra overhead of having, in effect, two accounting packages running on a machine

Measures That May Be Used For Intrusion Detection

Measure	Model	Type of Intrusion Detected
Login and Session Activity		
Login frequency by day and time	Mean and standard deviation	Intruders may be likely to log in during off-hours.
Frequency of login at different locations	Mean and standard deviation	Intruders may log in from a location that a particular user rarely or never uses.
Time since last login	Operational	Break-in on a "dead" account.
Elapsed time per session	Mean and standard deviation	Significant deviations might indicate masquerader.
Quantity of output to location	Mean and standard deviation	Excessive amounts of data transmitted to remote locations could signify leakage of sensitive data.
Session resource utilization	Mean and standard deviation	Unusual processor or I/O levels could signal an intruder.
Password failures at login	Operational	Attempted break-in by password guessing.
Failures to login from specified terminals	Operational	Attempted break-in.
Command or Program Execution Activity		
Execution frequency	Mean and standard deviation	May detect intruders, who are likely to use different commands, or a successful penetration by a legitimate user, who has gained access to privileged commands.
Program resource utilization	Mean and standard deviation	An abnormal value might suggest injection of a virus or Trojan horse, which performs side-effects that increase I/O or processor utilization.
Execution denials	Operational model	May detect penetration attempt by individual user who seeks higher privileges.
File Access Activity		
Read, write, create, delete frequency	Mean and standard deviation	Abnormalities for read and write access for individual users may signify masquerading or browsing.
Records read, written	Mean and standard deviation	Abnormality could signify an attempt to obtain sensitive data by inference and aggregation.
Failure count for read, write, create, delete	Operational	May detect users who persistently attempt to access unauthorized files.

Signature Detection

- rule-based anomaly detection
  - historical audit records are analyzed to identify usage patterns
  - rules are generated that describe those patterns
  - current behavior is matched against the set of rules
  - does not require knowledge of security vulnerabilities within the system
  - a large database of rules is needed
- rule-based penetration identification
  - key feature is the use of rules for identifying known penetrations or penetrations that would exploit known weaknesses
  - rules can also be defined that identify suspicious behavior
  - typically rules are specific to the machine and operating system

USTAT Actions vs. SunOS Event Types

USTAT Action	SunOS Event Type
Read	open_r, open_rc, open_rtc, open_rwc, open_rwtc, open_rt, open_rw, open_rwt
Write	truncate, ftruncate, creat, open_rtc, open_rwc, open_rwtc, open_rt, open_rw, open_rwt, open_w, open_wt, open_wc, open_wct
Create	mkdir, creat, open_rc, open_rtc, open_rwc, open_rwtc, open_wc, open_wtc, mknod
Delete	rmdir, unlink
Execute	exec, execve
Exit	exit
Modify_Owner	chown, fchown
Modify_Perm	chmod, fchmod
Rename	rename
Hardlink	link

