CE Linux Forum
Worldwide Embedded Linux Conference 2007
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TOMOYO Linux

"A Lightweight and Manageable Security System for PC and Embedded Linux"

http://tomoyo.sourceforge.jp/

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http://www.nttdata.co.jp/en/index.html

Hello, world!

- This is the very first presentation abroad for our work, “TOMOYO Linux”.
- TOMOYO Linux is a MAC (Mandatory Access Control) implementation for Linux.
- TOMOYO Linux consists of a set of patches for kernel 2.4/2.6 and a couple of administrative tools. It has been ported to various distributions.
- TOMOYO Linux is available at http://tomoyo.sourceforge.jp/ under the GPL license.
- You can browse&search the code at http://tomoyo.sourceforge.jp/cgi-bin/lxr/source

About NTT DATA

- http://www.nttdata.co.jp/en/index.html
- One of the largest SI companies in Japan.
  - Data
    - Established: May 23, 1988
    - Ordinary Income: **42,016 million yen**
    - Number of Employees: **8,406**
    - Common Stock: **142,520 million yen**
    - Net Sales: **907,281 million yen**
    - (see http://www.nttdata.co.jp/en/aboutus/a09.html for more detail)
- TOMOYO Linux project:
  - Launched March 2003.
  - Members: started from 2. currently 5.
  - Exceptionally small project in the largest company. :-)

TOMOYO Linux: Background

- Originated from NTT DATA CORPORATION R&D.
- Project started in March 2003.
- First public release in November 2005.
- Ported to Debian Sarge/Etch, RedHat Linux 9, Fedora Core 3-6, CentOS 4.4/5, OpenSUSE 10.1/10.2, Asianux 2.0, Ubuntu 6.10/7.04 and more (check the link below).
  - http://sourceforge.jp/projects/tomoyo/files/
- Suits well to embedded systems.

Topics Covered in This Session:

- Overview of TOMOYO Linux and MAC.
- What TOMOYO Linux can do/can't do.
- Concepts.
- Automatic policy configuring feature.
- TOMOYO Linux policy.
- How it works.
- Short demonstration.
- Comparison to other security enhanced OSs.

Topics NOT Covered in This Session:

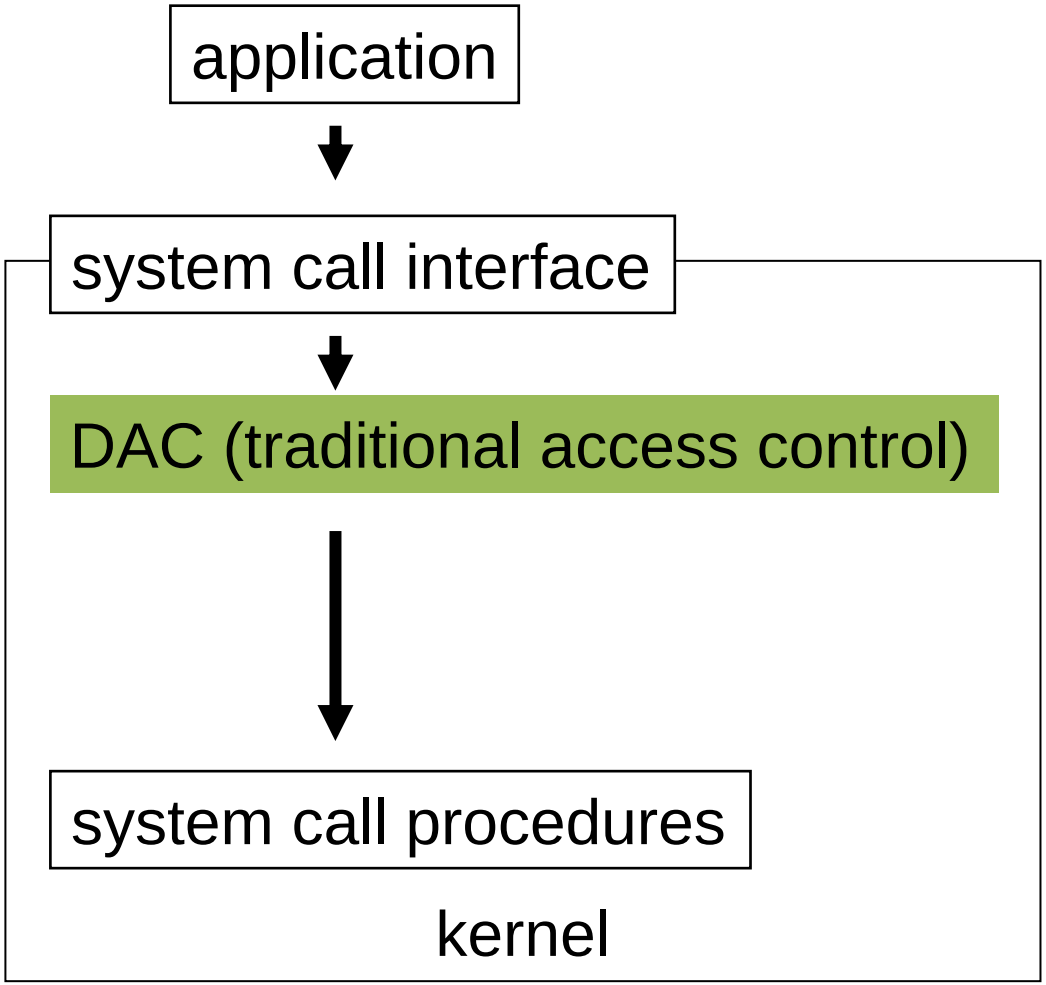
- Whether name-based access control is evil or not.
  - It's too technical and complex.
  - TOMOYO Linux will have a BOF session in the upcoming Ottawa Linux Symposium. Please join and *help/save us*!
- In-depth demonstration.
  - Will be shown in the following tutorial session, don't miss it! Or please consider installing binary package yourself (10 minutes job).
    - http://tomoyo.sourceforge.jp/en/1.4/install.html

Part 1
MAC and TOMOYO Linux Overview

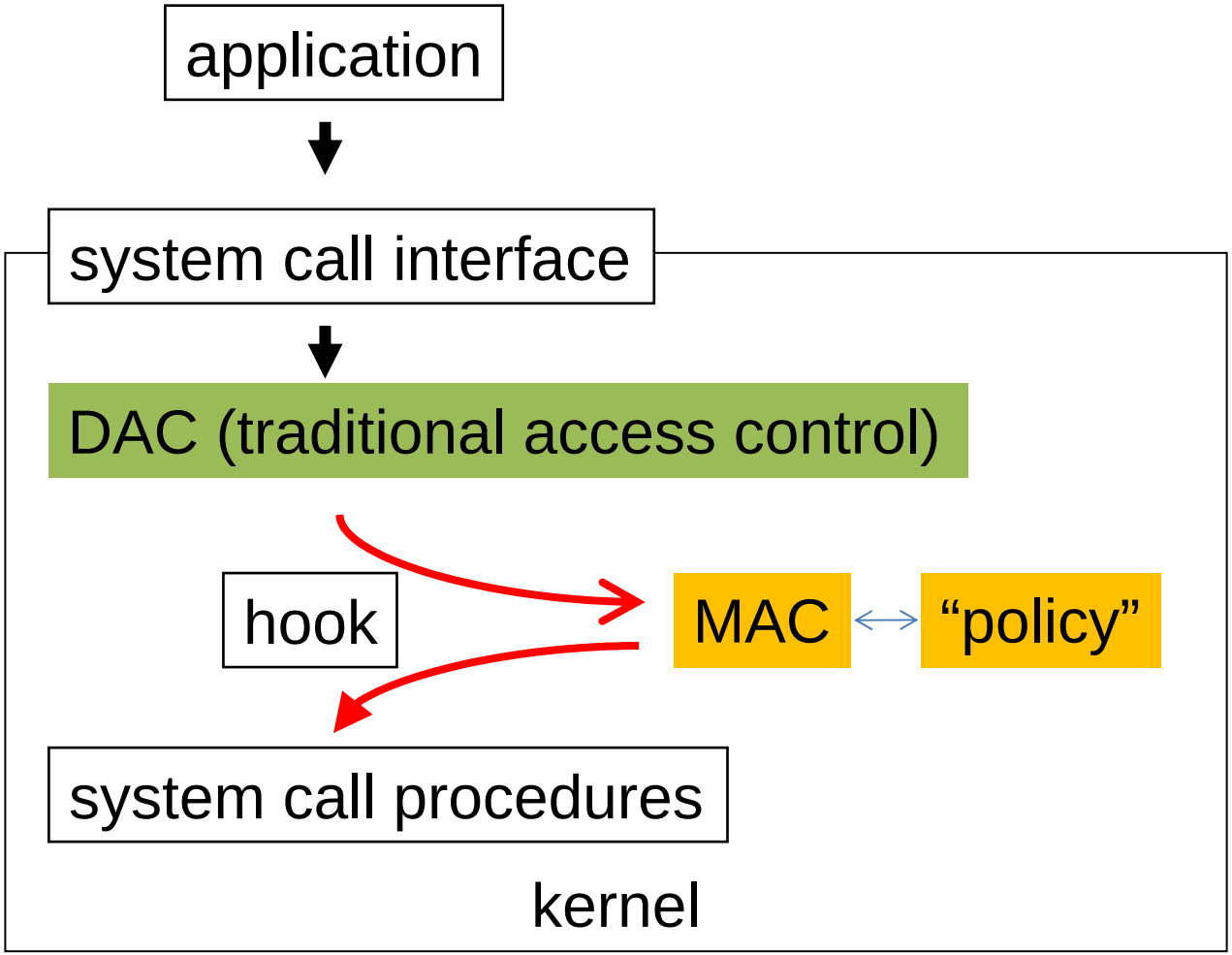
What is “MAC”?

