Systems and Internet Infrastructure Security

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Advanced Systems Security: Security-Enhanced Linux

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Reference Monitor for Linux

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- LSM provides a reference monitor interface for Linux
  - Complete Mediation
- You need a module and infrastructure to achieve the other two goals
  - Tamperproofing
  - Verifiability
- *SELinux is a comprehensive reference validation mechanism aiming at reference monitor guarantees*

SELinux History

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- Origins go back to the Mach microkernel retrofitting projects of the 1980s
  - DTMach (1992)
  - DTOS (USENIX Security 1995)
  - Flask (USENIX Security 1999)
  - SELinux (2000-…)
- Motivated by the security kernel design philosophy
  - But, practical considerations were made

Inevitability of Failure

- Philosophy of the approach
- Flawed Assumption:
  - That security can be managed by the application space without OS security support (protection is not sufficient)
- Paraphrase: Can't build a secure system without a reference monitor and MPS
  - And a secure operating system needs an entire ecosystem
- Come back to this later…

The Rest of the SELinux Story

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- Tamperproof
  - Protect the kernel
  - Protect the trusted computing base
  - *Use MPS to provide tamperproofing of TCB?*
- Verifiability
  - Code correctness
  - Policy satisfy a security goal
  - *Use MPS to express secrecy and integrity requirements*

Design MPS

- Do not believe that classical integrity is achievable in practice
  - Too many exceptions
  - Commercial systems will not accept constraints of classical integrity
- Instead, focus on providing comprehensive control of access aiming for
  - Confining root processes (tamperproof)
  - Least privilege in general (verifiability)
- *How does 'least privilege' affect security?*

SELinux Policy Model

- See slides in 07-TypeEnforcement…

SELinux Policy Rules

- SELinux Rules express an MPS
  - *Protection state – ALLOW subject-label object-label ops*
  - *Labeling state – TYPE_TRANSITION subject-label object-label new-label (at create – objects)*
    - Default is to label to same state as creator
  - *Transition state – TYPE_TRANSITION subject-label object-label new-label (at exec – processes)*
- Tens of thousands of rules are necessary for a standard Linux distribution
  - Protect system processes from user processes
  - User data can be protected by MLS

SELinux “Setuid”

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- How does SELinux enable a normal user to run a privileged (setuid) process, such as *passwd*?

SELinux Transition State

- For user to run passwd program
  - Only passwd should have permission to modify */etc/shadow*
- Need permission to execute the passwd program
  - *allow user_t passwd_exec_t:file execute (user can exec /usr/bin/passwd)*
  - *allow user_t passwd_t:process transition (user gets passwd perms)*
- Must transition to passwd_t from user_t
  - *allow passwd_t passwd_exec_t:file entrypoint (run w/ passwd perms)*
  - *type_transition user_t passwd_exec_t:process passwd_t*
- Passwd can the perform the operation
  - *allow passwd_t shadow_t:file {read write}* (can edit passwd file)

SELinux Deployment

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- You've configured your SELinux policy
  - *Now what is left?*
- Surprisingly, a lot
  - Many services must be aware of SELinux
  - Got to get the policy installed in the kernel
  - Got to manage all this policy
- And then there is the question of getting the policy to do what you want

User-space Services

- What kind of security decisions are made by user-space services?