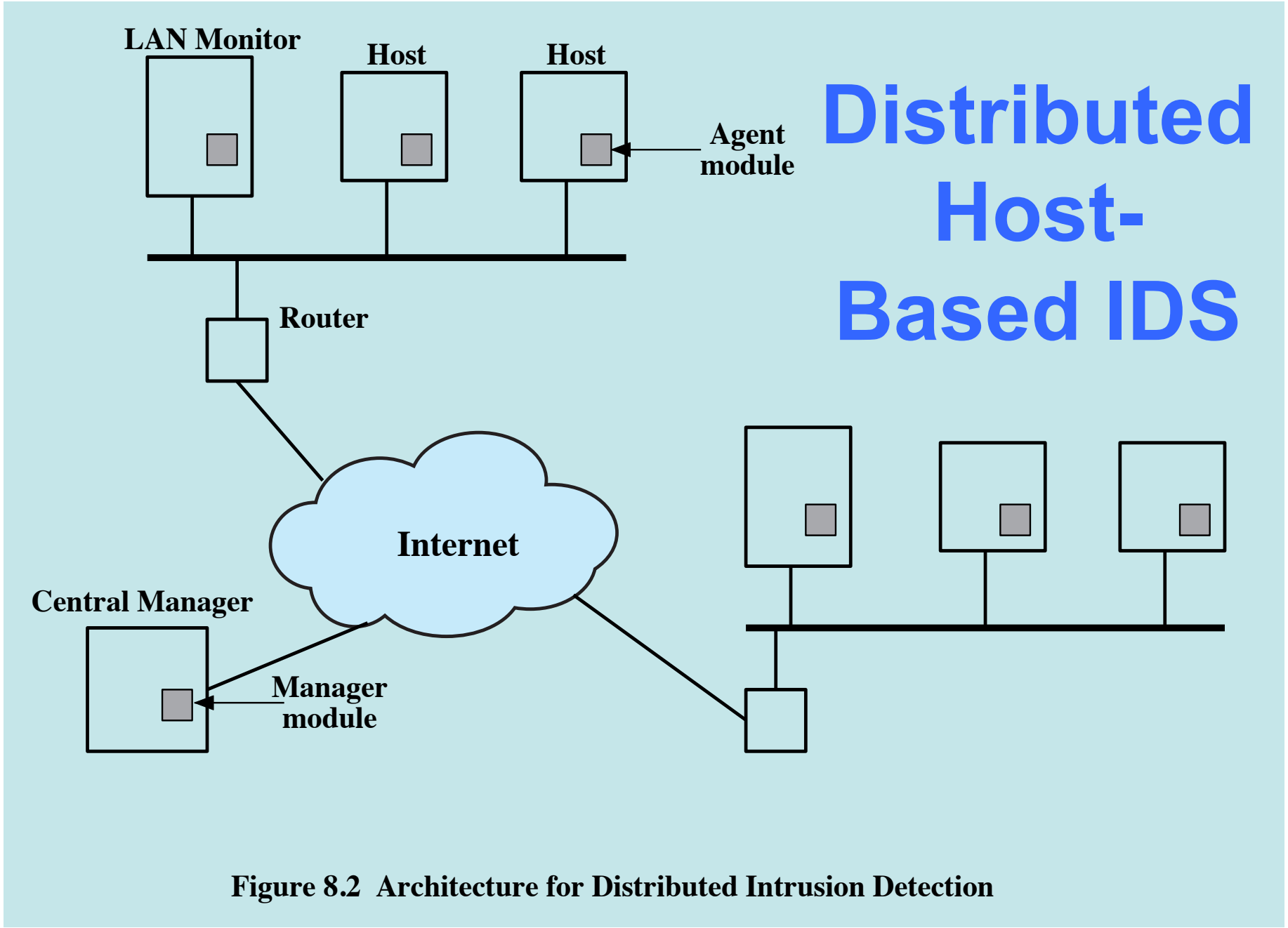


Figure 8.2 Architecture for Distributed Intrusion Detection

Distributed Host-Based IDS

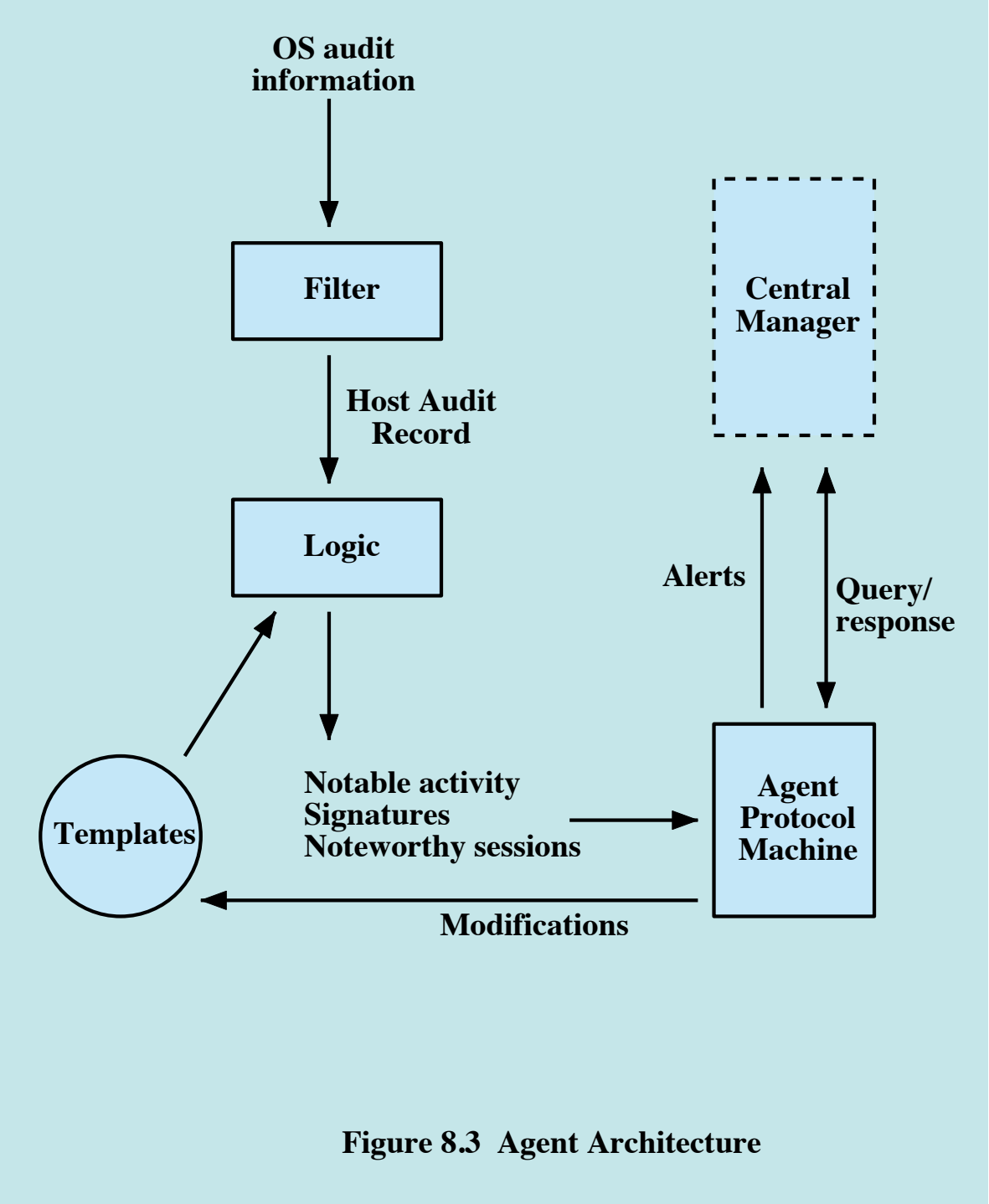


Figure 8.3 Agent Architecture

Network-Based IDS (NIDS)

monitors traffic at selected points on a network

examines traffic packet by packet in real or close to real time

may examine network, transport, and/or application-level protocol activity

