Native Host Intrusion Detection with RHEL6 and the Audit Subsystem

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Introduction

- How the audit system works
- How we can layer an IDS/IPS system on top of it

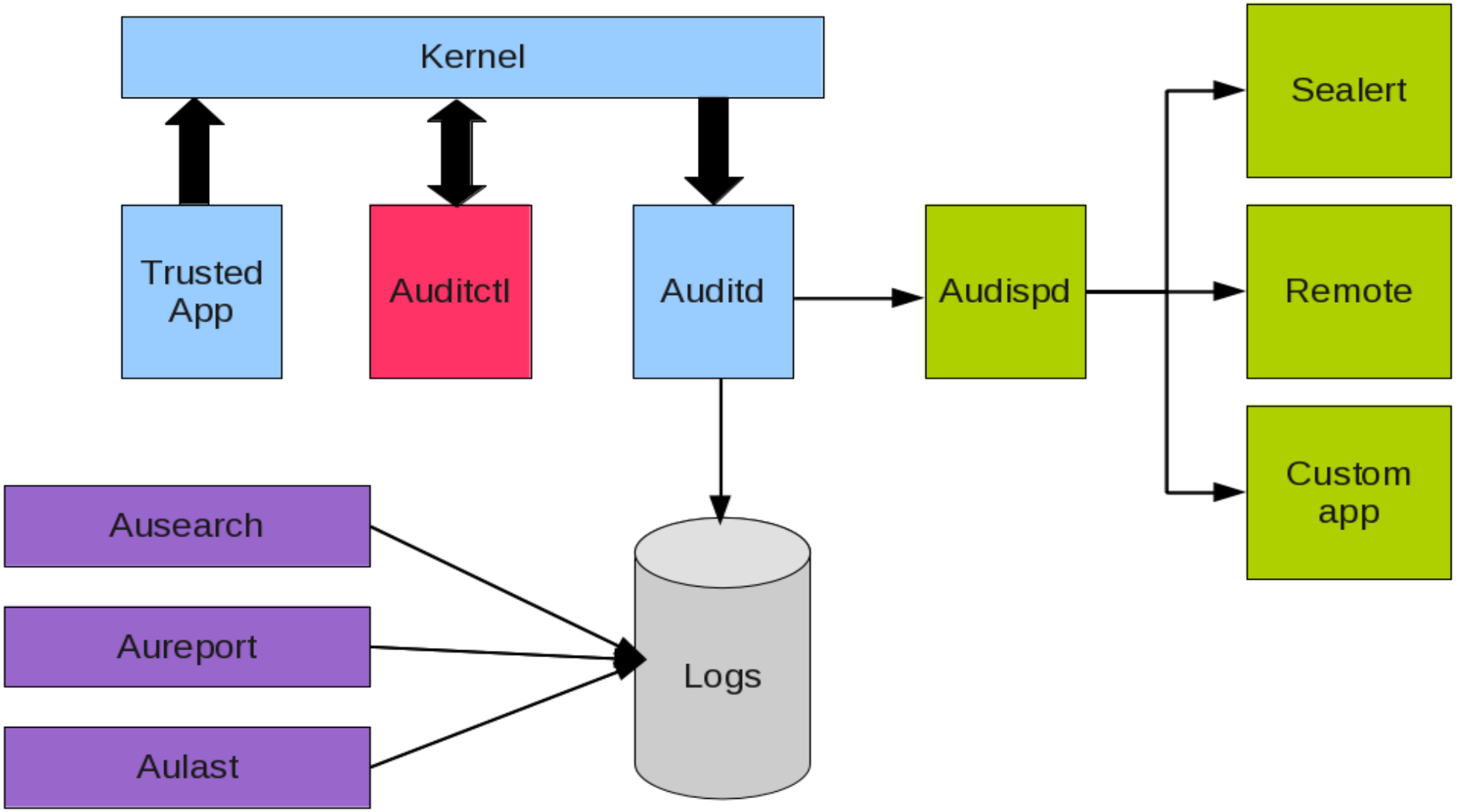
Introduction

- Designed to meet or exceed audit requirements of:
  - CAPP, LSPP, RSBAC, NISPOM, FISMA, PCI-DSS, STIG
- Evaluated by NIAP and BSI
- Certified to CAPP/EAL4+ on RHEL4
- Certified to LSPP/CAPP/RSBAC/EAL4+ on RHEL5
- Under evaluation for OSPP/EAL4+ on RHEL6

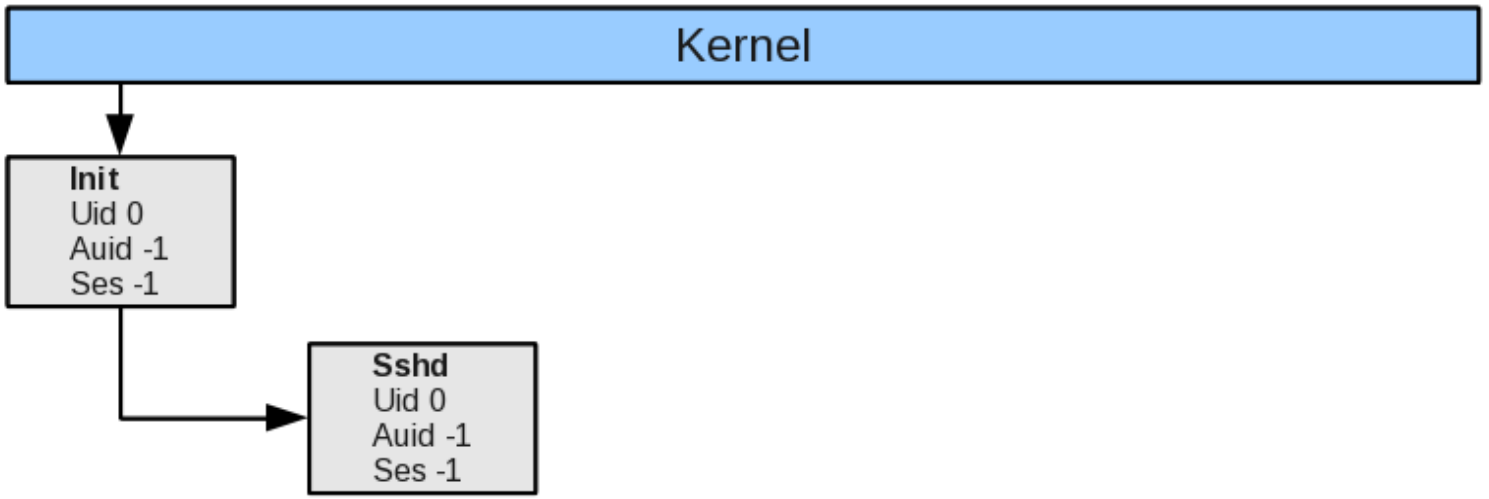
Introduction

- Some of the requirements for the audit system:
  - Shall be able to record at least the following
    - Date and time of event, type of event, subject identity, outcome
    - Sensitivity labels of subjects and objects
    - Be able to associate event with identity and login of user causing it
    - All modifications to audit configuration and attempted access to logs
    - All use of authentication mechanisms
    - Changes to any trusted database
    - Attempts to import/export information
    - Be able to include/exclude events based on user identity, subject/object labels, other attributes

Audit Components



Audit User Tracking



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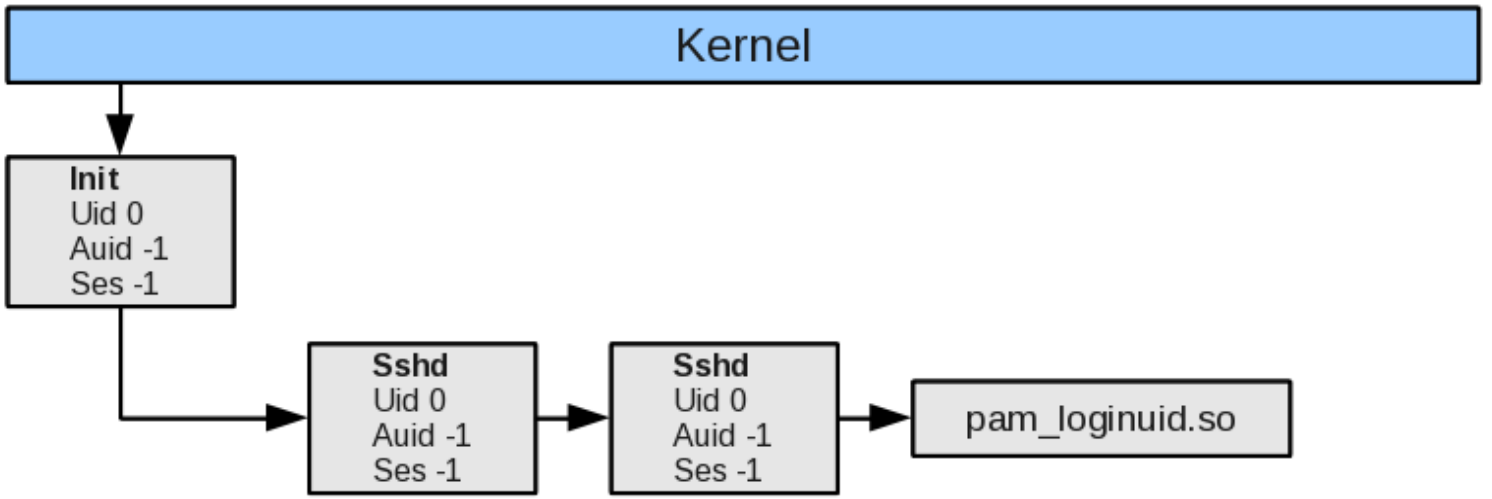

