# Computer Security: Principles and Practice

Fourth Edition

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# Chapter 8

Intrusion Detection

## Classes of Intruders

- Cyber Criminals
- Activists
- State-Sponsored Organizations
- Others

## Classes of Intruders – Cyber Criminals

- Individuals or members of an organized crime group with a goal of financial reward
- Their activities may include:
  - Identity theft
  - Theft of financial credentials
  - Corporate espionage
  - Data theft
  - Data ransoming
- (Based on historic statistics) Typically they are young, often Eastern European, Russian, or southeast Asian hackers, who do business on the Web
- They meet in underground forums like DarkMarket.org and theftservices.com to trade tips and data and coordinate attacks

## Classes of Intruders – Activists

- Are either individuals, usually working as insiders, or members of a larger group of outsider attackers, who are motivated by social or political causes
- Also know as hacktivists
    - Skill level is often quite low
- Aim of their attacks is often to promote and publicize their cause typically through:
    - Website defacement
    - Denial of service attacks
    - Theft and distribution of data that results in negative publicity or compromise of their targets
- Well-known recent examples include the activities of the groups:
    - Anonymous and LulzSec,
    - Edward Snowden

# Classes of Intruders – State-Sponsored Organizations

Groups of hackers sponsored by governments to conduct espionage or sabotage activities

Also known as Advanced Persistent Threats (APTs) due to the covert nature and persistence over extended periods involved with any attacks in this class

Widespread nature and scope of these activities by a wide range of countries from China to the USA, UK, and their intelligence allies

# Classes of Intruders – Others

- Hackers with motivations other than those previously listed
- Include classic hackers or crackers who are motivated by technical challenge or by peer-group esteem and reputation
- Many of those responsible for discovering new categories of buffer overflow vulnerabilities could be regarded as members of this class
- Given the wide availability of attack toolkits, there is a pool of "hobby hackers" using them to explore system and network security

## Intruder Skill Levels

- Apprentice
- Journeyman
- Master

# Intruder Skill Levels – Apprentice

- Hackers with minimal technical skill who primarily use existing attack toolkits
- They likely comprise the largest number of attackers, including many criminal and activist attackers
- Given their use of existing known tools, these attackers are the easiest to defend against
- Also known as "script-kiddies" due to their use of existing scripts (tools)

# Intruder Skill Levels – Journeyman

- Hackers with sufficient technical skills to modify and extend attack toolkits to use newly discovered, or purchased, vulnerabilities
- They may be able to locate new vulnerabilities to exploit that are similar to some already known
- Hackers with such skills are likely found in all intruder classes
- They adapt tools for use by others

## Intruder Skill Levels – Master

- Hackers with high-level technical skills capable of discovering brand new categories of vulnerabilities
- Write new powerful attack toolkits
- Some of the better known classical hackers are of this level
- Some are employed by state-sponsored organizations
- Defending against these attacks is of the highest difficulty

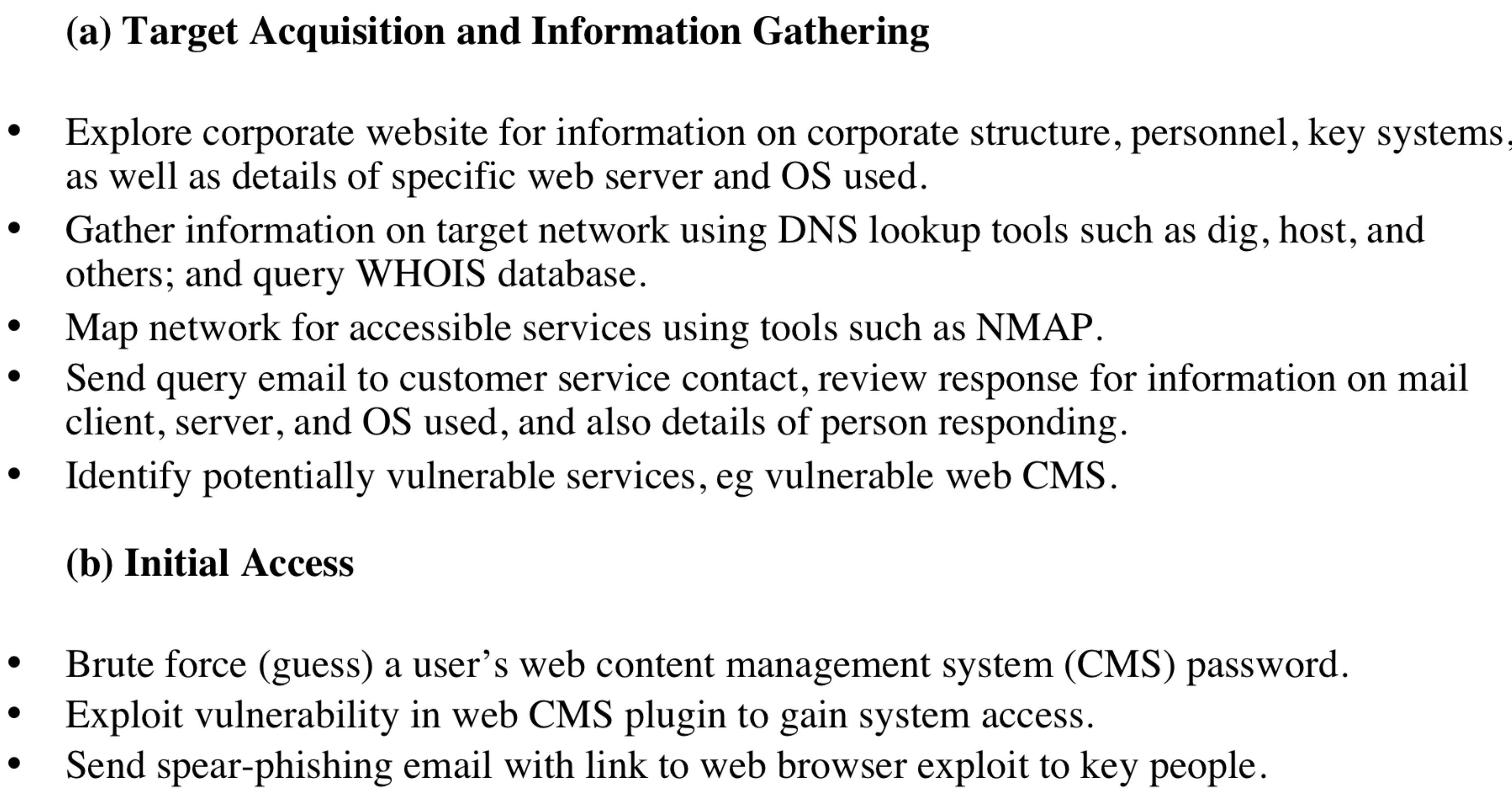
## Examples of Intrusion

- 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/access point to access internal network
- Impersonating an executive to get information
- Using an unattended workstation

# Intruder Behavior

- Target acquisition and information gathering
- Initial access
- Privilege escalation
- Information gathering or system exploit
- Maintaining access
- Covering tracks