comprised of a number of sensors, one or more servers for NIDS management functions, and one or more management consoles for the human interface

analysis of traffic patterns may be done at the sensor, the management server or a combination of the two

NIDS Sensor Deployment

- inline sensor
  - inserted into a network segment so that the traffic that it is monitoring must pass through the sensor
- passive sensors
  - monitors a copy of network traffic

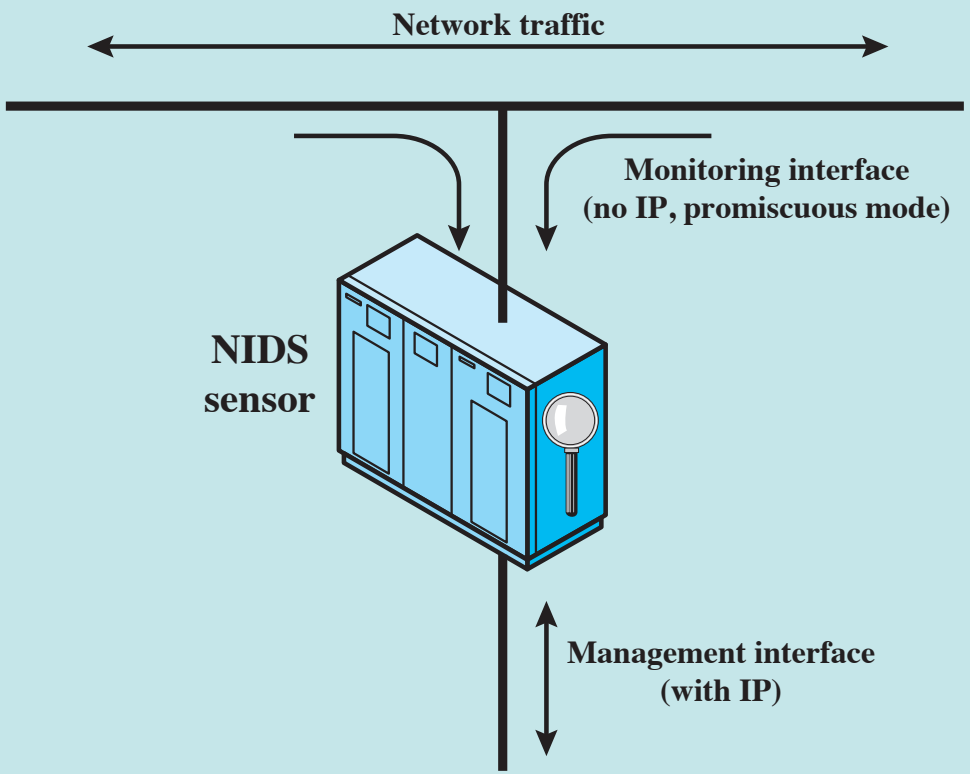


Figure 8.4 Passive NIDS Sensor (based on [CREM06])