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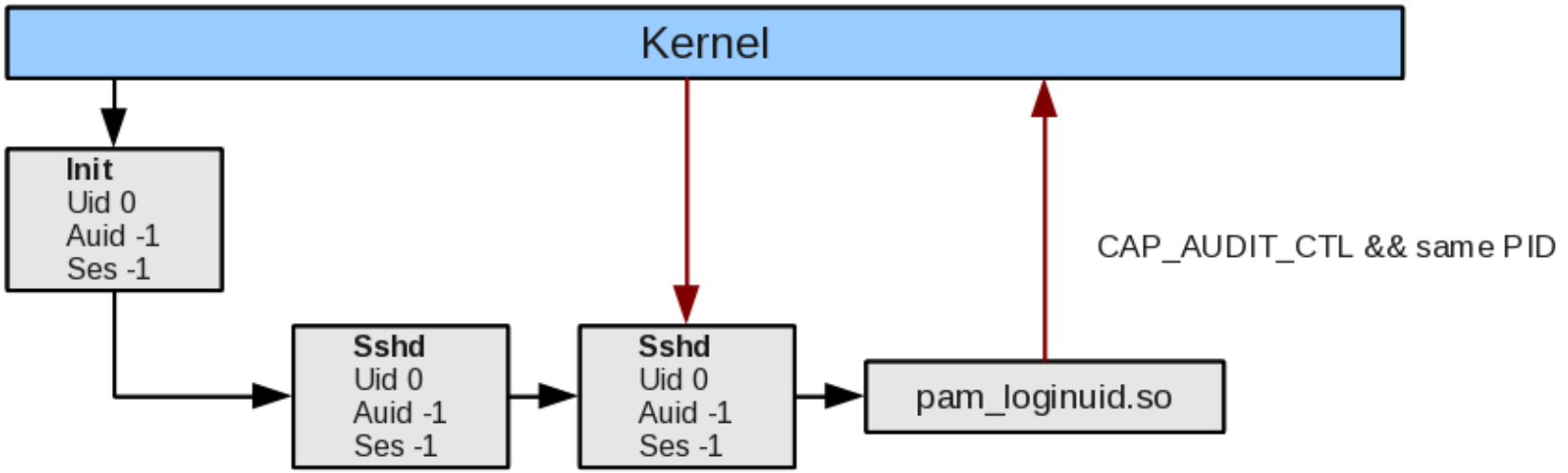
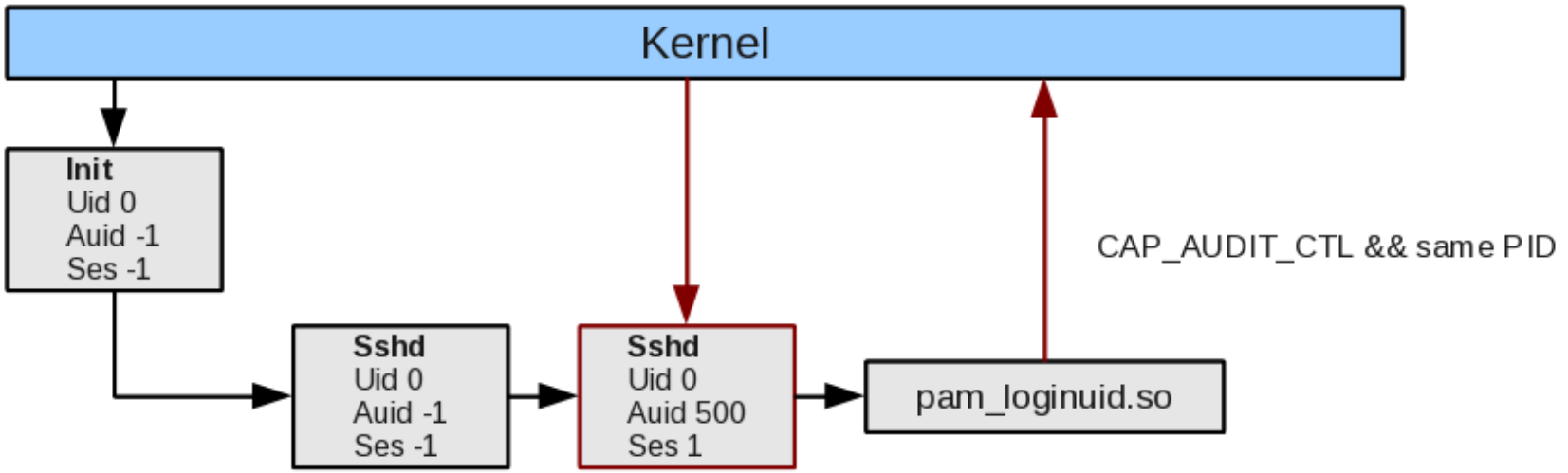