User-space Services

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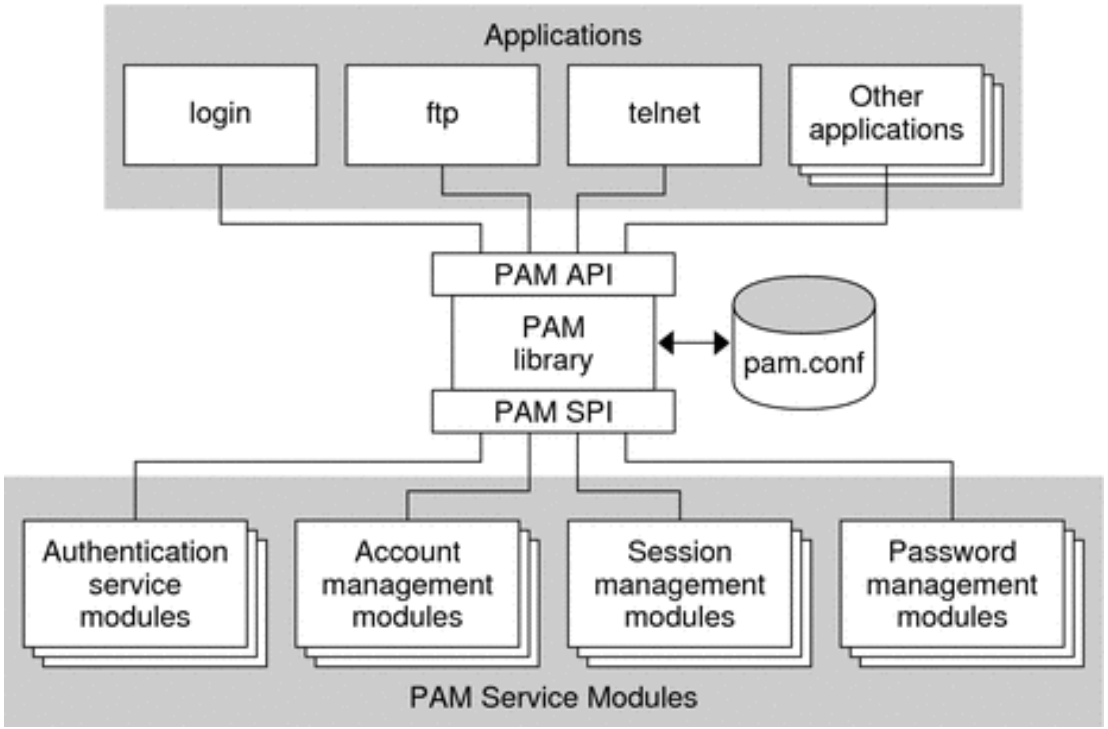
- What kind of security decisions are made by user-space services?
  - Authentication (e.g., sshd)
  - Access control (e.g., X windows, DBs (servers), browsers (middleware), etc.)
  - Configuration (e.g., policy build and installation)
- Also, many services need to be aware of SELinux to enable usability
  - E.g., Listing files/processes with SELinux contexts (ls/ps)

User-space Services

- Authentication
  - Various authentication services need to create a "SELinux subject context" on a user login
  - Like login in general, except we set an SELinux context and a UID for the generated shell
- How do you get all these ad hoc authentication services to interact with SELinux?

Authentication for SELinux

- Pluggable Authentication Modules
  - There is a module for SELinux that various authentication services use to create a subject context