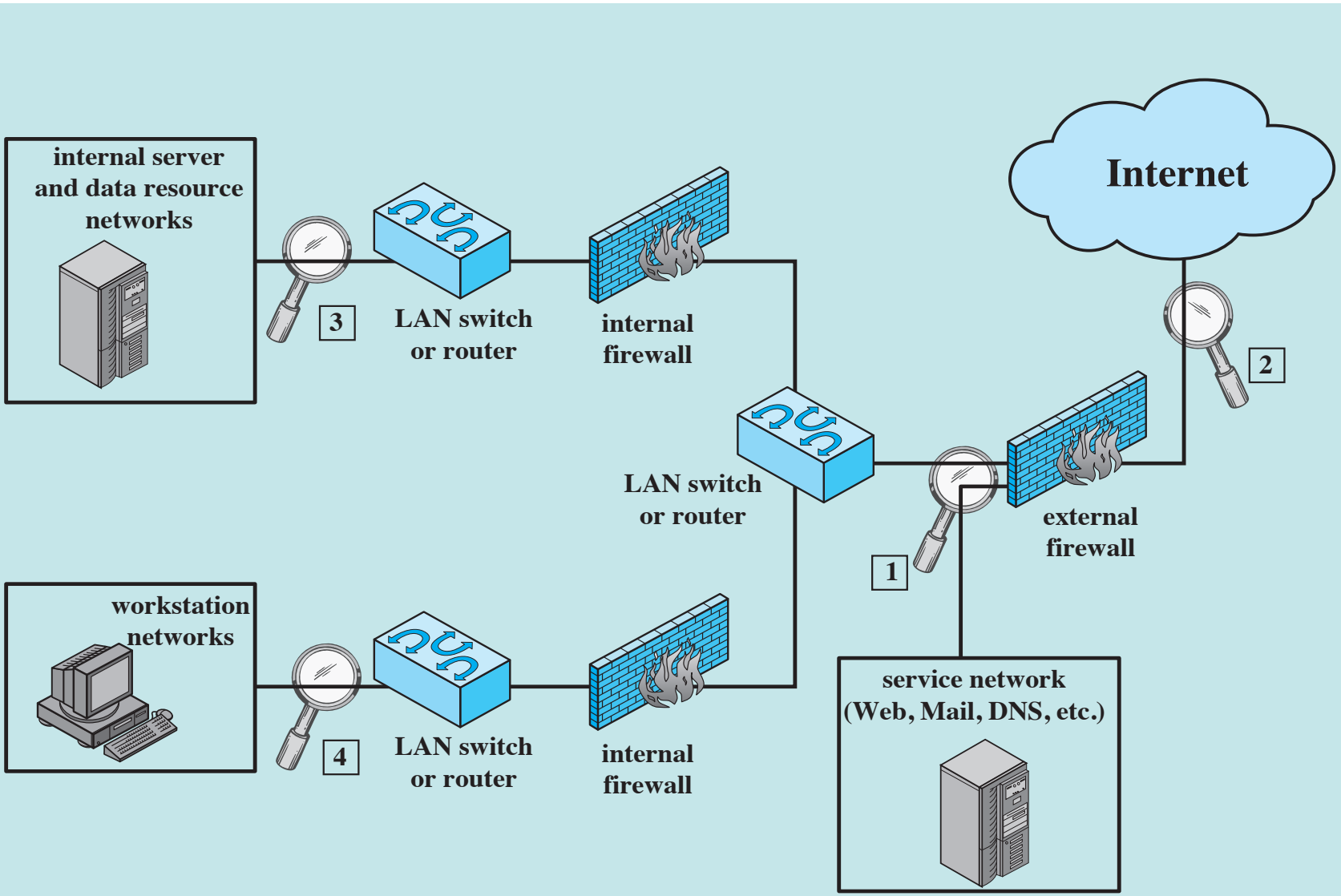