- “Mandatory Access Control”
  - No exceptions even for “root” users and no bypass.
  - Accesses are strictly judged according to the rules (called “policy”).
  - Traditional access control is referred as DAC (Discretionary Access Control).
- Implementation.
  - (1) “Hook” a request (e.g. system call).
  - (2) “Judge” whether to execute the request or not.
  - (3) “Process” the request.
  - 2.6 kernel has a built-in framework for hooks – LSM (Linux Security Modules).

What is “hook”?


application
system call interface
DAC (traditional access control)
system call procedures
kernel

What is “hook”?


application
system call interface
DAC (traditional access control)
hook
MAC
“policy”
system call procedures
kernel

What is “policy”?

- DAC checks “rwx” attributes associated with filesystem. (very simple)
- MAC engine needs “rules” to make decision.
- “Policy” is the name for the rules**.**
  - MAC is useless without good policy.
- No standard policy syntax exists (so far).
- Policy is defined as a set of “conditions”.
  - *if (condition) then Access is (granted/denied).*

What is TOMOYO Linux?

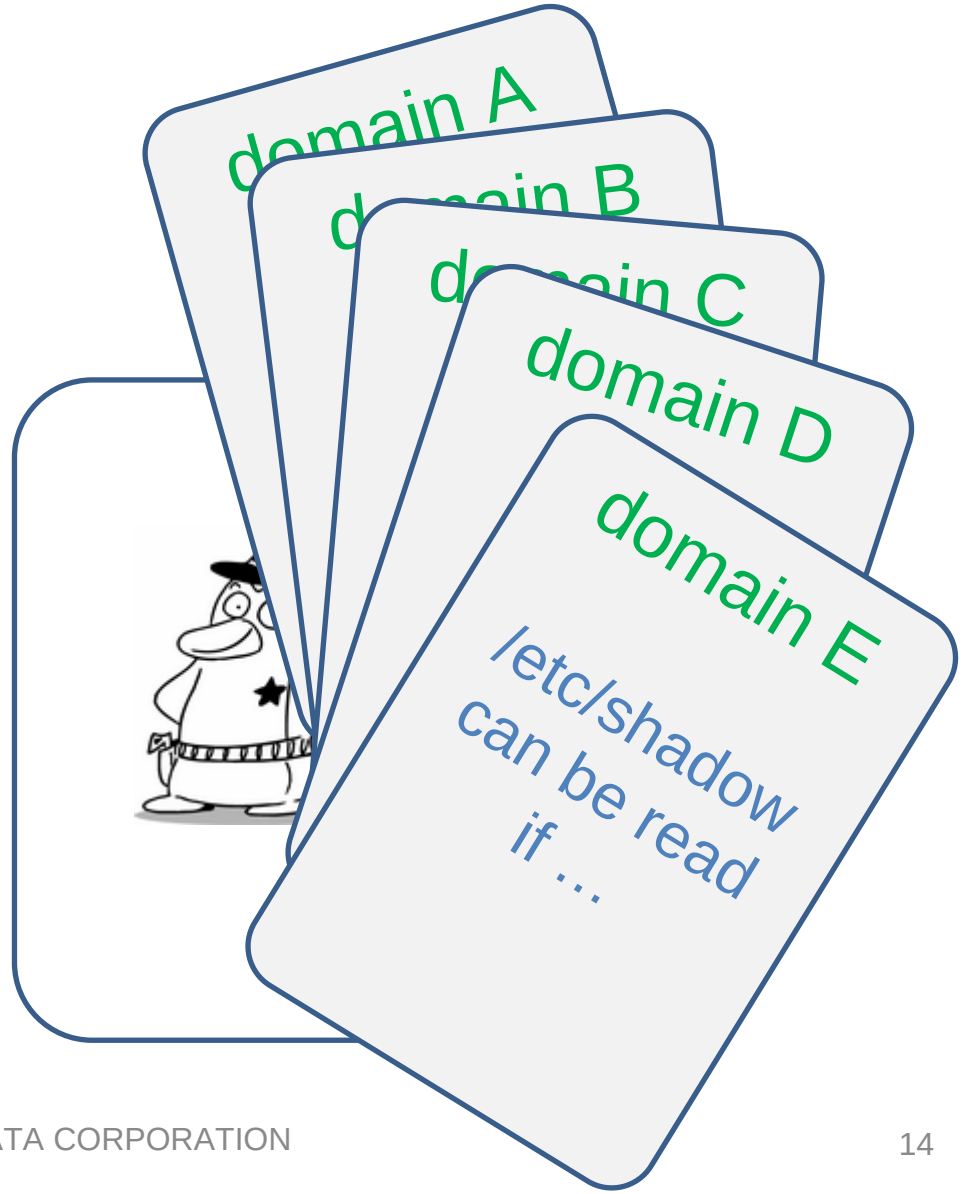
- “Lightweight” and “usable” Mandatory Access Control for Linux, with
  - “automatic policy configuring” feature.
  - administrators friendly policy language.
  - English documentation.
  - 2.4 kernel and BusyBox support.
  - no filesystem limitations (runs with any filesystem).
  - no need of libselinux nor userland program modifications.

What is TOMOYO Linux?

- TOMOYO Linux
  - is not using LSM (Linux Security Modules) .
    - Some work is in progress.
  - does not have MLS (Multi Level Security), RBAC (Role Based Access Control) mechanisms..
    - If you need MLS, use SELinux.
    - RBAC like usages are available.
  - is not included in Linux kernel source.
    - yet
  - can do unusual things and playing with TOMOYO Linux is so much fun.
  - is no guarantee. (use at your own risk, of course)

