Securing Linux Systems with AppArmor

May, 2007

Novell®

AppArmor

AppArmor is an open source application security tool that helps protect Linux systems from unknown security flaws

Designed for ease of use

Deploy security policy in hours not days

Allow programs to do only what they are supposed to do and nothing else

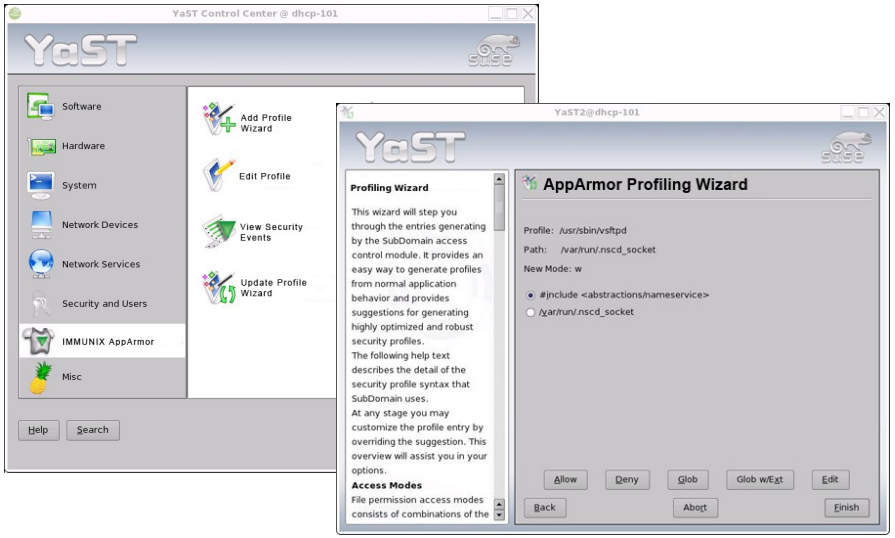
- AppArmor 2.0 integrated with SLES/SLED for “out of the box” protection
- AppArmor support included with SUSE Linux Enterprise support contracts
- Consulting available to assist customer with deployment and custom policy development if needed

Best Targets for AppArmor

- Any Company whose networked servers are running mission critical applications
- Any organization with a high cost associated with compromised data
- Any organization faced with regulatory compliance
- Any application that matters and is exposed to attack

Novell® AppArmor
Linux Application Security

- Creates firewall around any Linux program (custom, open source, third party)
- Prevents the exploitation of application vulnerabilities
- Protects against unknown or undiscovered flaws
- Prevents unauthorized access to all system resources
- Doesn't rely on attack signature database



Benefits of Novell® AppArmor

- Increased IT productivity
  - Empowers IT professionals to plan system updates, not just react
- Software Reliability
  - Much easier to specify what your application should do than to make bug-free software
- Peace of mind
  - Protects against unknown threats and “zero-day” attacks

