Advanced Systems Security: Principles

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XSS Problems

- Web application/Media player
  - Failure to identify malicious input
  - Failure to filter malice from input
- Operating system
  - Failure to confine media player (HTTPS backdoor)
  - Failure to limit access to TCB processes
- TCB process
  - Failure to filter malicious input
- Failure to prevent malicious function

Authorization and Authentication

- Authentication
  - Def: Verifying someone or something's identity
  - E.g., XSS content
- Authorization
  - Def: Deciding whether a subject can perform a requested operation on an object
  - Deciding whether the media player can read content
- Combination
  - *Authentication is performed for authorization*

Protection System

- Manages the access control policy for a system
  - Security goal
- It represents
  - *Protection state*
  - *Protection state operations*
- It describes what operations each subject (via their processes) can perform on each object

The Access Matrix

- An access matrix is one way to represent policy.
  - Frequently used mechanism for describing policy
- Columns are objects, subjects are rows.
- To determine if S_i has right to access object O_j, find the appropriate entry.
- Succinct descriptor for O (|S|*|O|) entries
- Matrix for each right.

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

Access Matrix Protection System

- Protection State
  - Current state of matrix
- Can modify the protection state
  - Via protection state operations
  - E.g., can create subjects and objects
  - E.g., owner can add a subject, operation mapping for their objects
- Lampson's "Protection" paper
  - Can even delegate authority to perform protection state ops

XSS Problems

- Web application/Media player
  - Failure to identify malicious input (labeling)
  - Failure to filter malice from input (mediation)
- Operating system
  - Failure to confine media player (protection state ops)
  - Failure to limit access to TCB processes (transition)
- What do we need to achieve necessary controls?