# Table 8.1 Examples of Intruder Behavior



**(a) Target Acquisition and Information Gathering**

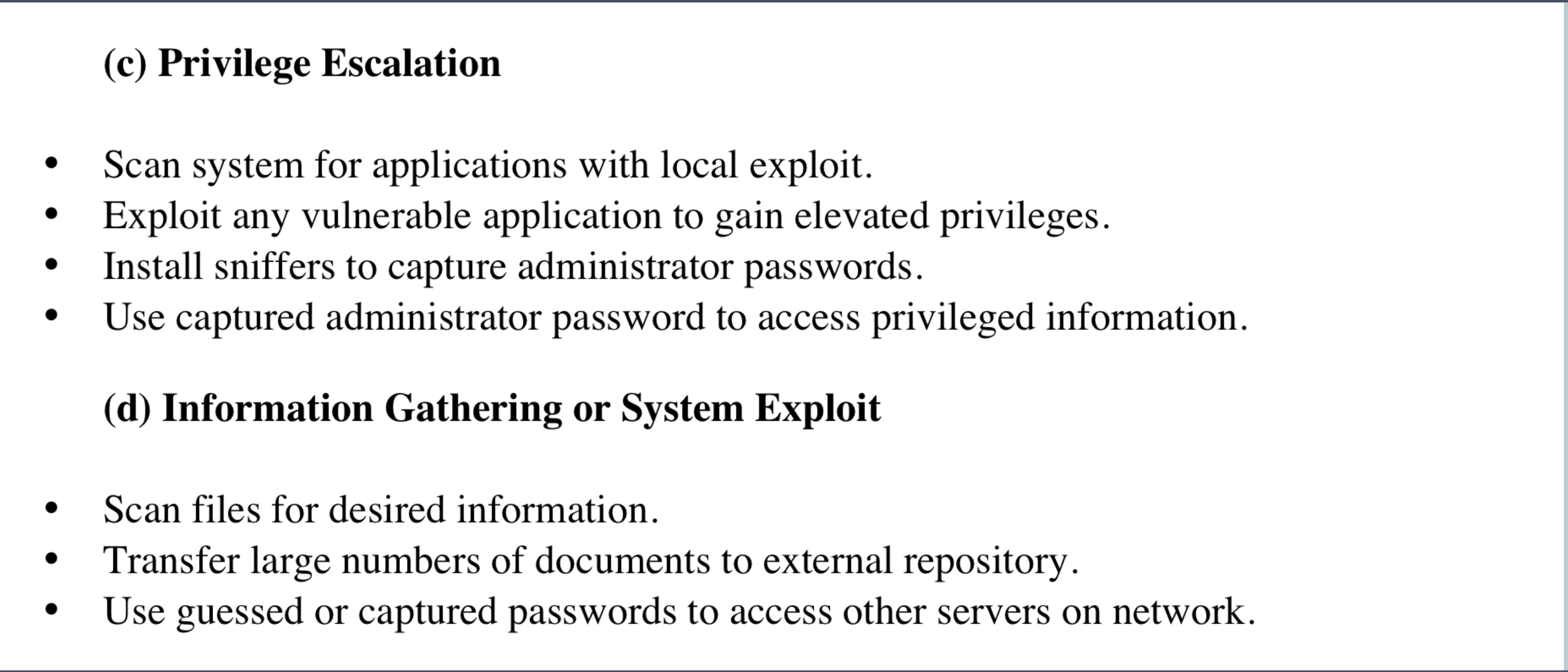
- Explore corporate website for information on corporate structure, personnel, key systems, as well as details of specific web server and OS used.
- Gather information on target network using DNS lookup tools such as dig, host, and others; and query WHOIS database.
- Map network for accessible services using tools such as NMAP.
- Send query email to customer service contact, review response for information on mail client, server, and OS used, and also details of person responding.
- Identify potentially vulnerable services, eg vulnerable web CMS.

**(b) Initial Access**

- Brute force (guess) a user's web content management system (CMS) password.
- Exploit vulnerability in web CMS plugin to gain system access.
- Send spear-phishing email with link to web browser exploit to key people.

(Table can be found on pages 255-256 in the textbook.)

## Table 8.1 Examples of Intruder Behavior



**(c) Privilege Escalation**

- Scan system for applications with local exploit.
- Exploit any vulnerable application to gain elevated privileges.
- Install sniffers to capture administrator passwords.
- Use captured administrator password to access privileged information.

**(d) Information Gathering or System Exploit**

- Scan files for desired information.
- Transfer large numbers of documents to external repository.
- Use guessed or captured passwords to access other servers on network.

(Table can be found on pages 255-256 in the textbook.)

# Table 8.1 Examples of Intruder Behavior

**(e) Maintaining Access**

- Install remote administration tool or rootkit with backdoor for later access.
- Use administrator password to later access network.
- Modify or disable anti-virus or IDS programs running on system.

**(f) Covering Tracks**

- Use rootkit to hide files installed on system.
- Edit logfiles to remove entries generated during the intrusion.

(Table can be found on pages 255-256 in the textbook.)

# Definitions

- Security Intrusion:

  Unauthorized act of bypassing the security mechanisms of a system

- Intrusion Detection:

  A hardware or software function that gathers and analyzes information from various areas within a computer or a network to identify possible security intrusions

# Intrusion Detection System (IDS)

- Host-based IDS (HIDS)
  - Monitors the characteristics of a single host for suspicious activity
- Network-based IDS (NIDS)
  - Monitors network traffic and analyzes network, transport, and application protocols to identify suspicious activity
- Distributed or hybrid IDS
  - Combines information from a number of sensors, often both host and network based, in a central analyzer that is able to better identify and respond to intrusion activity

**Comprises three logical components:**

- **Sensors - collect data**
- **Analyzers - determine if intrusion has occurred**
- **User interface - view output or control system behavior**