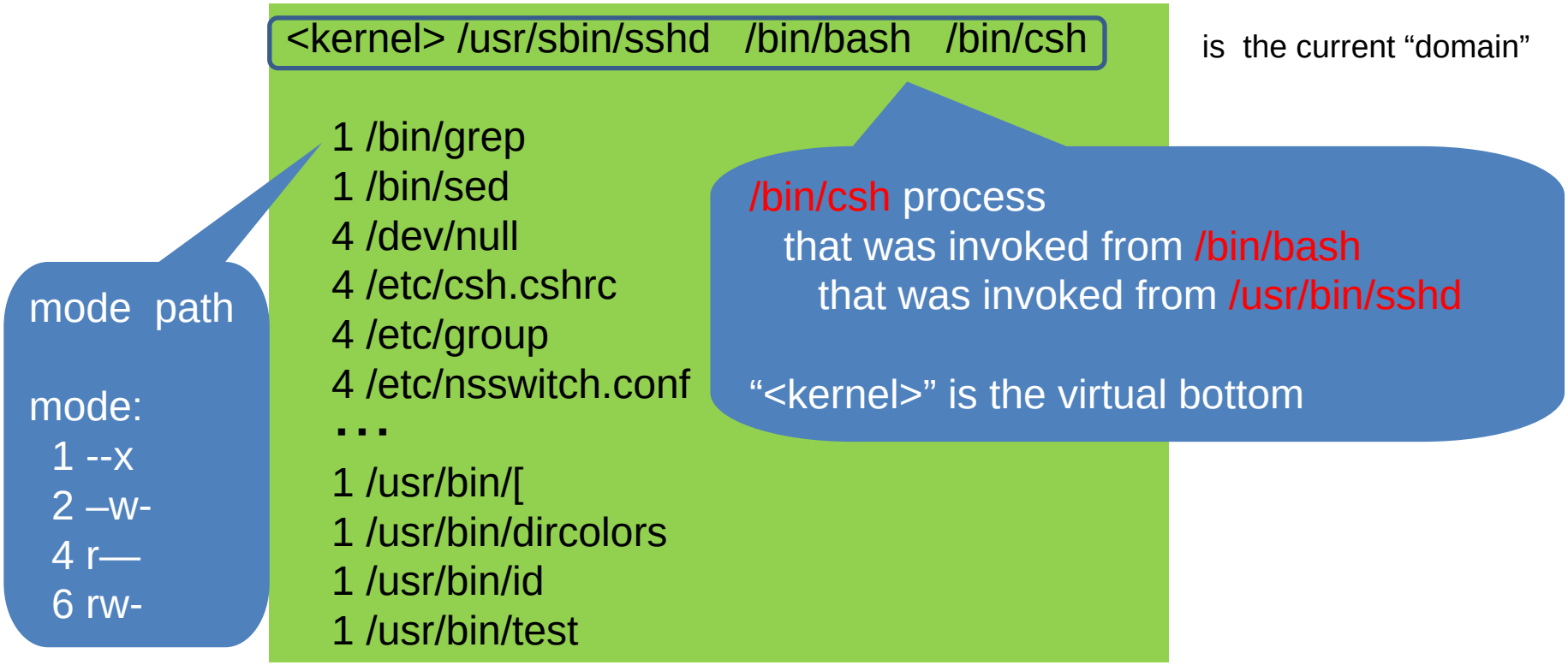
What is “domain”?

- Whether a request is legal or not depends on the “context”.
- Most MAC system refers this context as “domain”.
- “Domain” is a kind of group/unit.

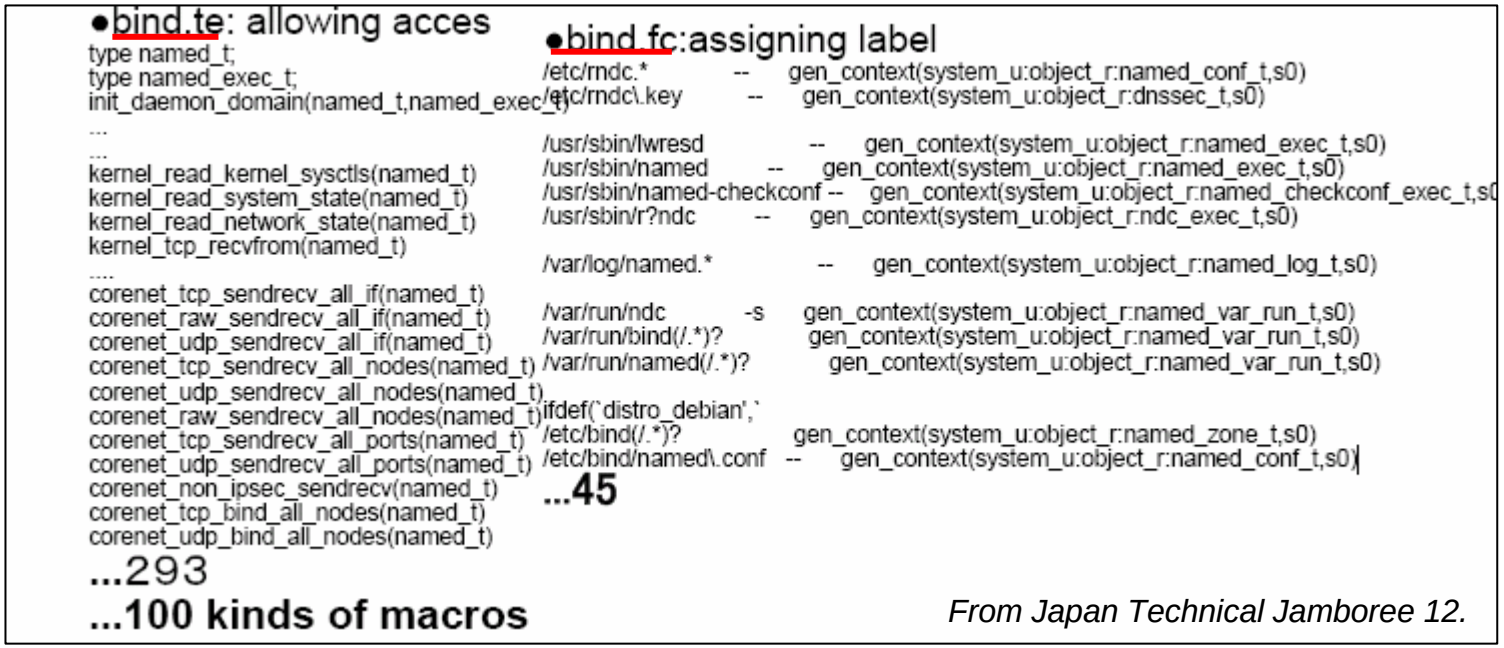


TOMOYO Linux Policy

- Exceptionally simple. Any Linux/UNIX users can read and write it.



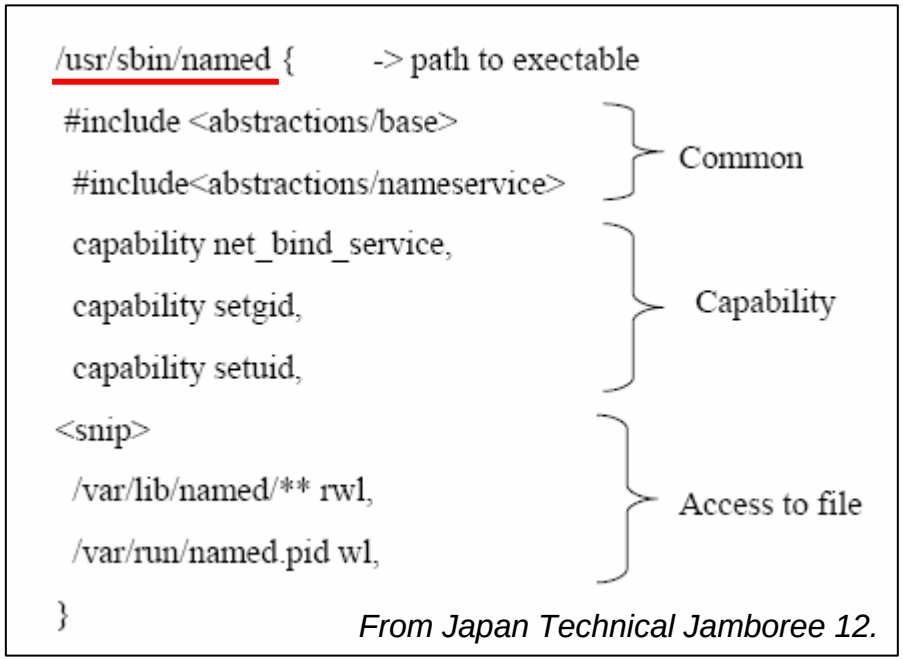
SELinux Policy



From Japan Technical Jamboree 12.

"*.te": access control definitions for "*".
"*.fc": label definitions for "bind". "fc" stands for "file context".
Policy is described in terms of label, not path name. (but label definition is described in terms of path names). Macros are introduced to make policy more readable. SELinux kernel needs policy to be compiled before use.

AppArmor Policy



From Japan Technical Jamboree 12.

