WILLIAM & MARY
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CSCI 445: Mobile Application Security

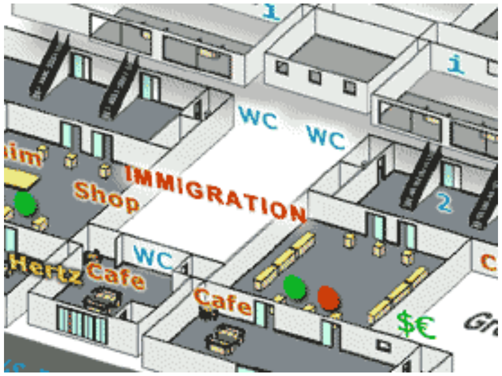
Lecture 7

Prof. Adwait Nadkarni

Derived from slides by William Enck, Patrick McDaniel and Trent Jaeger

Policy

- A policy specifies the rules of security
  - Some statement of secure procedure or configuration that parameterizes the operation of a system
  - Example: Airport Policy
    - Take off your shoes
    - No bottles that could contain > 3 ozs
    - Empty bottles are OK?
    - You need to put your things through X-ray machine
    - Laptops by themselves, coat off
    - Go through the metal detector



- Goal: prevent on-airplane (metal) weapon, flammable liquid, dangerous objects … (successful?)

Computer Security Policy Goals

- Secrecy
  - Don’t allow reading by unauthorized subjects
  - Control where data can be written by authorized subjects
    - Why is this important?
- Integrity
  - Don’t permit dependence on lower integrity data/code
    - Why is this important?
  - What is “dependence”?
- Availability
  - The necessary function must run
  - Doesn’t this conflict with above?

… when policy goes wrong

- Driving license test: take until you pass
  - Mrs. Miriam Hargrave of Yorkshire, UK failed her driving test *39* times between 1962 and 1970!!!!
  - … she had 212 driving lessons ….
  - She finally got it on the 40th try.
  - Some years later, she was quoted as saying, "sometimes I still have trouble *turning right*"

"A policy is a set of acceptable behaviors."