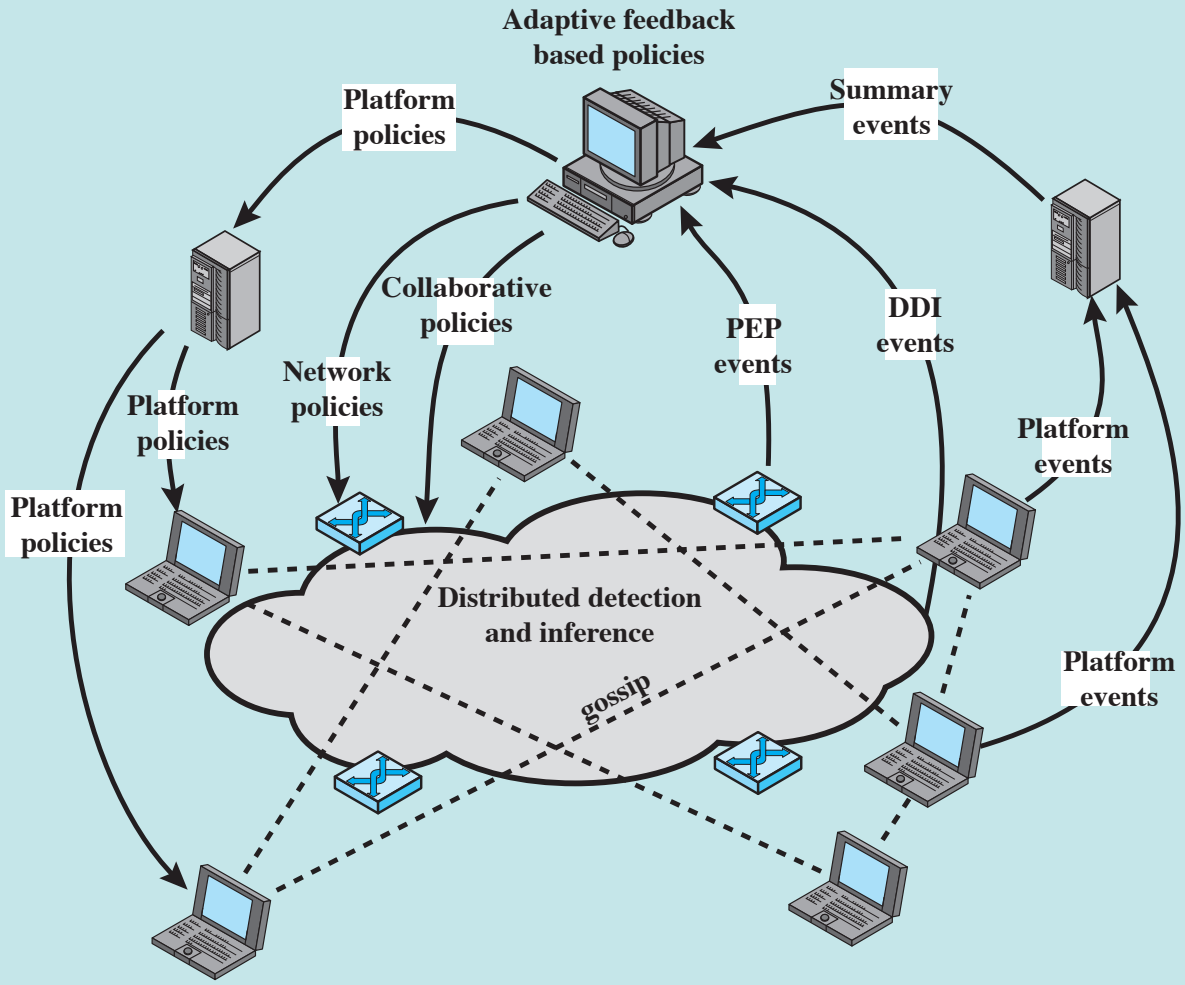


