The Linux Audit System

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- Working with Prof. Adam Bates
- Research Interests:
  - System Security
  - Data provenance

Recent Cyber Attacks

- **Equifax**
  - 145 million americans' sensitive data (e.g. SSN) was stolen
- **WannaCry**
  - A ransomware attack that spans over 150 countries
  - Hackers demanded money to unlock files
- **A Yahoo bombshell**
  - Yahoo's 3 billion accounts was hacked in 2013 – found out in 2016

Recent Cyber Attacks

- **Equifax**
- **Advanced Persistent Threat (APT)**

  Targeted: Targets specific organizations to exfiltrate information or disrupt the systems.
- **A Yahoo bombshell**
  - Yahoo's 3 billion accounts was hacked in 2013 – found out in 2016

5 Stages of APTs

1. **Reconnaissance**
   - Understand about the target using social media or company's website
2. **Incursion**
   - Enters into victim's system using different attack vectors (e.g. social engineering)
3. **Discovery**
   - The attackers stay low and operate patiently in order to avoid detection
4. **Capture**
   - Hackers access unprotected systems and capture data over an extended period of time
5. **Exfiltration**
   - Finally, captured information is sent back to the attack team's home base for analysis

5 Stages of APTs

1. **Reconnaissance**
2. [illegible]
3. [illegible]
4. [illegible]
   - [illegible]iod of time
5. **Exfiltration**
   - Finally, captured information is sent back to the attack team's home base for analysis

Due to complexity of APTs

Attack investigation such as finding root cause is challenging

Audit Logging Or Data Provenance

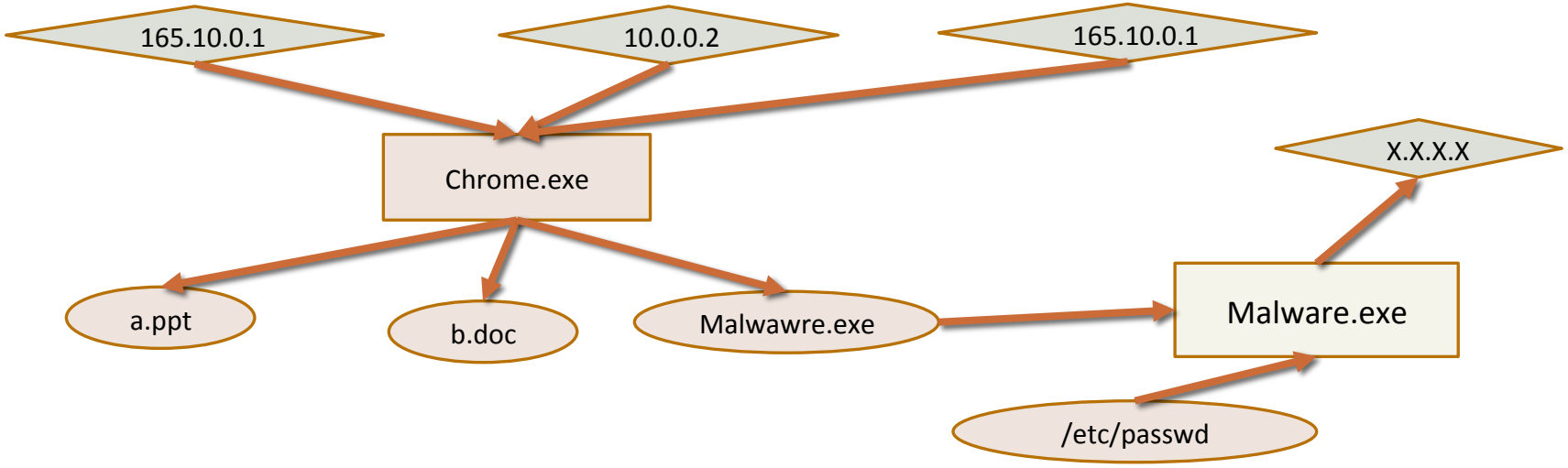
- Attack investigation and reconstruction technique
- Captures data life cycle:
  - Modifications
  - Deletions
  - Creations
- Detects causal dependencies between different events