Audit User Tracking



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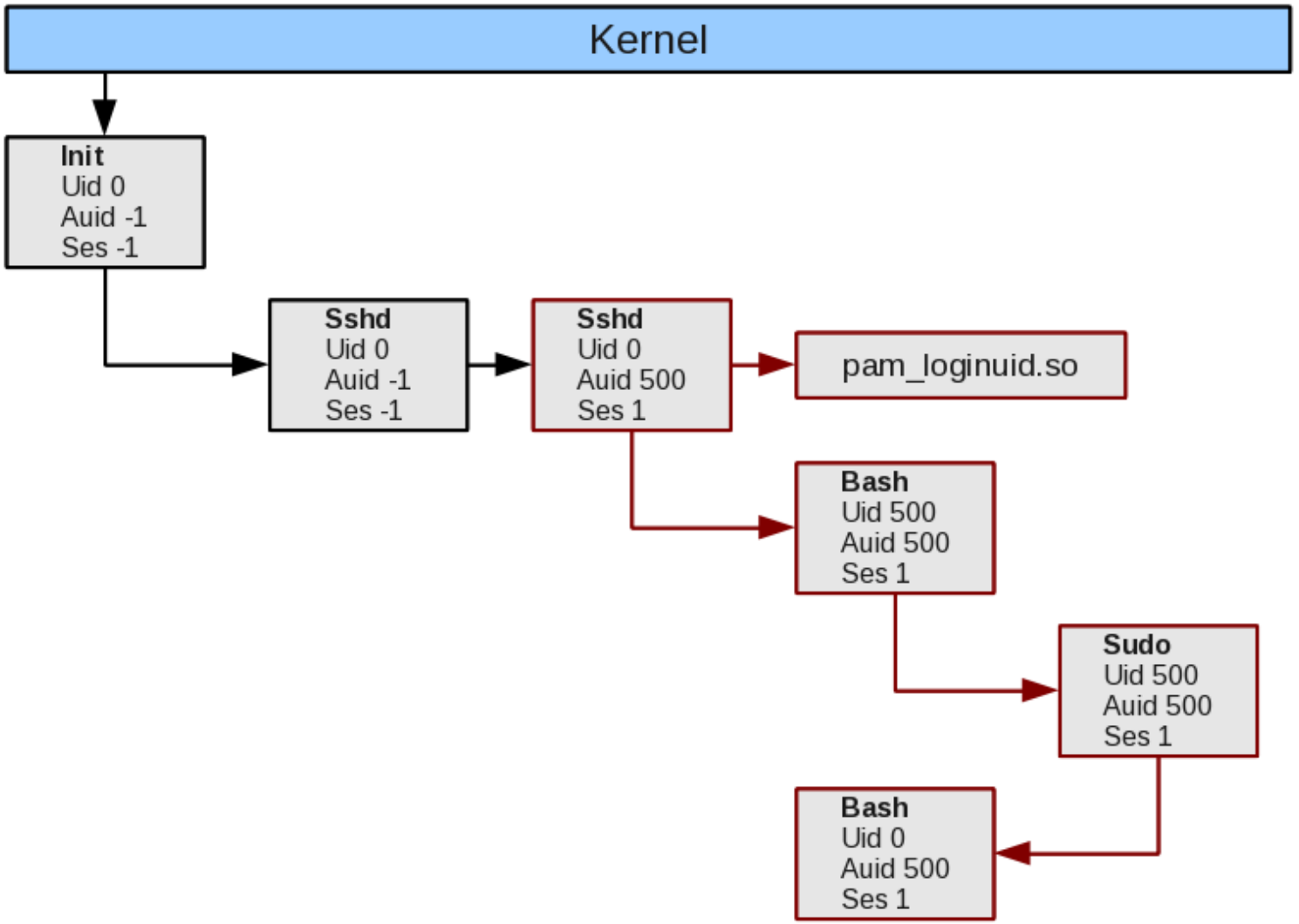
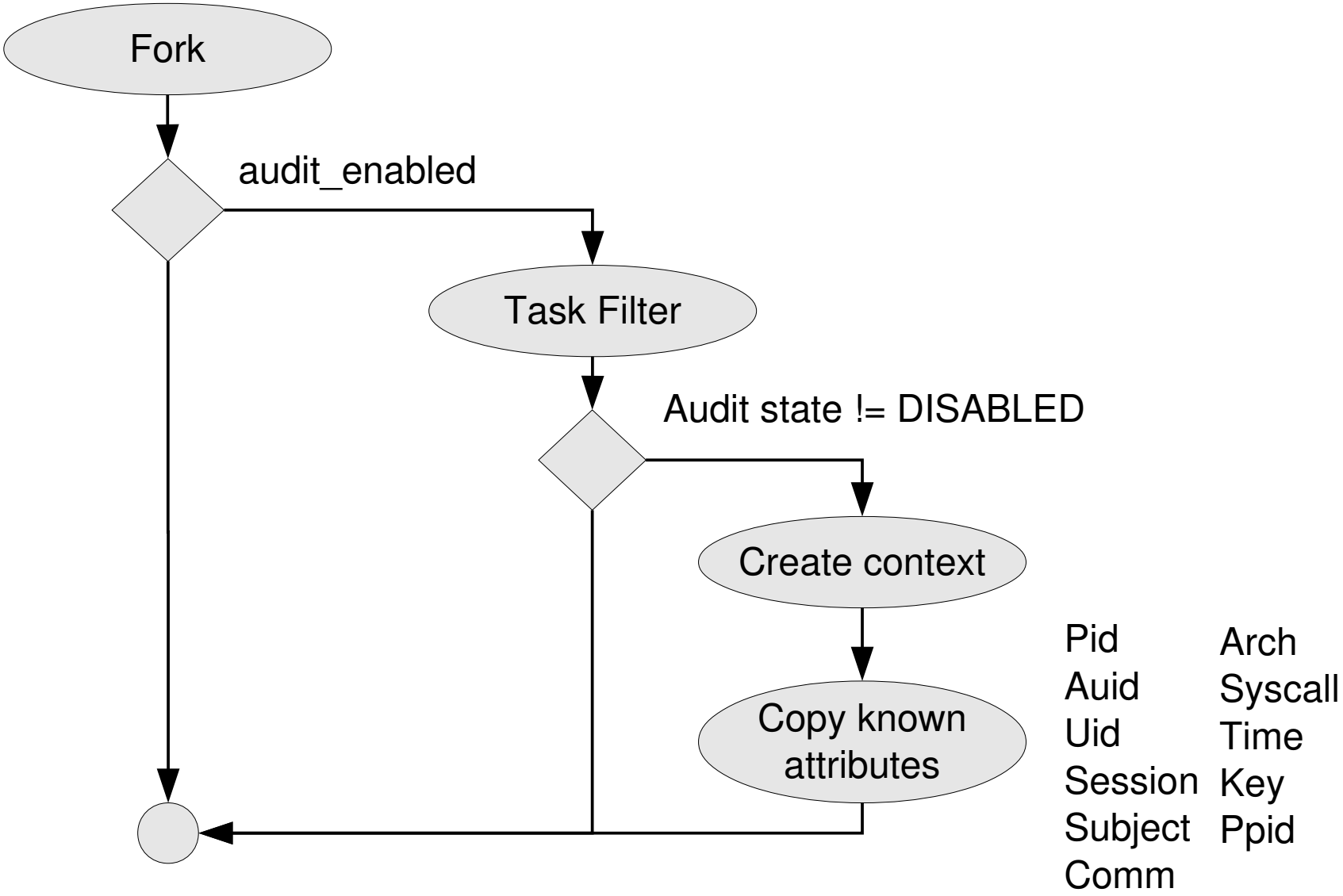


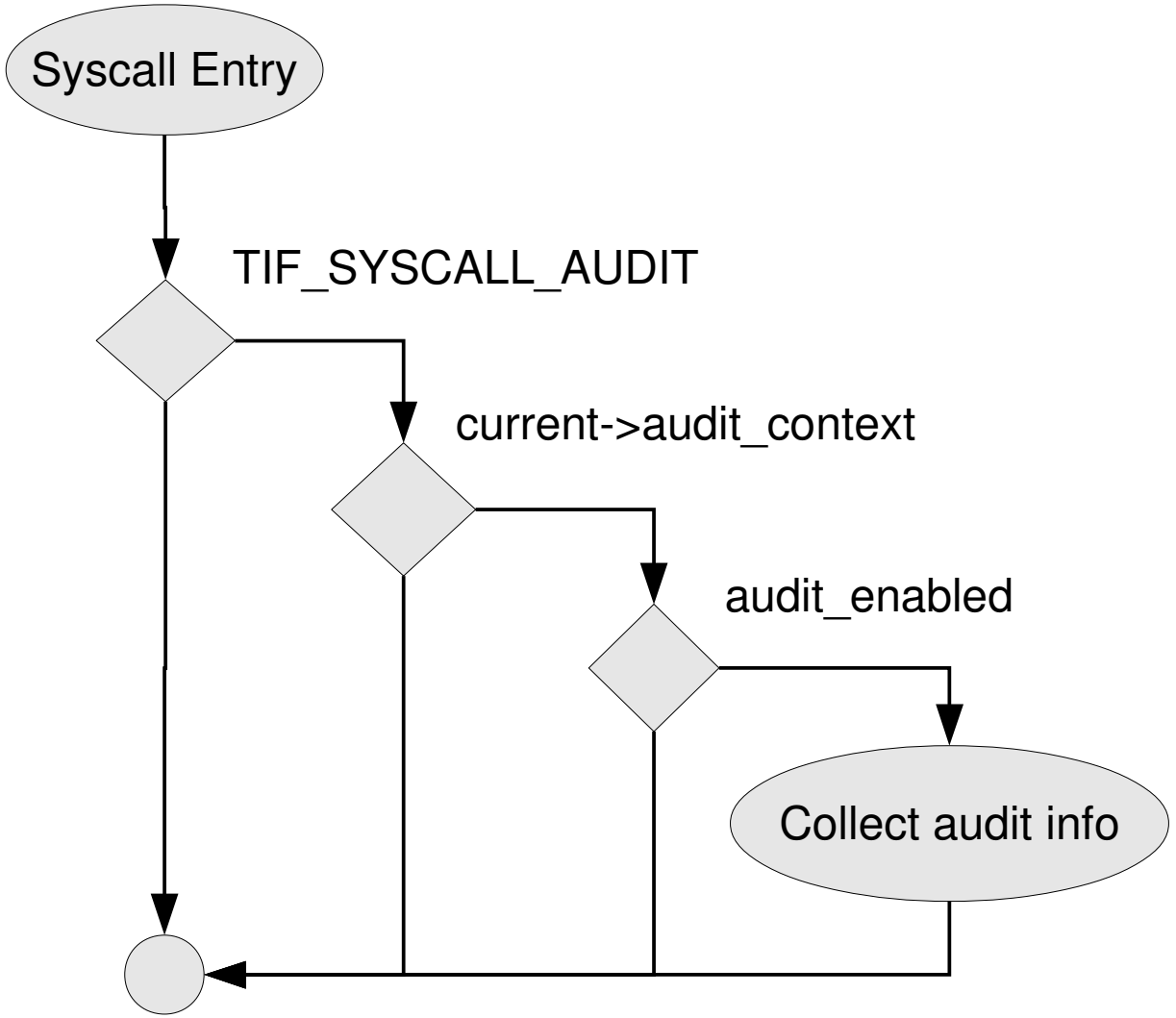
Kernel

- Designed to minimize the performance impact as little as possible
- Relies on a flag, TIF_SYSCALL_AUDIT, which is part of the thread's information flags variable.
- Flag is inheritted at fork when audit_enabled is true
- Flag is never reset
- If you need audit of all processes, you must use audit=1 as a boot parameter.