- Above definition is applied to every instance of /usr/sbin/named (No process invocation history mechanism exists with AppArmor).
- In TOMOYO Linux, “<kernel> /foo /bar /usr/sbin/named” and “<kernel> /boo /bar /baz /usr/sbin/named” is distinguished and treated independently.
- SELinux simply cares about “label”.

AppArmor Policy (cont.)

- Similarities with TOMOYO Linux:
  - Both use “pathname based” definition.
- Differences:
  - TOMOYO Linux distinguishes domain by a process invocation history while AppArmor does by a single process.
  - TOMOYO Linux provides MAC for network and signals.

Domains in TOMOYO Linux

- In TOMOYO Linux
  - every process belongs to a domain.
  - every process remembers its ancestors.
  - ACL are controlled by the domain, not by a current process name.
- Utility program, “ccstree”, prints out domain information for running processes.

```
0  +- sshd (2859) <kernel> /usr/sbin/sshd
0    +- sshd (3807) <kernel> /usr/sbin/sshd
1      +- bash (3809) <kernel> /usr/sbin/sshd /bin/bash
2        +- ccstree (3942) <kernel> /usr/sbin/sshd /bin/bash /root/ccstools/ccstree
```

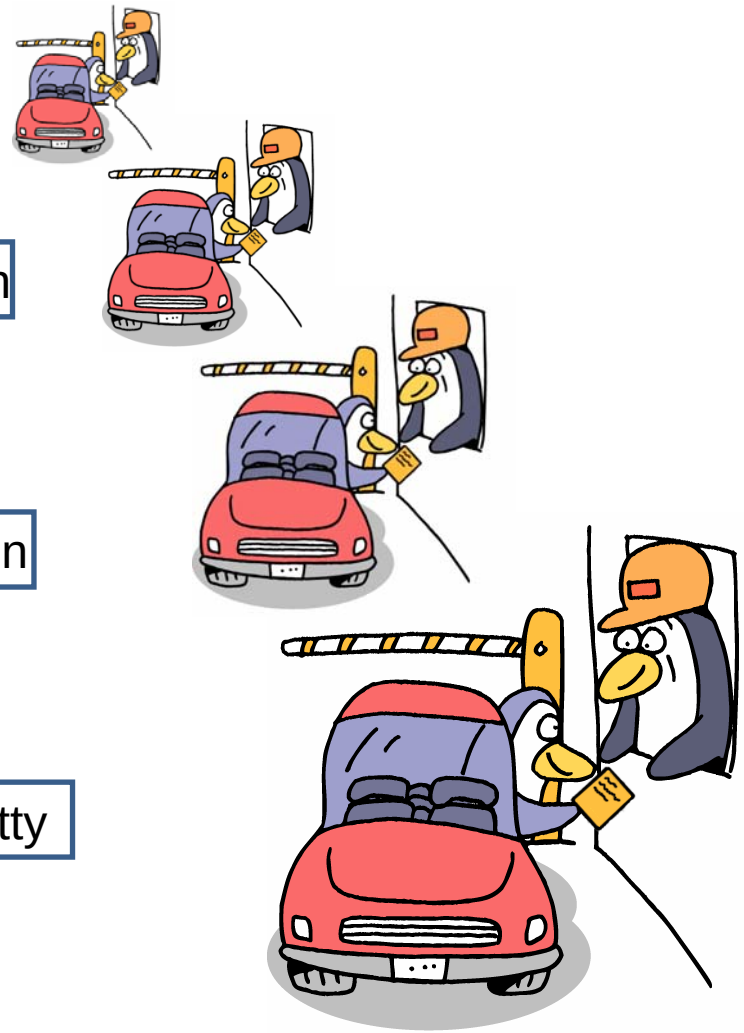
TOMOYO Keeps Track of Process Invocation History

<kernel> /sbin/mingetty /bin/login /bin/bash /bin/ls

<kernel> /sbin/mingetty /bin/login /bin/bash

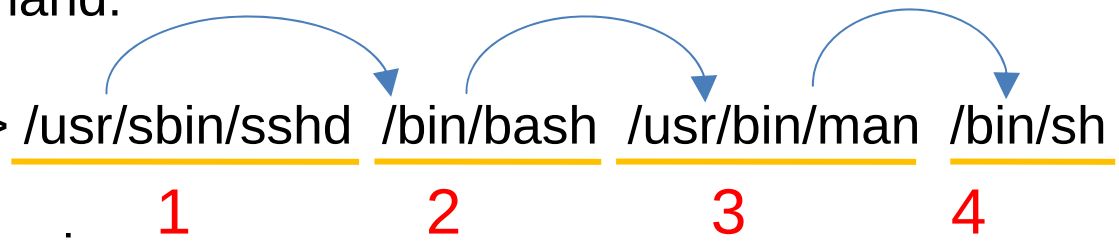
<kernel> /sbin/mingetty /bin/login

<kernel> /sbin/mingetty



A Slightly Complicated Example

Suppose that you are logged-in into a ssh server and execute a *man* command:



1 /bin/gunzip
2 /dev/null
6 /dev/tty
4 /etc/mtab
1 /usr/bin/bzip2
1 /usr/bin/gtbl
1 /usr/bin/less
1 /usr/bin/nroff
2 /var/cache/man/cat1/pstree.1.bz2
allow_truncate /var/cache/man/cat1/pstree.1.bz2

Automatic Policy Generation

- How to use:
  1. Change “mode (explained later)” of TOMOYO Linux kernel to “policy generation”.
  2. Just operate as you want.
  3. TOMOYO Linux generates the required access control lists as policy.
  4. Check it and modify it.
  5. Done
- Advantages
  - Saves time enormously.
  - The resulting policy is quite “readable”.

Demo

Automatic Policy Generation

- How it works?
  - TOMOYO kernel keeps track of:
    - access requests (by original hooks).
    - process invocation history (something like *pstree* originated from /sbin/init) – every process knows its ancestors under TOMOYO Linux.
    - assigns each individual “process invocation history” as a “domain”.
      - ex. “<kernel> /sbin/init /etc/rc.d/rc /etc/rc.d/rc.local”

Life with TOMOYO Linux

- Administrating TOMOYO Linux is easy and fun.

Life with Other MAC Systems

- Why it’s not working?
- Is it failure of my APP or my policy? How am I suppose to find?
- I’d rather disable it …