User-space Services

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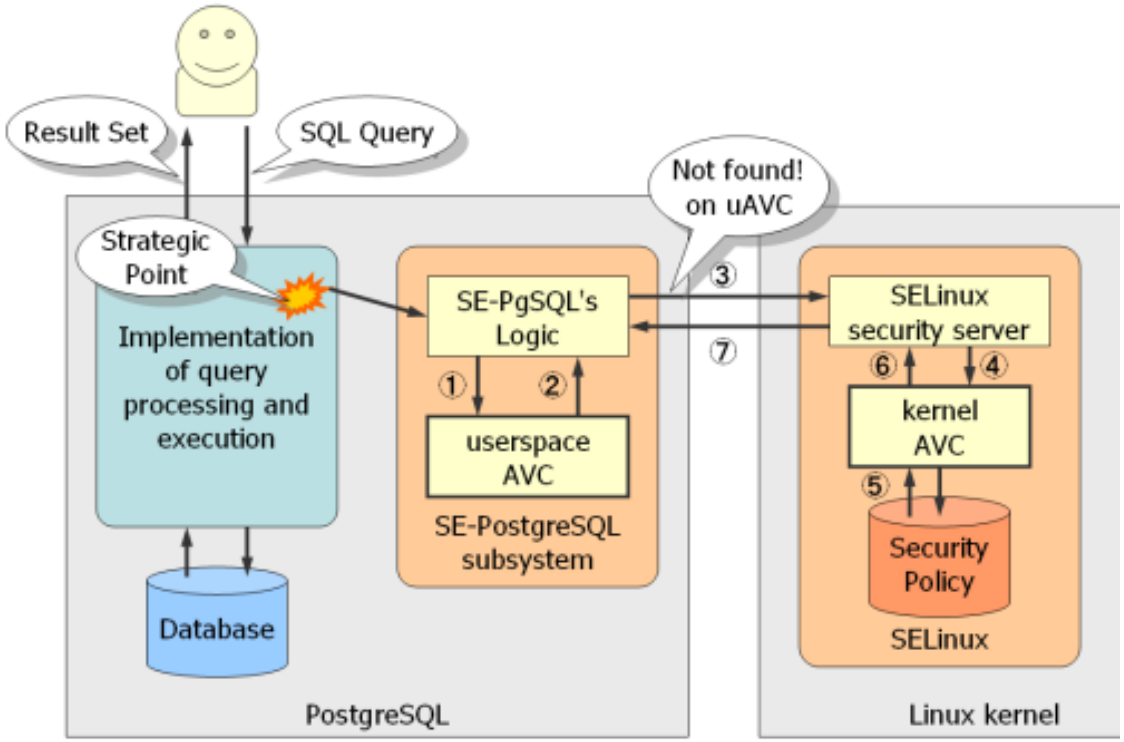
- Access Control
  - Many user-space services are shared among mutually untrusting clients
    - Problem: service may leak one client's secret to another
- If your SELinux policy allows multiple, mutually untrusting clients to talk to the same service, what can SELinux do to prevent exploits?

User-space Services

- Add SELinux support to the service
  - X Windows, postgres, dbus, gconf, telephony server
- E.g., Postgres with the SELinux user-space library

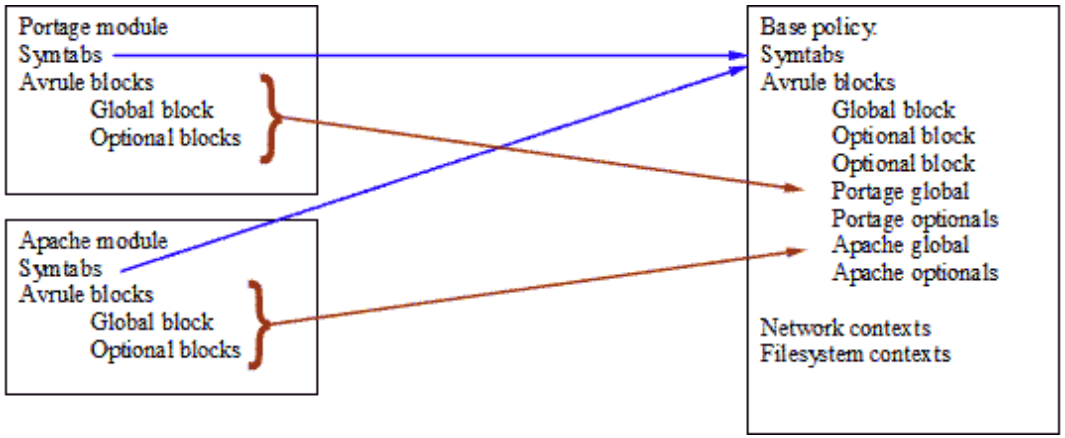


User-space Services

- Configuration
  - You need to get the SELinux policy constructed and loaded into the kernel
    - Without allowing attacker to control the system policy
    - And policy can change dynamically
- How to compose policies?
- How to install policies?

