Intrusion Detection Systems

Raj Jain
Washington University in Saint Louis
Saint Louis, MO 63130
Jain@cse.wustl.edu

Audio/Video recordings of this lecture are available at:

http://www.cse.wustl.edu/~jain/cse571-07/

Overview

- Concepts
- Intrusion vs. Extrusion Detection
- Types of IDS
- Host vs. Network IDS
- Protocols for IDS: Syslog, BEEP, IDXP

Concepts

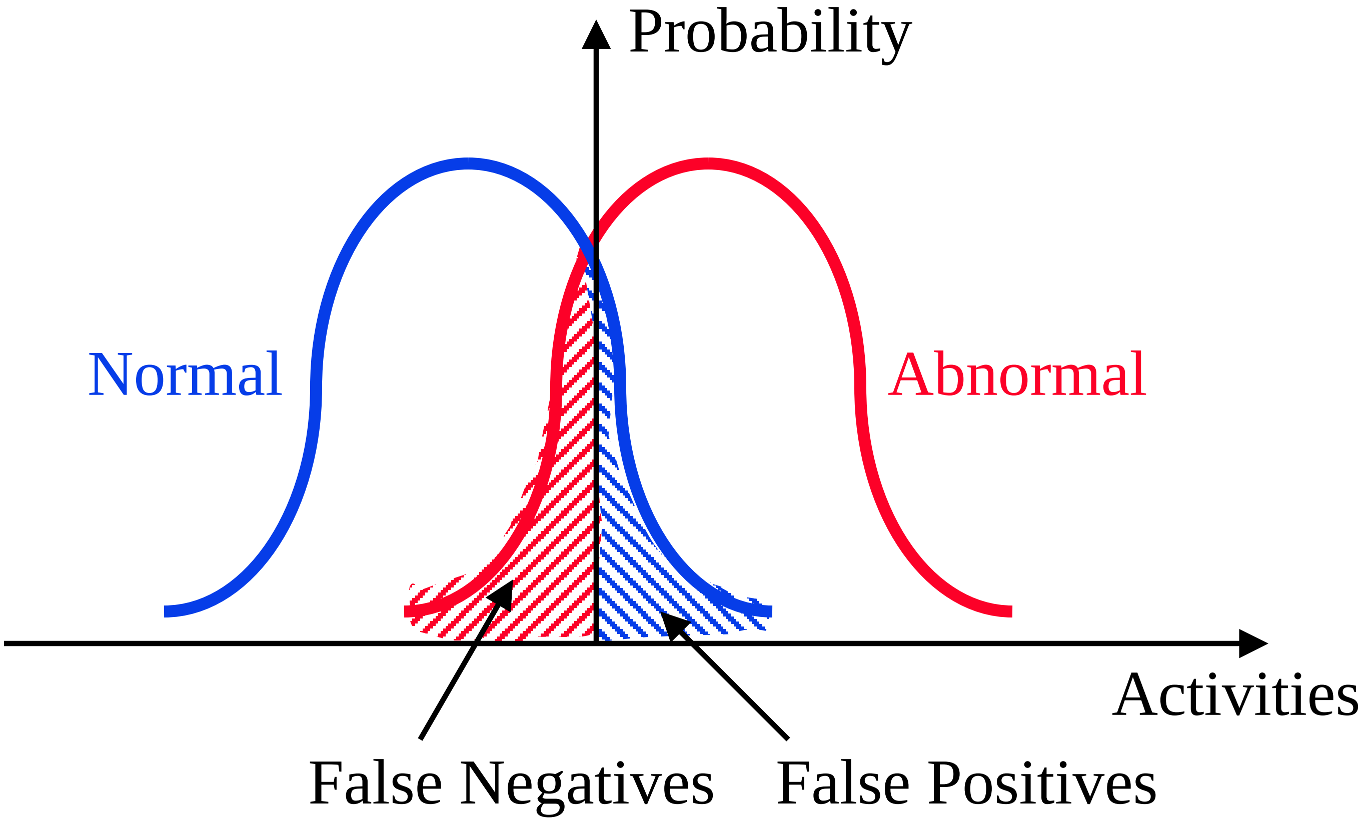
- **Intrusion**: Break into, misuse, or exploit a system (against policy)
- **Intruders**: Insiders or outsiders
  Most IDS are designed for outsiders
- **Vulnerability**: Weakness that could be used by the attacker
- **Threat**: Party that exploits a vulnerability
- **Structured Threat**: Adversaries with a formal methodology, a financial sponsor, and a defined objective.
- **Unstructured Threat**: Compromise victims out of intellectual curiosity