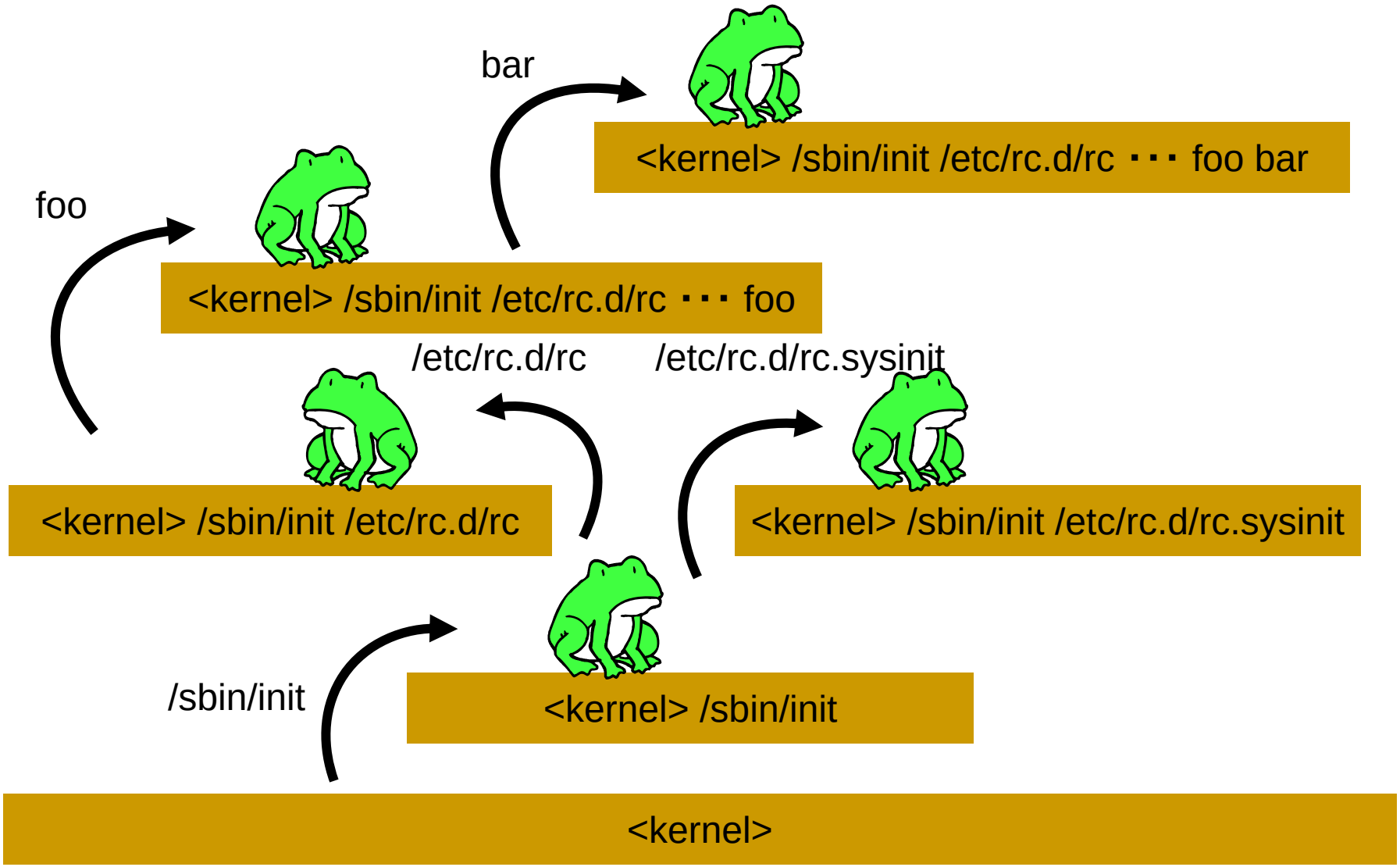
SELinux FAQ says:

- *The security of an unmodified Linux system depends on the correctness of the kernel, all the privileged applications, and each of their configurations. A problem in any one of these areas may allow the compromise of the entire system.*
- *In contrast, the security of a modified system based on the Security-enhanced Linux kernel depends primarily on the correctness of the kernel and* ***its security policy configuration****.*

Domain Transition

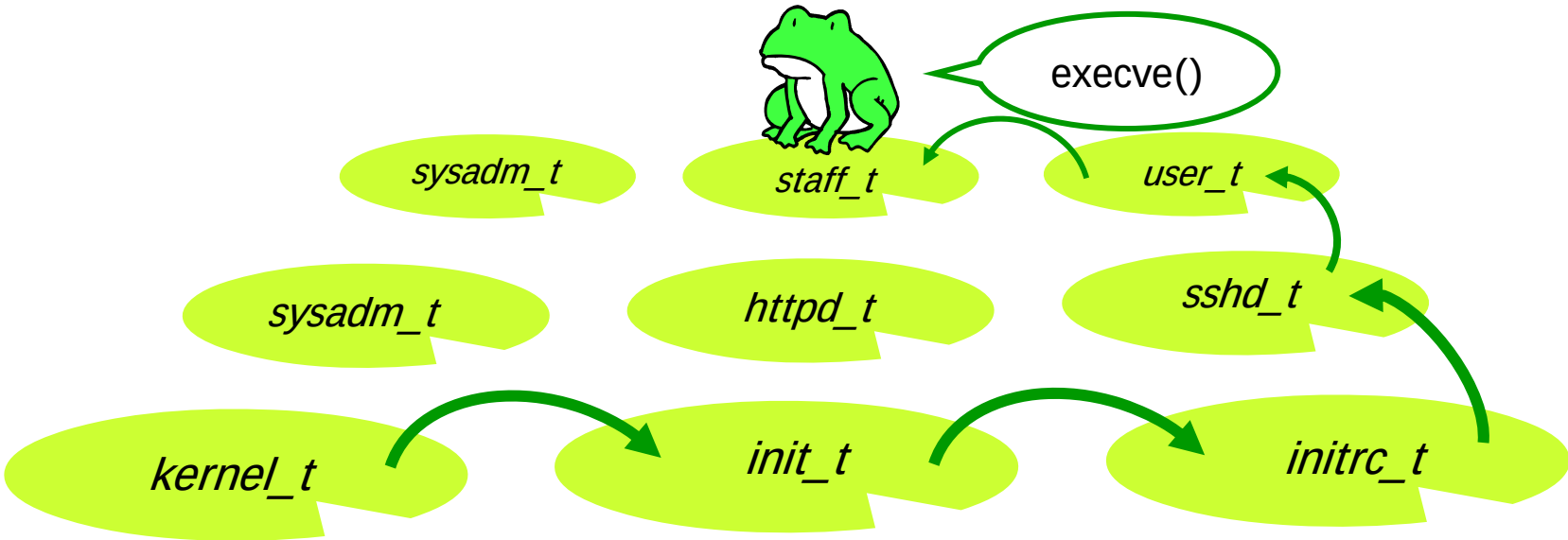
- Handled by TOMOYO Linux kernel automatically .
- Domain simply gets deeper by default.
- The name of a domain is like “<kernel> /sbin/init …”.
  - No administrator operation necessary.
  - No file context definition necessary.
  - No need of “xattr”.

Domain Transition



Domains in SELinux

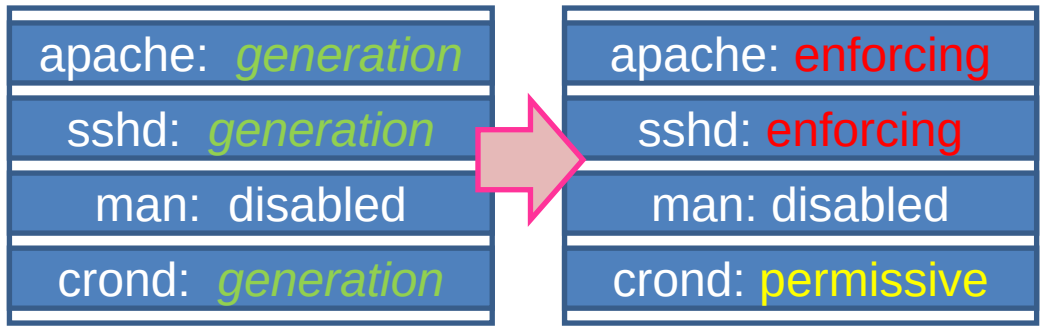
- Domain names and domain transition conditions must be defined beforehand.
- Domains are flat and have no levels.



Mode

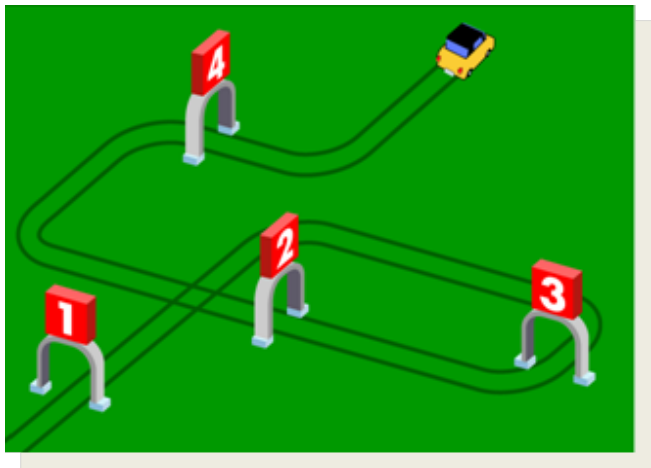
disabled/permissive/
enforcing

- SELinux
  - has 3 modes.
    - disabled
    - permissive (it is “ok”, even if policy says “no”)
    - enforcing (if policy says “no”, it is “no”)
  - Mode is system global in SELinux.
- TOMOYO Linux
  - 4 modes.
    - disabled
    - permissive
    - policy generation
    - enforcing
  - **Mode is selectable on a per domain basis.**



Part 2

TOMOYO Linux for Embedded Systems



MAC for Embedded Systems

- Embedded systems need security, too.
- Resource issues:
  - SELinux need “xattr” aware filesystems.
  - Tight requirements for memory and CPU.
- BusyBox issue:
  - Sharing a binary image is good for saving storage, but sharing “context” can harm MAC.
  - BusyBox has incorporated SELinux supports recently.
  - TOMOYO Linux has built-in support for BusyBox.