Figure 8.5 Example of NIDS Sensor Deployment

Intrusion Detection Techniques

- signature detection
  - at application, transport, network layers; unexpected application services, policy violations
- anomaly detection
  - denial of service attacks, scanning, worms
- when a sensor detects a potential violation it sends an alert and logs information related to the event
  - used by analysis module to refine intrusion detection parameters and algorithms
  - security administration can use this information to design prevention techniques



PEP = policy enforcement point
DDI = distributed detection and inference

Figure 8.6 Overall Architecture of an Autonomic Enterprise Security System

Intrusion Detection Exchange Format

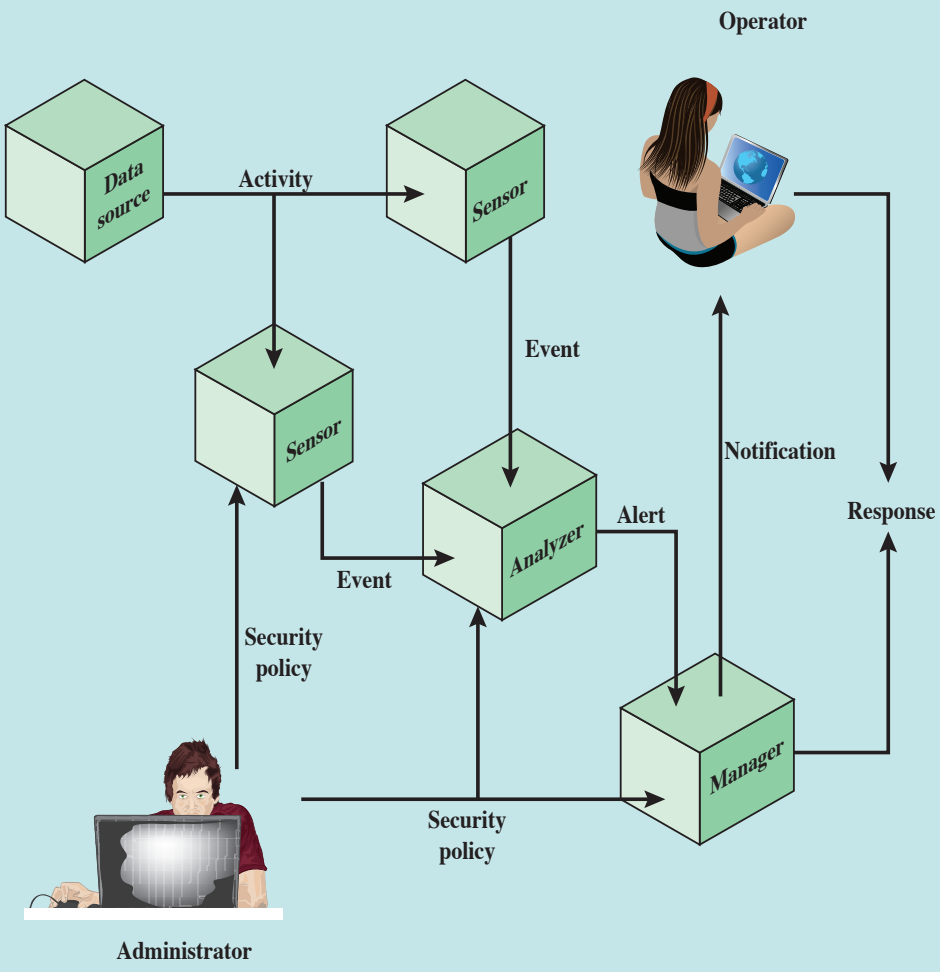


Figure 8.7 Model For Intrusion Detection Message Exchange

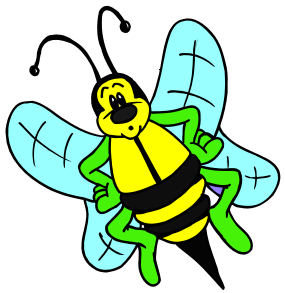
Honeypot

- decoy systems designed to:
  - lure a potential attacker away from critical systems
  - collect information about the attacker's activity
  - encourage the attacker to stay on the system long enough for administrators to respond

- filled with fabricated information that a legitimate user of the system wouldn't access

- resource that has no production value
  - incoming communication is most likely a probe, scan, or attack
  - outbound communication suggests that the system has probably been compromised

- once hackers are within the network, administrators can observe their behavior to figure out defenses