Example Audit Log


```
chromium.exe reads from ip 10.0.0.2
chromium.exe reads from ip 165.10.0.1
chromium.exe reads from ip 91.0.0.2


chromium.exe downloads a.ppt
chromium.exe downloads b.doc
chromium.exe downloads malware.exe


malware.exe reads /etc/passwd
malware.exe sends /etc/passwd to ip
X.X.X.X
```

Represented as causal graph

- Vertices represents system entities (e.g. chrome process, a.ppt)
- Edges represents causal relationships (e.g. created, read, open)



Linux Audit System

- Linux Audit System collects audit logs
- Available on vanilla Linux kernels > version 2.6
- It collects information regarding:
  - Kernel event (System calls)
  - User events (Audit-enable programs)
  - It does not, however, provide additional security itself—it does not protect your system from code malfunctions

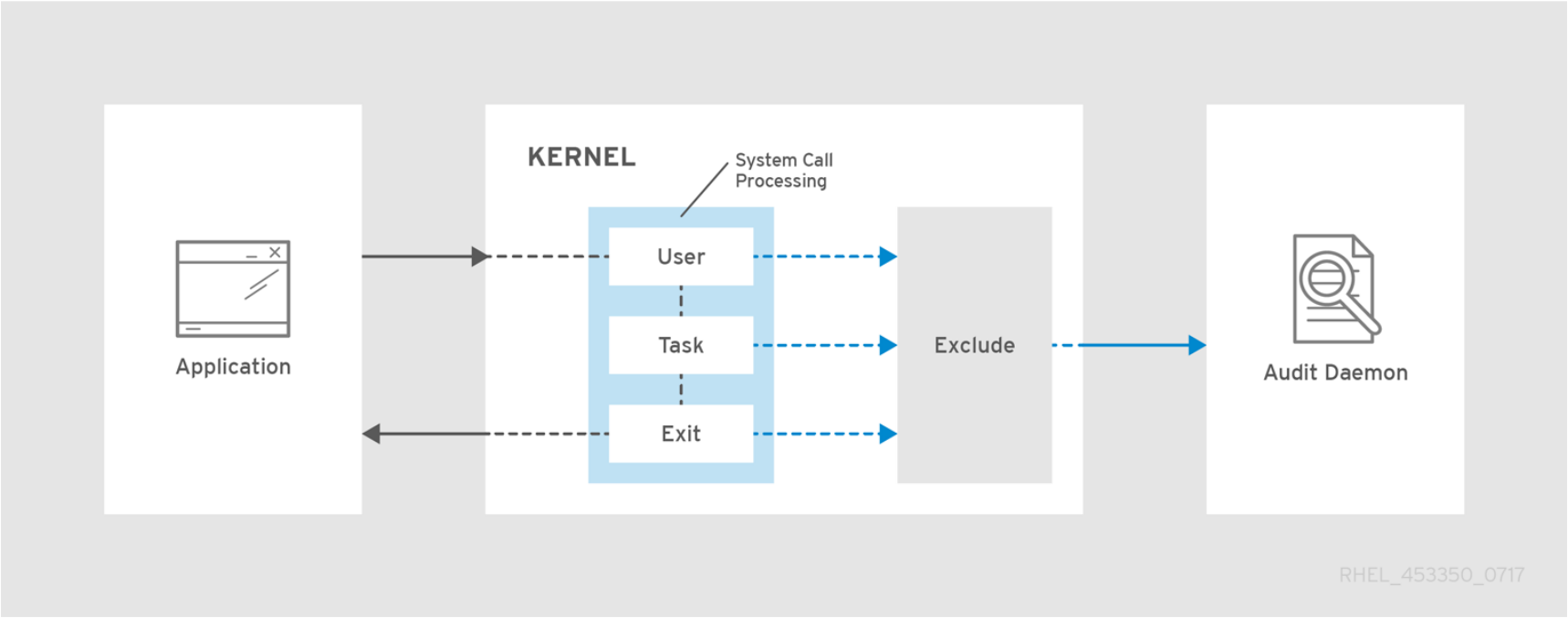
Linux Audit Use cases

- **Watching file access:**
  - Audit can track whether a file or a directory has been accessed, modified, executed
- **Monitoring system calls:**
  - Generate a log entry every time a particular system call is used
- **Recording commands run by a user:**
- **Monitoring network access:**
  - The **iptables** and **ebtables** utilities can be configured to trigger Audit events

How Linux Audit Works?

- Audit kernel module intercepts the system calls and records the relevant events
- The auditd daemon writes the audit reports to disk.
- Various command line utilities take care of displaying, querying, and archiving the audit trail.

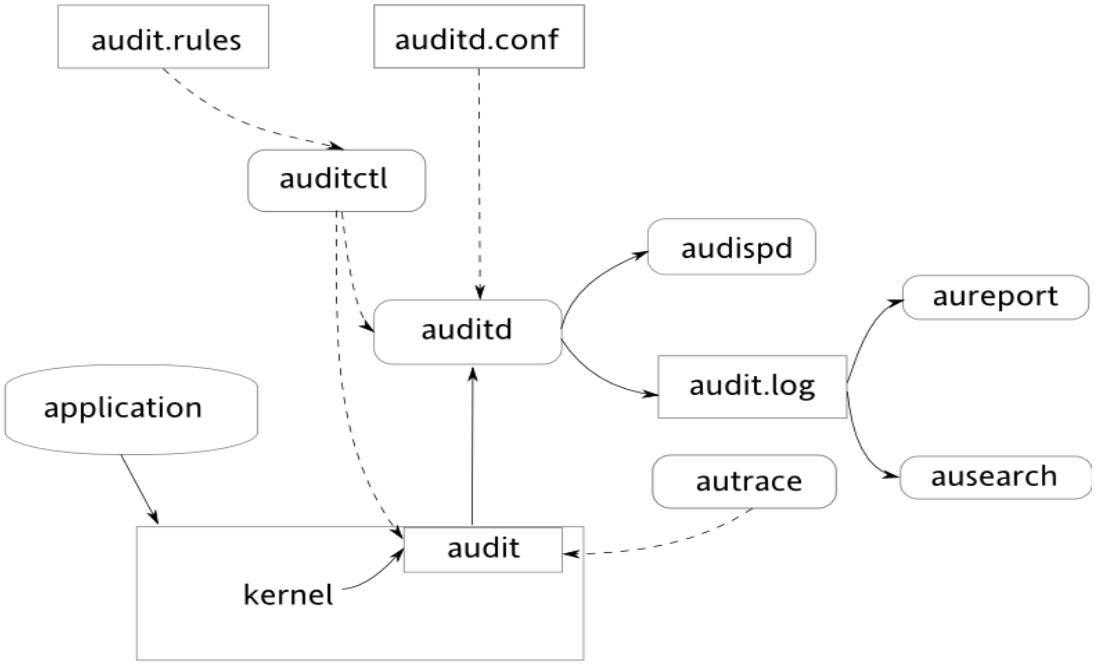
How Linux Audit Works?



