Mandatory Access Control in Linux

CMPSC 443 - Spring 2012

Introduction Computer and Network Security

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In the early 2000s

- Root and administrator
  - Many programs needed privilege, so they ran will full system permissions
- Consider a network-facing daemon
  - Services requests at a well-known port
  - Low-numbered, so needs root access
  - But, also accessible to adversaries
  - A bad combination...
- What should we do?

Confining Network-Facing Daemons

- Limit permissions of network-facing daemons
  - "Confine" them
- Keep them confined
  - Cannot change their permissions
- How do we do that?
  - Short answer & a long story...

Mandatory Access Control

- System-Defined Policy
  - Fixed Set of Subject and Object Labels
  - Fixed Permission Assignments
  - Fixed Label Assignments: (e.g., file to object label)
  - Fixed Transitions (e.g., setuid)

	O_1	O_2	O_3
J	R	R W	R W
S_2	N	R	R W
S_3	N	R	R W

Multi-Level Security is MAC

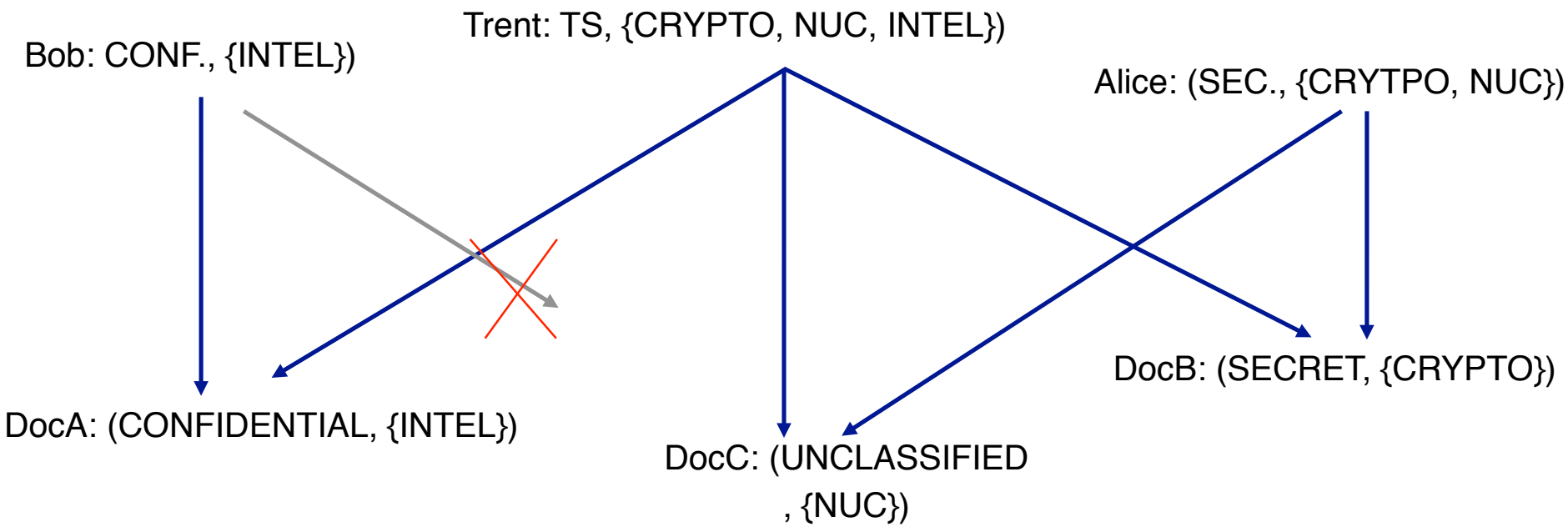
Access is allowed if

subject clearance level >= object access class *and*

object categories subset-of subject categories (*read down*)

Q: What would *write-up* be?