Technical Details

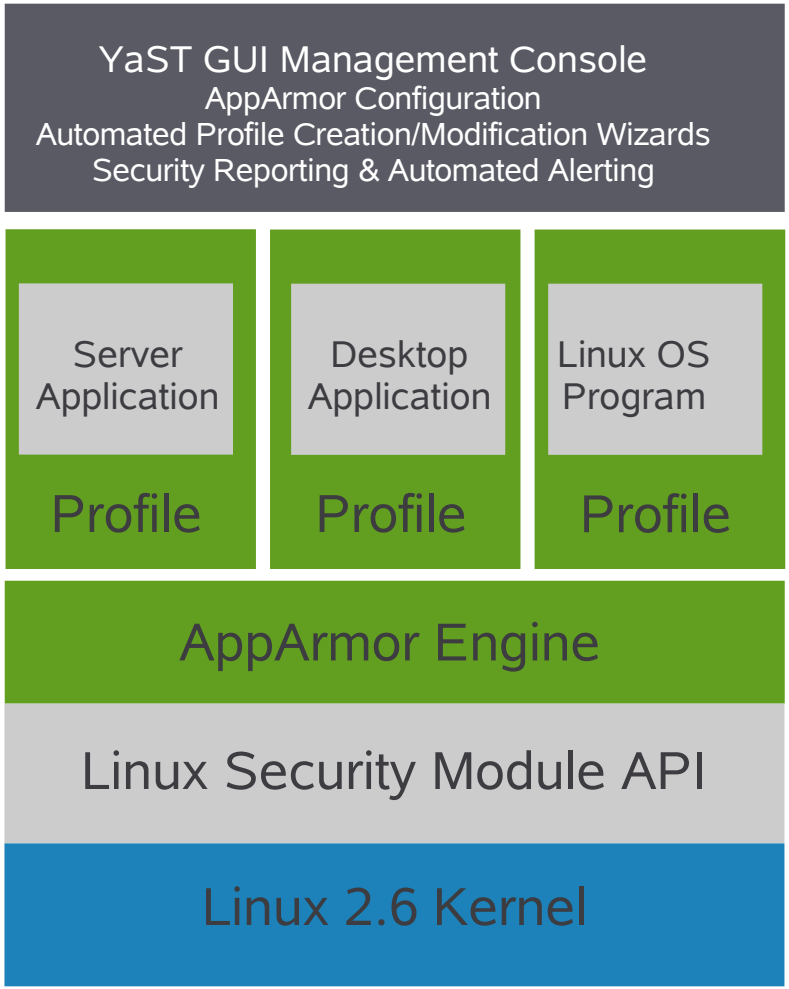
A Closer Look at AppArmor

Security Model

- Proactive “whitelist” approach, **no** attack signature database
- Profiles grant access to the **minimal** list of files/directories and POSIX capabilities required by the application
- Complete kernel-level mediation through Linux Security Module

Automated Workflow

- Auto-scan: finds applications listening to open network ports and checks for existing profile
- Auto-generate: create profile template based on static analysis
- Auto-learn mode: automatically expands profile while running the application through normal operation
- Interactive optimizer: suggests best rules, assists in simplifying profiles



Program-based Access Control

- Whenever a protected program runs regardless of UID, AppArmor controls:
  - The POSIX capabilities it can have (even if it is running as root)
  - The directories/files it can read/write/execute