Intrusion vs. Extrusion Detection

- **Intrusion Detection**: Detecting unauthorized activity by inspecting inbound traffic
- **Extrusion Detection**: Detecting unauthorized activity by inspecting outbound traffic
- **Extrusion**: Insider visiting malicious web site or a Trojan contacting a remote internet relay chat channel

Notification Alarms

- False Positive: Valid traffic causes an alarm
- False Negative: Invalid traffic does not cause an alarm

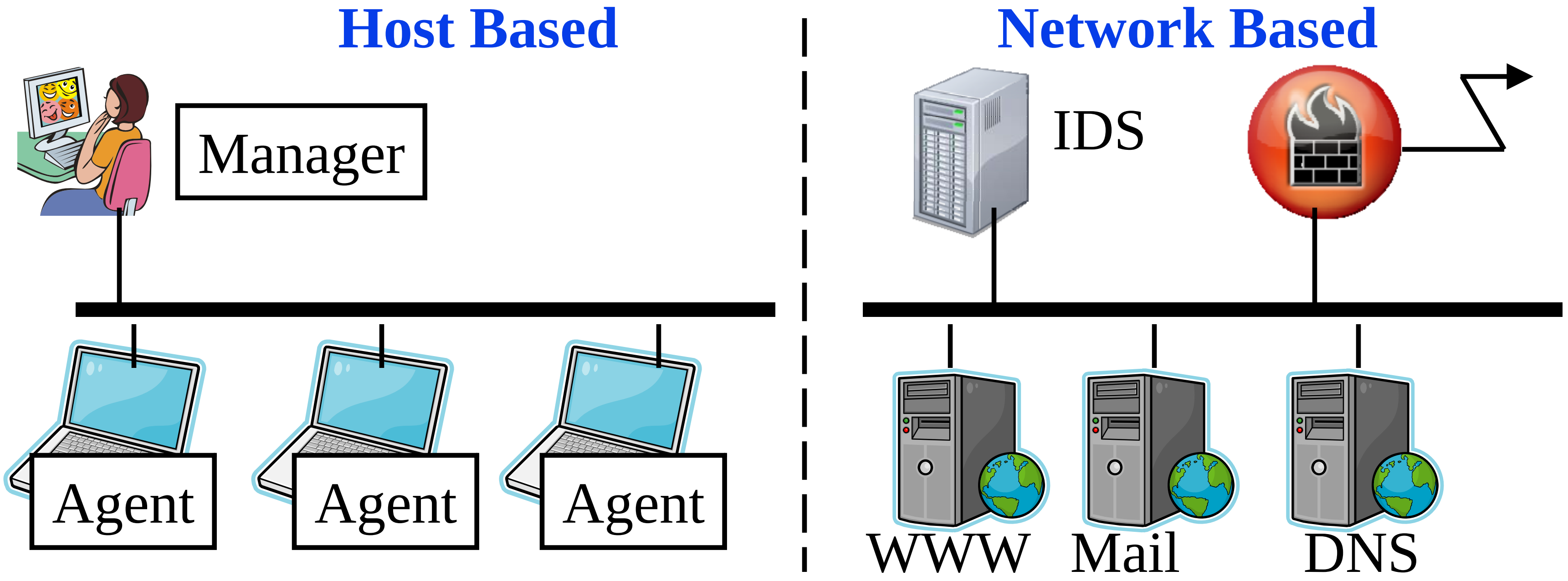


Types of IDS Sensors

- Log analyzers: Matching log entry ⇒ Action
- Signature based sensors
- System call analyzers: Shim between applications and OS
- Application behavior analyzers: E.g., web server writing a file
- File Integrity checkers

Types of IDS

- IDS Sensor: SW/HW to collect and analyze network traffic
- Host IDS: Runs on each server or host
- Network IDS: Monitors traffic on the network
  Network IDS may be part of routers or firewalls



Host vs. Network IDS

IDS Type	Pros	Cons
Host IDS	Verification of success or failure of an attack possible	OS/HW dependent
	Specific to a system	Impacts performance of the host
	Not limited by network bandwidth or encryption	One per host ⇒ Expensive
Network IDS	Protects all hosts	Challenging to see all traffic in a switched environment
	Independent of OS/HW	Too much traffic to analyze
	Useful against probes and DoS attacks	Not effective against single packet attacks and encrypted traffic

Types of IDS (Cont)