- F. Schneider

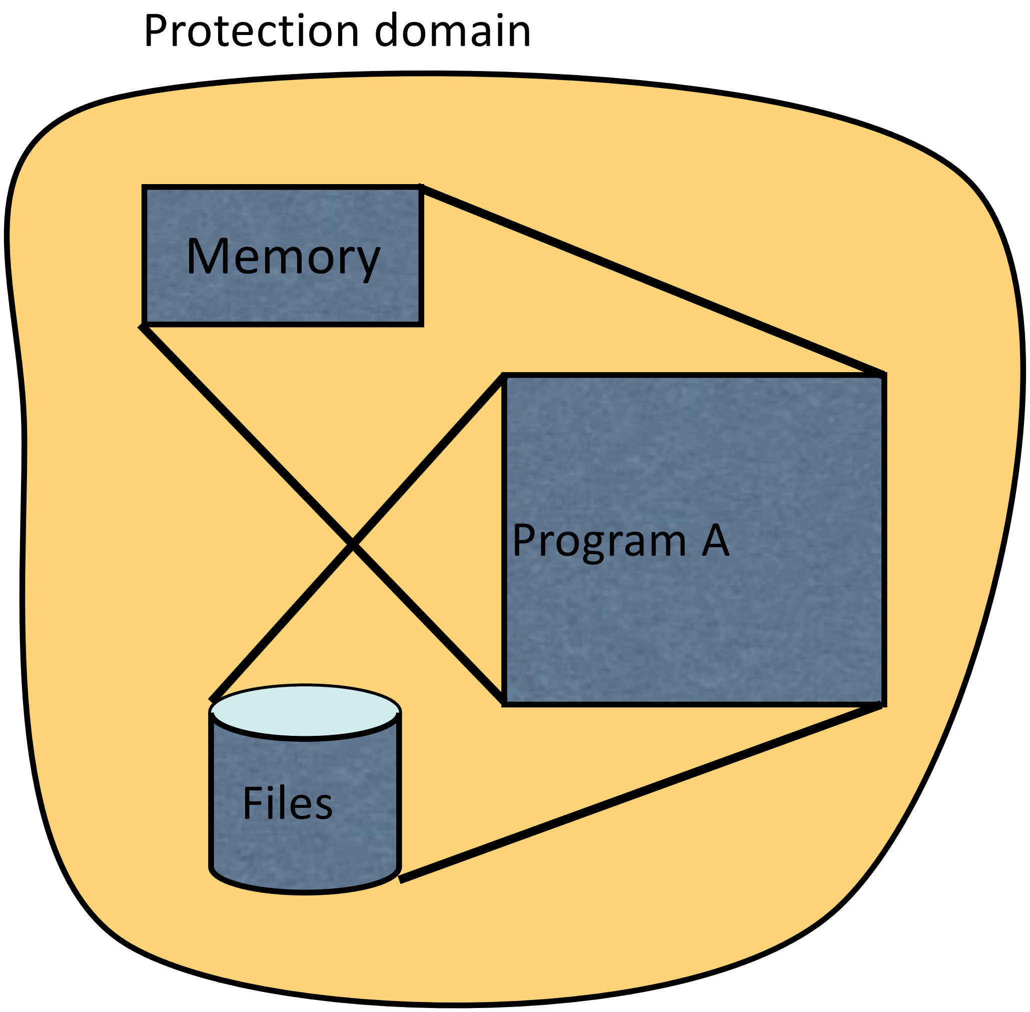
Access Control/Authorization

- An ***access control*** system determines what *rights* a particular *entity/subject* has for a set of *objects*
- It answers the question
  - E.g., do you have the right to read /etc/passwd
  - Does Alice have the right to view the CS website?
  - Do students have the right to share project data?
  - Does Dr. Nadkarni have the right to change your grades?
- An Access Control Policy answers these questions

Simplified Access Control

- Subjects are the active entities that do things
  - E.g., you, Alice, students, Prof. Nadkarni
- Objects are passive things that things are done to
  - E.g., /etc/passwd, CSCI website, project data, grades
- Rights are actions that are taken
  - E.g., read, write, *share*

Protection Domains



- A *protection domain* specifies the set of resources (objects) that a process can access and the operations that the process may use to access such resources.
- How is this done today?
  - Memory protection
  - E.g., UNIX protected memory, file-system permissions (rwx…)

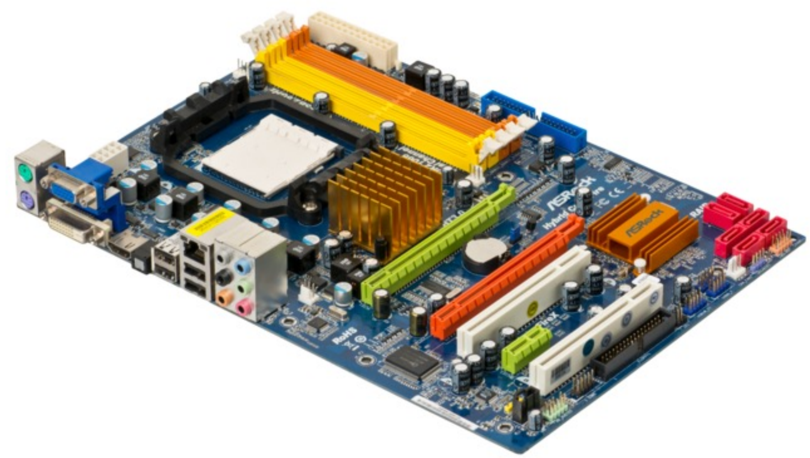
Policy is defined with respect to the protection domain it governs.

Access Policy Enforcement

- A *protection state* defines what each subject can do
  - E.g., in an access bits --- the policy
- A *reference monitor* enforces the protection state
  - A service that responds to the query...
- A correct reference monitor implementation meets the following guarantees
  1. Complete Mediation
  2. Tamperproof
  3. Simple enough to verify
- A *protection system* consists of a (1) protection state, (2) operations to modify that state, and (3) a reference monitor to enforce that state

Trusted Computing Base (TCB)

- The trusted computing base is the infrastructure that you assume will behave correctly
- What do we trust?
  - Hardware (keyboard, monitor, …)
  - Operating Systems
  - Implementations
  - Local networks
  - Administrators
  - Other users on the same system



- Axiom: the larger the TCB, the more assumptions you must make (and hence, the more opportunity to have your assumptions violated).