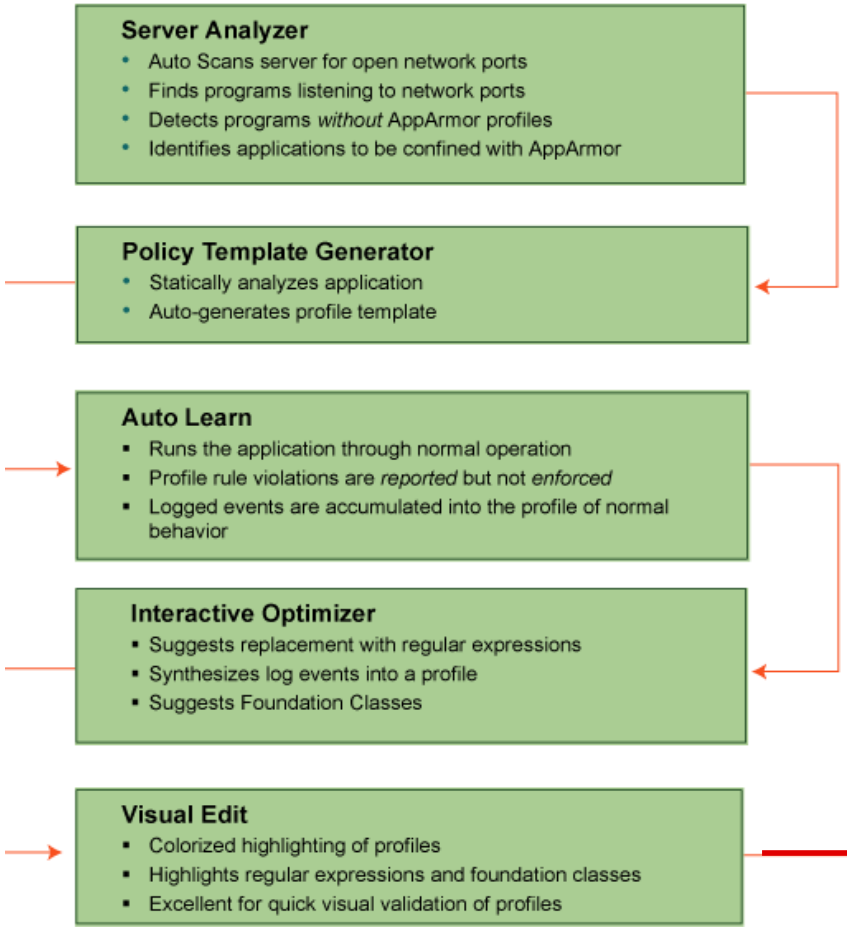
Example security profile for **ntpd**

```
/usr/sbin/ntpd {
  #include <abstractions/base>
  #include <abstractions/nameservice>

  capability ipc_lock,
  capability net_bind_service,
  capability sys_time,
  capability sys_chroot,
  capability setuid,

  /etc/ntp.conf                 r,
  /etc/ntp/drift*                               rwl,
  /etc/ntp/keys                 r,
  /etc/ntp/step-tickers                         r,
  /tmp/ntp*                                     rwl,
  /usr/sbin/ntpd                rix,
  /var/log/ntp                  w,
  /var/log/ntp.log              w,
  /var/run/ntpd.pid             w,
  /var/lib/ntp/drift            rwl,
  /var/lib/ntp/drift.TEMP       rwl,
  /var/lib/ntp/var/run/ntp/ntpd.pid             w,
  /var/lib/ntp/drift/ntp.drift                  r,
  /drift/ntp.drift.TEMP         rwl,
  /drift/ntp.drift              rwl,
}
```

Automated Workflow

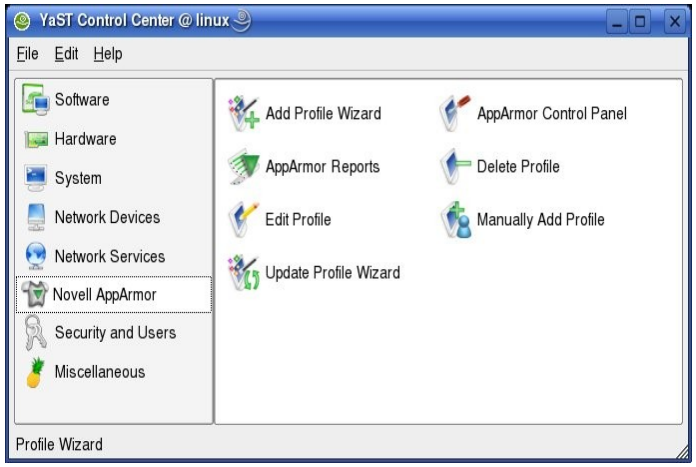



```
/usr/sbin/ntpd {
  #include <abstractions/base>
  #include <abstractions/nameservice>
  capability ipc_lock,
  capability net_bind_service,
  capability sys_time,
  capability sys_chroot,
  capability setuid,
  /etc/ntp.conf                    r,
  /etc/ntp/drift*                  rwl,
  /etc/ntp/keys                    r,
  /etc/ntp/step-tickers            r,
  /tmp/ntp*                        rwl,
  /usr/sbin/ntpd                   rix,
  /var/log/ntp                     w,
  /var/log/ntp.log                 w,
  /var/run/ntpd.pid                w,
```