Kernel – audit flag inheritance



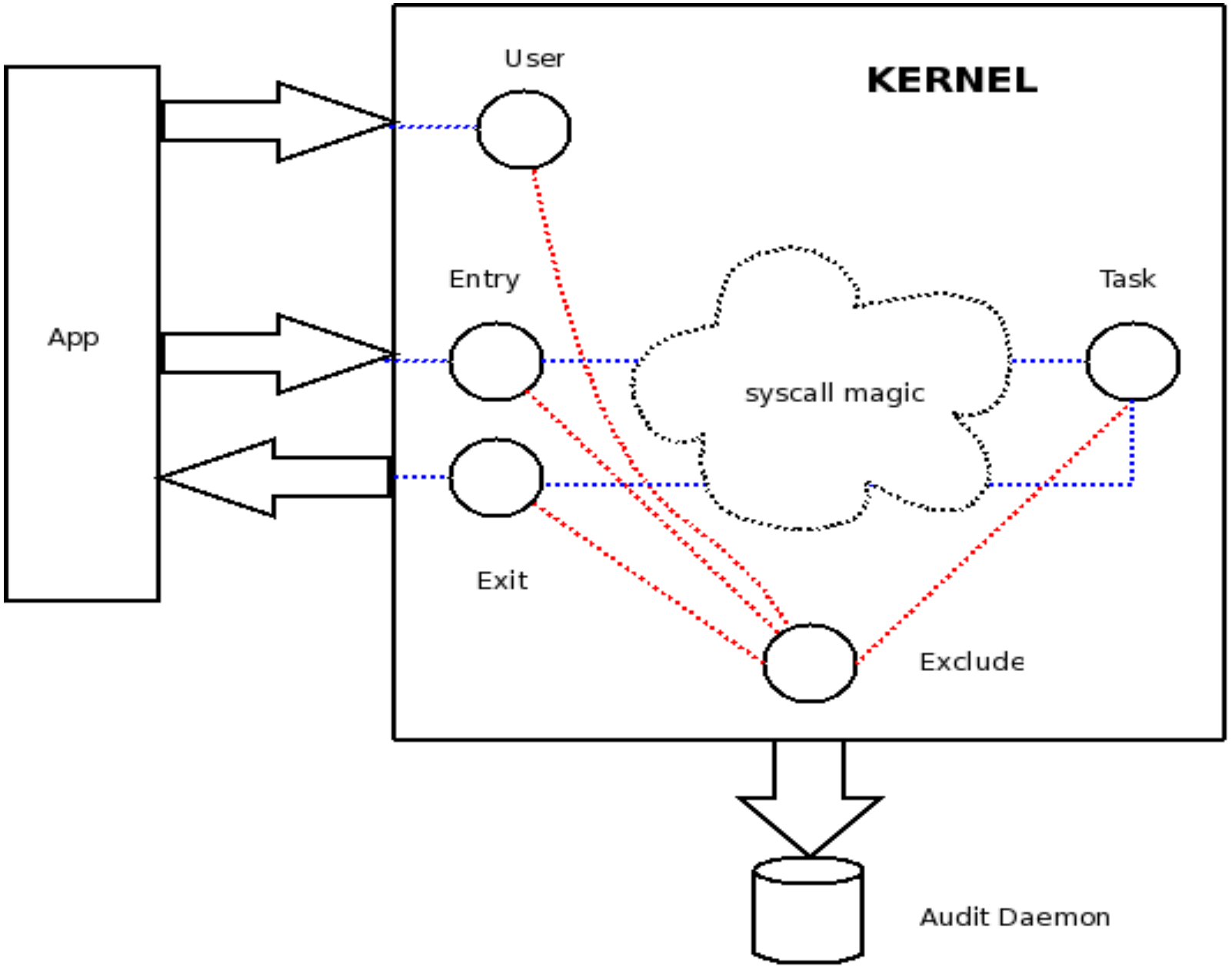
Kernel – syscall entry



Arch
Syscall number
Syscall arguments
Time

Kernel

- Need to decide if the syscall excursion is of interest
- Audit context has a state variable: DISABLED, BUILD, and RECORD
- Filters decide if event is interesting
  - Exit
  - Task
  - User
  - Exclude


User
KERNEL
App
Entry
Task
syscall magic
Exit
Exclude
Audit Daemon

Kernel

- Syscall Exit
  - If context marked auditable emit event
  - Event can be multi-part
    - Ex. Message Queue attributes, IPC attributes, execve args, socket addr, socket call args, file paths, and current working directory.
  - All are tied together with time stamp and serial number
  - Free allocated resources

Subsystem Control

- Audit rules are stored at /etc/audit/audit.rules
- Audit rules are loaded by auditctl
- Auditctl can control the kernel settings:
  - -e 0/1/2 disable/enable/enabled and immutable
  - -f 0/1/2 failure mode silent/printk/panic
  - -b 320 backlog (default too low for production use)
  - -r 0 event rate limit
  - -s get status
  - -l list all rules
  - -D delete all rules

Syscall Rules

Follows the general form:
-a filter,action -S syscall -F field=value

Example to see failed opens for user 500:
-a exit,always -S open -S openat -F exit=-EPERM -F auid=500

-F can be one of: a0, a1, a2, a3, arch, auid, devmajor, devminor, dir, user/group ids, file type, inode, msgtype, object/subject context parts, path, personality, pid, ppid, or success.

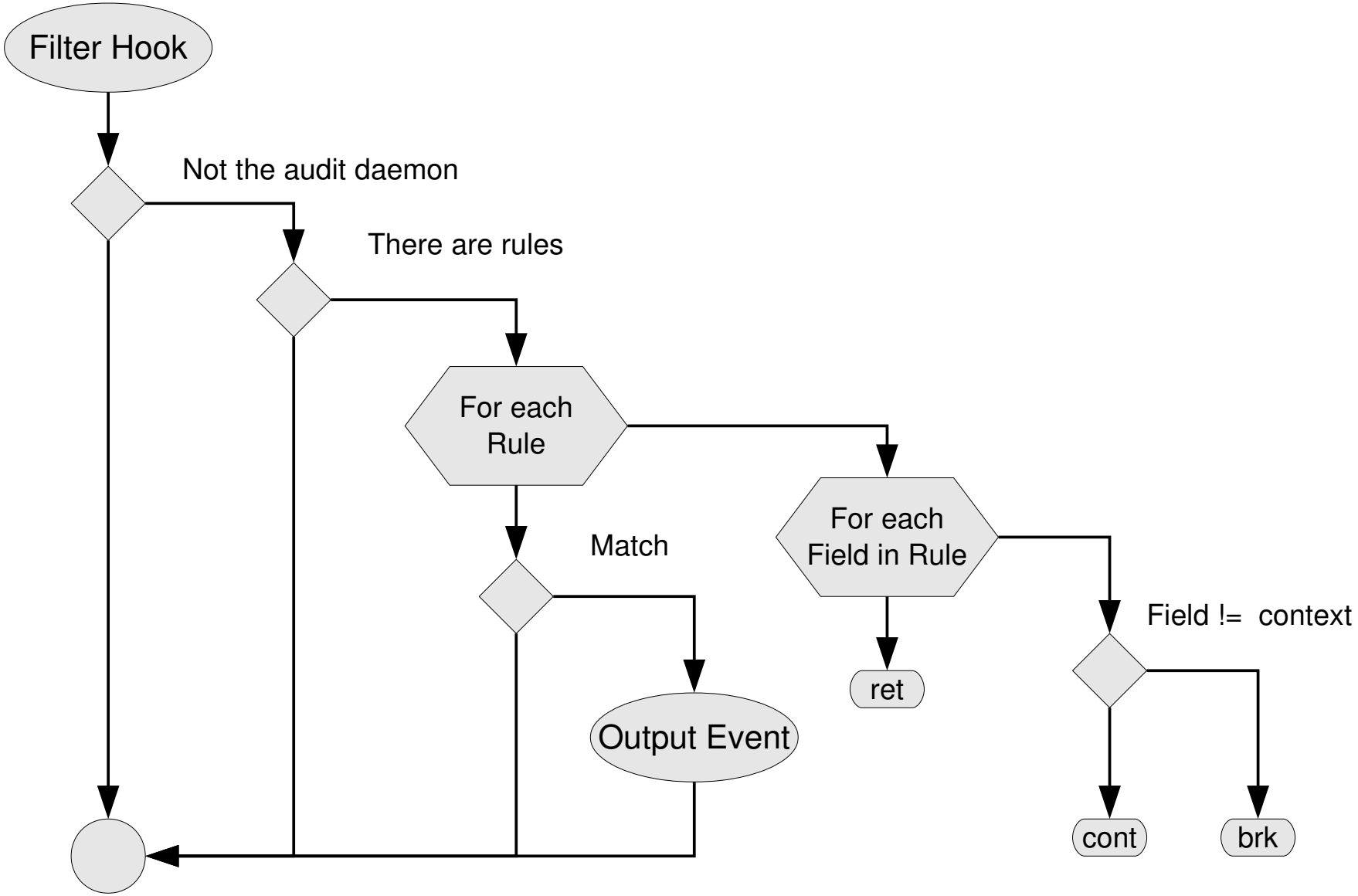
Label can be applied with -F key=name

“and” created by adding more “-F” name/value pairs.
“or” is created by adding a new rule with same key value.