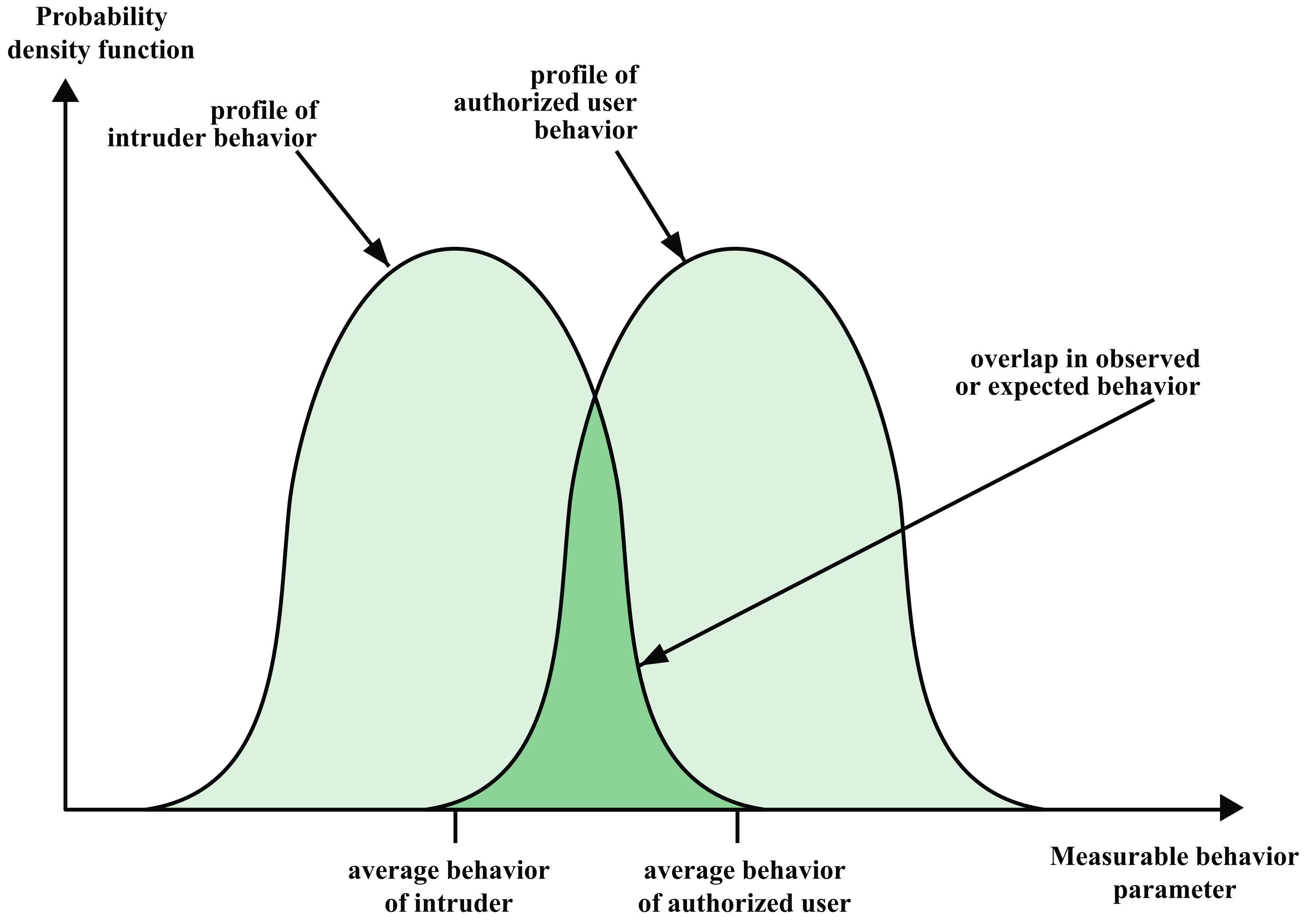


**Figure 8.1 Profiles of Behavior of Intruders and Authorized Users**

# 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

# Analysis Approaches

## Anomaly detection

- Involves the collection of data relating to the behavior of legitimate users over a period of time
- Current observed behavior is analyzed to determine whether this behavior is that of a legitimate user or that of an intruder

## Signature/Heuristic detection

- Uses a set of known malicious data patterns or attack rules that are compared with current behavior
- Also known as misuse detection
- Can only identify known attacks for which it has patterns or rules

# Anomaly Detection

A variety of classification approaches are used:

| Statistical | Knowledge based | Machine-learning |
|---|---|---|
| • Analysis of the observed behavior using univariate, multivariate, or time-series models of observed metrics | • Approaches use an expert system that classifies observed behavior according to a set of rules that model legitimate behavior | • Approaches automatically determine a suitable classification model from the training data using data mining techniques |

# Signature or Heuristic Detection

## Signature approaches

Match a large collection of known patterns of malicious data against data stored on a system or in transit over a network

The signatures need to be large enough to minimize the false alarm rate, while still detecting a sufficiently large fraction of malicious data

Widely used in anti-virus products, network traffic scanning proxies, and in NIDS

## Rule-based heuristic identification

Involves the use of rules for identifying known penetrations or penetrations that would exploit known weaknesses

Rules can also be defined that identify suspicious behavior, even when the behavior is within the bounds of established patterns of usage

Typically rules used are specific

SNORT is an example of a rule-based NIDS

# Host-Based Intrusion Detection (HIDS)

- Adds a specialized layer of security software to vulnerable or sensitive systems
- Can use either anomaly or signature and heuristic approaches
- 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

## Data Sources and Sensors

A fundamental component of intrusion detection is the sensor that collects data

Common data sources include:

- System call traces
- Audit (log file) records
- File integrity checksums
- Registry access

## Table 8.2

## Linux System Calls and Windows DLLs Monitored

**(a) Ubuntu Linux System Calls**

accept, access, acct, adjtime, aiocancel, aioread, aiowait, aiowrite, alarm, async_daemon, auditsys, bind, chdir, chmod, chown, chroot, close, connect, creat, dup, dup2, execv, execve, exit, exportfs, fchdir, fchmod, fchown, fchroot, fcntl, flock, fork, fpathconf, fstat, fstat, fstatfs, fsync, ftime, ftruncate, getdents, getdirentries, getdomainname, getdopt, getdtablesize, getfh, getgid, getgroups, gethostid, gethostname, getitimer, getmsg, getpagesize, getpeername, getpgrp, getpid, getpriority, getrlimit, getrusage, getsockname, getsockopt, gettimeofday, getuid, gtty, ioctl, kill, killpg, link, listen, lseek, lstat, madvise, mctl, mincore, mkdir, mknod, mmap, mount, mount, mprotect, mpxchan, msgsys, msync, munmap, nfs_mount, nfssvc, nice, open, pathconf, pause, pcfs_mount, phys, pipe, poll, profil, ptrace, putmsg, quota, quotactl, read, readlink, readv, reboot, recv, recvfrom, recvmsg, rename, resuba, rfssys, rmdir, sbreak, sbrk, select, semsys, send, sendmsg, sendto, setdomainname, setdopt, setgid, setgroups, sethostid, sethostname, setitimer, setpgid, setpgrp, setpgrp, setpriority, setquota, setregid, setreuid, setrlimit, setsid, setsockopt, settimeofday, setuid, shmsys, shutdown, sigblock, sigpause, sigpending, sigsetmask, sigstack, sigsys, sigvec, socket, socketaddr, socketpair, sstk, stat, stat, statfs, stime, stty, swapon, symlink, sync, sysconf, time, times, truncate, umask, umount, uname, unlink, unmount, ustat, utime, utimes, vadvise, vfork, vhangup, vlimit, vpixsys, vread, vtimes, vtrace, vwrite, wait, wait3, wait4, write, writev

**(b) Key Windows DLLs and Executables**

comctl32
kernel32
msvcpp
msvcrt
mswsock
ntdll
ntoskrnl
user32
ws2_32

(Table can be found on page 264 in the textbook)