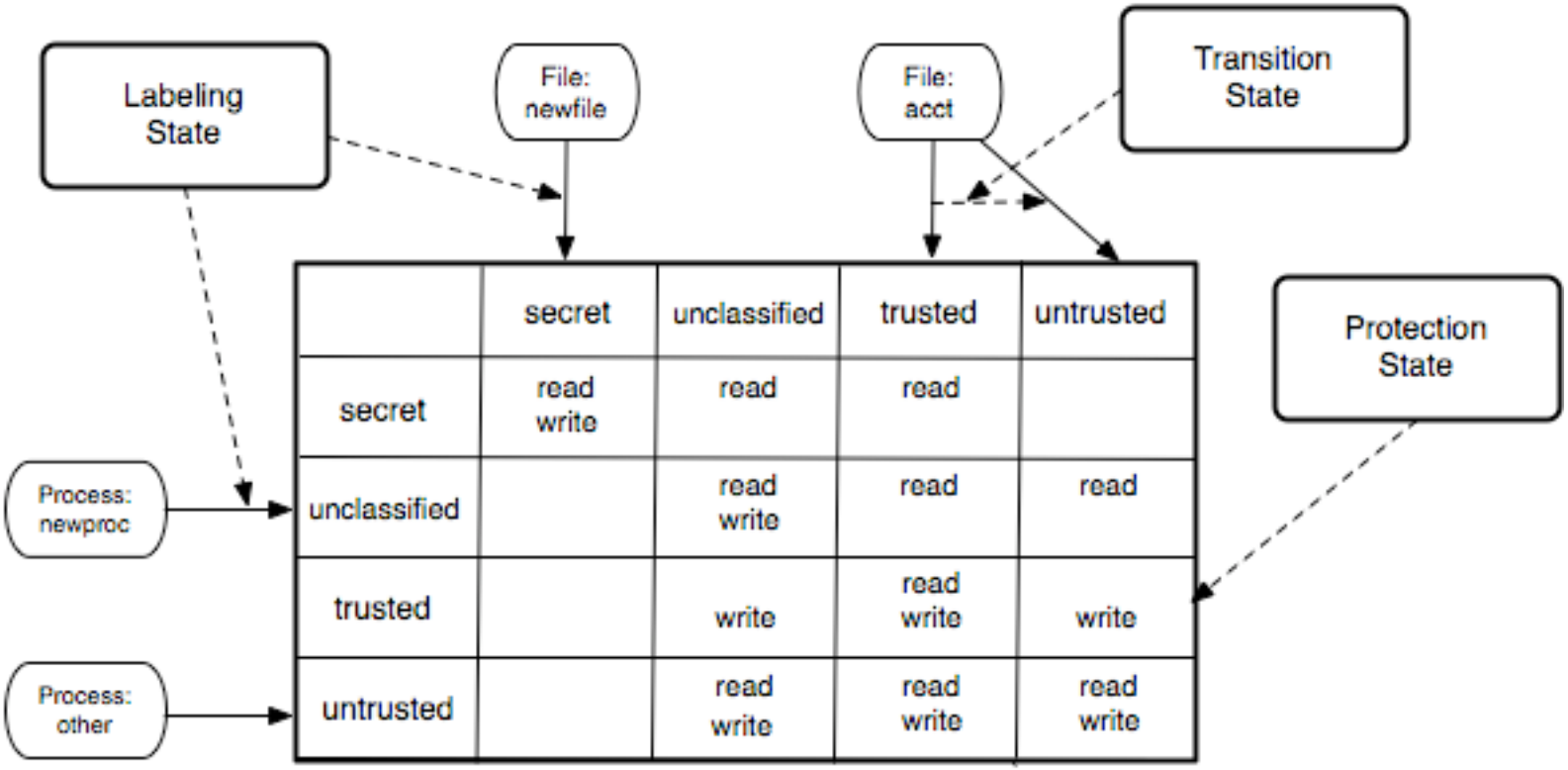
Define and Enforce Goals

- Claim: *If we can define and enforce a security policy that ensures security goals, then we can prevent such attacks*
- How do we know the policy is expresses effective goals?
  - Will look into this in depth later
- How should such a policy be represented/managed?
- How can we ensure its enforcement?
- How do we know the enforcement mechanism will behave as expected?

Mandatory Protection System

- Is a *protection system* that can be modified only by *trusted administration* that consists of
  - A *mandatory protection state* where the protection state is defined in terms of a set of *labels* associated with subjects and objects
    - Label set is defined by trusted administration
  - A *labeling state* that assigns system subjects and objects to those labels in the mandatory protection state
  - A *transition state* that determines the legal ways that subjects and objects may be relabeled

Mandatory Protection System



	secret	unclassified	trusted	untrusted
secret	read write	read	read	
unclassified		read write	read	read
trusted		write	read write	write
untrusted		read write	read write	read write

Mandatory Protection State

- Immutable table of
  - Subject labels
  - Object labels
  - Operations authorized for former upon latter
- MPS for OS
  - Allow media player to communicate with browser, exec certain files
  - No network access
- MPS for media player
  - Play only trusted input
- Why is it *immutable*?

Labeling State

- Immutable rules mapping
  - Processes to subject labels
  - IPC to object labels
- Labeling State of OS
  - Browser, Media Player for user label
  - Programs with trusted labels
  - Outputs from media player to a trusted program
- Labeling State of Web Application
  - Content – untrusted

Transition State

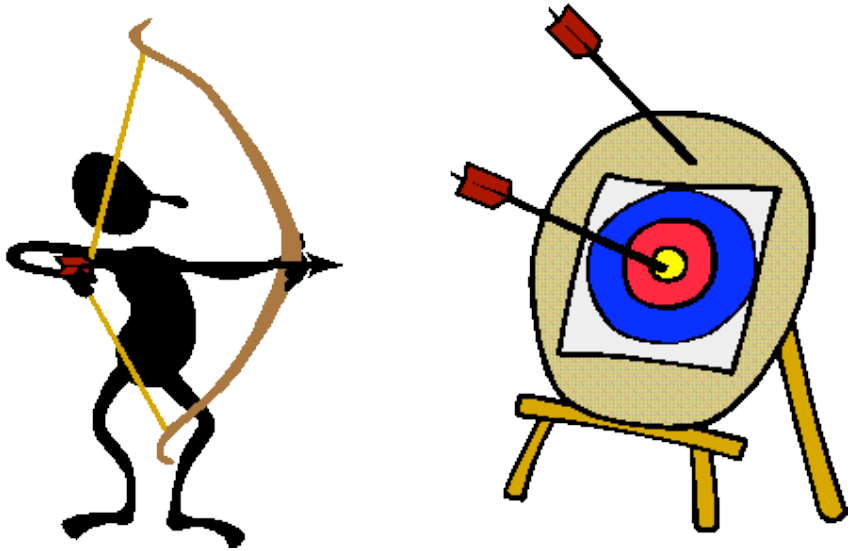
- Immutable rules mapping
  - Processes to conditions that change their subject labels
  - IPC to conditions that change their object labels
- Transition State of OS
  - Change label of processes that receive untrusted input
  - Change label of outputs of these processes
- Transition State of Objects
  - Server, Browser, Media Player change their label on untrusted processing
  - Server, Browser, Media Player change label of IPC channel