Per Task Audit Context

- Opaque pointer in task structure
- Contains
  - Time, serial number, syscall number, first 4 syscall arguments, exit code, array of file paths, credentials, arch, and data for auxiliary records, and internal house keeping data.

Kernel Filter



Audit Event

type=PATH msg=audit(10/11/2011 17:10:48.489:63) : item=0 name=/var/run/ inode=14909478 dev=08:07 mode=dir,755 ouid=root ogid=root rdev=00:00 obj=system_u:object_r:var_run_t:s0

type=CWD msg=audit(10/11/2011 17:10:48.489:63) : cwd=/

type=SYSCALL msg=audit(10/11/2011 17:10:48.489:63) : arch=x86_64 syscall=unlink success=no exit=-13(Permission denied) a0=439928 a1=0 a2=3f29b96600 a3=0 items=2 ppid=1 pid=1280 auid=unset uid=haldaemon gid=haldaemon euid=haldaemon suid=haldaemon fsuid=haldaemon egid=haldaemon sgid=haldaemon fsgid=haldaemon tty=(none) ses=unset comm=hald exe=/usr/sbin/hald subj=system_u:system_r:hald_t:s0 key=delete

Kernel – File System Auditing

- Syscall auditing presents us with a problem when we need to monitor files
- Audit system does collect devmajor/minor information and inode
- But many interesting files are edited as temp copy and then replace original file
- This causes the inode to change

Kernel – File System Auditing

- Audit rules specified as a path and permission
- Kernel translates into inode rule
- When something replaces a watched file, inode rule updated in kernel
- Reconciliation is done by syscall exit filter
- Audit on directory is recursive to bottom of tree
- Mounted subtrees need additional rule added to include subtree in watch
- Limitations:
  - No wildcards for paths
  - If path specifies directory, it audits changes to dir entries

File System Audit Rules

File system audit rules take the general form of:
-w /full/path-to-file -p wrxa -k rule-note

Can also be expressed as syscall audit rule:
-a exit,always -F path=/full/path-to-file -F perm=wrxa -F key=rule-note

The perm field selects the syscalls that are involved in file writing, reading, execution, or attribute change.

Recursive directory audit for writes:
-a exit,always -F dir=/etc -F perm=wa -F key=rule-note

Trusted App Events

- Trusted apps can send events
- Must have CAP_AUDIT_WRITE
- Automatically included in audit trail, no rules needed
- Can be trimmed a little with USER or EXCLUDE filters.

TTY Auditing

- Security requirements ask for super user usage of the system
- Shell or tty based can be defeated or escaped
- Only good place to do this was from kernel
- Enable by adding pam_tty_audit.so to entry point's pam stack
- Both keystrokes and bash completions can be recorded
  - Depends on bash having CAP_AUDIT_WRITE
- Event is hex encoded ASCII – must use ausearch to read
- NOTE: DOES CAPTURE PASSWORDS!

Audit Event Type Classes

1000 - 1099 are for commanding the audit system
1100 - 1199 user space trusted application messages
1200 - 1299 messages internal to the audit daemon
1300 - 1399 kernel audit events (syscall / file system / TTY)
1400 - 1499 kernel SE Linux use
1600 - 1699 kernel crypto events
1700 - 1799 kernel anomaly records
1800 - 1899 kernel integrity labels and related events (IMA)
1900 - 2099 future kernel use
2100 - 2199 user space anomaly records
2200 - 2299 user space actions taken in response to anomalies
2300 - 2399 user space generated MAC events
2400 - 2499 user space crypto events (nss)
2500 - 2599 user space virtualization management events (libvirt)
2600 - 2999 future user space (maybe integrity labels and related events)

Audit Event Record Types

ADD_GROUP
ADD_USER
ANOM_ABEND
ANOM_ACCESS_FS
ANOM_ADD_ACCT
ANOM_AMTU_FAIL
ANOM_CRYPTO_FAIL
ANOM_DEL_ACCT
ANOM_EXEC
ANOM_LOGIN_ACCT
ANOM_LOGIN_FAILURES
ANOM_LOGIN_LOCATION
ANOM_LOGIN_SESSIONS
ANOM_LOGIN_TIME
ANOM_MAX_DAC
ANOM_MAX_MAC
ANOM_MK_EXEC
ANOM_MOD_ACCT
ANOM_PROMISCUOUS
ANOM_RBAC_FAIL
ANOM_RBAC_INTEGRITY_FAIL
ANOM_ROOT_TRANS
AVC
AVC_PATH
BPRM_FCAPS
CAPSET
CHGRP_ID
CHUSER_ID
CONFIG_CHANGE
CRED_ACQ
CRED_DISP
CRED_REFR
CRYPTO_FAILURE_USER
CRYPTO_KEY_USER
CRYPTO_LOGIN
CRYPTO_LOGOUT
CRYPTO_PARAM_CHANGE_USER
CRYPTO_REPLAY_USER
CRYPTO_SESSION
CRYPTO_TEST_USER
CWD
DAC_CHECK
DAEMON_ABORT
DAEMON_ACCEPT
DAEMON_CLOSE
DAEMON_CONFIG
DAEMON_END
DAEMON_RESUME
DAEMON_ROTATE
DAEMON_START
DEL_GROUP
DEL_USER
EOE
EXECVE
FD_PAIR
FS_RELABEL
GRP_AUTH
INTEGRITY_DATA
INTEGRITY_HASH
INTEGRITY_METADATA
INTEGRITY_PCR
INTEGRITY_RULE
INTEGRITY_STATUS
IPC
IPC_SET_PERM
KERNEL
KERNEL_OTHER
LABEL_LEVEL_CHANGE
LABEL_OVERRIDE
LOGIN
MAC_CIPSOV4_ADD
MAC_CIPSOV4_DEL
MAC_CONFIG_CHANGE
MAC_IPSEC_ADDSA
MAC_IPSEC_ADDSPD
MAC_IPSEC_DELSA
MAC_IPSEC_DELSPD
MAC_IPSEC_EVENT
MAC_MAP_ADD
MAC_MAP_DEL
MAC_POLICY_LOAD
MAC_STATUS
MAC_UNLBL_STCADD
MAC_UNLBL_STCDEL
MMAP
MQ_GETSETATTR
MQ_NOTIFY
MQ_OPEN
MQ_SENDRECV
NETFILTER_CFG
NETFILTER_PKT
OBJ_PID
PATH
RESP_ACCT_LOCK
RESP_ACCT_LOCK_TIMED
RESP_ACCT_REMOTE
RESP_ACCT_UNLOCK_TIMED
RESP_ALERT
RESP_ANOMALY
RESP_EXEC
RESP_HALT
RESP_KILL_PROC
RESP_SEBOOL
RESP_SINGLE
RESP_TERM_ACCESS
RESP_TERM_LOCK
ROLE_ASSIGN
ROLE_REMOVE
SELINUX_ERR
SERVICE_START
SERVICE_STOP
SOCKADDR
SYSTEM_BOOT
SYSTEM_RUNLEVEL
SYSTEM_SHUTDOWN
TEST
TRUSTED_APP
TTY
USER
USER_ACCT
USER_AUTH
USER_AVC
USER_CHAUTHTOK
USER_CMD
USER_END
USER_ERR
USER_LABELED_EXPORT
USER_LOGIN
USER_LOGOUT
USER_MAC_POLICY_LOAD
USER_MGMT
USER_ROLE_CHANGE
USER_SELINUX_ERR
USER_START
USER_TTY
USER_UNLABELED_EXPORT
USYS_CONFIG

Ausearch

- The ausearch program is the preferred way to look at audit logs
- Can do simple queries
- Correlates the individual records to 1 event
- Can interpret some fields from numeric data to human readable form
- Can be used to extract events from audit logs

Ausearch Examples

- Searching for bad logins:
  - ausearch -m USER_AUTH,USER_ACCT --success no
- Searching for events on shadow file today
  - ausearch --start today -f shadow
- Searching for failed file opens for user acct 500
  - ausearch -m PATH --success no --syscall open --loginuid 500
- Extracting logs for 2 days
  - ausearch --start yesterday --raw > new.log
- Output can be piped to other audit utilities but requires --raw output

Aureport

- Utility that provides columnar reports on audit data
- Intended to be used for scripting more interesting reports from raw data
- Gives a summary report about what's been happening on your machine
- Each item in summary report leads to a report on that topic where summary or columnar data is given.
- Can read from stdin so that ausearch can pipe data to it

Aureport Output

Summary Report
======================
Range of time in logs: 10/11/2011 17:05:50.053 - 10/14/2011 11:13:01.139
Selected time for report: 10/09/2011 00:00:00 - 10/14/2011 11:13:01.139
Number of changes in configuration: 360
Number of changes to accounts, groups, or roles: 2
Number of logins: 9
Number of failed logins: 0
Number of authentications: 14
Number of failed authentications: 0
Number of users: 3
Number of terminals: 11
Number of host names: 1
Number of executables: 21
Number of files: 22
Number of AVC's: 8
Number of MAC events: 17
Number of failed syscalls: 111
Number of anomaly events: 0
Number of responses to anomaly events: 0
Number of crypto events: 0
Number of keys: 9
Number of process IDs: 135
Number of events: 660