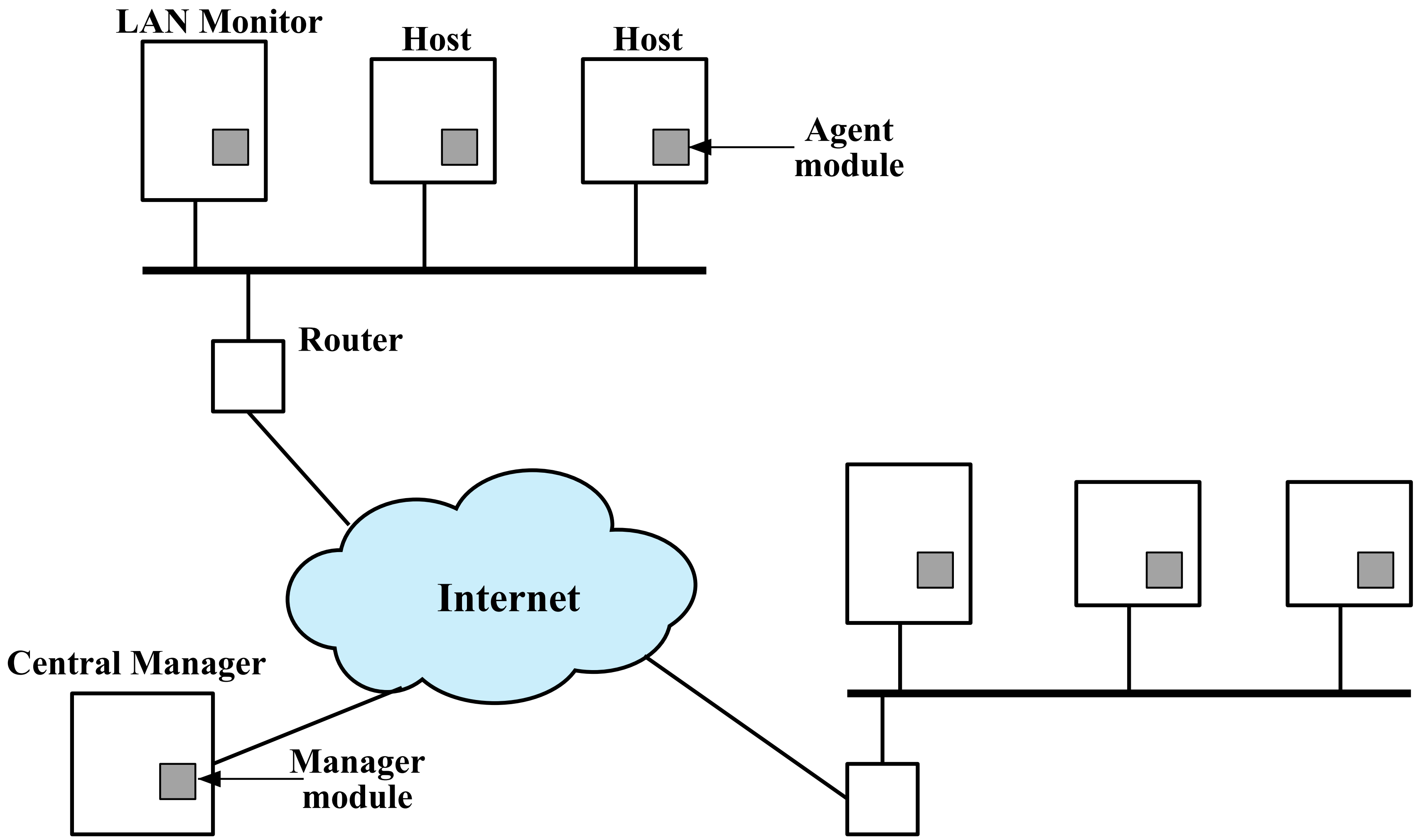


Figure 8.2  Architecture for Distributed Intrusion Detection

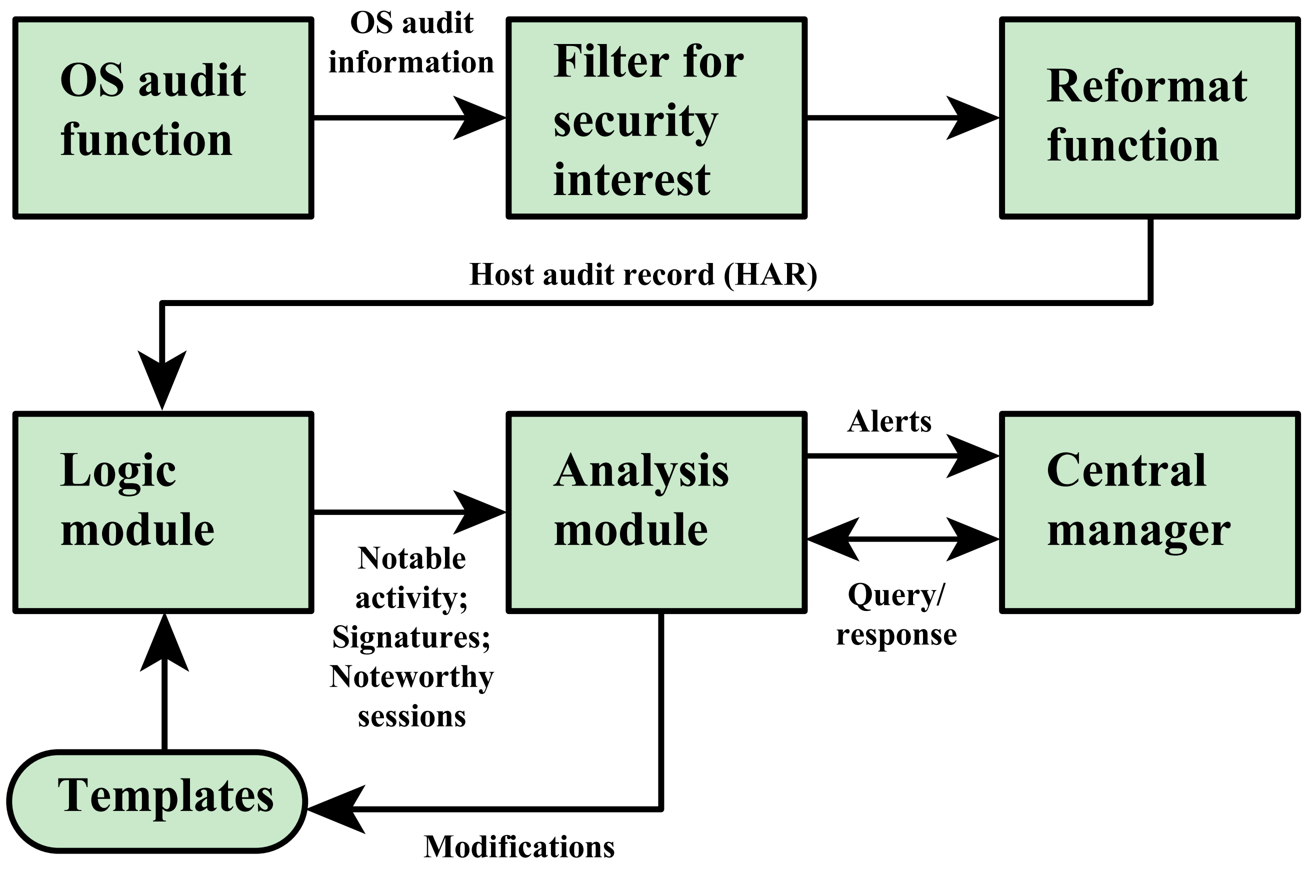


Figure 8.3 Agent Architecture

# 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

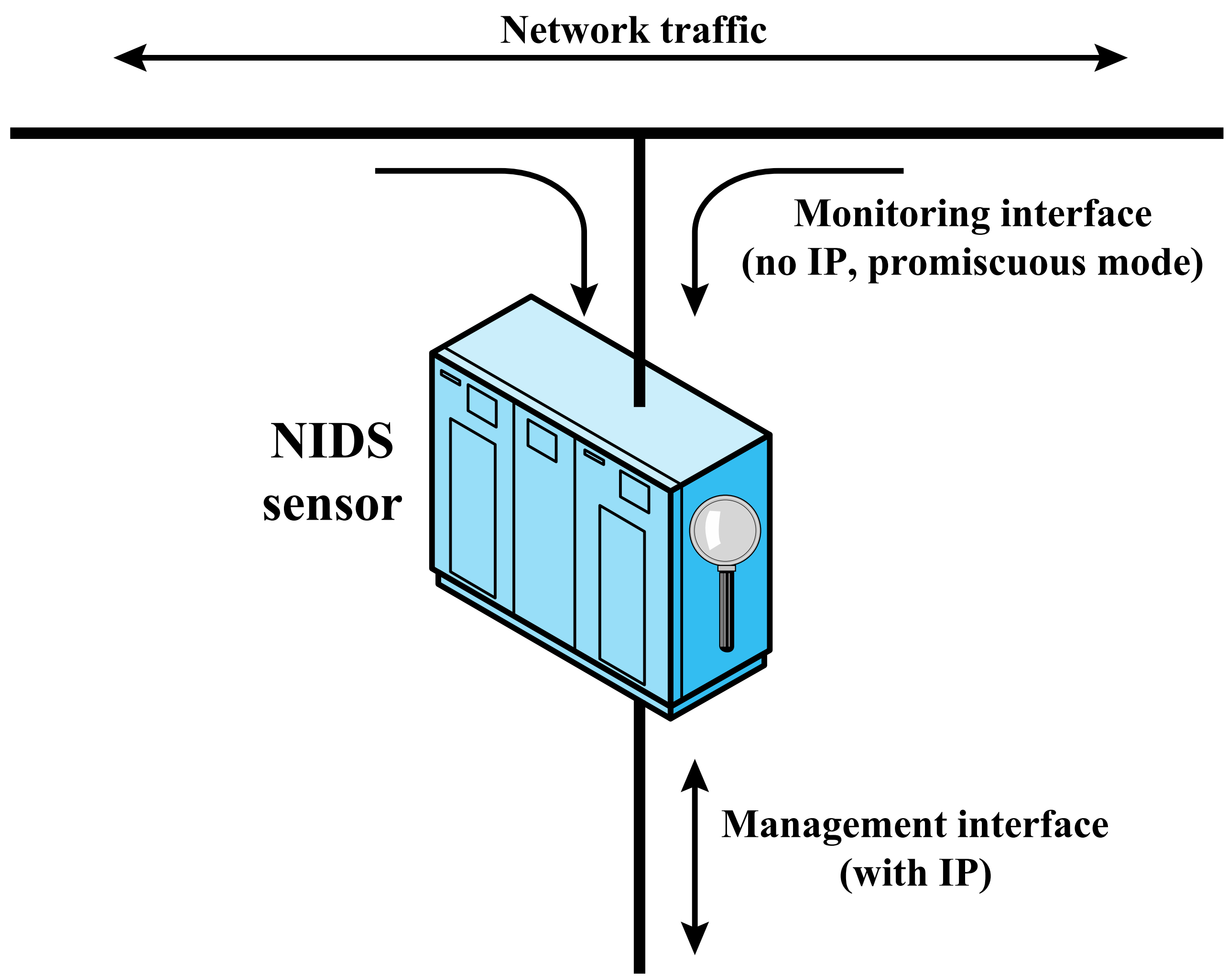


Figure 8.4  Passive NIDS Sensor

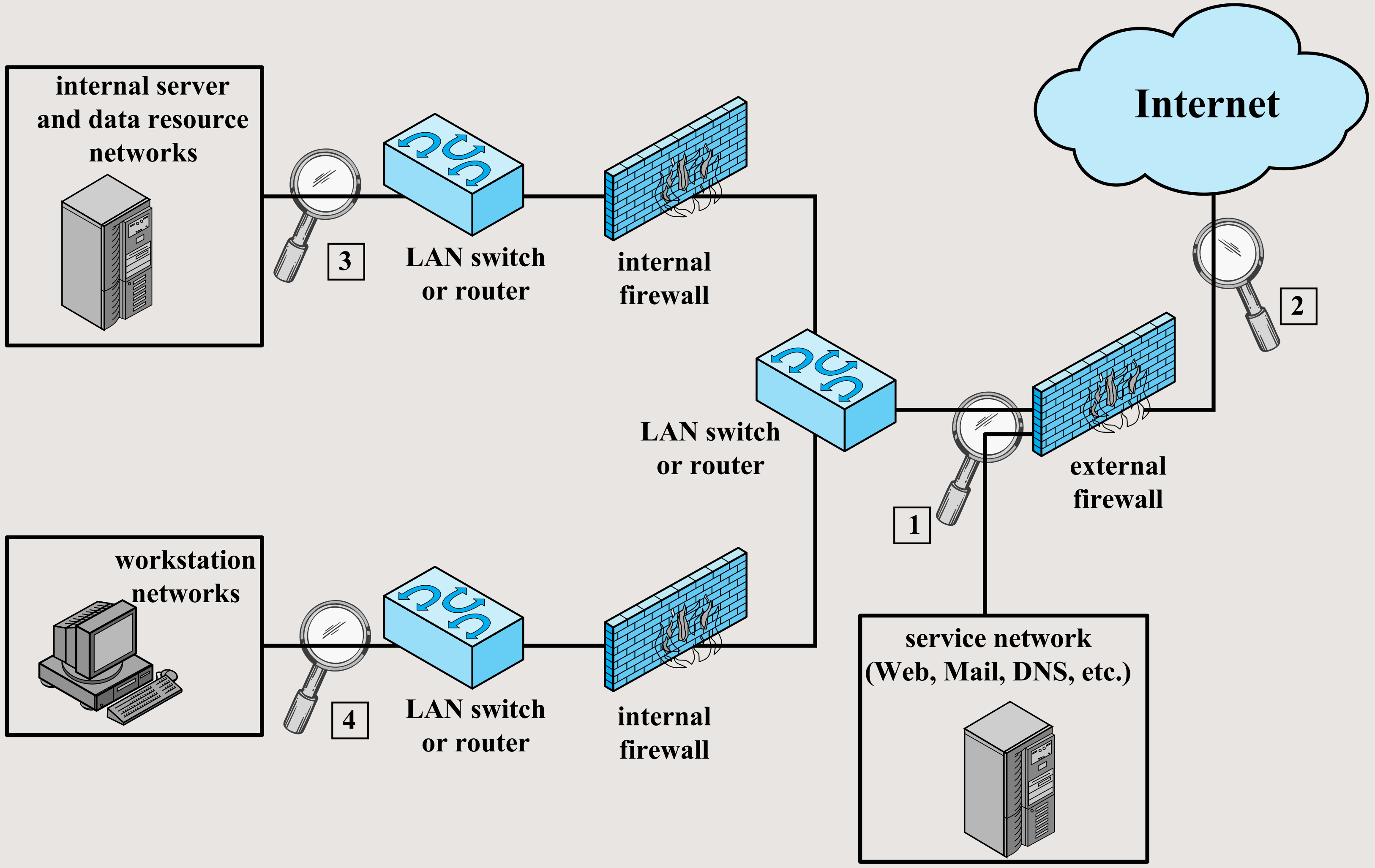


Figure 8.5 Example of NIDS Sensor Deployment

## Intrusion Detection Techniques

Attacks suitable for Signature detection

- Application layer reconnaissance and attacks
- Transport layer reconnaissance and attacks
- Network layer reconnaissance and attacks
- Unexpected application services
- Policy violations

Attacks suitable for Anomaly detection

- Denial-of-service (DoS) attacks
- Scanning
- Worms

## Stateful Protocol Analysis (SPA)

- Subset of anomaly detection that compares observed network traffic against predetermined universal vendor supplied profiles of benign protocol traffic
  - This distinguishes it from anomaly techniques trained with organization specific traffic protocols
- Understands and tracks network, transport, and application protocol states to ensure they progress as expected
