Security Policies

Introduction

- Overview of security policies
- Confidentiality policies
- Integrity policies
- Hybrid polices

Security Policy

- Policy partitions system states into:
  - Authorized (secure)
    - These are states the system can enter
  - Unauthorized (nonsecure)
    - If the system enters any of these states, it's a security violation
- Secure system
  - Starts in authorized state
  - Never enters unauthorized state

Confidentiality, Integrity, and Availability

Confidentiality

- X set of entities, I information
- I has *confidentiality* property with respect to X if no $x \in X$ can obtain information from I
- I can be disclosed to others
- Example:
  - X set of students
  - I final exam answer key
  - I is confidential with respect to X if students cannot obtain final exam answer key

Integrity

- X set of entities, I information
- I has *integrity* property with respect to X if all $x \in X$ trust information in I
- Types of integrity:
  - trust I, its conveyance and protection (data integrity)
  - I information about origin of something or an identity (origin integrity, authentication)
  - I resource: means resource functions as it should (assurance)

Availability

- *X* set of entities, *I* resource
- *I* has *availability* property with respect to *X* if all $x \in X$ can access *I*
- Types of availability:
  - traditional: x gets access or not
  - quality of service: promised a level of access (for example, a specific level of bandwidth) and not meet it, even though some access is achieved

Types of Security Policies

- Confidentiality policy
  - Policy protecting only confidentiality
- Integrity policy
  - Policy protecting only integrity
- Hybrid policy

Mechanisms

- Entity or procedure that enforces some part of the security policy
  - Access controls (like bits to prevent someone from reading a homework file)
  - Disallowing people from bringing USB drives into a computer facility to control what is placed on systems

Policy Languages

Policy Languages

- Express security policies in a precise way
- High-level languages
  - Policy constraints expressed abstractly
- Low-level languages
  - Policy constraints expressed in terms of program options, input, or specific characteristics of entities on system

High-Level Policy Languages

- Constraints expressed independent of enforcement mechanism
- Constraints restrict entities, actions
- Constraints expressed unambiguously
  - Requires a precise language, usually a mathematical, logical, or programming-like language

Sample Constraint

- At most 100 network connections open
- *Socket* class defines network interface
  - *Network.numconns* method giving number of active network connections
- Constraint

```
deny( -| Socket) when
        (Network.numconns >= 100)
```

Low-Level Policy Languages

- Set of inputs or arguments to commands
  - Check or set constraints on system
- Low level of abstraction
  - Need details of system, commands

Example: X Window System

- UNIX X11 Windowing System
- Access to X11 display controlled by list
  - List says what hosts allowed, disallowed access

```
xhost +groucho -chico
```

- Connections from host groucho allowed
- Connections from host chico not allowed

Confidentiality Policy

Confidentiality Policies

- Goal: prevent the unauthorized disclosure of information
  - Deals with information flow
  - Integrity incidental
- Multi-level security models are best-known examples
  - Bell-LaPadula Model basis for many, or most, of these

Bell-LaPadula Model (1)

- Security levels arranged in linear ordering
  - Top Secret: highest
  - Secret
  - Confidential
  - Unclassified: lowest
- Levels consist of *security clearance* $L(s)$
  - Objects have *security classification* $L(o)$

Example

Security level	**Subject**	**Object**
Top Secret	Tamara	Personnel Files
Secret	Samuel	E-Mail Files
Confidential	Claire	Activity Logs
Unclassified	Ulaley	Telephone Lists

- Tamara can read all files
- Claire cannot read Personnel or E-Mail Files
- Ulaley can only read Telephone Lists

Reading Information

- Information flows *up*, not *down*
  - "Reads up" disallowed, "reads down" allowed
- Simple Security Condition
  - Subject *s* can read object *o* iff, $L(o) \le L(s)$ and *s* has permission to read *o*
    - Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)
  - Sometimes called "no reads up" rule

Writing Information

- Information flows up, not down
  - "Writes up" allowed, "writes down" disallowed
- *-Property
  - Subject *s* can write object *o* iff $L(s) \le L(o)$ and *s* has permission to write *o*
    - Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)
  - Sometimes called "no writes down" rule

Basic Security Theorem

- If a system is initially in a secure state, and every transition of the system satisfies the simple security condition, and the *-property, then every state of the system is secure
  - Proof: induct on the number of transitions

Bell-LaPadula Model (2)

Bell-LaPadula Model (2)

- "Need to know" principle
- Expand notion of security level to include categories
- Security level is (*clearance*, *category set*)
- Examples
  - (Top Secret, { NUC, EUR, ASI })
  - (Confidential, { EUR, ASI })
  - (Secret, { NUC, ASI })

Levels and Ordering

- Security levels partially ordered
  - Any pair of security levels may (or may not) be related by *dom*
- "dominates" serves the role of "greater than"

Reading Information

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Basic Security Theorem

- If a system is initially in a secure state, and every transition of the system satisfies the simple security condition, and the *-property, then every state of the system is secure
  - Proof: induct on the number of transitions
  - In actual Basic Security Theorem, discretionary access control treated as third property, and simple security property and *-property phrased to eliminate discretionary part of the definitions — but simpler to express the way done here.