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.
  - There is a matrix for each right.
- The access matrix is a succinct descriptor for O(|S|*|O|) rules

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

The Access Matrix

- Do systems store the entire access control matrix?
- Two ways:
  - Store with the objects (Access control lists (ACL))
  - Store with the subjects (Capability Lists (CL))

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

Access Control

- Suppose the private key file for J is object O_1
  - Only J can read
- Suppose the public key file for J is object O_2
  - All can read, only J can modify
- Suppose all can read and write from object O_3
- What's the access matrix?

	O_1	O_2	O_3
J	?	?	?
S_2	?	?	?
S_3	?	?	?

Secrecy

- Does the following protection state ensure the secrecy of J's private key in O_1?

	O_1	O_2	O_3
J	R	RW	RW
S_2	-	R	RW
S_3	-	R	RW

Integrity

- Does the following access matrix protect the integrity of J's public key file O_2?

	O_1	O_2	O_3
J	R	RW	RW
S_2	-	R	RW
S_3	-	R	RW

Trusted Processes

- *Does it matter if we do not trust some of J's processes?*
  - *Trojan Horse*: Attacker controlled code run by J can violate secrecy.
  - *Confused Deputy*: Attacker may trick trusted code to violate integrity

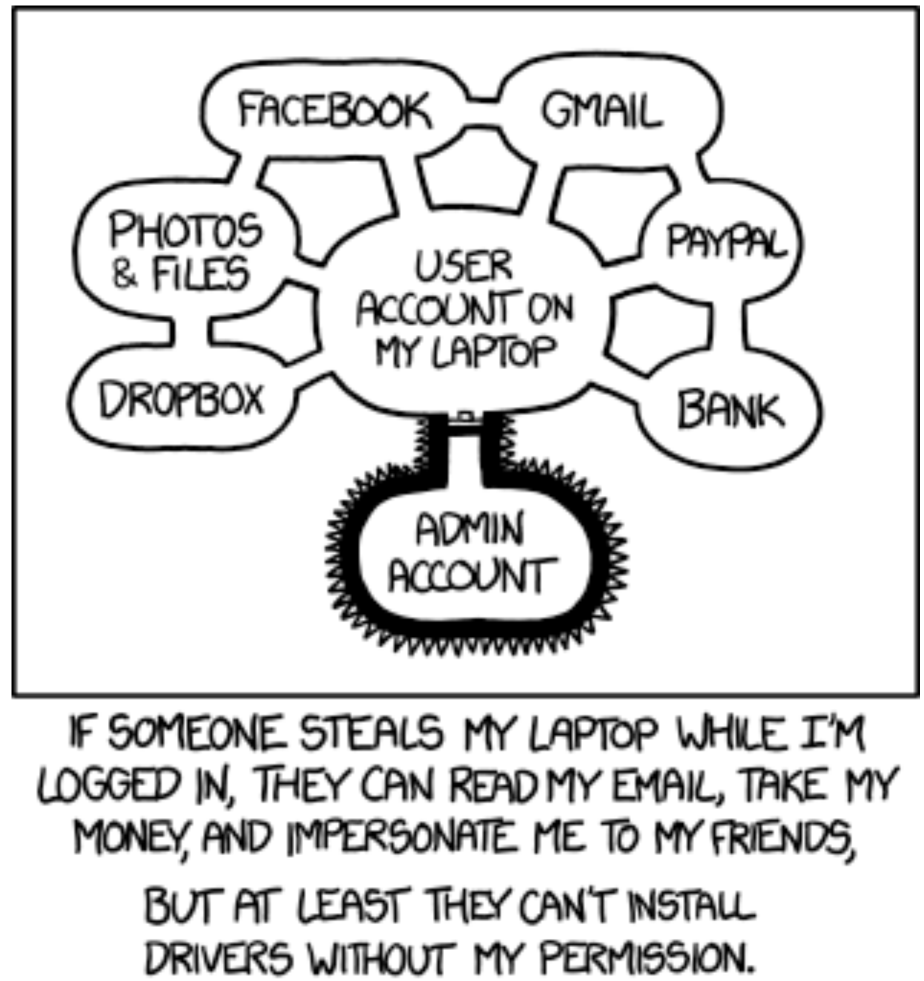
	O_1	O_2	O_3
J	R	RW	RW
S_2	-	R	RW
S_3	-	R	RW