Affinity with Embedded Linux

- Small memory footprint.
  - 100KB for kernel code and data.
  - A few hundred KB for policy.
- Targeted Protection.
  - You can protect selectively.
- Small performance impact.
  - No checks for read()/write() system calls.

Affinity with Embedded Linux

- Program invocation via symbolic link.
  - “alias /bin/bash /bin/sh” will allow you to distinguish /bin/bash and /bin/sh .
- Program invocation via hard link.
  - You can distinguish /bin/gzip and /bin/gunzip without any prescription.

Affinity with Embedded Linux

- No xattr support required.
  - 100% filesystem independent.
- No GUI environment required.
  - Administration tasks are quite simple enough that you can do it using CUI (e.g. console or ssh session).
- No modification required.
  - You don’t need any patches for your userland programs.

Affinity with Embedded Linux

- Dynamically created files.
  - Sometimes files are dynamically created in a volatile filesystem. Such files have no fixed inode-number nor determinate inode-xattr.
  - LIDS needs stable inode-number.
  - SELinux needs stable inode-xattr.
  - TOMOYO doesn’t need either.

Affinity with Embedded Linux

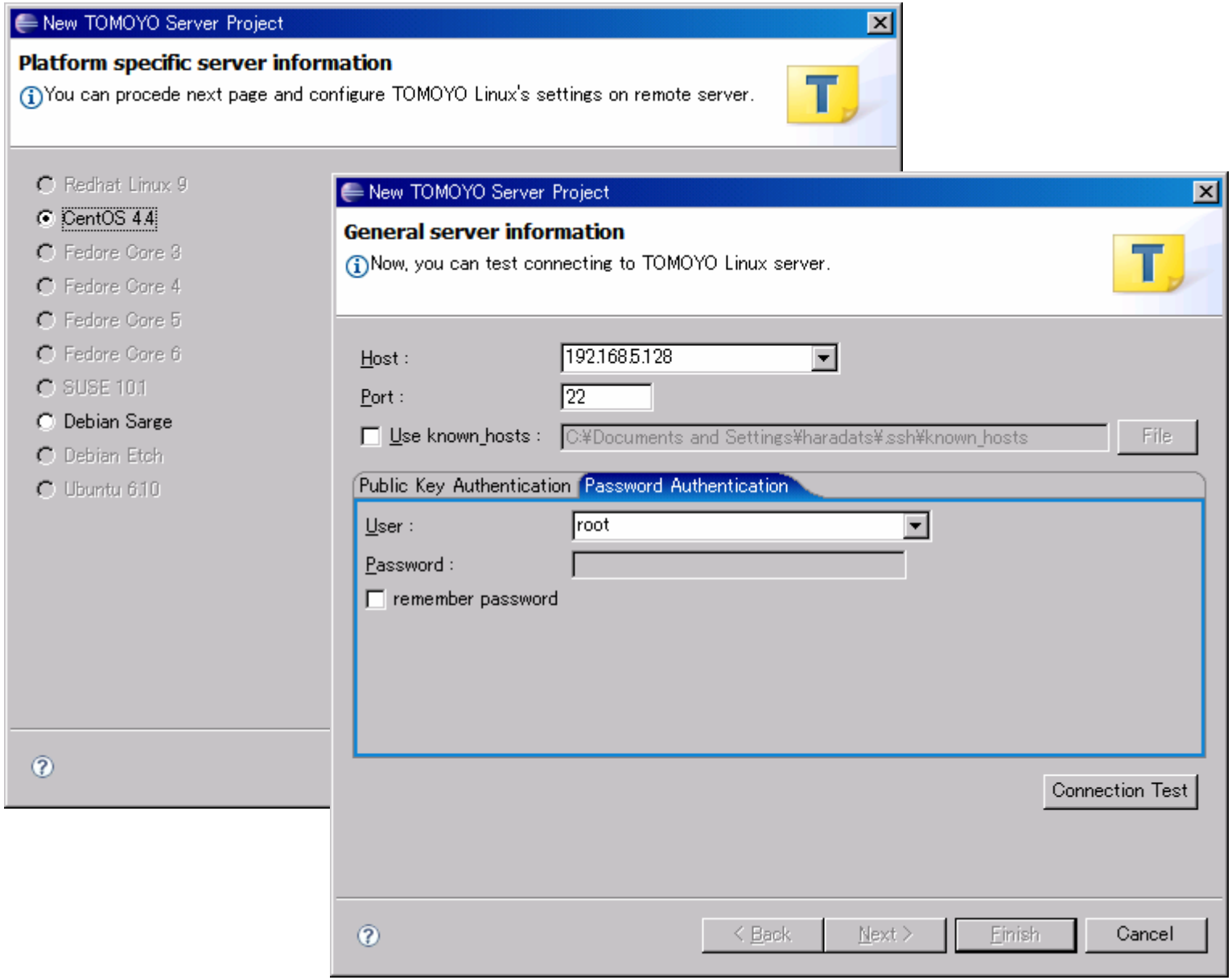
- Automatic policy generation.
  - TOMOYO will observe your system's behavior and build the exact policy for you.
  - You have got a professional tailor!
- Easy policy accommodation.
  - You can assign multiple pathnames to a file.
  - No need for accommodation of label assignment like SELinux.