Honeypot Deployment

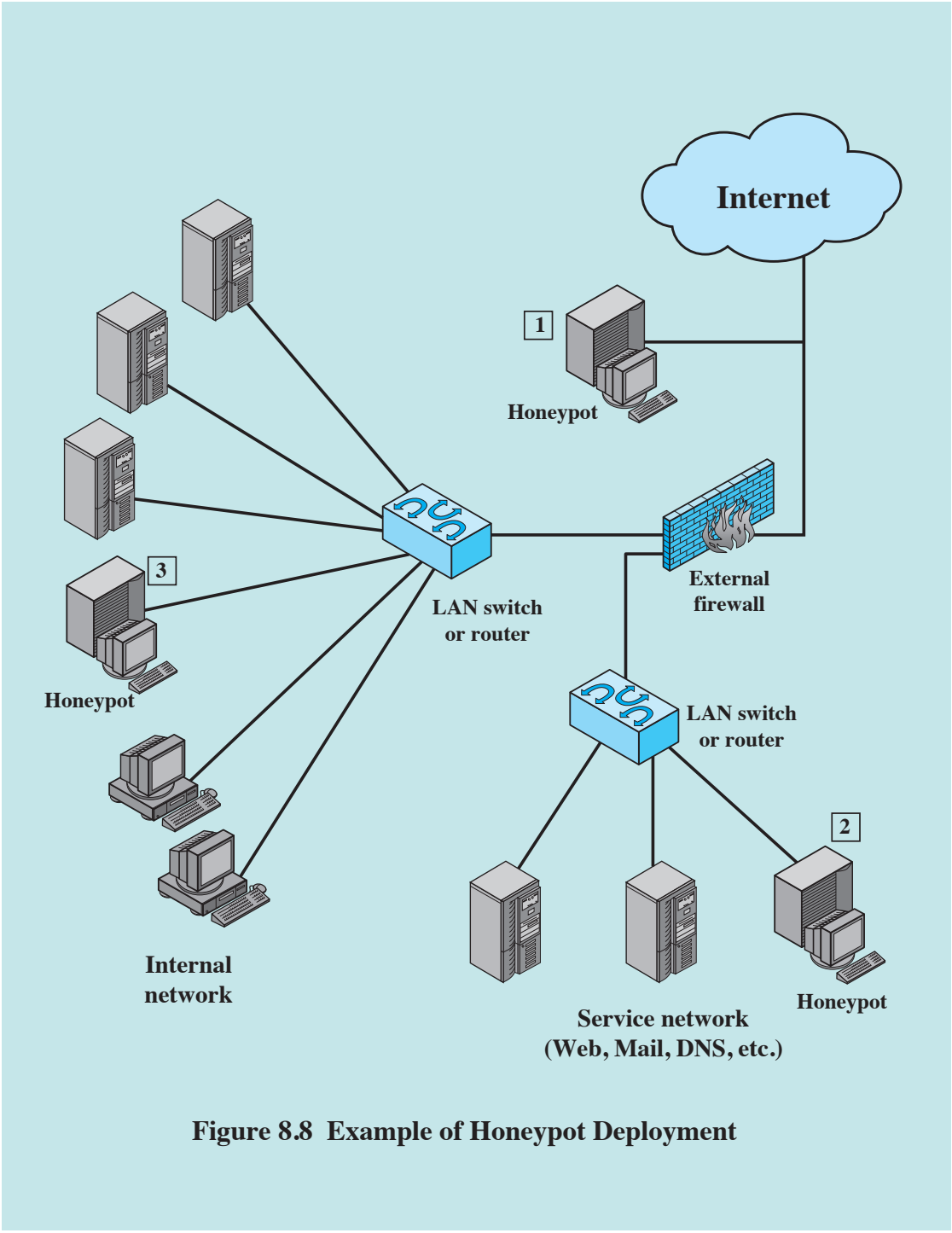


Figure 8.8 Example of Honeypot Deployment

SNORT

- lightweight IDS
  - real-time packet capture and rule analysis
  - easily deployed on nodes
  - uses small amount of memory and processor time
  - easily configured