Components of Linux Audit

- **auditctl** — utility for managing the auditd daemon; returns information on the audit subsystem's current status and can be used to add and delete rules
- **ausearch** — utility for searching for events in log files
- **aureport** — utility for generating reports on the audit system

Components of Linux Audit



Creating rules

- auditctl is command line utility to :
  - Control behaviour of audit daemon (auditd)
  - Add and remove audit rules
- There are two main types of rules:
  - File system audit rules
  - System call audit rules

File System Rules

- File System rules are sometimes called watches.
- These rules are used to audit access to particular files or directories that you may be interested in.
- The syntax of these rules generally follow this format:

  -w path-to-file -p permissions -k keyname
- where the permission are any one of the following:
  - r - read of the file
  - w - write to the file
  - x - execute the file
  - a - change in the file's attribute

System call rules

- The system call rules are loaded into a matching engine that intercepts each syscall that all programs on the system makes.
- Very important to only use syscall rules when you have to since these affect performance
- Syscall rules take the general form of:

  -a action,list -S syscall -F field=value -k keyname

- To see files opened by a specific user:

  -a exit,always -S open -F auid=l337
- To see unsuccessful open calls:

  -a exit,always -S open -F success=0

Example

- Track a file by inode number

 # auditctl -a exit,always -S open -F inode=`ls -i /etc/auditd.conf | gawk '{print $1}'`

 # auditctl -l

AUDIT_LIST: exit,always inode=1637178 (0x18fb3a) syscall=open

- When someone opens the files you receive following log message

type=PATH msg=audit(1251123553.303:206): item=0 name="/etc/audit/audit.rules" inode=77546 dev=fd:01 mode=0100640 ouid=0 ogid=0 rdev=00:00 obj=system_u:object_r:auditd_etc_t:s0

Analyzing logs -- ausearch

- Ausearch is a command-line utility to query your audit logs
- ausearch -f
- ausearch -ui

Analyzing logs - aureport

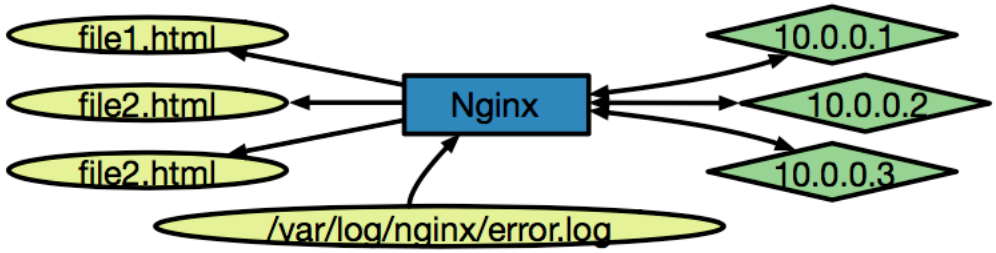
```
$  sudo aureport -s

Syscall Report
=======================================
# date time syscall pid comm auid event
=======================================
1. 08/03/2015 15:45:03 313 10285 modprobe -1 52501
2. 08/03/2015 15:45:03 313 10290 modprobe -1 52502
3. 08/03/2015 15:45:03 54 10296 iptables -1 52503
4. 08/03/2015 15:45:03 54 10302 iptables -1 52504
5. 08/03/2015 15:45:03 54 10305 iptables -1 52505
6. 08/03/2015 15:45:03 54 10313 iptables -1 52506
7. 08/03/2015 15:45:03 54 10325 iptables -1 52507
8. 08/03/2015 15:45:03 54 10329 iptables -1 52508
9. 08/03/2015 15:45:03 54 10343 iptables -1 52509
10. 08/03/2015 15:45:03 54 10345 iptables -1 52510
11. 08/03/2015 15:45:03 54 10349 iptables -1 52511
```

Audit Data Visualization

- Various tools to generate causal graphs from audit logs.
- I use SPADE tool
- SPADE (https://github.com/ashish-gehani/SPADE)
  - Parses audit log in realtime
  - Generates causal graphs which can be queried to find the root cause of attack

Audit Data Visualization

- ADD here about SPADE tools



Resources

- The Audit Manual Pages:
  - There are several man pages installed along with the audit tools that provide valuable and very detailed information
- http://people.redhat.com/sgrubb/audit/index.html
  - The home page of the Linux audit project.