Problem

- Colonel has (Secret, {NUC, EUR}) clearance
- Major has (Secret, {EUR}) clearance
  - Major can talk to colonel (“write up” or “read down”)
  - Colonel cannot talk to major (“read up” or “write down”)

Solution

- Define maximum, current levels for subjects
  - *maxlevel*(*s*) *dom curlevel*(*s*)
- Example
  - Treat Major as an object (Colonel is writing to him/her)
  - Colonel has *maxlevel* (Secret, { NUC, EUR })
  - Colonel sets *curlevel* to (Secret, { EUR })
  - Now *L*(Major) *dom curlevel*(Colonel)
    - Colonel can write to Major without violating "no writes down"
  - Does *L*(*s*) mean *curlevel*(*s*) or *maxlevel*(*s*)?
    - Formally, we need a more precise notation

Integrity Policy

Principles of Operation

- Separation of duty
  - E.g., developer & installer
- Separation of function
  - E.g., development system & production system
- Auditing
  - Auditing + recovery and accountability

Requirements of Policies

1. Users will not write their own programs, but will use existing production programs and databases.
2. Programmers will develop and test programs on a non-production system; if they need access to actual data, they will be given production data via a special process, but will use it on their development system.
3. A special process must be followed to install a program from the development system onto the production system.
4. The special process in requirement 3 must be controlled and audited.
5. The managers and auditors must have access to both the system state and the system logs that are generated.

Clark-Wilson Integrity Model

- Integrity defined by a set of constraints
  - Data in a *consistent* or valid state when it satisfies these
- Example: Bank
  - *D* today's deposits, *W* withdrawals, *YB* yesterday's balance, *TB* today's balance
  - Integrity constraint: $D + YB - W = TB$
- *Well-formed transaction* move system from one consistent state to another
- Issue: who examines, certifies transactions done correctly?

Entities

- CDIs: constrained data items
  - Data subject to integrity controls, e.g., account balance
- UDIs: unconstrained data items
  - Data not subject to integrity controls, e.g., gift to account holder
- IVPs: integrity verification procedures
  - Procedures that test the CDIs conform to the integrity constraints, e.g., check all accounts are balanced
- TPs: transformation procedures
  - Procedures that take the system from one valid state to another, e.g., deposit money

Certification Rules 1 and 2

CR1 When any IVP is run, it must ensure all CDIs are in a valid state

CR2 For some associated set of CDIs, a TP must transform those CDIs in a valid state into a (possibly different) valid state

- Defines relation *certified* that associates a set of CDIs with a particular TP
- Example: TP balance, CDIs accounts, in bank example

Enforcement Rules 1 and 2

ER1 The system must maintain the certified relations and must ensure that only TPs certified to run on a CDI manipulate that CDI.

ER2 The system must associate a user with each TP and set of CDIs. The TP may access those CDIs on behalf of the associated user. The TP cannot access that CDI on behalf of a user not associated with that TP and CDI.

- System must maintain, enforce certified relation
- System must also restrict access based on user ID (*allowed* relation)

Users and Rules

Triples *(user, TP, {CDI set})*

CR3 The allowed relations must meet the requirements imposed by the principle of separation of duty.

ER3 The system must authenticate each user attempting to execute a TP

- Type of authentication undefined, and depends on the instantiation
- Authentication *not* required before use of the system, but *is* required before manipulation of CDIs (requires using TPs)

Logging

CR4 All TPs must append enough information to reconstruct the operation to an append-only CDI.

- This CDI is the log
- Auditor needs to be able to determine what happened during reviews of transactions

Handling Untrusted Input

CR5 Any TP that takes as input a UDI may perform **<u>only valid</u>** transformations, or **<u>no</u>** transformations, for all possible values of the UDI. The transformation either rejects the UDI or transforms it into a CDI.

- E.g., deposit money into an ATM

Separation of Duty In Model

ER4 Only the certifier of a TP may change the list of entities associated with that TP.

- No certifier of a TP, or of an entity associated with that TP, may ever have execute permission with respect to that entity.
- Enforces separation of duty with respect to certified and allowed relations

Comparison With Requirements

- Users can't certify TPs, so CR5 and ER4 enforce this
- Procedural, so model doesn't directly cover it; but special process corresponds to using TP
  - No technical controls can prevent programmer from developing program on production system; usual control is to delete software tools
- TP does the installation, trusted personnel do certification

Comparison With Requirements

- CR4 provides logging; ER3 authenticates trusted personnel doing installation; CR5, ER4 control installation procedure
  - New program UDI before certification, CDI (and TP) after
- Log is CDI, so appropriate TP can provide managers, auditors access
  - Access to state handled similarly

Hybrid Policy

Chinese Wall Model

Problem:

- Tony advises Bank of American about investments
- He is asked to advise Citibank about investments
- Conflict of interest to accept, because his advice for either bank would affect his advice to the other bank