Session Reporting

- Aulast is designed to give reports on login sessions
- Designed to look and act like the 'last' command
- Based on audit logs rather than utmp
- Proof mode
  - Output what events it used to bound the session
  - Provide the ausearch command to extract the session for further analysis

Aulast Output

```
reboot   system boot  2.6.35.14-97.fc1 Fri Oct 14 07:12 - 07:53  (00:40)
sgrubb   tty1         ?                Fri Oct 14 10:09 - 10:27  (00:17)
reboot   system boot  2.6.35.14-97.fc1 Fri Oct 14 10:08 - 10:27  (00:18)
reboot   system boot  2.6.35.14-97.fc1 Fri Oct 14 12:39 - 13:47  (01:07)
sgrubb   tty1         ?                Fri Oct 14 12:40 - down
reboot   system boot  2.6.35.14-97.fc1 Fri Oct 14 18:06 - 18:35  (00:29)
sgrubb   tty1         ?                Fri Oct 14 18:08 - 18:35  (00:26)
reboot   system boot  2.6.35.14-97.fc1 Sat Oct 15 08:31
sgrubb   tty1         ?                Sat Oct 15 08:32   still logged in
```

```
reboot   system boot  2.6.35.14-97.fc1 Fri Oct 14 18:06 - 18:35  (00:29)
    audit event proof serial numbers: 5, 0, 173
    Session data can be found with this search:
    ausearch --start 10/14/2011 18:06:01 --end 10/14/2011 18:35:08

sgrubb   tty1         ?                Fri Oct 14 18:08 - 18:35  (00:26)
    audit event proof serial numbers: 61, 64, 174
    Session data can be found with this search:
    ausearch --start 10/14/2011 18:08:56 --end 10/14/2011 18:35:08 --session 1
```

Investigation Tips

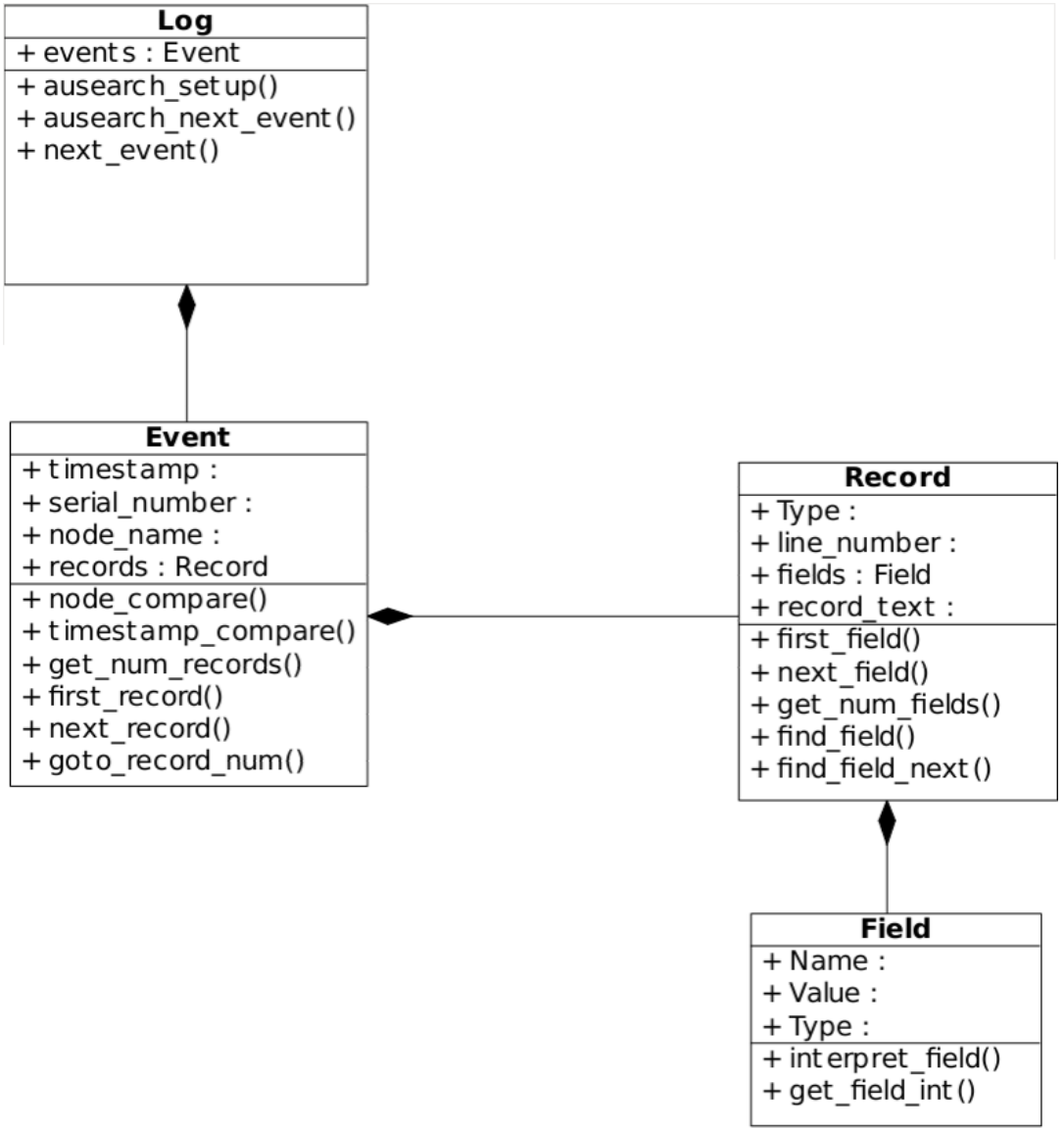
- Main idea is to use 'keys' to group events
- Use key summary report of aureport
- Use ausearch --key to grab events with same key
  - Feed those into aureport for summary reports like file, executable, user, host
  - Audit.rules man page has examples
  - More examples can be found in issue #5 of

    http ://magazine.hitb.org/hitb-magazine.html

Audit Parsing Library

- Design goals
  - Completely hide the log file format in case it changes over time
  - Abstract all internal data structures to make friendly to other languages
  - Create iterator approach like database libraries
  - Search API so that only records of interest can be found
  - Ability to translate from numeric values to human readable