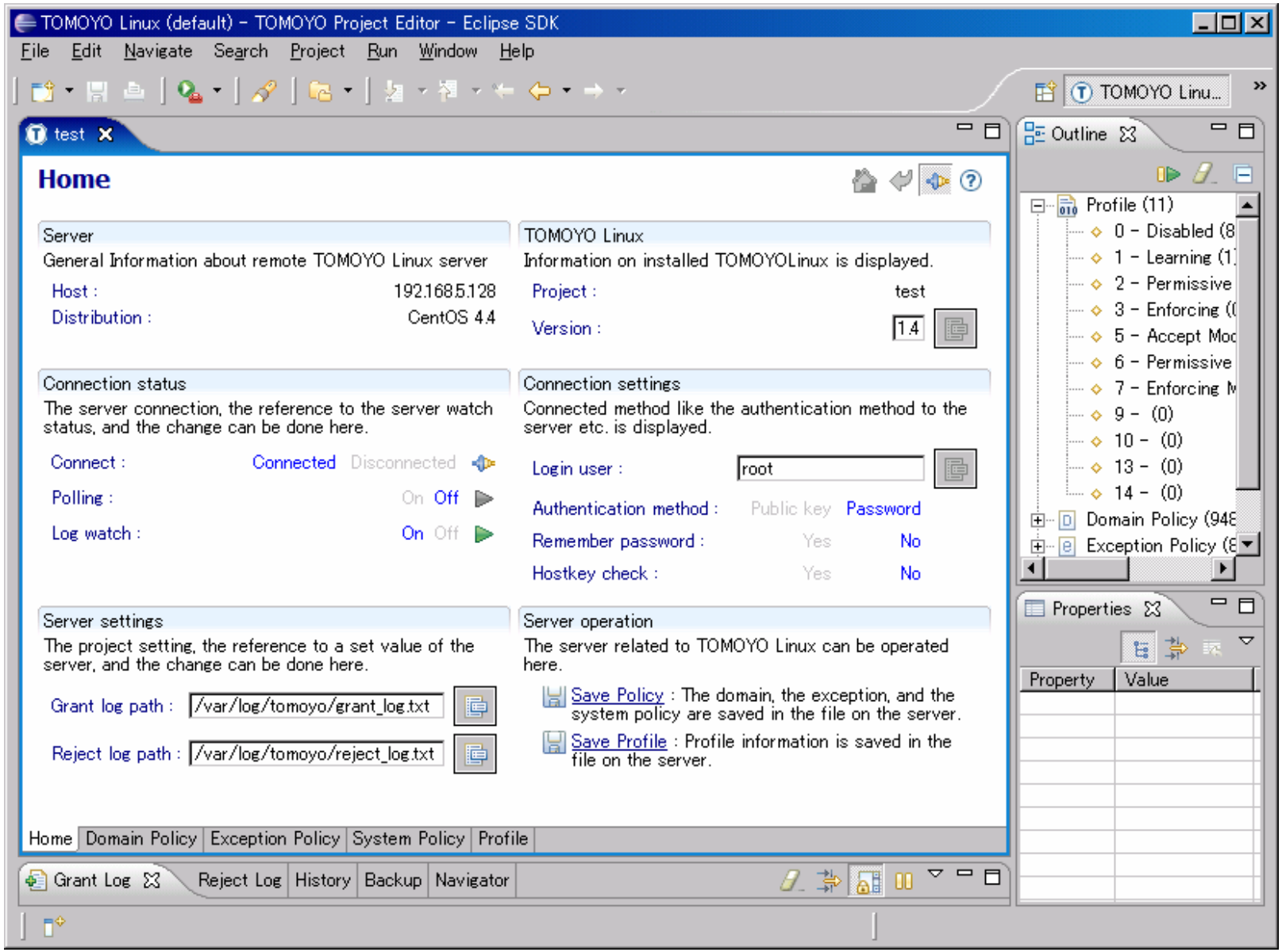
Affinity with Embedded Linux

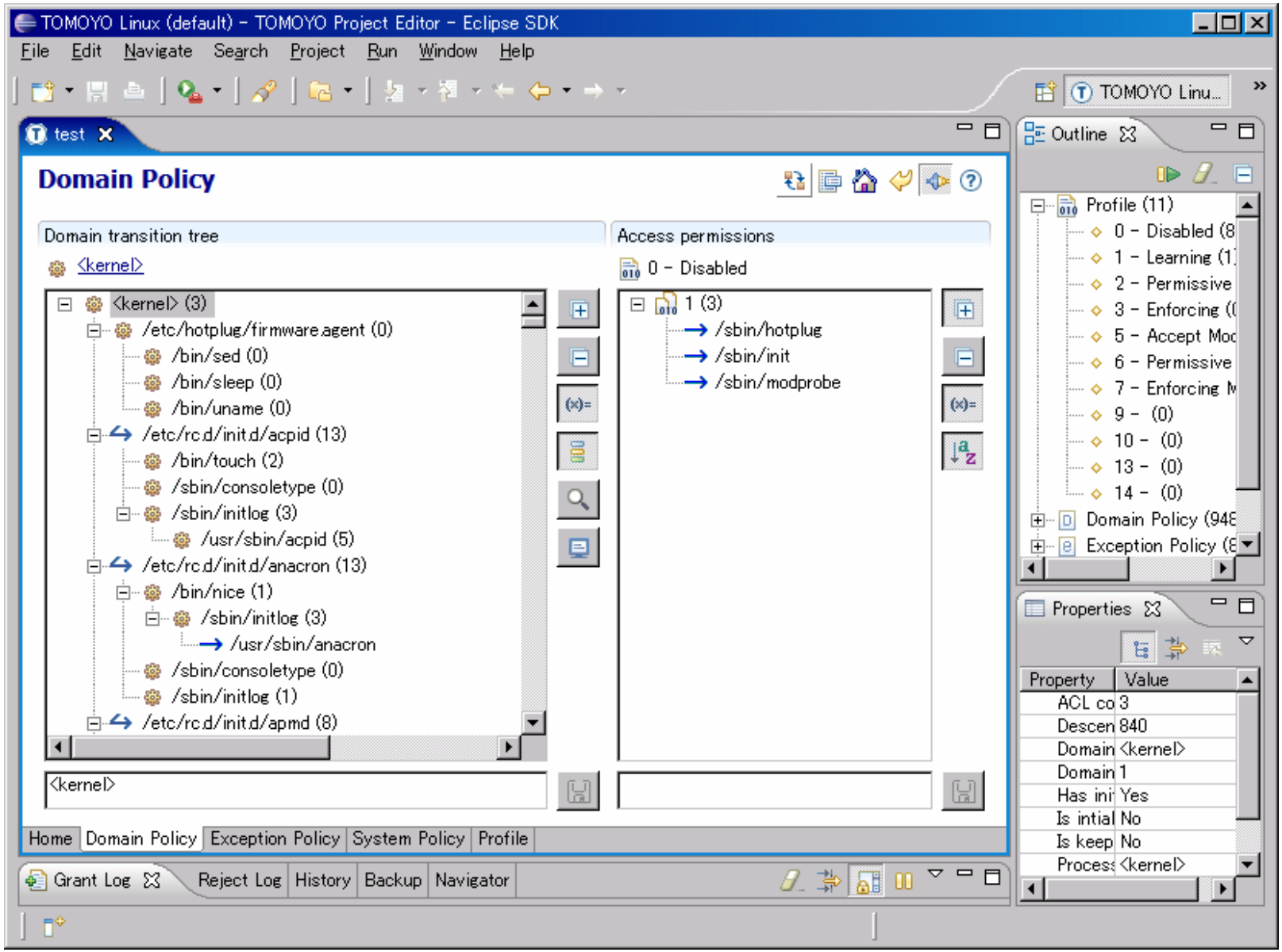
- Unusual pathnames.
  - TOMOYO Linux is a pathname based MAC.
  - TOMOYO Linux can handle any characters including white-spaces, carriage-return, non-printable characters (e.g. BS), non-ASCII characters (e.g. EUC_JP) in the pathname.
  - All names in TOMOYO Linux consist of ASCII printable characters.