- Signature Based IDS: Search for known attack patterns using pattern matching, heuristics, protocol decode
- Rule Based IDS: Violation of security policy
- Anomaly-Based IDS
- Statistical or non-statistical detection
- Response:
  - Passive: Alert the console
  - Reactive: Stop the intrusion ⇒ Intrusion Prevention System ⇒ Blocking

Signature Based IDS

- 5-tuple packet filtering (SA/DA/L4 protocol/ports)
- Use Ternary Content Addressable Memories (TCAMs)
- Deep packet inspection requires pattern string matching algorithms (Aho-Corasik algorithm and enhancements)
- Regular expression signatures

Types of Signatures

Category	Types
IP	IP Options
	IP Fragmentation
	Bad IP packets
ICMP	ICMP Traffic Records
	Ping Sweeps
	ICMP attacks
TCP	TCP Traffic Records
	TCP Port Scans
	TCP host Sweeps
	Mail attacks
…	…

- Ref: Sasdat Malik's book

Sample Signatures

- ICMP Floods directed at a single host
- Connections of multiple ports using TCP SYN
- A single host sweeping a range of nodes using ICMP
- A single host sweeping a range of nodes using TCP
- Connections to multiple ports with RPC requests between two nodes

Anomaly Based IDS

- Traffic that deviates from normal, e.g., routing updates from a host
- Statistical Anomaly: sudden changes in traffic characteristics
- Machine Learning: Learn from false positives and negatives
- Data Mining: Develop fuzzy rules to detect attacks

Open Issues

- Performance degradation
- Encrypted traffic
- Polymorphic attacks: change their signatures
- Human intervention: Inconvenient and slows down
- Newer and Newer Attacks: Need to keep signatures updated

Protocols for IDS

- SYSLOG Protocol
- SYSLOG Packet Format
- Remote Data Exchange Protocol (RDEP)
- BEEP
- IDMEF

SYSLOG Protocol

- RFC 3164, August 2001
- Designed for BSD. Now used on many OSs.
- Used to send event data
- Device: Originates event data
- Collector (Server): Consumes/logs/acts on event data
- Relay: forwards event data
- Sender/Receiver
- Uses UDP port 514

SYSLOG Packet Format

- 3 Parts: PRI, Header, Msg
- PRI = <nnn> = Facility*8+Severity
- Facility: 0=Kernel, 1=User-level, 2=Mail, ...
- Severity: 0=Emergency, 1=Alert, ...
- Header: Timestamp and Hostname
- MSG: Additional info
- Example:
- <34>Dec 10 22:14:15 siesta su: 'su root' failed for jain on /dev/csf/
- No connection ⇒ No security, integrity, reliability
- Reliability ⇒ Syslog over TCP, RFC 3195, November 2001

Remote Data Exchange Protocol (RDEP)

- Cisco protocol to exchange IDS events
- Alarms remain on the sensors until pulled by the management system
- Uses XML encoding for data
- Out-of-band or in-band communication using secure channel
- Ref: Joe Minieri, "RDEP Client," http:

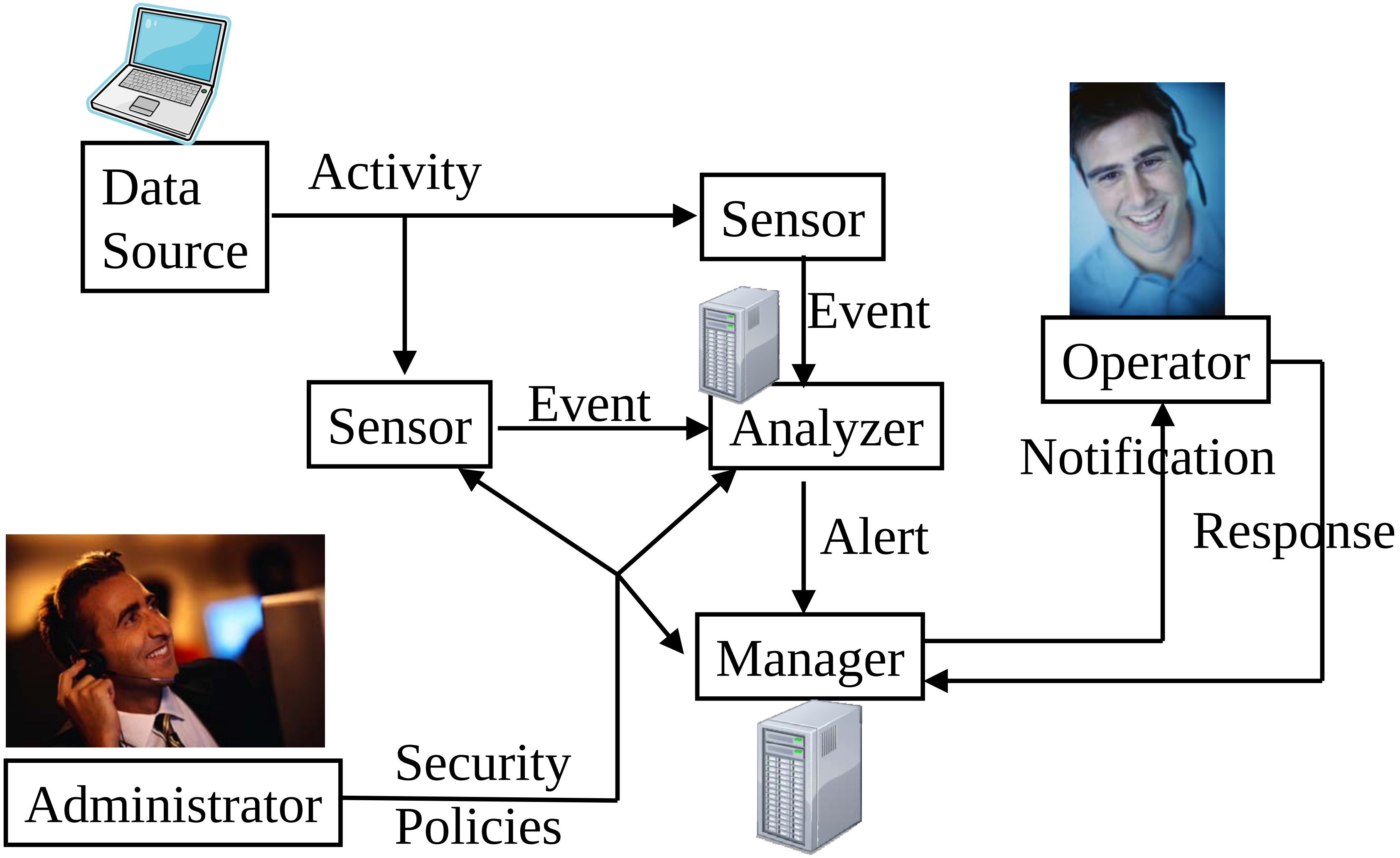
BEEP

- Block Extensible Exchange Protocol
- RFC 3080, March 2001
- Generic application protocol kernel for connection-oriented asynch interactions
- Supports both textual and binary messages
- Messages are arbitrary MIME content, usually XML
- Supports multiple simultaneous exchanges - channels
- Each channel has a associated profile that defines syntax and semantics
- Channel management profile,
- TLS transport security profile
- BEEP peer advertises the profiles it supports and later offers one of the profile for the channel

IDMEF

- Intrusion Detection Message Exchange Format
- RFC 4765, 4766, 4767, March 2007
- Many IDS sensor vendors, Many management consoles ⇒ Need standard data format and protocol
- Data format and exchange procedures for sharing IDS info
- Uses Extensible Markup Language (XML)
- Allows vendors to extend the definition

IDMEF Concepts



Data Source

Activity

Sensor

Event

Sensor

Event

Analyzer

Operator

Notification

Response

Alert

Manager

Administrator

Security Policies

IDMEF Concepts (Cont)

- **Data source**: Raw network packets, audit logs, application logs
- **Sensor**: Collects from data source and forwards to analyzer
- **Analyzer**: Analyzes the data collected by sensor
- **Manager**: Used by operator to configure sensors, analyzers, data consolidation, etc.
- **Operator**: Human user of IDS manager
- **Administrator**: Human responsible for security policies
- **Activity**: Any action - Unauthorized file access, login failure
- **Alert**: Message from analyzer to manager
- **Event**: Activity that results in an alert
- **Notification**: from manager to administrator
- **Response**: Action taken in response to an event
- **Signature**: Rule used by analyzer
- **Security Policy**: Formal document on what is allowed

