#### Intrusion Detection

### 2.6.Outline

- Intruders
- Intrusion Detection
- Analysis Approaches
- Host-Based Intrusion Detection
- Network-Based Intrusion Detection
- Distributed or Hybrid Intrusion Detection
- Intrusion Detection Exchange Format
- Honeypots
- Example System: Snort

# 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
- Typically they are young, often Eastern European, Russian, or southeast Asian hackers, who do business on the Web
- They meet in underground forums 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
  - ie. Anonymous and LulzSec

### 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

- 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
- 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 of an e-mail server
- 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

### 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.

#### (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.

#### (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.

#### Examples of Intruder Behavior

### 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

**Resist subversion.** The IDS Be fault tolerant. It must be Run continually with minimal must be able to monitor itself able to recover from system and detect if it has been human supervision crashes modified by an attacker Adapt to changes in systems Configured according to Impose a minimal overhead and users behavior over system security policies on system time **Provide graceful** degradation of service. if Allow dynamic some components of the IDS Scale to monitor large reconfiguration. the ability to numbers of systems stop working for any reason, reconfigure the IDS without the rest of them should be having to restart it. affected as little as possible.

# 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

 Analysis of the observed behavior using univariate, multivariate, or time-series models of observed metrics

#### Knowledge based

Approaches use an expert system that classifies observed
behavior according to a set of rules that model legitimate
behavior

#### Machine-learning

Approaches

 automatically
 determine a
 suitable
 classification
 model from the
 training data
 using data
 mining
 techniques

### Machine-Learning

A variety of machine-learning approaches have been tried, with varying success.

Bayesian networks	Markov models	Neural networks	Fuzzy logic	Genetic algorithms	Clustering and outlier detection
• Encode probabilistic relationships among observed metrics.	• Develop a model with sets of states, some possibly hidden, interconnected by transition probabilities.	• Simulate human brain operation with neurons and synapse between them, that classify observed data.	• Uses fuzzy set theory where reasoning is approximate, and can accommodate uncertainty	• Uses techniques inspired by evolutionary biology	• Group the observed data into clusters based on some similarity or distance measure, and then identify subsequent data as either belonging to a cluster or as an outlier.

### Signature or Heuristic Detection



Host-Based Intrusion Detection (HIDS)

- 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
- Can use either anomaly or signature and heuristic approaches

### 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



**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 Attacks suitable for Anomaly detection

- Application layer reconnaissance and attacks (DNS, FTP, HTTP etc.)
- Transport layer reconnaissance and attacks (TCP, UDP)
- Network layer reconnaissance and attacks (IP v4/v6, ICMP)
- Unexpected application services
- Policy violations

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

# Stateful Protocol Analysis (SPA)

- NIST SP 800-94 details this 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 attacks on other systems



Figure 8.8 Example of Honeypot Deployment



- Snort is an open source, highly configurable and portable host-based or network-based IDS
- Snort is referred to as a lightweight IDS
  - Easily deployed on most nodes (host, server, router) of a network
  - Efficient operation that uses small amount of memory and processor time
  - Easily configured by system administrators who need to implement a specific security solution in a short amount of time
- Snort can perform real-time packet capture, protocol analysis, and content searching and matching

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

#### (a) Rule Header

Option	Option	
Keyword	Arguments	

(b) Options

#### **Figure 8.10 Snort Rule Formats**

#### **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.
<b>reference</b> Defines a link to an external attack identification system, which provides additional information.
pavload
antent English Sport to perform a asso consistive search for apacific content (text and/or
content Enables short to perform a case-sensitive search for specific content (text and/or
binary) in the packet payload.
<b>depth</b> Specifies how far into a packet Snort should search for the specified pattern. Depth
modifies the previous content keyword in the rule.
offect Spacifies where to start searching for a pattern within a packet. Offect modifies the
onset spectrics where to start scarcing for a pattern within a packet. Onset mountes the
previous content keyword in the rule.
<b>nocase</b> Snort should look for the specific pattern, ignoring case. Nocase modifies the previous
content keyword in the rule.
non-navload
ttl Check the IP time to live value. This option was intended for use in the detection of
the circle in the do-invervalue. 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.
popular with some interests
daine Test the postet period size. This may be used to shock for share-the sized restricts. In
usize 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.

Examples of Snort Rule Options