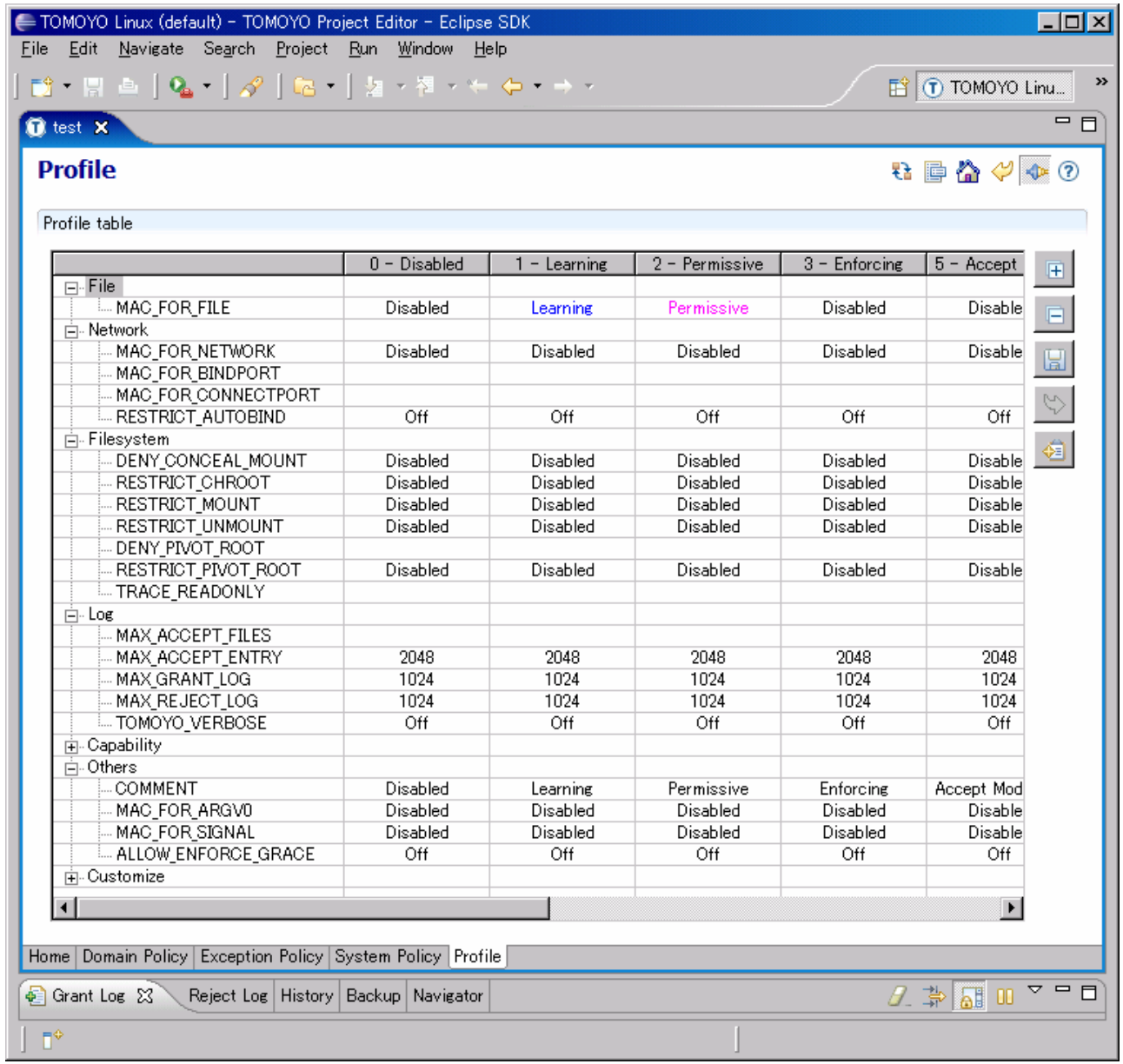
GUI

- TOMOYO Linux can be fully controlled via tty and no GUI is necessary, but
- we are developing a Eclipse plug-in for GUI lovers/addicts.
- The plug-in talks to TOMOYO Linux kernel through SSH protocol.
- No server side libraries are required.
- English is supported as well as Japanese.


New TOMOYO Server Project
Platform specific server information
You can procede next page and configure TOMOYO Linux's settings on remote server.
Redhat Linux 9
CentOS 4.4
Fedore Core 3
Fedore Core 4
Fedore Core 5
Fedore Core 6
SUSE 10.1
Debian Sarge
Debian Etch
Ubuntu 6.10
New TOMOYO Server Project
General server information
Now, you can test connecting to TOMOYO Linux server.
Host :
192.168.5.128
Port :
22
Use known_hosts :
C:¥Documents and Settings¥haradats¥.ssh¥known_hosts
File
Public Key Authentication
Password Authentication
User :
root
Password :
remember password
Connection Test
< Back
Next >
Finish
Cancel


TOMOYO Linux (default) - TOMOYO Project Editor - Eclipse SDK
File Edit Navigate Search Project Run Window Help
TOMOYO Linu...
test
Home
Server
General Information about remote TOMOYO Linux server
Host : 192.168.5.128
Distribution : CentOS 4.4
TOMOYO Linux
Information on installed TOMOYOLinux is displayed.
Project : test
Version : 1.4
Connection status
The server connection, the reference to the server watch status, and the change can be done here.
Connect : Connected Disconnected
Polling : On Off
Log watch : On Off
Connection settings
Connected method like the authentication method to the server etc. is displayed.
Login user : root
Authentication method : Public key Password
Remember password : Yes No
Hostkey check : Yes No
Server settings
The project setting, the reference to a set value of the server, and the change can be done here.
Grant log path : /var/log/tomoyo/grant_log.txt
Reject log path : /var/log/tomoyo/reject_log.txt
Server operation
The server related to TOMOYO Linux can be operated here.
Save Policy : The domain, the exception, and the system policy are saved in the file on the server.
Save Profile : Profile information is saved in the file on the server.
Home Domain Policy Exception Policy System Policy Profile
Grant Log Reject Log History Backup Navigator
Outline
Profile (11)
0 - Disabled (8
1 - Learning (1
2 - Permissive
3 - Enforcing (
5 - Accept Mod
6 - Permissive
7 - Enforcing M
9 - (0)
10 - (0)
13 - (0)
14 - (0)
Domain Policy (948
Exception Policy (8
Properties
Property Value


TOMOYO Linux (default) - TOMOYO Project Editor - Eclipse SDK
File Edit Navigate Search Project Run Window Help
TOMOYO Linu...
test
Domain Policy
Domain transition tree
<kernel>
Access permissions
0 - Disabled
<kernel> (3)
/etc/hotplug/firmware.agent (0)
/bin/sed (0)
/bin/sleep (0)
/bin/uname (0)
/etc/rc.d/init.d/acpid (13)
/bin/touch (2)
/sbin/consoletype (0)
/sbin/initlog (3)
/usr/sbin/acpid (5)
/etc/rc.d/init.d/anacron (13)
/bin/nice (1)
/sbin/initlog (3)
/usr/sbin/anacron
/sbin/consoletype (0)
/sbin/initlog (1)
/etc/rc.d/init.d/apmd (8)
1 (3)
/sbin/hotplug
/sbin/init
/sbin/modprobe
<kernel>
Home Domain Policy Exception Policy System Policy Profile
Grant Log Reject Log History Backup Navigator
Outline
Profile (11)
0 - Disabled (8
1 - Learning (1
2 - Permissive
3 - Enforcing (
5 - Accept Moc
6 - Permissive
7 - Enforcing M
9 - (0)
10 - (0)
13 - (0)
14 - (0)
Domain Policy (948
Exception Policy (8
Properties
Property Value
ACL co 3
Descen 840
Domain <kernel>
Domain 1
Has ini Yes
Is intial No
Is keep No
Process <kernel>


TOMOYO Linux (default) - TOMOYO Project Editor - Eclipse SDK
File Edit Navigate Search Project Run Window Help
TOMOYO Linu...
test
Profile
Profile table
0 - Disabled | 1 - Learning | 2 - Permissive | 3 - Enforcing | 5 - Accept
File
MAC_FOR_FILE | Disabled | Learning | Permissive | Disabled | Disable
Network
MAC_FOR_NETWORK | Disabled | Disabled | Disabled | Disabled | Disable
MAC_FOR_BINDPORT
MAC_FOR_CONNECTPORT
RESTRICT_AUTOBIND | Off | Off | Off | Off | Off
Filesystem
DENY_CONCEAL_MOUNT | Disabled | Disabled | Disabled | Disabled | Disable
RESTRICT_CHROOT | Disabled | Disabled | Disabled | Disabled | Disable
RESTRICT_MOUNT | Disabled | Disabled | Disabled | Disabled | Disable
RESTRICT_UNMOUNT | Disabled | Disabled | Disabled | Disabled | Disable
DENY_PIVOT_ROOT
RESTRICT_PIVOT_ROOT | Disabled | Disabled | Disabled | Disabled | Disable
TRACE_READONLY
Log
MAX_ACCEPT_FILES
MAX_ACCEPT_ENTRY | 2048 | 2048 | 2048 | 2048 | 2048
MAX_GRANT_LOG | 1024 | 1024 | 1024 | 1024 | 1024
MAX_REJECT_LOG | 1024 | 1024 | 1024 | 1024 | 1024
TOMOYO_VERBOSE | Off | Off | Off | Off | Off
Capability
Others
COMMENT | Disabled | Learning | Permissive | Enforcing | Accept Mod
MAC_FOR_ARGV0 | Disabled | Disabled | Disabled | Disabled | Disable
MAC_FOR_SIGNAL | Disabled | Disabled | Disabled | Disabled | Disable
ALLOW_ENFORCE_GRACE | Off | Off | Off | Off | Off
Customize
Home | Domain Policy | Exception Policy | System Policy | Profile
Grant Log | Reject Log | History | Backup | Navigator

Usages Other Than Security

- TOMOYO is not only for security!
  - You can analyze your Linux very deeply.
  - TOMOYO Linux can find out unused files and unexpected behavior for you (you can save space by deleting them).
  - “rm –rf *” will cause a disaster on normal Linux, but it will not if you are running TOMOYO Linux and keeping proper policies.
  - Just looking at the policies is so much fun. it also helps to understand OS mechanisms.

Plans

- 2007 Ottawa Linux Symposium BoF.
  - Introduce TOMOYO Linux to label-guys.
  - Is “name based access control” a fatal illness?
- We would like to merge our work to be included in main line (if we survive Ottawa).
  - Propose patches to LSM (to make pathname based MAC work).
  - Propose capabilities extension to LSM.

Please Come to See TOMOYO Linux

April 18, Room B

18-340 15:40-16:30 Presentation

18-440 16:40-17:30 Tutorial

Don't miss it!