Hence,



Why MLS Won't Work

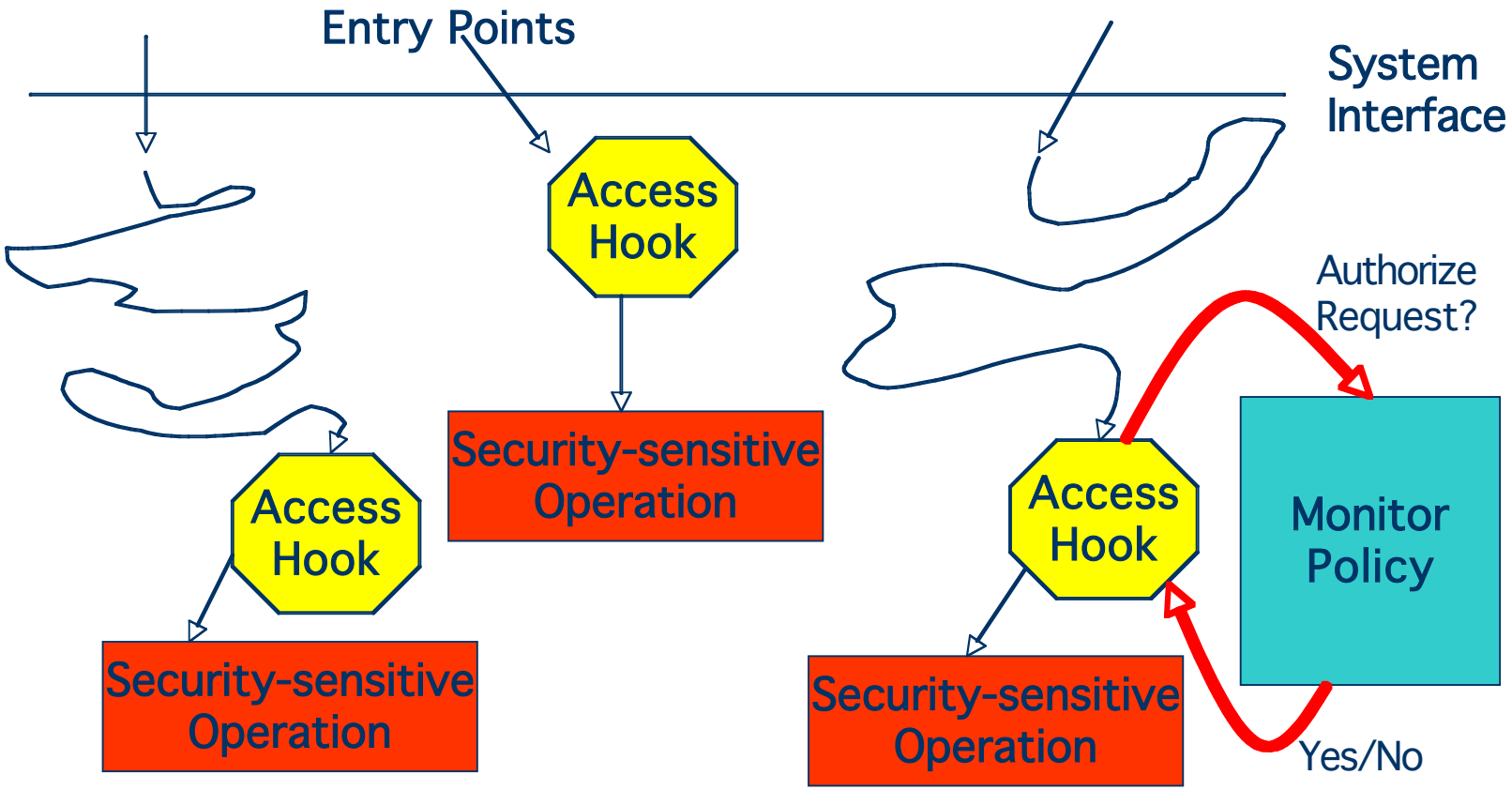
- Lots of information flows that violate MLS
  - For secrecy
  - And integrity
- Have to manage manually
  - No way...
- So, what do we do?
  - LOMAC
  - MIC
  - Others
    - Type Enforcement

MAC in Linux

- In 2001, Linus Torvalds authorized the development of a reference monitor for Linux
  - So, he didn't have to choose a single security approach
- Linux Security Modules framework was born
  - LSM defines an interface for reference monitoring modules
  - Anybody could build an LSM!
- Introduced in Linux 2.6
  - Version built for FreeBSD
  - Underway for MAC OS X
  - Also, implemented in a variety of user-space programs (X)
- MAC has been in Trusted Solaris for years...
  - But, only one MLS approach (now includes more)

Linux Security Modules Approach

- Reference monitor interface, module, policy



Where Do Hooks Go?