- A key disadvantage is the high resource use it requires

## Logging of Alerts

- Typical information logged by a NIDS sensor includes:
  - Timestamp
  - Connection or session ID
  - Event or alert type
  - Rating
  - Network, transport, and application layer protocols
  - Source and destination IP addresses
  - Source and destination TCP or UDP ports, or ICMP types and codes
  - Number of bytes  transmitted over the connection
  - Decoded payload data, such as application requests and responses
  - State-related information

# IETF Intrusion Detection Working Group

- Purpose is to define data formats and exchange procedures for sharing information of interest to intrusion detection and response systems and to management systems that may need to interact with them
- The working group issued the following RFCs in 2007:

**Intrusion Detection Message Exchange Requirements (RFC 4766)**

- Document defines requirements for the Intrusion Detection Message Exchange Format (IDMEF)
- Also specifies requirements for a communication protocol for communicating IDMEF

**The Intrusion Detection Message Exchange Format (RFC 4765)**

- Document describes a data model to represent information exported by intrusion detection systems and explains the rationale for using this model
- An implementation of the data model in the Extensible Markup Language (XML) is presented, and XML Document Type Definition is developed, and examples are provided

**The Intrusion Detection Exchange Protocol (RFC 4767)**

- Document describes the Intrusion Detection Exchange Protocol (IDXP), an application level protocol for exchanging data between intrusion detection entities
- IDXP supports mutual authentication, integrity, and confidentiality over a connection oriented protocol

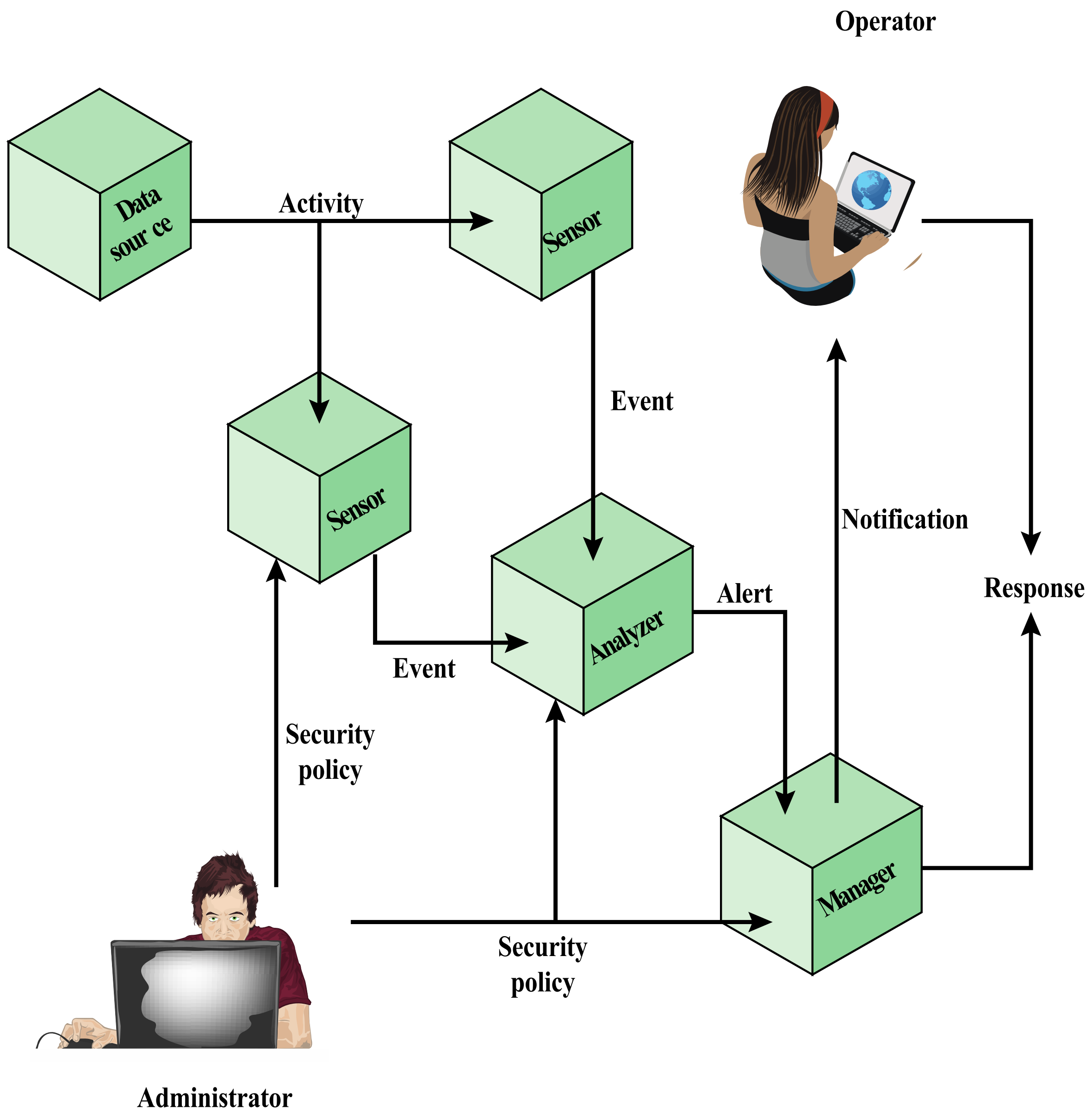


Figure 8.7 Model For Intrusion Detection Message Exchange

# Honeypots

- 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
- Systems are filled with fabricated information that a legitimate user of the system wouldn't access
- Resources that have no production value
  - Therefore incoming communication is most likely a probe, scan, or attack
  - Initiated outbound communication suggests that the system has probably been compromised