Protection vs. Security

- Protection
    - Security goals met under *trusted* processes
    - Protects against an error by a non-malicious entity
- Security
    - Security goals met under *potentially malicious* processes
    - Protects against any malicious entity
    - Hence, For J:
        - Non-malicious process shouldn't leak the private key by writing it to O_3
        - A potentially malicious process that may contain a Trojan horse that writes the private key to O_3 should not be able to do so

Do you own a computer?

- Linux/ Windows/ Mac?
- (DONOT) execute everything as the admin user!
  - Create a separate "standard" user. *Why?*
- *Caveat: Still need to protect the standard user account.*



Principle of Least Privilege

A system should only provide those rights needed to perform the processes function and no more.

- Implication 1: you want to reduce the protection domain to the smallest possible set of objects
- Implication 2: you want to assign the minimal set of rights to each subject
- Caveat: of course, you need to provide enough rights and a large enough protection domain to get the job done.

Least Privilege

- Limit permissions to those required and no more
  - Restrict privilege of the process of J to prevent leaks
    - Cannot R/W O3

	O_1	O_2	O_3
J	R	RW	-
S_2	-	R	-
S_3	-	R	RW

Conflicting Goals

- Challenges of building a secure system
  - What are the *users*' goals?
  - What do *application developers* want?
  - What about the *data owners* (corporations/governments)?
  - What is the purpose of *system administrators*?
  - What about the requirements of *operating system designers*?

- Need a *satisfying* balance among these goals?

Access Control Administration

There are two central ways to specify a policy

- *Discretionary* - object "owners" define policy
  - Users have discretion over who has access to what objects and when (trusted users)
  - Canonical example: the UNIX filesystem
    - RWX assigned by file owners
- *Mandatory* - Environment enforces static policy
  - Access control policy defined by environment, user has no control over access control (untrusted users)
  - Canonical example: process labeling
    - System assigns labels for processes, objects, and a dominance calculus is used to evaluate rights

DAC vs. MAC

- **<u>Discretionary</u> Access Control**
  - User defines the access policy
  - Can pass rights onto other subjects (called *delegation*)
  - Their programs can pass their rights
    - Consider a Trojan horse
- **<u>Mandatory</u> Access Control**
  - System defines access policy
  - Subjects cannot pass rights
  - Subjects' programs cannot pass rights
    - Consider a Trojan horse here

DAC vs. MAC in Access Matrix

- Subjects:
  - DAC: users
  - MAC: labels
- Objects:
  - DAC: files, sockets, etc.
  - MAC: labels
- Operations:
  - Same
- Administration:
  - DAC: owner, copy flag, ...
  - MAC: external, reboot
- MAC: largely static matrix;
- DAC: all can change

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

Safety Problem

- For a protection system
  - (ref mon, protection state, and administrative operations)
- Prove that any future state will not result in the leakage of an access right to an unauthorized user
  - Q: Why is this important?
- For most discretionary access control models,
  - Safety is *undecideable*
- Means that we need another way to prove safety
  - Restrict the model (no one uses)
  - Test incrementally (constraints)
- *How does the safety problem affect MAC models?*

Sandboxing

- An execution environment for programs that contains a limited set of rights
    - A subset of your permissions (meet secrecy and integrity goals)
    - Cannot be changed by the running program (mandatory)

Sandboxing, on Android

- Android is a *Linux-based system*
- Apps are security principles, *treated as users*
- Apps acquire *permissions* to access ...
- What separates apps from one another?
- What separates Apps from the kernel?
- What prevents apps from access arbitrary storage?

Access Control Models

- What language should I use to express policy?
  - Access Control Model
- Oodles of these
  - Some specialize in secrecy
    - Bell-LaPadula
  - Some specialize in integrity
    - Clark-Wilson
  - Some focus on jobs
    - RBAC
  - Some specialize in least privilege
    - SELinux Type Enforcement
- Q: Why are there so many different models?

The End