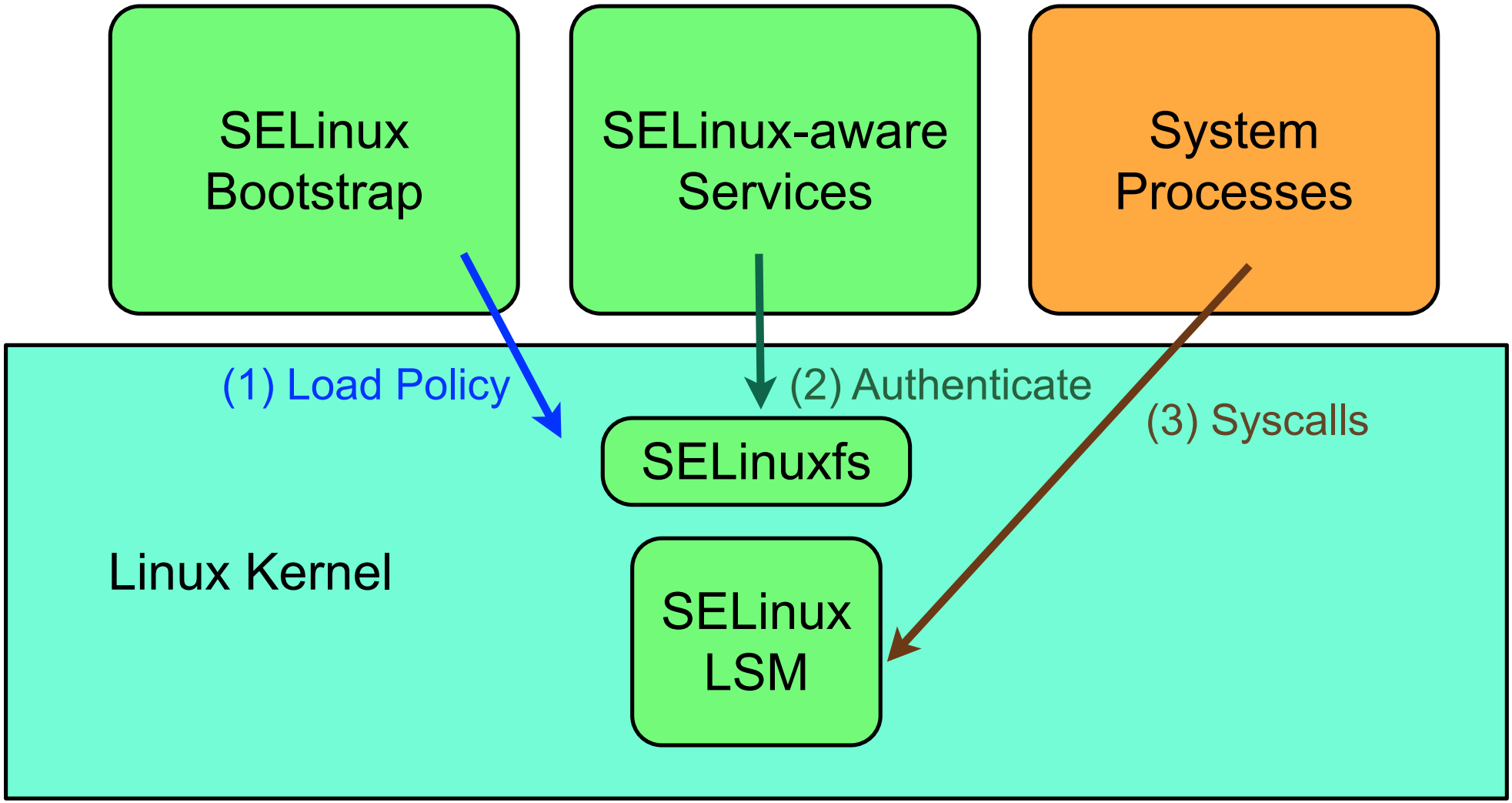
- What property must an authorization hook placement satisfy?
  - Think reference monitor
- How do you know when you have satisfied this property?
  - Not easy
  - Several missing placements were later identified
- Still looking for an automated method to place authorization hooks in legacy code

MAC and Systems

- What is necessary to be a system that enforces MAC policies?
  - Specify: Mandatory Protection System
  - Enforce: Reference Monitor
- Plus, others
  - Management: Policy development tools
  - Services: MAC-aware services
  - Applications: Work with MAC limitations
- What do these systems look like?
  - We'll examine SELinux

SELinux

- LSM + much more



SELinux uses Type Enforcement

- MAC Policy
  - Subjects and Objects Labeled
- Access Matrix Policy
  - Processes with subject label
  - Can access object of object label
  - If operations in matrix cell allow
- Focus: Least Privilege
  - Just permissions necessary