## Honeypot Classifications

- Low interaction honeypot
  - Consists of a software package that emulates particular IT services or systems well enough to provide a realistic initial interaction, but does not execute a full version of those services or systems
  - Provides a less realistic target
  - Often sufficient for use as a component of a distributed IDS to warn of imminent attack
- High interaction honeypot
  - A real system, with a full operating system, services and applications, which are instrumented and deployed where they can be accessed by attackers
  - Is a more realistic target that may occupy an attacker for an extended period
  - However, it requires significantly more resources
  - If compromised could be used to initiate other attacks on other systems

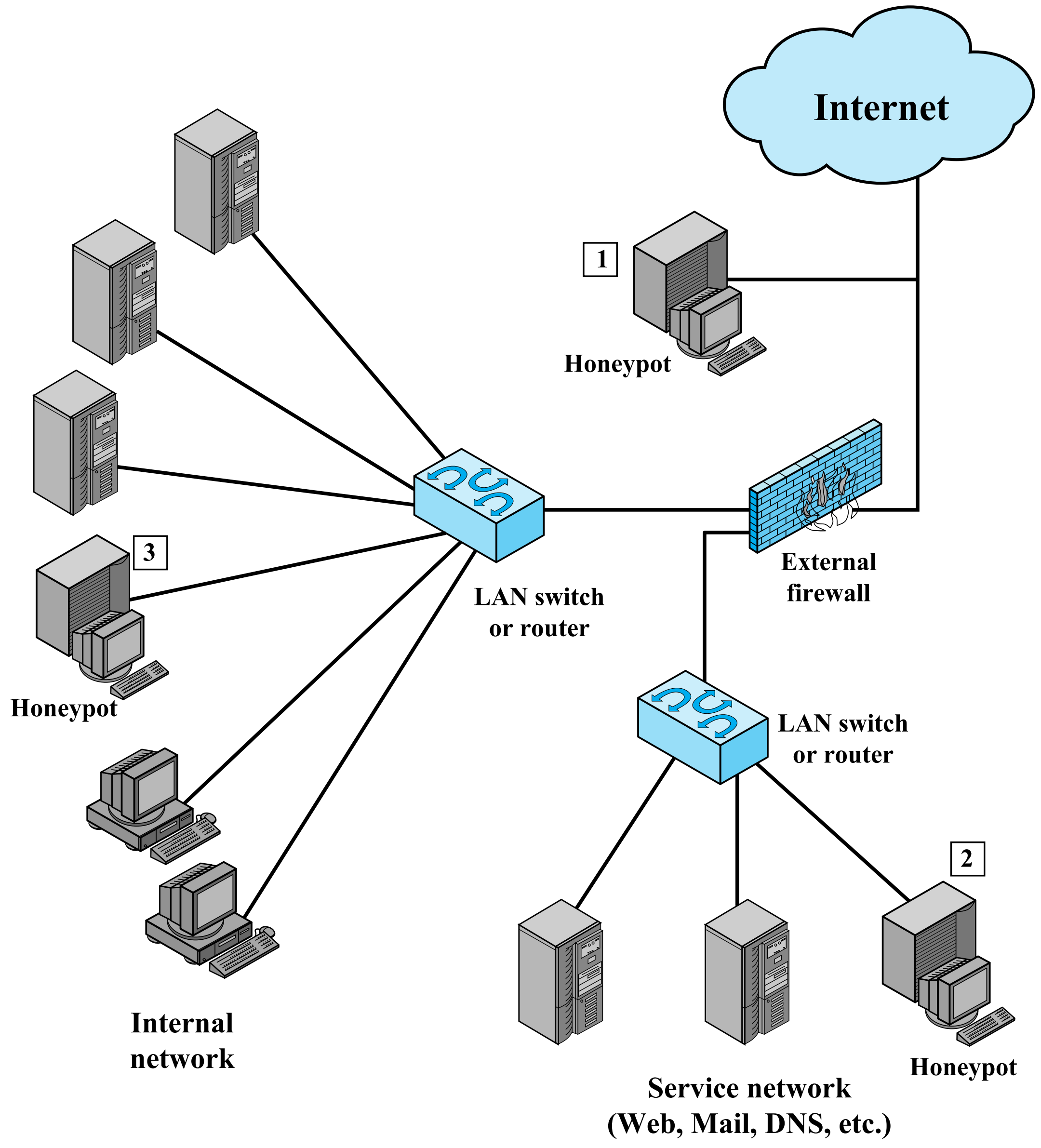


Figure 8.8 Example of Honeypot Deployment

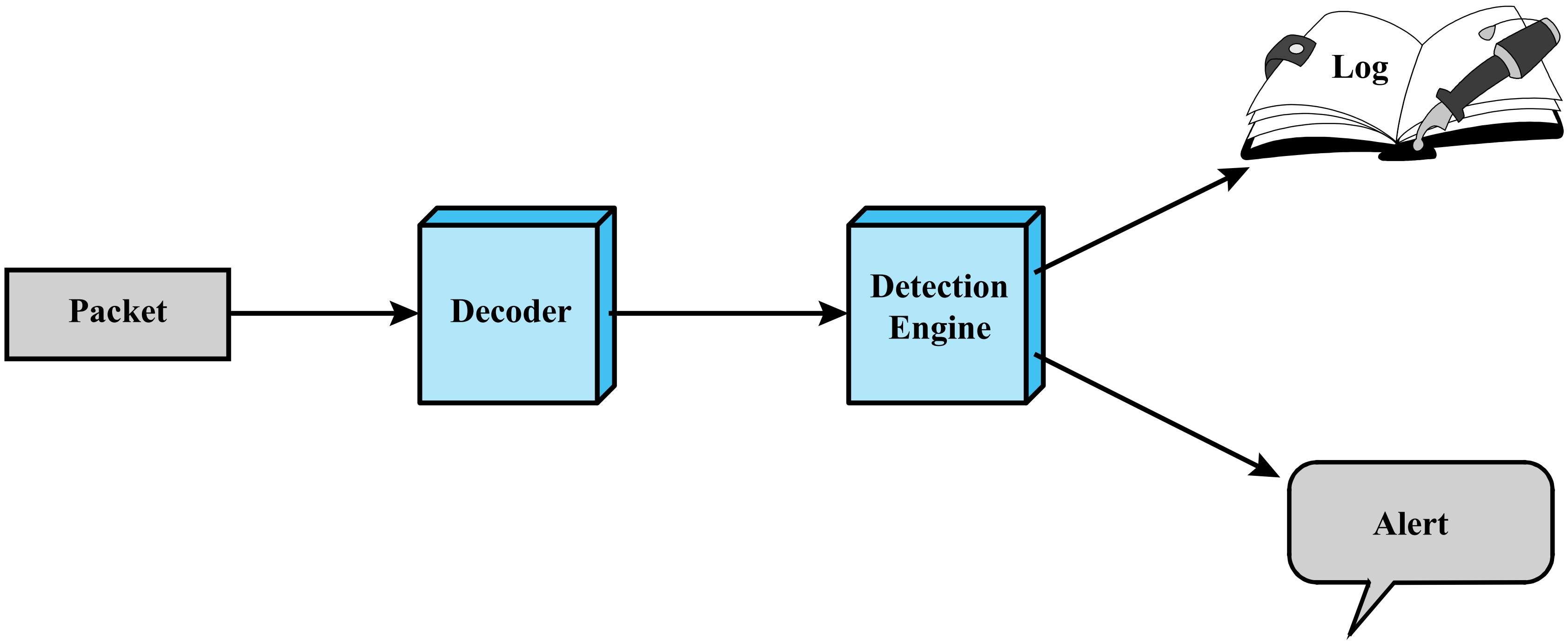


**Figure 8.9 Snort Architecture**

| Action | Protocol | Source IP address | Source Port | Direction | Dest IP address | Dest Port |
|---|---|---|---|---|---|---|

(a) Rule Header

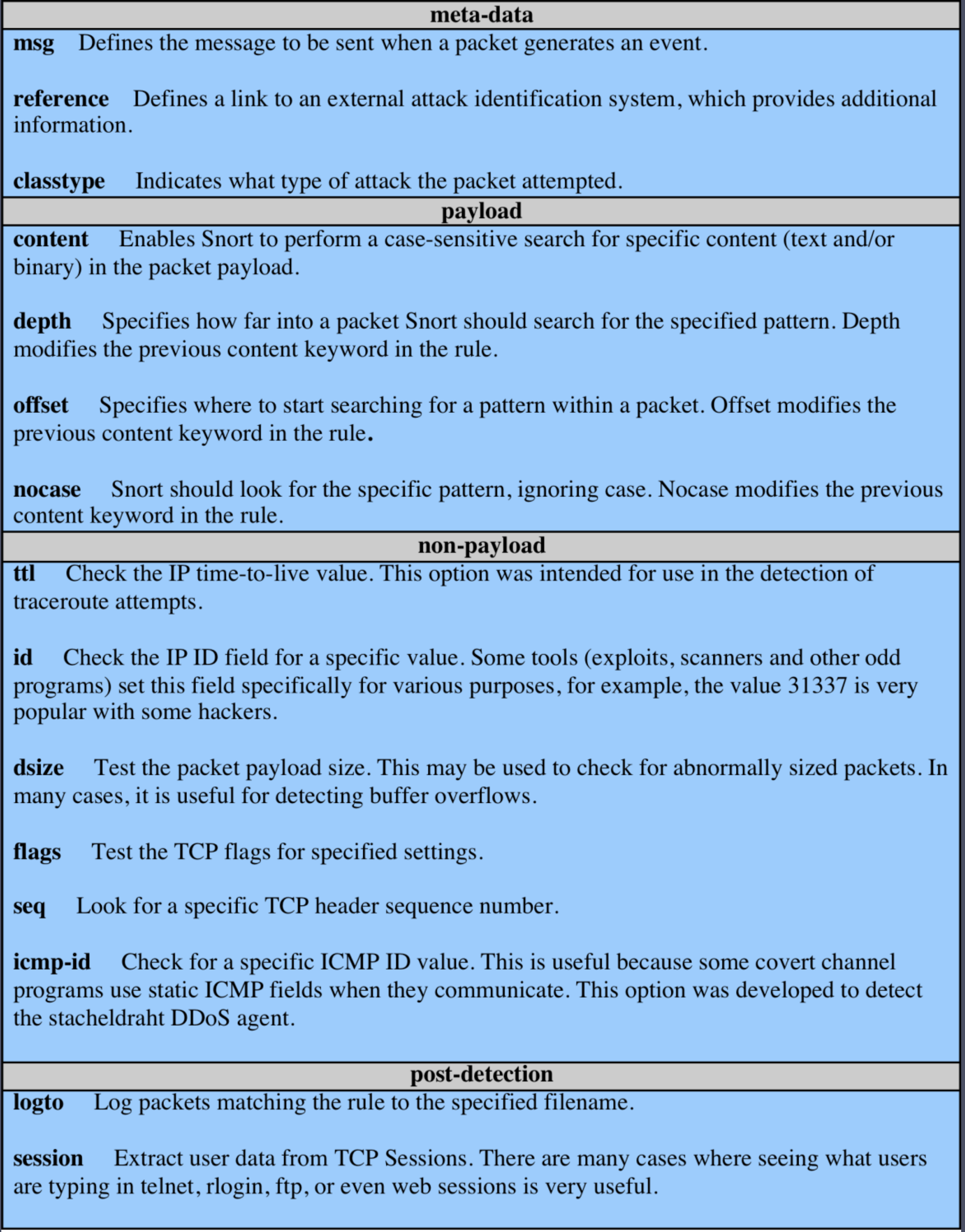
| Option Keyword | Option Arguments | • • • |
|---|---|---|

(b) Options

**Figure 8.10 Snort Rule Formats**

# Table 8.3
# Snort Rule Actions

| 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. |



| | |
|---|---|
| **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. |

## Table 8.4

## Examples of Snort Rule Options

(Table can be found on page 283 in textbook.)

# Summary

- Intruders
  - Intruder behavior
- Intrusion detection
  - Basic principles
  - The base-rate fallacy