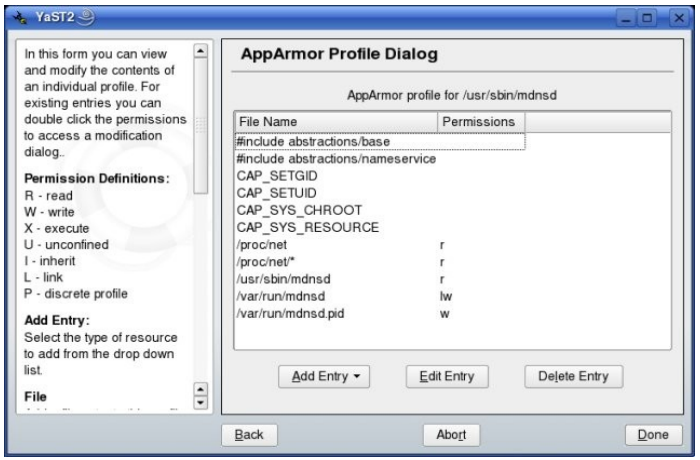
Includes Standard Set of Profiles

- Component library includes fully-configured profiles for common operating system services and applications:
  - Apache Web server
  - Postfix mail server
  - Sendmail mail server
  - OpenSSH
  - Squid
  - ntpd
  - nscd
  - Others