	O_1	O_2	O_3
S_1	Y	Y	N
S_2	N	Y	N
S_3	N	Y	Y

SELinux Protection State

- The permissions in an SELinux system are produced by a runtime analysis (same with AppArmor)
- Step 1: Run programs
  - In a controlled (no attacker) environment
  - No enforcement is on
- Step 2: Audit all permissions used
- Step 3: Generate policy file
  - Give the subject label associated with that program
  - All the permissions in the audit file

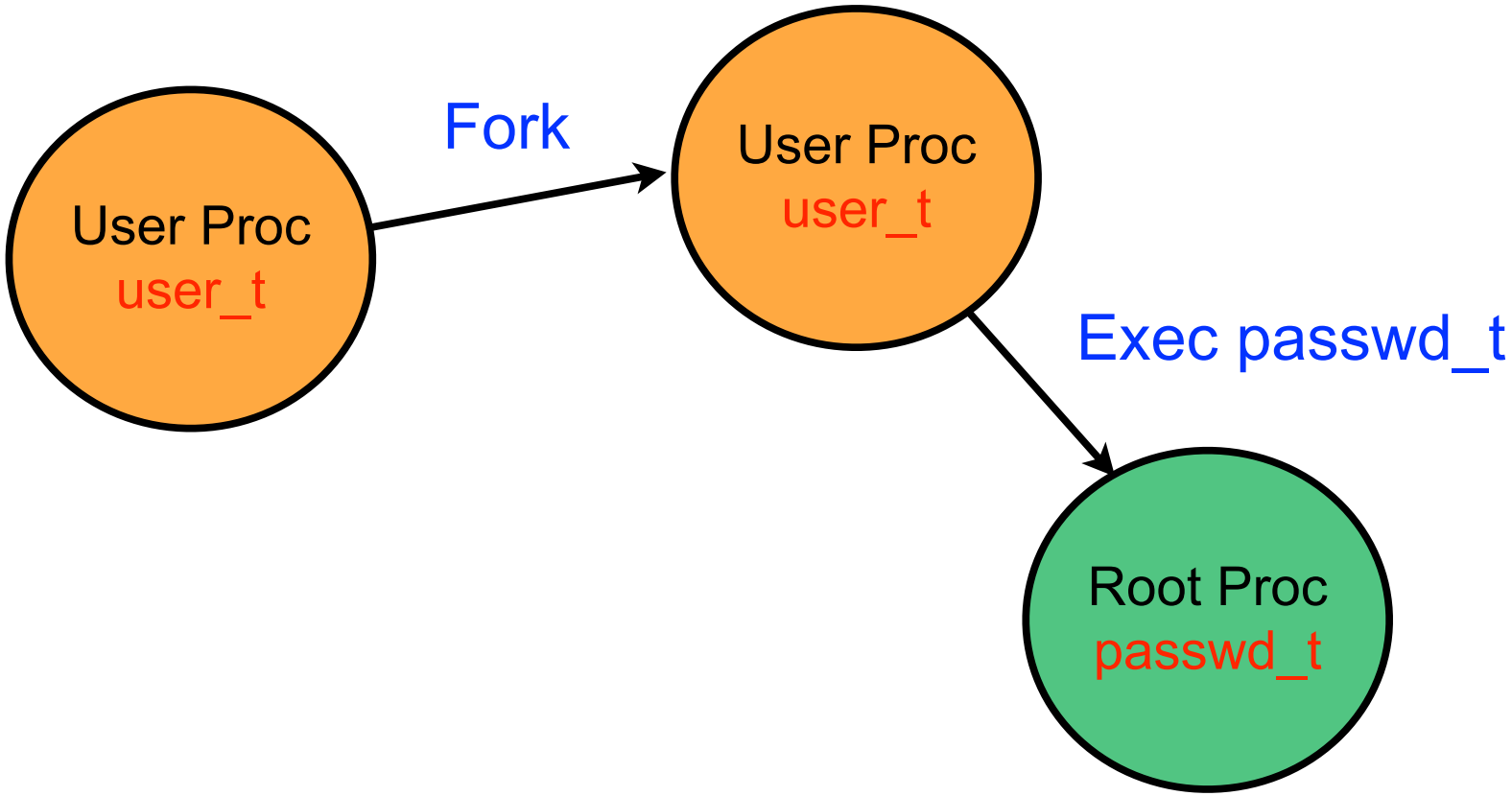
- Why does this satisfy confidentiality or integrity?