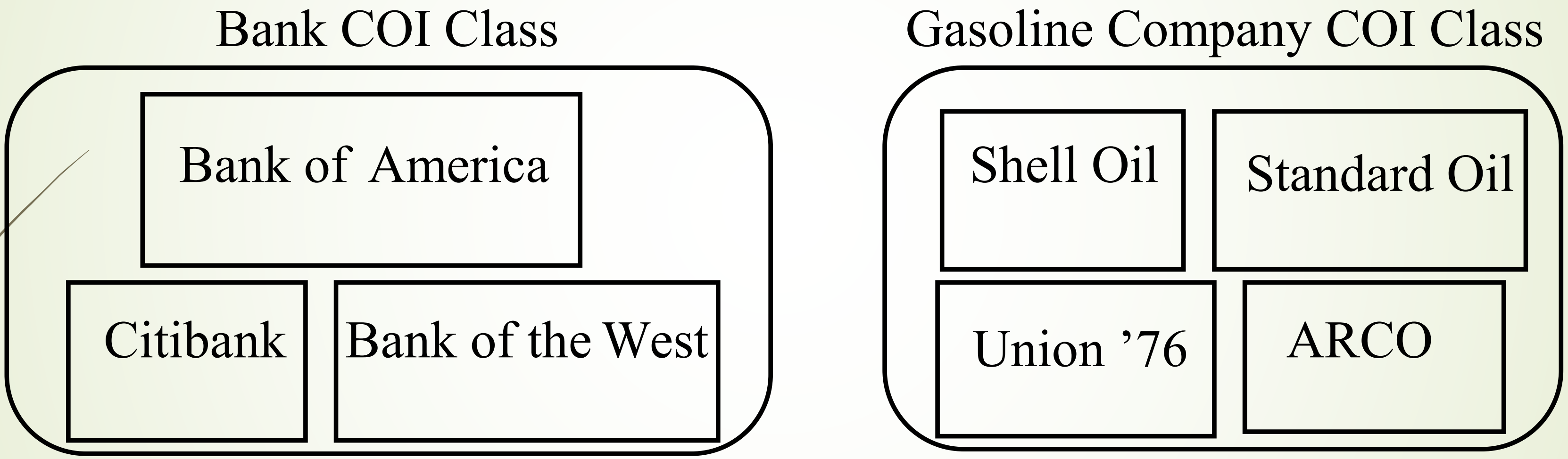
Organization

- Organize entities into "conflict of interest" classes
- Control subject accesses to each class
- Control writing to all classes to ensure information is not passed along in violation of rules
- Allow sanitized data to be viewed by everyone

Definitions

- *Objects*: items of information related to a company
- *Company dataset* (CD): contains objects related to a single company
  - Written *CD*(*O*)
- *Conflict of interest class* (COI): contains datasets of companies in competition
  - Written *COI*(*O*)
  - Assume: each object belongs to exactly one *COI* class

Example


Bank COI Class
Bank of America
Citibank
Bank of the West
Gasoline Company COI Class
Shell Oil
Standard Oil
Union '76
ARCO

Temporal Element

- If Tony reads any CD in a COI, he can *never* read another CD in that COI
  - Possible that information learned earlier may allow him to make decisions later
  - Let $PR(S)$ be set of objects that S has already read

CW-Simple Security Condition

- *s* can read o iff either condition holds:
  1. There is an o' such that *s* has accessed o' and $CD(o') = CD(o)$
     - Meaning *s* has read something in *o*'s dataset
  2. For all $o' \in O$, $o' \in PR(s) \Rightarrow COI(o') \neq COI(o)$
     - Meaning *s* has not read any objects in *o*'s conflict of interest class
- Ignores sanitized data (see below)
- Initially, $PR(s) = \varnothing$, so initial read request granted

Sanitization

- Public information may belong to a CD
  - As is publicly available, no conflicts of interest arise
  - So, should not affect ability of analysts to read
  - Typically, all sensitive data removed from such information before it is released publicly (called *sanitization*)
- Add third condition to CW-Simple Security Condition:

  3. o is a sanitized object

Writing

- Tony, Susan work in same trading house
- Tony can read BoA's CD, Shell Oil's CD
- Susan can read Citibank's CD, Shell Oil's CD
- If Tony could write to Shell Oil's CD, Susan can read it
  - Hence, indirectly, she can read information from BoA, a clear conflict of interest

CW-*-Property

- *s* can write to *o* iff both of the following hold:
  1. The CW-simple security condition permits *s* to read *o*; and
  2. For all *unsanitized* objects *o*′, if *s* can read *o*′, then *CD*(*o*′) = *CD*(*o*)
- Says that s can write to an object if all the (unsanitized) objects it can read are in the same dataset

Key Points

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- Overview of policies
- Confidentiality policies
  - Bell-LaPadula Model
- Integrity policies
  - Clark-Wilson Integrity Model
- Hybrid polices
  - Chinese Wall Model