Managing MPS

- Challenge
  - Determining how to set and manage an MPS in a complex system involving several parties
- Parties
  - What does programmer know about deploying their program securely?
  - What does an OS distributor know about running a program in the context of their system?
  - What does an administrator know about programs and OS?

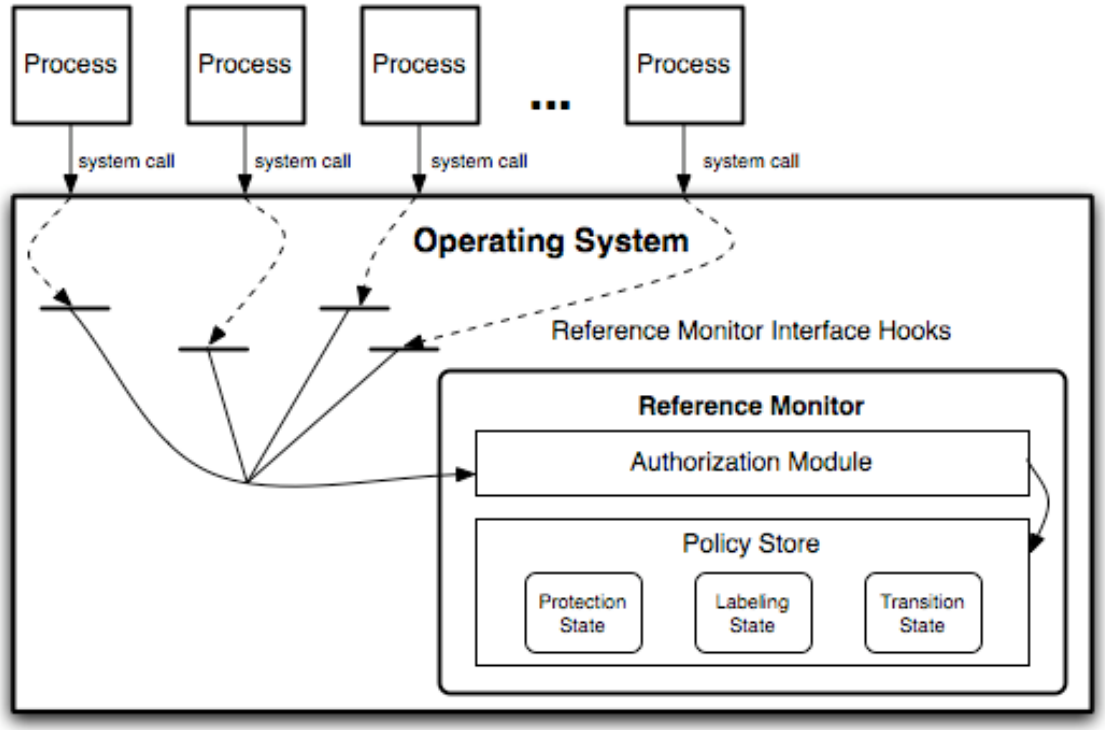
Reference Monitor

- Purpose: Ensure enforcement of security goals
  - Mandatory protection state defines goals
  - Reference monitor ensures enforcement



Reference Monitor

- Components
  - Reference monitor interface (e.g., LSM)
  - Authorization module (e.g., SELinux)
  - Policy store (e.g., policy binary)