SELinux Labeling State

- Files and users known to the system at boot-time must be associated with their MAC policy labels
  - Map file paths to labels (regular expressions)
  - Map users to labels (by name)
    - These labels are assigned to their initial processes
- How are new files/processes labeled?
- How does “setuid” work?

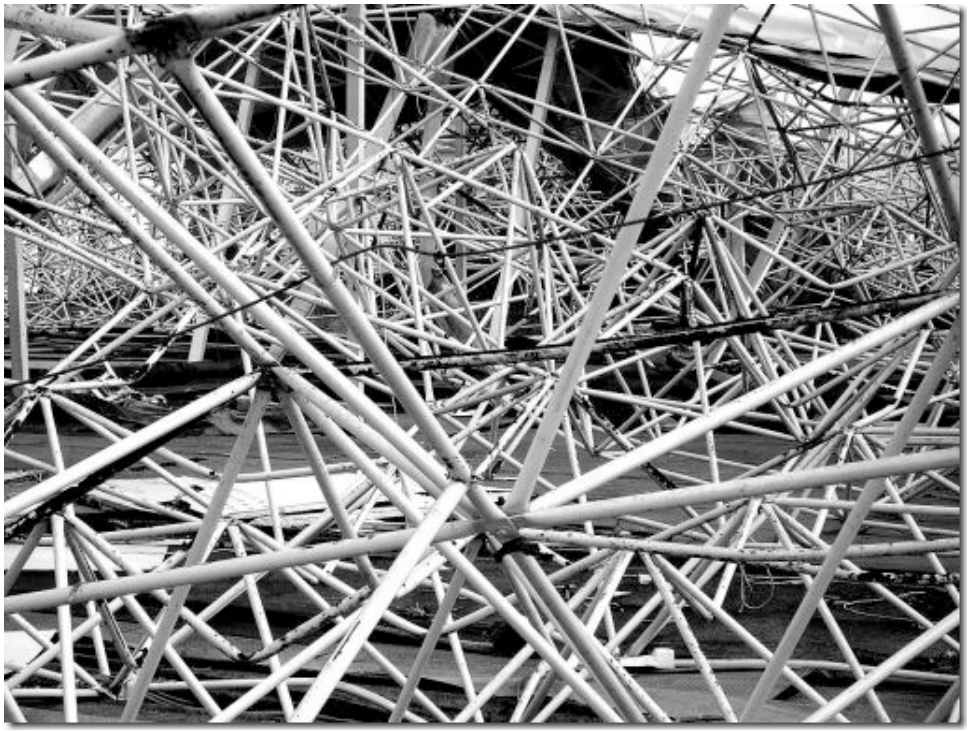
SELinux Transition State

- Run the privileged *passwd* program
- Simplified view -- takes 4 policy rules to do this



SELinux Mandatory Protection System

- How many rules are necessary for a Linux distribution?
  - Labeling State - every file and process
  - Protection State - every subject, object, operation
  - Transition State - every process and file transition on access



Configuring Secure Systems

- How do administrators manage MAC systems?
- Step 1: Choose an OS distribution
  - Has a MAC policy already
- Step 2: Configure a firewall policy
  - Connects MAC processes with network access to network
  - Most processes are given network access
- Step 3: Track vulnerabilities
  - Pick your favorite site - CERT, CVE, BugTraq, SANS, ...
- Step 4: Run vulnerability scanners on your system
  - See if you are vulnerable
  - If so, remove/update that program or change network
- NOTE: Do not change the MAC policy

MAC Upsides

- Security
  - Limits access of root processes
  - Controls network-facing daemons
  - Protects system processes
  - Protects kernel
- Usability
  - Default configuration with OS Distros
  - Mostly enables system to run
  - Does not require any effort for admins
- Bottom line: MAC is here, but in a more limited way than people expected

(Commodity) MAC Myths

- Security
  - MAC protects one of your processes from another
  - MAC protects one of your processes from another user's processes
  - MAC controls processes use of network
  - MAC ensures that system processes only receive trusted data
  - MAC makes the adversary compromise several processes to access the kernel
  - MAC enforces confidentiality and integrity

Take Away

- In the early part of the last decade adversaries were taking advantage of weak access protections
- MAC was introduced into commodity systems to prevent this
- MAC threat model is network attacks
  - Network-facing daemons
- MAC and code hardening of these daemons have improved the situation
  - but now escalation from untrusted clients through local exploits is common
- Could SELinux prevent Stuxnet?