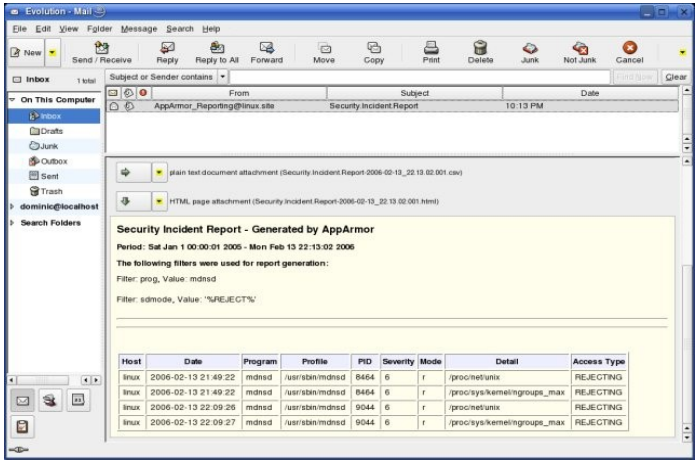
Interacting with AppArmor via YaST



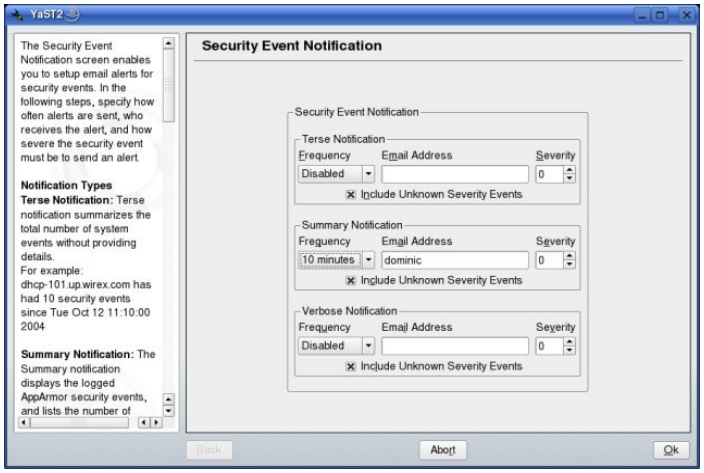
Configuration



Automated Policy Development

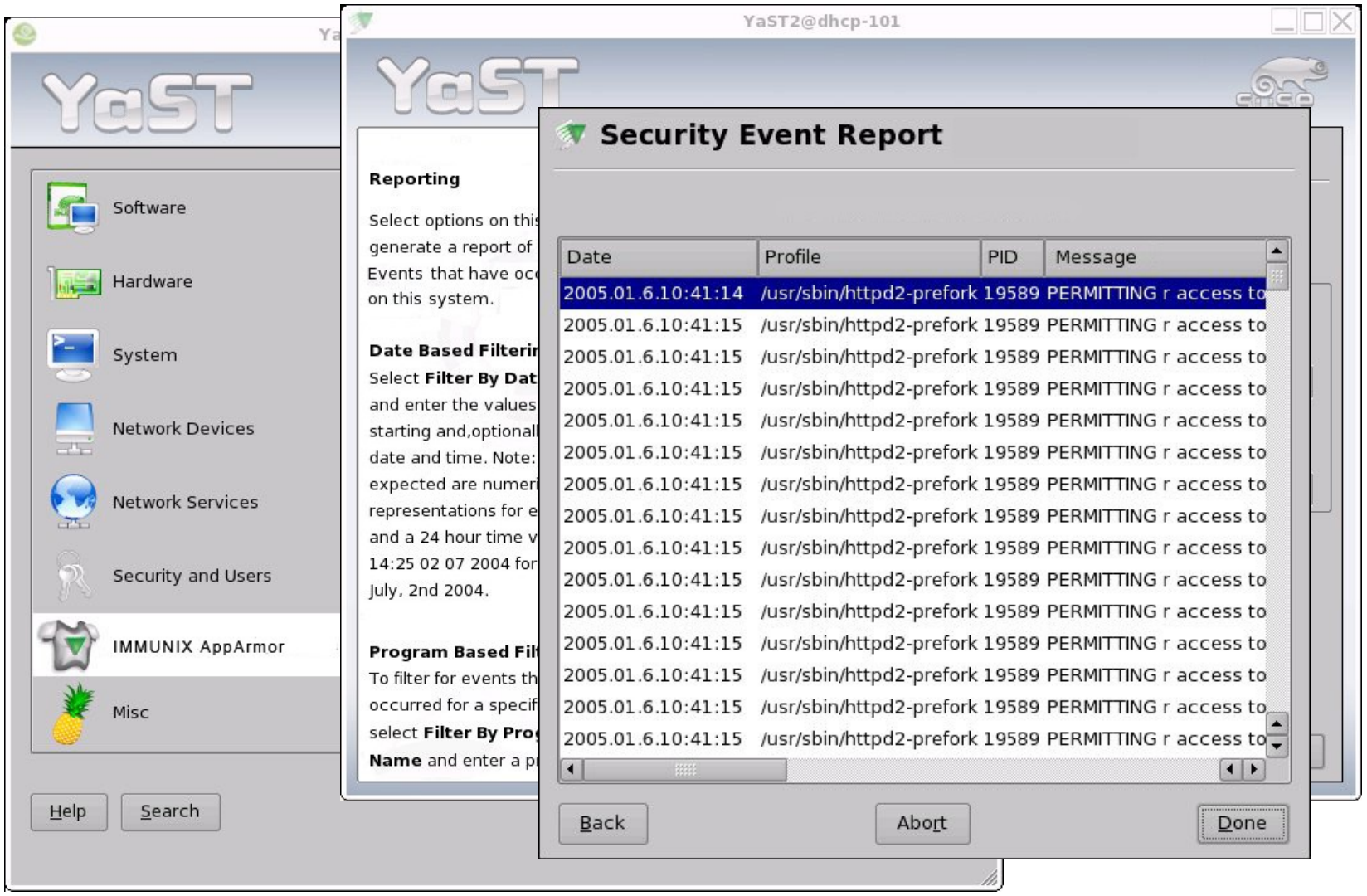


Reporting / Alerting



Security Event Notification

Configurable Alerting & Reporting



Command-line Interface

- There is also a command-line interface

Deployment Scenarios

Best Targets for AppArmor

Networked Servers

- Isolate all programs interacting with outside world
- Auto-scan tool finds applications that should be profiled
- Profiles represent your total exposure – auditable policy