Auparse Overview



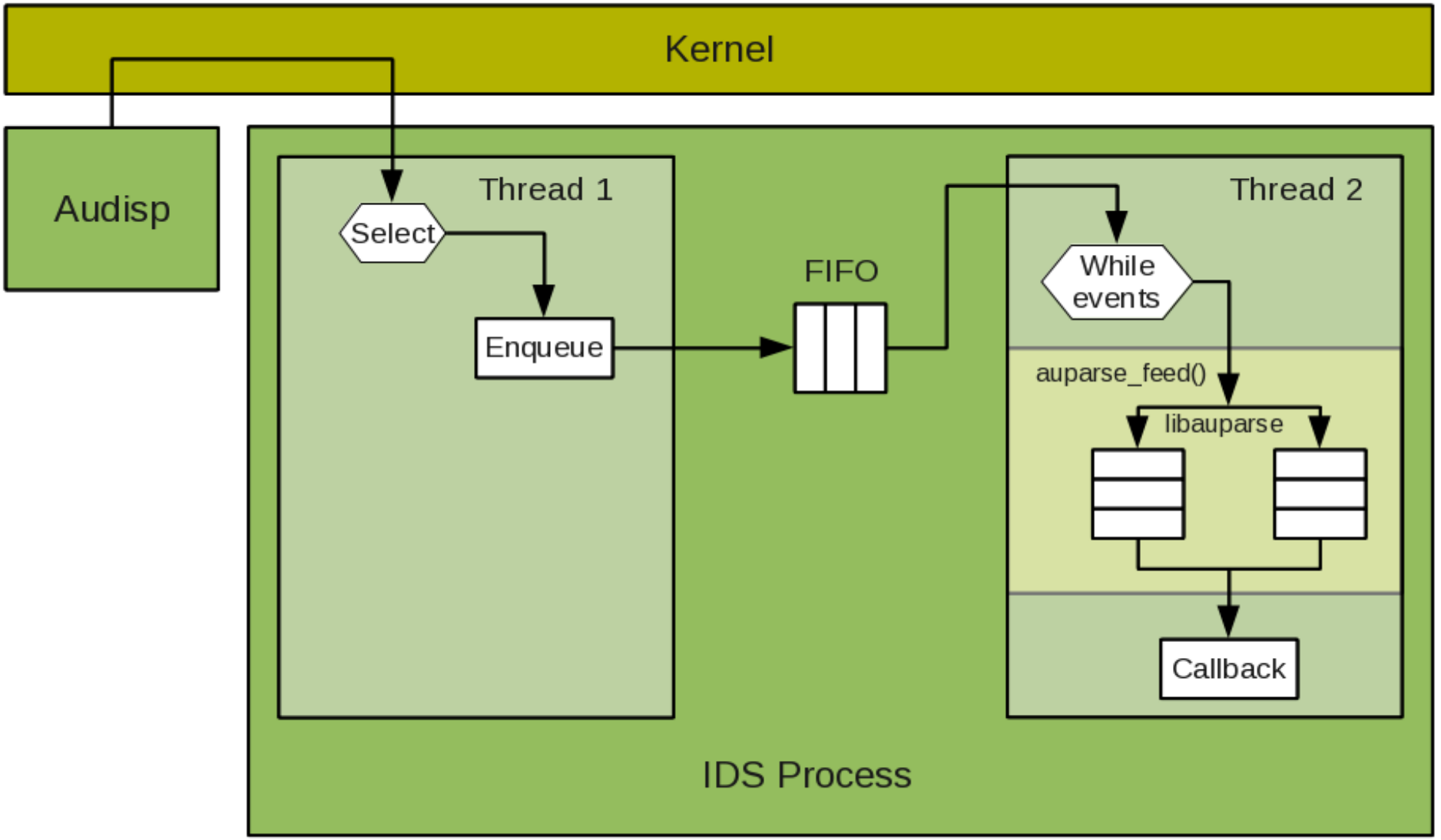
Audit Parsing Library Example - C

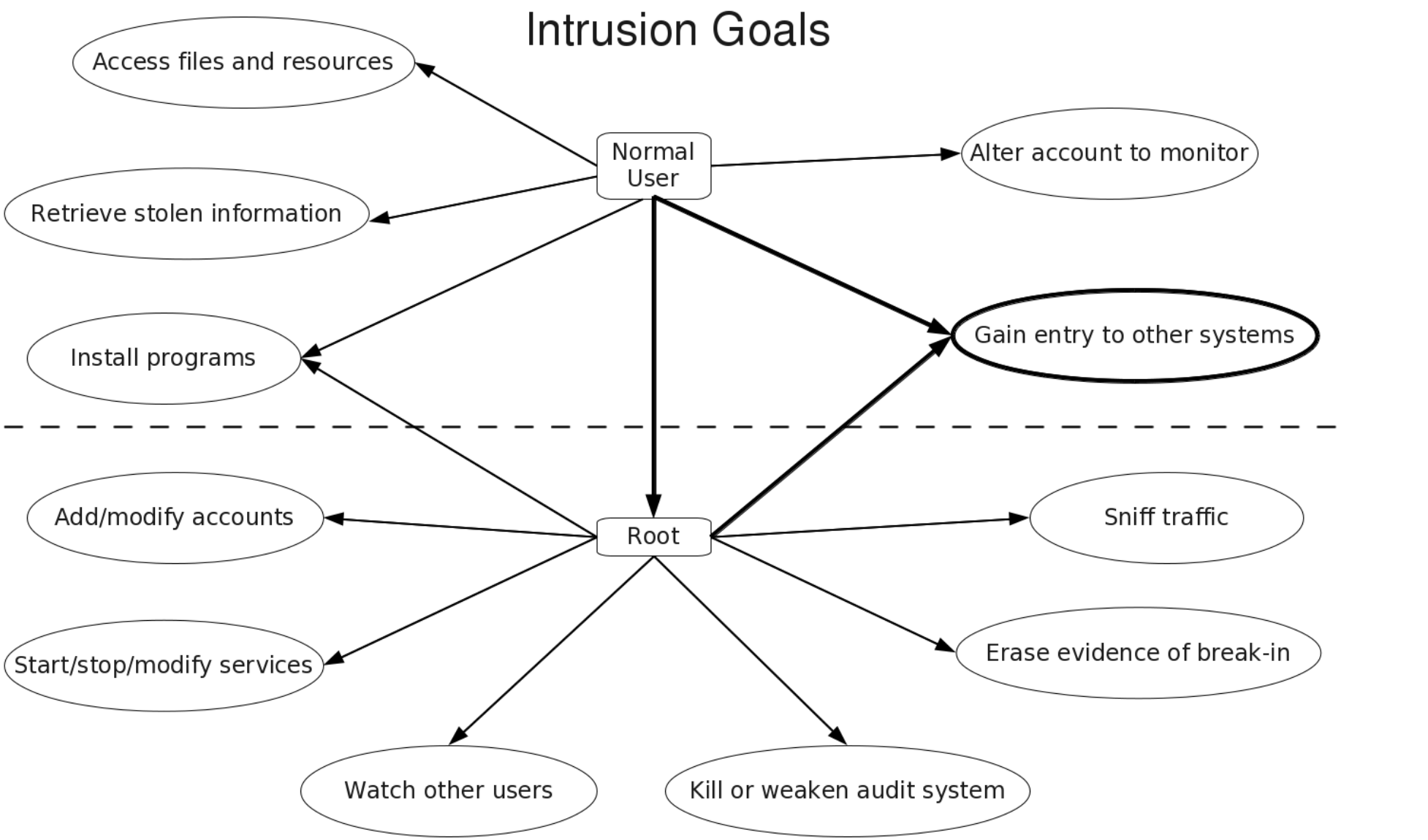
```
auparse_state_t *au = auparse_init(AUSOURCE_FILE, "./test.log");
do {
    do {
        do {
                printf("%s=%s (%s)\n", auparse_get_field_name(au),
                auparse_get_field_str(au), auparse_interpret_field(au));
        } while (auparse_next_field(au) > 0);
    } while(auparse_next_record(au) > 0);
} while (auparse_next_event(au) > 0);
```

Audit Parsing Library Example - Python

```
au = auparse.AuParser(auparse.AUSOURCE_FILE, "./test.log");
while True:
    while True:
        while True:
            print "%s=%s (%s)" % (au.get_field_name(), au.get_field_str(), au.interpret_field())
            if not au.next_field(): break
        if not au.next_record(): break
if not au.parse_next_event(): break
```

Auparse Feed API





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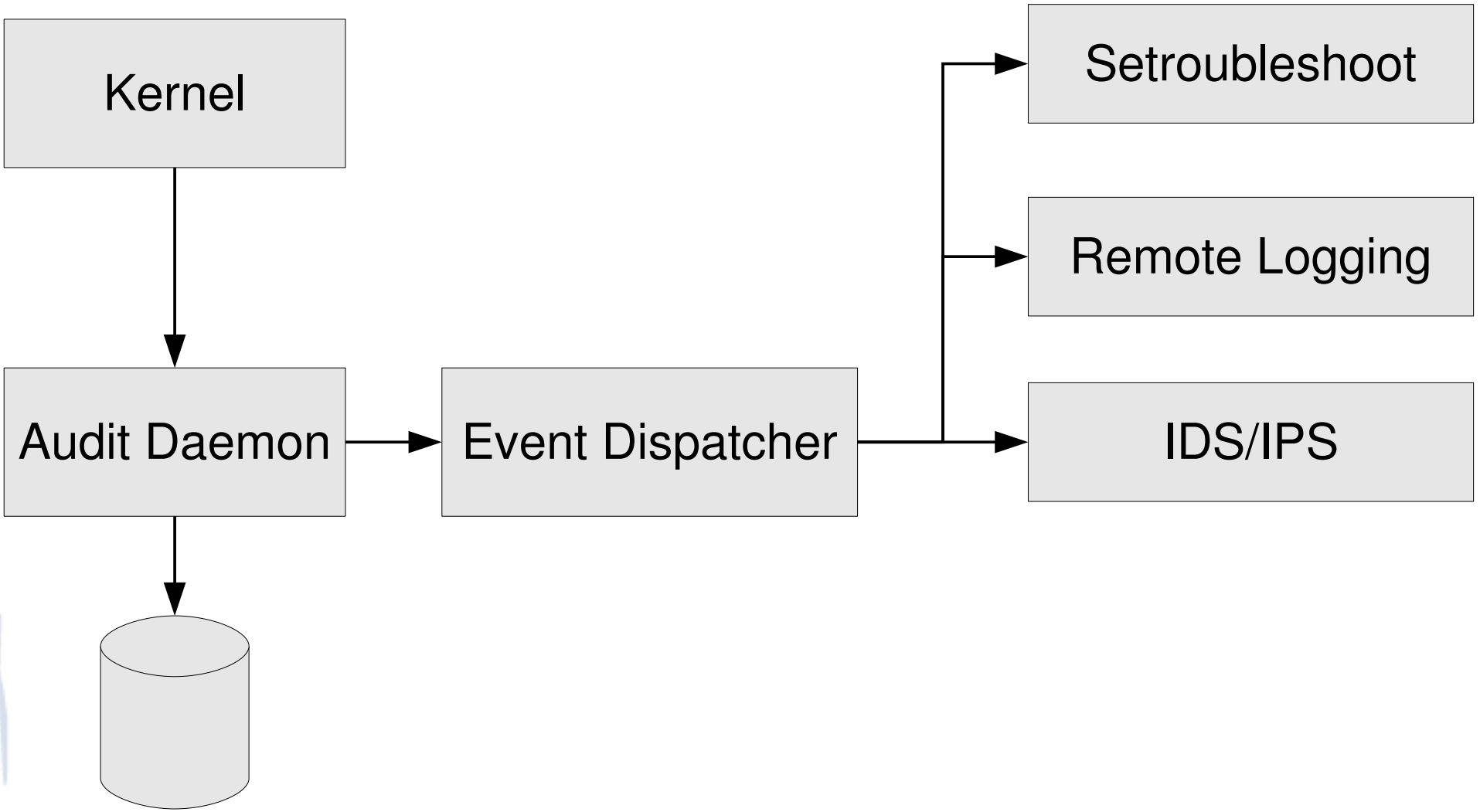
Requirements for IDS/IPS