Compose Policies

- The SELinux policy is modular
  - Although not in a pure, object-oriented sense
    - Too much had been done
- Policy management system composes the policy from modules, linking a module to previous definitions and loads them



Installing Policies

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- How would you enable user-space processes to push data (e.g., MPS configuration) into the kernel?

sysfs Background

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- During the 2.5 development cycle, the Linux driver model was introduced to fix several shortcomings of the 2.4 kernel:
  - No unified method of representing driver-device relationships existed.
  - There was no generic hotplug mechanism.
  - *procfs* was cluttered with lots of non-process information.
- Main uses
  - Configure drivers
  - Export driver information

sysfs Example: load_policy

From kernel: security/selinux/selinuxfs.c

```
enum sel_inos {
    SEL_ROOT_INO = 2,
    SEL_LOAD,       /* load policy */
    SEL_ENFORCE,    /* get or set enforcing status */

static struct tree_descr selinux_files[] = {
    [SEL_LOAD] = {"load", &sel_load_ops, S_IRUSR|S_IWUSR},
    [SEL_ENFORCE] = {"enforce", &sel_enforce_ops,
                                S_IRUGO|S_IWUSR},

static struct file_operations sel_load_ops = {
        .write          = sel_write_load,
};
```

sysfs Example: load_policy

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From userspace: libselinux/src/load_policy.c

```
int security_load_policy(void *data, size_t len)
{
        char path[PATH_MAX];
        int fd, ret;

        snprintf(path, sizeof path, "%s/load", selinux_mnt);
        fd = open(path, O_RDWR);
        if (fd < 0)
                return -1;

        ret = write(fd, data, len);
        close(fd);
```

sysfs Example: load_policy

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From kernel: security/selinux/selinuxfs.c

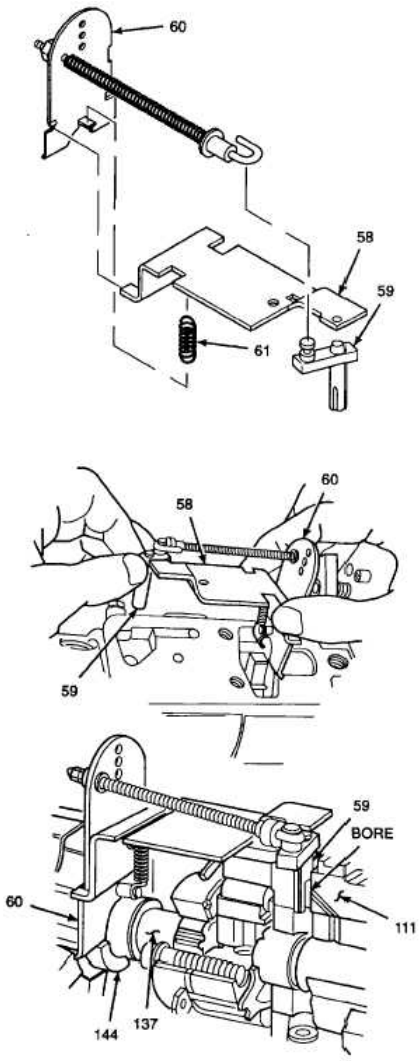
```
static ssize_t sel_write_load(struct file * file, const char __user * buf,
                              size_t count, loff_t *ppos)
{
…

length = task_has_security(current, SECURITY__LOAD_POLICY);
        if (length)
                goto out;
…

if (copy_from_user(data, buf, count) != 0)
        goto out;
length = security_load_policy(data, count); --- ss/services.c
if (length)
        goto out;
```

When Are We Done?

- There is a significant configuration effort to get the SELinux system deployed
  - Who does this?
  - What happens if I want to change something?
  - Does it prevent the major threats?



Take Away

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- Problem: Turn the SELinux policy into a working, usable reference monitor
  - Work with user-space services
  - Design the policy that you want
- There are many requirements for user-space services to provide authentication, access control, and policy configuration itself
  - PAM, Policy Mgmt, User-space access, Network support
- Design of MPS can only be semi-automated
  - Prevent network threats and design for app integrity