Intrusion Detection

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Method of last resort

- Intrusion prevention
  - Network firewall
    - Restrict flow of packets; cover in another lecture
  - System security
    - Find buffer overflow vulnerabilities and remove them!
- Intrusion detection
  - Discover system modifications
    - Tripwire
  - Look for attack in progress
    - Network traffic patterns
    - System calls, other system events

Tripwire

- Outline of standard attack
  - Gain user access to system
  - Gain root access
  - Replace system binaries to set up backdoor
  - Use backdoor for future activities
- Tripwire detection point: system binaries
  - Compute hash of key system binaries
  - Compare current hash to hash stored earlier
  - Report problem if hash is different
  - Store reference hash codes on read-only medium

Is Tripwire too late?

- Typical attack on server
  - Gain access
  - Install backdoor
    - This can be in memory, not on disk!
  - Use it
- Tripwire
  - Is a good idea
  - Wont catch attacks that don't change system files
  - Detects a compromise that has happened

Remember: Defense in depth

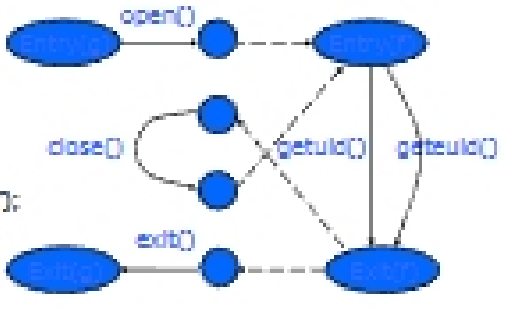
Detect modified binary in memory?

- Can use system-call monitoring techniques
- For example [Wagner, Dean IEEE S&P '01]
  - Build automaton of expected system calls
    - Can be done automatically from source code
  - Monitor system calls from each program
  - Catch violation

Results so far: lots better than not using source code!

Example code and automaton

```
f(int x) {
  x ? getuid() : geteuid();
  x++
}
g() {
  fd = open("foo", O_RDONLY);
  f(0); close(fd); f(1);
  exit(0);
}
```



If code behavior is inconsistent with automaton, something is wrong

General intrusion detection

http://www.snort.org/

- Many intrusion detection systems
  - Close to 100 systems with current web pages
  - Network-based, host-based, or combination
- Two basic models
  - Misuse detection model
    - Maintain data on known attacks
    - Look for activity with corresponding signatures
  - Anomaly detection model
    - Try to figure out what is "normal"
    - Report anomalous behavior
- Fundamental problem: too many false alarms

Misuse example - rootkit

- Rootkit sniffs network for passwords
  - Collection of programs that allow attacker to install and operate a packet sniffer (on Unix machines)
  - Emerged in 1994, has evolved since then
  - 1994 estimate: 100,000 systems compromised
- Rootkit attack
  - Use stolen password or dictionary attack to get user access
  - Get root access using vulnerabilities in rdist, sendmail, /bin/mail, loadmodule, rpc.ypupdated, lpr, or passwd
  - Ftp Rootkit to the host, unpack, compile, and install it
  - Collect more username/password pairs and move on

Rootkit covers its tracks

- Modifies netstat, ps, ls, du, ifconfig, login
  - Modified binaries hide new files used by rootkit
  - Modified login allows attacker to return for passwords
- Rootkit fools simple Tripwire checksum
  - Modified binaries have same checksum
  - But a better hash would be able to detect rootkit

Detecting rootkit on system

- Sad way to find out
  - Disk is full of sniffer logs
- Manual confirmation
  - Reinstall clean ps and see what processes are running
- Automatic detection
  - Rootkit does not alter the data structures normally used by netstat, ps, ls, du, ifconfig
  - Host-based intrusion detection can find rootkit files
    - As long as an update version of Rootkit does not disable your intrusion detection system …

Detecting network attack (Sept 2003)

- Symantec honeypot running Red Hat Linux 9
- Attack
  - Samba 'call_trans2open' Remote Buffer Overflow (BID 7294)
  - Attacker installed a copy of the SHV4 Rootkit
- Snort NIDS generated alerts, from this signature

```
alert tcp $EXTERNAL_NET any -> $HOME_NET 139 \
(msg:"NETBIOS SMB trans2open buffer overflow attempt"; \
flow:to_server,established; \
content:"|00|"; offset:0; depth:1; \
content:"|ff|SMB|32|"; offset:4; depth:5; \
content:"|00 14|"; offset:80; depth:2; \
...
```