  - Requirements
- Analysis approaches
  - Anomaly detection
  - Signature or heuristic detection
- Distributed or hybrid intrusion detection
- Intrusion detection exchange format
- Honeypots
- Host-based intrusion detection
  - Data sources and sensors
  - Anomaly HIDS
  - Signature or heuristic HIDS
  - Distributed HIDS
- Network-based intrusion detection
  - Types of network sensors
  - NIDS sensor deployment
  - Intrusion detection techniques
  - Logging of alerts
- Example system: Snort
  - Snort architecture
  - Snort rules

## Practical 7

- Demonstrate the working of a honeypot.
- Tips:
  - Demonstrate it in a virtual environment, i.e. VirtualBox
- Make screen video of your demo. 5min max
- Prefer to use YouTube and submit a link only
- Must state your name, student no at beginning
- May NOT use videos from Internet, only yours!
- **Submission deadline: 26/10/2022, 11:59pm**
- Absolutely no late submissions will be allowed. No excuse of slow server etc.
- No email submissions will be accepted.

# Practical 7

- Marks awarding:
  - Video time utilization – Max 5min. Mark: 10
  - Variety of demonstration (different honeypots?). Must at least have one. Mark: 20
  - Construction and flow of video (clarity, logic etc.). Mark: 20
  - Total: 50
  - Bonus: 10
  - Hints for bonus:
    - Anything more than required above.
    - Must have a summary in your video where you indicate what you think can be for bonus marks.
    - If your video guides very well how to recreate your demo by the person watching it, you will get bonus. There are lots of free video capturing software available.