- The tools shall build upon audit reduction and analysis tools to aid the ISSO or ISSM in the monitoring and detection of suspicious, intrusive, or attack-like behavior patterns.
- The capability of the system to monitor occurrences of, or accumulation of, auditable events that may indicate an imminent violation of security policies.
- The capability of the system to notify the ISSO of suspicious events and taking the least-disruptive action to terminate the suspicious events.
- In real time

Audit Event Data Flow



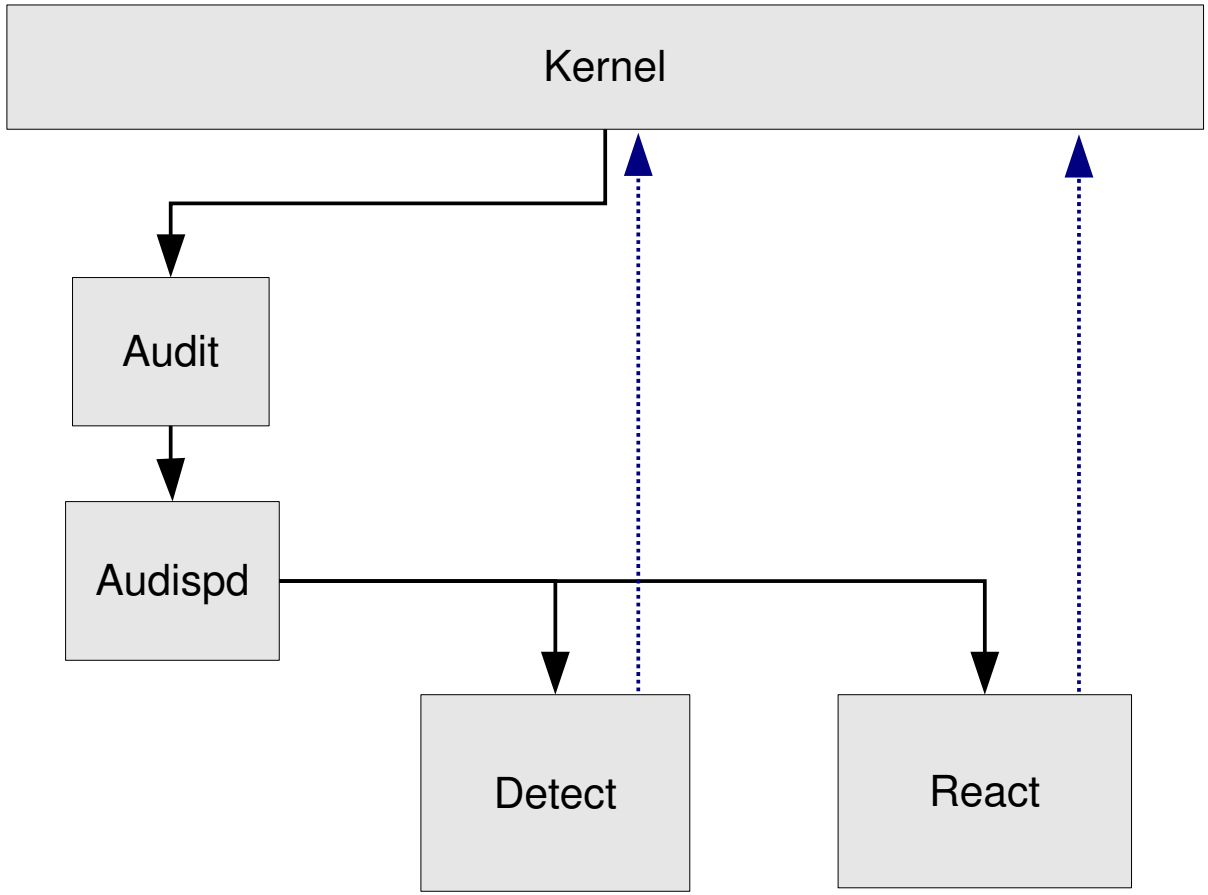
Audit Event Dispatcher Plugins

- Programming rules
  - Must read from stdin
  - Must obey signals such as SIGHUP, SIGTERM
  - Must read config information from file
- Types of plugins
  - Output (passes event to something else)
    - Remote logging, af_unix, setroubleshooter
  - Translational (changes event content/format)
    - Event filter, protocol converter, IDMEF

Audit Event Feeds

- Kernel
- Trusted Programs
  - Pam
  - Login, sshd, gdm, sudo, crond
  - Shadow-utils, passwd
  - Semanage, init, libvirt, dbus, nscd, cups
- MAC selinux-policy
- Test Apps
  - Amtu
  - Aide
- (Security Scanning Tool)

IDS/IPS System



Attacks – Anomaly Record Types

- Gain Entry to system
  - Login / exploit
    - AUDIT_ANOM_LOGIN_FAILURES - Failed login limit reached
    - AUDIT_ANOM_LOGIN_TIME - Login attempted at bad time
    - AUDIT_ANOM_LOGIN_SESSIONS - Max concurrent sessions reached
    - AUDIT_ANOM_LOGIN_ACCT - Login attempted to watched acct
    - AUDIT_ANOM_LOGIN_LOCATION - Login from forbidden location
    - AUDIT_ANOM_ABEND - Process ended abnormally
    - AUDIT_ANOM_MAX_MAC - Max MAC failures reached

Attacks – Anomaly Record Types

- Access files or resources
  - AUDIT_ANOM_MAX_DAC - Max DAC failures reached
  - AUDIT_ANOM_MAX_MAC - Max MAC failures reached
  - AUDIT_ANOM_ACCESS_FS - Access of file or dir
  - AUDIT_ANOM_EXEC - Execution of program
- Become root
  - AUDIT_ANOM_ROOT_TRANS – Unexpected transition to uid 0
- Change trusted database
  - AUDIT_ANOM_ACCESS_FS - Access of file or dir
  - AUDIT_ANOM_AMTU_FAIL - AMTU failure

Attacks – Anomaly Record Types

- Add or modify account and passwords
  - AUDIT_ANOM_ADD_ACCT - Adding an acct
  - AUDIT_ANOM_DEL_ACCT - Deleting an acct
  - AUDIT_ANOM_MOD_ACCT - Changing an acct
- Install programs
  - AUDIT_ANOM_MK_EXEC - Make an executable
  - Integrity events probably need a mapping to AUDIT_ANOM_
- Start / stop services
  - AUDIT_ANOM_EXEC - Execution of file
- Watch other users
  - AUDIT_ANOM_ACCESS_FS - Access of file or dir
  - AUDIT_ANOM_MK_EXEC - Make an executable

Attacks – Anomaly Record Types

- Kill audit system
  - AUDIT_ANOM_RBAC_FAIL - RBAC self test failure
  - Plugin would also see an audit daemon stop event and the user sending it
- Sniff traffic
  - AUDIT_ANOM_PROMISCUOUS - Device changed promiscuous mode
- Gain entry to other systems
  - We would have to correlate logging from all machines

Attack Reaction Types

- AUDIT_RESP_ANOMALY - Anomaly not reacted to
- AUDIT_RESP_ALERT - Alert email was sent
- AUDIT_RESP_KILL_PROC - Kill program
- AUDIT_RESP_TERM_ACCESS - Terminate session
- AUDIT_RESP_ACCT_REMOTE - Acct locked from remote access
- AUDIT_RESP_ACCT_LOCK_TIMED - User acct locked for time
- AUDIT_RESP_ACCT_UNLOCK_TIMED - User acct unlocked from time
- AUDIT_RESP_ACCT_LOCK - User acct was locked
- AUDIT_RESP_TERM_LOCK - Terminal was locked
- AUDIT_RESP_SEBOOL - Set an SE Linux Boolean
- AUDIT_RESP_EXEC - Execute a script
- AUDIT_RESP_SINGLE - Go to single user mode
- AUDIT_RESP_HALT - take the system down

Questions?

Email: sgrubb@redhat.com

Web Page: http://people.redhat.com/sgrubb/audit