More info: https://tms.symantec.com/members/AnalystReports/030929-Analysis-SHV4Rootkit.pdf

Misuse example - port sweep

- Attacks can be OS specific
  - Bugs in specific implementations
  - Oversights in default configuration
- Attacker sweeps net to find vulnerabilities
  - Port sweep tries many ports on many IP addresses
  - If characteristic behavior detected, mount attack
    - SGI IRIX responds TCPMUX port (TCP port 1)
    - If machine responds, SGI IRIX vulnerabilities can be tested and used to break in
- Port sweep activity can be detected

Anomaly Detection

- Basic idea
  - Monitor network traffic, system calls
  - Compute statistical properties
  - Report errors if statistics outside established range
- Example – IDES (Denning, SRI)
  - For each user, store daily count of certain activities
    - E.g., Fraction of hours spent reading email
  - Maintain list of counts for several days
  - Report anomaly if count is outside weighted norm

Big problem: most unpredictable user is the most important

[Hofmeyr, Somayaji, Forrest]

Anomaly – sys call sequences

- Build traces during normal run of program
  - Example program behavior (sys calls)
    open read write open mmap write fchmod close
  - Sample traces stored in file (4-call sequences)
    open read write open
    read write open mmap
    write open mmap write
    open mmap write fchmod
    mmap write fchmod close
  - Report anomaly if following sequence observed
    open read read open mmap write fchmod close

    Compute # of mismatches to get mismatch rate

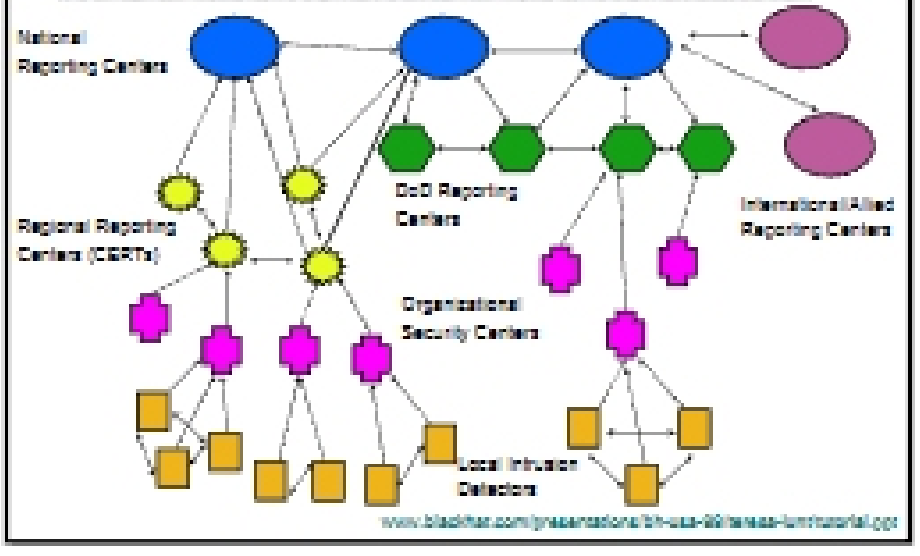
Difficulties in intrusion detection

- Lack of training data
  - Lots of "normal" network, system call data
  - Little data containing realistic attacks, anomalies
- Data drift
  - Statistical methods detect changes in behavior
  - Attacker can attack gradually and incrementally
- Main characteristics not well understood
  - By many measures, attack may be within bounds of "normal" range of activities
- False identifications are very costly
  - Sys Admin spend many hours examining evidence

Response to intrusion?

- Ideally,
  - Identify attack (possible if misuse, hard if anomaly)
  - Limit damage, stop attack, block further attacks
  - Restore system, identify and prosecute attacker
- Cliff Stoll
  - Detected attacker at Lawrence Berkeley
  - Created large file with nuclear weapons keywords
  - Traced international phone call during download

Strategic Intrusion Assessment [Lunt]



Strategic Intrusion Assessment [Lunt]

- Test over two-week period
  - AFIWC's intrusion detectors at 100 AFBs alarmed on 2 million sessions
  - Manual review identified 12,000 suspicious events
  - Further manual review => four actual incidents
- Conclusion
  - Most alarms are false positives
  - Most true positives are trivial incidents
  - Of the significant incidents, most are isolated attacks to be dealt with locally