IDXP

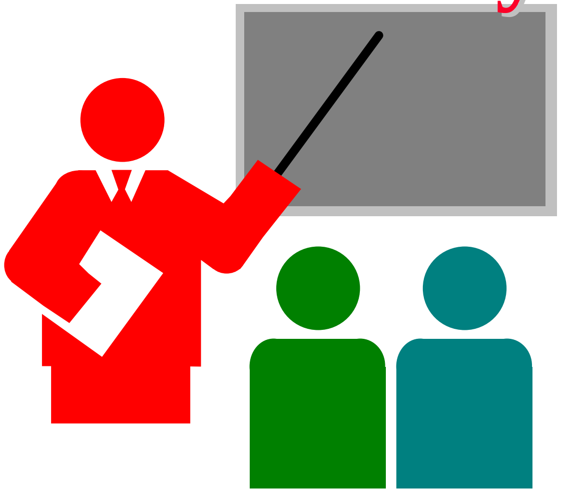
- Intrusion Detection Exchange Protocol
- RFC 4767, March 2007
- Application level protocol for exchanging IDS data
- A profile of Blocks Extensible Exchange Protocol (BEEP)
- BEEP offers the security part using TLS or Simple Authentication and Security Layer (SASL) profiles
- BEEP also has a TUNNEL profile for going over proxy servers (untrusted)
- IDXP provides the messages for IDS data exchange
- Only peer-to-peer two-party communication
- Multi-party to multi-party communication using pair-wise connections

IDMEF Example: Teardrop Attack

- Teardrop= IP Fragments with overlapping oversize payloads

```
<?xml version="1.0" encoding="UTF-8"?>
 <idmef:IDMEF-Message xmlns:idmef=http://iana.org/idmef version="1.0">
 <idmef:Alert messageid="abc123456789">
    <idmef:Analyzer analyzerid="hq-dmz-analyzer01">
    <idmef:Node category="dns">
    <idmef:location>Headquarters DMZ Network</idmef:location>
    <idmef:name>analyzer01.example.com</idmef:name>
    </idmef:Node>
    </idmef:Analyzer>
    <idmef:CreateTime ntpstamp="0xbc723b45.0xef449129">
      2000-03-09T10:01:25.93464-05:00
    </idmef:CreateTime>
    <idmef:Source ident="a1b2c3d4">
    <idmef:Node ident="a1b2c3d4-001" category="dns">
    <idmef:name>badguy.example.net</idmef:name>
     …
  </idmef:Alert>
</idmef:IDMEF-Message>
```

Summary



- Intrusion detection systems: Host based and Network Based
- Analyzers can be signature based, anomaly based
- Syslog provides a simple efficient method for IDS data
  But it is not secure or reliable
- IDXP provides a secure, reliable method of IDS data exchange

References

- S. Kumar, "Survey of Current Network Intrusion Detection Techniques," http://www.cse.wustl.edu/~jain/cse571-07/p_nid.html
- NIST, Guide to Intrusion Detection and Prevention Systems (IDPS), Special Publication SP 800-94, Sep 2006, http://csrc.nist.gove/publications/PubsSPs.html
- Open Directory Projects IDS Page, http://www.dmos.org/Computers/Security/Intrusion_Detection_Systems/ *Has a list of 25 open source and 96 commercial tools, 79 security scanners, 25 security scanner services*
- Architectural Issues of Intrusion Detection Infrastructure in Large Enterprises, http://www.softpanorama.org/Security/intrusion_detection.shtml
- SANS Institute, "Intrusion Detection FAQ," http://www.sans.org/resources/idfaq/index.php?portal=46489b3fa8324804cb8de1e1ff4ae9e7

RFCs

- RFC 3080 “The Blocks Extensible Exchange Protocol Core,” March 2001
- RFC 3164 “The BSD Syslog Protocol,” August 2001.
- RFC 3195 “Reliable Delivery for syslog,” November 2001.
- RFC 4765 “The Intrusion Detection Message Exchange Format (IDMEF),” March 2007.
- RFC 4766 “Intrusion Detection Message Exchange Requirements,” March 2007.
- RFC 4767 “The Intrusion Detection Exchange Protocol (IDXP),” March 2007.

References: Books Used

- Gert DeLaet, Gert X. Schauwers, "Network Security Fundamentals," Cisco Press, Sep 2004, 400 pp., ISBN:1587051672.
- Richard Bejtlich, "The Tao Of Network Security Monitoring : Beyond Intrusion Detection," Addison-Wesley, Jul 2004, 798 pp., ISBN:321246772.
- Richard Bejtlich, "Extrusion Detection: Security Monitoring for Internal Intrusions," Addison-Wesley Professional, Nov 2005, Paperback 416 pp., ISBN:0321349962.
- Saadat Malik, "Network Security Principles and Practices," Macmillan Technical Pub, Nov 2002, 400 pp., ISBN:1587050250.
- Terry Escamilla, "Intrusion Detection : Network Security Beyond the Firewall," Wiley, Oct 1998, 348 pp., ISBN:0471290009.