Reference Monitor Guarantees

- **Complete Mediation**
  - The reference validation mechanism must always be invoked
- **Tamperproof**
  - The reference validation mechanism must be tamperproof
- **Verifiable**
  - The reference validation mechanism must be subject to analysis and tests, the completeness of which must be assured

Complete Mediation

- Every security-sensitive operation must be mediated
  - What's a "security-sensitive operation"?
  - Operation that enables a subject of one label to access an object that may be a different label
- How do we validate complete mediation?
  - Every such operation must be identified
  - Then we can check for dominance of mediation
- **Mediation**: Does interface mediate correctly?
- **Mediation**: On all resources?
- **Mediation**: Verifably?

Tamperproof

- Prevent modification by untrusted entities
  - Interface, mechanism, policy of reference monitor
  - Code and policy that can affect reference monitor mods
- How to detect tamperproofing?
  - Transitive closure of operations
  - Challenge: Often some operations are present
- **Tamperproof**: Is reference monitor protected?
- **Tamperproof**: Is system TCB protected?

Verification

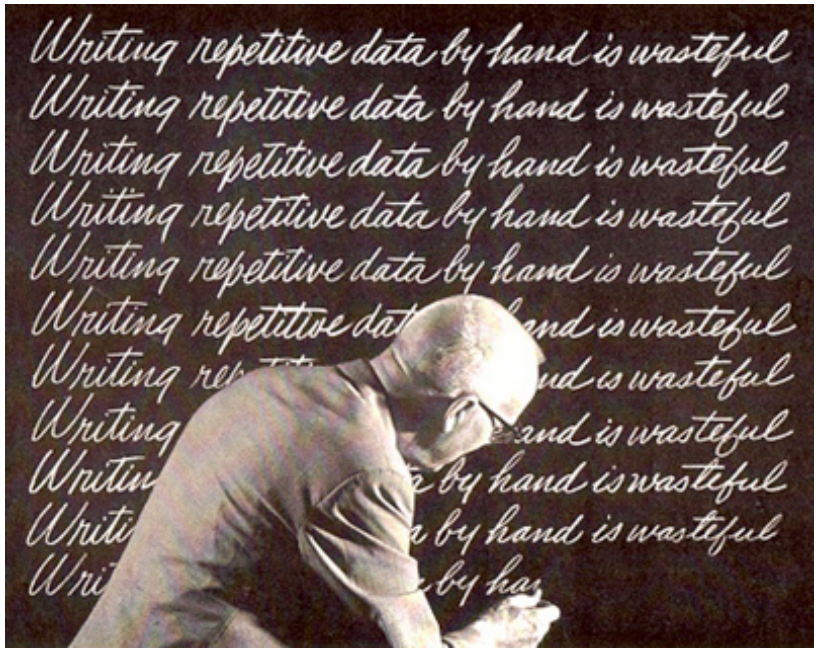
- Test and analyze reference validation mechanism
  - And tamperproof dependencies
  - And what security goals the system enforces
- Determine correctness of code and policy
  - What defines correct code?
  - What defines a correct policy?
- **Verifiable**: Is TCB code base correct?
- **Verifiable**: Does the protection system enforce the system's security goals?

Evaluation

- **Mediation**: Does interface mediate correctly?
- **Mediation**: On all resources?
- **Mediation**: Verifably?
- **Tamperproof**: Is reference monitor protected?
- **Tamperproof**: Is system TCB protected?
- **Verifiable**: Is TCB code base correct?
- **Verifiable**: Does the protection system enforce the system's security goals?

Multiple Reference Monitors

- The reference monitor concept approach was designed with a centralized reference validation mechanism in mind
  - What about the case where there are several such mechanisms grouped together?



Take Away

- Mandatory Protection System
  - Means to define security goals that applications cannot impact
- Reference Monitor Concept
  - Requirements for a reference validation mechanism that can correctly enforce an MPS
  - NOTE: This will be a major focus of this course
- *Until we come up with coherent approach to defining MPS and validating reference monitor guarantees, we will continue to have insecure systems*
  - That is the challenge of systems security research