Business Applications

- Complex, not easily auditable for security
- May be closed source
- Prevents attacks on one component from spreading to other components or systems

Corporate Desktop

- Profiles for desktop applications that process external data
- Separates these programs from other applications/data on the system
- Protects high-risk programs

POS Terminals, Kiosks

- Isolate all programs interacting with outside world
- Comprehensive profile set defined for specific uses
- Limits misuse of machines
- AppArmor profiles for user session and executable apps

Competitive Information

AppArmor vs. SELinux:

	AppArmor	SELinux
Type of Security	• Pathname-based system does not require labelling or relabelling filesystem • When developing profiles incrementally, there is much less reason to modify other profiles, because all profiles simply refer to the pathnames they use • Pathnames are easy to understand and audit	• Attaches labels to all files, processes • Labels identify the channels of communication, so adding new profiles may require modifying existing profiles to split channels of communication, making incremental policy development difficult • Not all applications preserve labels
Consequences	• Automated tools in place • Easier integration with Novell platforms	• Hard to maintain • Low adoption rate
Ease of Use	• Auditable policies • Integrated GUI/Console toolset • Proficiency with 1-2 days training • Usability is primary goal	• Complex policy language • Hard to manage rules • Lack of integrated tools • Substantial training investment

AppArmor vs. SELinux:
More Automated

SELinux audit2allow

1. Create a file at $SELINUX_SRC/domains/program/foo.te.
2. Put the daemon domain macro call in the file.
3. Create the file contexts file.
4. Put the first list of file contexts in file.fc.
5. Load the new policy with make load.
6. Label the foo files.
7. Start the daemon, service foo start.
8. Examine your audit log for denial messages.
9. Familiarize yourself with the errors the daemon is generating.
10. Use audit2allow to start the first round of policy rules
11. Look to see if the `foo_t` domain tries to create a network socket
12. Continue to iterate through the basic steps to generate all the rules you need.
13. If the domain tries to access `port_t`, which relates to `tclass=tcp_socket` or `tclass=udp_socket` in the AVC log message, you need to determine what port number foo needs to use.
14. Iterate through the remaining AVC denials. When they are resolved with new policy, you can configure the unique port requirements for the `foo_t` domain.
15. With the daemon started, determine which port foo is using.
16. Remove the generic port_t rule, replacing it with a specific rule for a new port type based on the foo_t domain.

AppArmor

1. Open YaST Control Center
2. Run Server Analyzer to determine which programs to profile
3. Run the Profile Wizard to generate a profile template
4. Run the application through normal operation
5. Run the interactive optimizer to synthesize log events into a profile