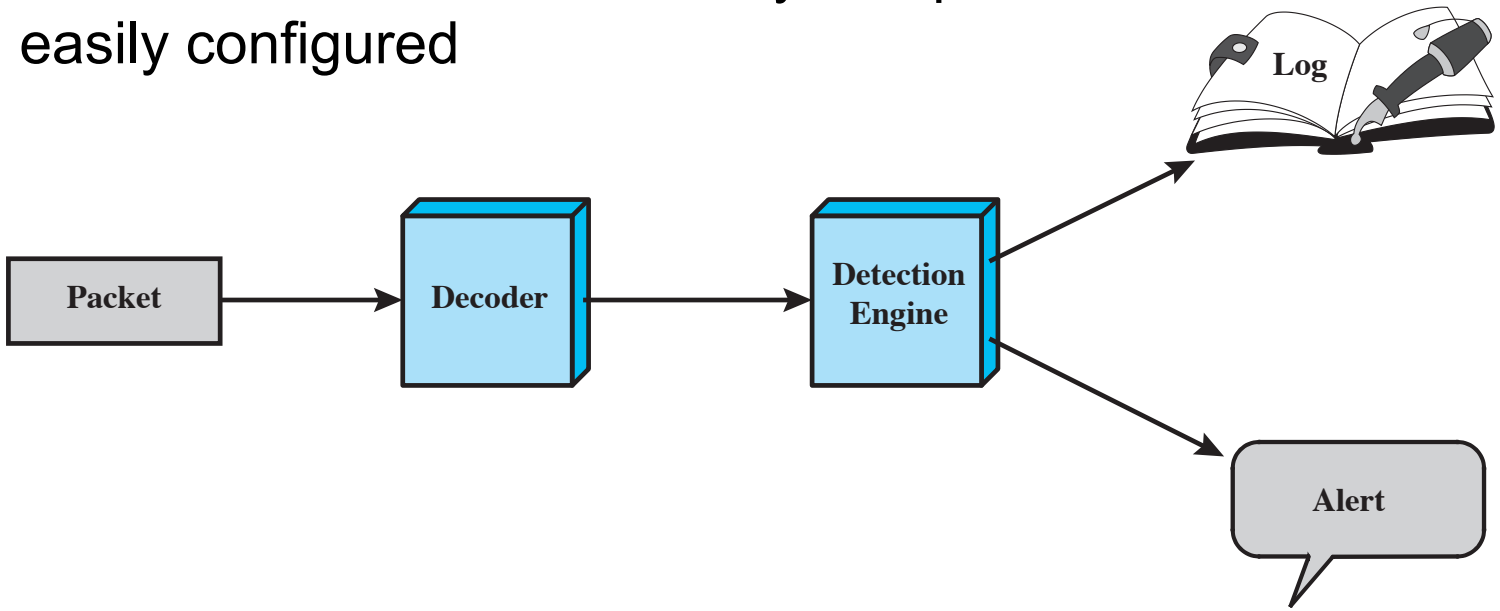


Figure 8.9 Snort Architecture

SNORT Rules

- use a simple, flexible rule definition language
- each rule consists of a fixed header and zero or more options

Action	Description
alert	Generate an alert using the selected alert method, and then log the packet.
log	Log the packet.
pass	Ignore the packet.
activate	Alert and then turn on another dynamic rule.
dynamic	Remain idle until activated by an activate rule , then act as a log rule.
drop	Make iptables drop the packet and log the packet.
reject	Make iptables drop the packet, log it, and then send a TCP reset if the protocol is TCP or an ICMP port unreachable message if the protocol is UDP.
sdrop	Make iptables drop the packet but does not log it.

Examples of SNORT Rule Options

meta-data
msg Defines the message to be sent when a packet generates an event. **reference** Defines a link to an external attack identification system, which provides additional information. **classtype** Indicates what type of attack the packet attempted.
payload
content Enables Snort to perform a case-sensitive search for specific content (text and/or binary) in the packet payload. **depth** Specifies how far into a packet Snort should search for the specified pattern. Depth modifies the previous content keyword in the rule. **offset** Specifies where to start searching for a pattern within a packet. Offset modifies the previous content keyword in the rule. **nocase** Snort should look for the specific pattern, ignoring case. Nocase modifies the previous content keyword in the rule.
non-payload
ttl Check the IP time-to-live value. This option was intended for use in the detection of traceroute attempts. **id** Check the IP ID field for a specific value. Some tools (exploits, scanners and other odd programs) set this field specifically for various purposes, for example, the value 31337 is very popular with some hackers. **dsize** Test the packet payload size. This may be used to check for abnormally sized packets. In many cases, it is useful for detecting buffer overflows. **flags** Test the TCP flags for specified settings. **seq** Look for a specific TCP header sequence number. **icmp-id** Check for a specific ICMP ID value. This is useful because some covert channel programs use static ICMP fields when they communicate. This option was developed to detect the stacheldraht DDoS agent.
post-detection
logto Log packets matching the rule to the specified filename. **session** Extract user data from TCP Sessions. There are many cases where seeing what users are typing in telnet, rlogin, ftp, or even web sessions is very useful.

Summary

- intruders
  - masquerader
  - misfeasor
  - clandestine user
- intruder behavior patterns
  - hacker
  - criminal enterprise
  - internal threat
- security intrusion/intrusion detection
- intrusion detection systems
  - host-based
  - network-based
  - sensors, analyzers, user interface
- host-based
  - anomaly detection
  - signature detection
- audit records
- distributed host-based intrusion detection
- network-based
  - sensors: inline/passive
- distributed adaptive intrusion detection
- intrusion detection exchange format
- honeypot
- SNORT