AppArmor vs. SELinux
More Compact

SELinux

```
################################
#
# Rules for the ftpd_t domain
#
type ftp_port_t, port_type;
type ftp_data_port_t, port_type;
daemon_domain(ftpd, `, auth_chkpwd')
type etc_ftpd_t, file_type, sysadmfile;

can_network(ftpd_t)
can_ypbind(ftpd_t)
allow ftpd_t self:unix_dgram_socket create_socket_perms;
allow ftpd_t self:unix_stream_socket create_socket_perms;
allow ftpd_t self:process {getcap setcap};
allow ftpd_t self:fifo_file rw_file_perms;

allow ftpd_t bin_t:dir search;
can_exec(ftpd_t, bin_t)
allow ftpd_t { sysctl_t sysctl_kernel_t }:dir search;
allow ftpd_t sysctl_kernel_t:file { getattr read };
allow ftpd_t urandom_device_t:chr_file { getattr read };

ifdef(`crond.te', `
system_crond_entry(ftpd_exec_t, ftpd_t)
can_exec(ftpd_t, { sbin_t shell_exec_t })
')

allow ftpd_t ftp_data_port_t:tcp_socket name_bind;

ifdef(`ftpd_daemon', `
define(`ftpd_is_daemon', `')
') dnl end ftpd_daemon
ifdef(`ftpd_is_daemon', `
rw_dir_create_file(ftpd_t, var_lock_t)
allow ftpd_t ftp_port_t:tcp_socket name_bind;
allow ftpd_t self:unix_dgram_socket { sendto };
can_tcp_connect(userdomain, ftpd_t)
', `
ifdef(`inetd.te', `
domain_auto_trans(inetd_t, ftpd_exec_t, ftpd_t)
ifdef(`tcpd.te', `domain_auto_trans(tcpd_t, ftpd_exec_t,
     ftpd_t)')
```

```
# Use sockets inherited from inetd.
allow ftpd_t inetd_t:fd use;
allow ftpd_t inetd_t:tcp_socket rw_stream_socket_perms;

# Send SIGCHLD to inetd on death.
allow ftpd_t inetd_t:process sigchld;
') dnl end inetd.te
')dnl end (else) ftp_is_daemon
ifdef(`ftp_shm', `
allow ftpd_t tmpfs_t:file { read write };
allow ftpd_t { tmpfs_t initrc_t }:shm { read write
     unix_read unix_write associate };
')

# Use capabilities.
allow ftpd_t ftpd_t:capability { net_bind_service
     setuid setgid fowner fsetid chown sys_resource
     sys_chroot };

# Append to /var/log/wtmp.
allow ftpd_t wtmp_t:file { getattr append };

# allow access to /home
allow ftpd_t home_root_t:dir { getattr search };

# Create and modify /var/log/xferlog.
type xferlog_t, file_type, sysadmfile, logfile;
file_type_auto_trans(ftpd_t, var_log_t, xferlog_t,
     file)
# Execute /bin/ls (can comment this out for proftpd)
# also may need rules to allow tar etc...
can_exec(ftpd_t, ls_exec_t)

allow { ftpd_t initrc_t } etc_ftpd_t:file r_file_perms;
allow ftpd_t { etc_t resolv_conf_t etc_runtime_t }:file
     { getattr read };
allow ftpd_t proc_t:file { getattr read };


')dnl end if ftp_home_dir
```

AppArmor

```
/usr/sbin/in.ftpd {
  #include <immunix-standard/base>
  #include <immunix-standard/nameservice>
  #include <immunix-
     standard/authentication>
  #include <user-custom/ftpd>
  /                                  r,
  /dev/urandom                       r,
  /etc/fstab                         r,
  /etc/ftpaccess                     r,
  /etc/ftpconversions                r,
  /etc/ftphosts                      r,
  /etc/ftpusers                      r,
  /etc/shells                        r,
  /usr/sbin/in.ftpd                  r,
  /usr/share/ssl/certs/ca-bundle.crt
      r,
  /usr/share/ssl/certs/ftpd-rsa.pem
      r,
  /usr/share/ssl/private/ftpd-rsa-key.pem
      r,
  /usr/share/ssl/.rnd                w,
  /var/log/xferlog                   w,
  /var/run                           wr,
  /var/run/ftp.{pids,rips}-all       wr,
}
```

AppArmor profile for the *same program* is about 4x smaller

Availability

Availability

- AppArmor bundled with all SUSE® Linux Enterprise 10 and openSUSE™ 10.* products
- Important new AppArmor features in SUSE Linux Enterprise 10 SP1 are:
  - Tomcat Support – AppArmor containment for Java servlets
  - PAM change_hat – strengthens security of AppAmor's role-based shell functionality for applications that use PAM (e.g. sshd, gdm, ftp)
- AppArmor is open source: GPL
  - http://opensuse.org/AppArmor
  - Mailing lists: apparmor-announce, apparmor-general, apparmor-dev

For More Information

http://www.novell.com/apparmor
http://www.opensuse.org/Apparmor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