Lecture 3
September 30, 2024

Question

- Policy disallows cheating
    - Includes copying homework, with or without permission
- CS class has students do homework on computer
- Anne forgets to read-protect her homework file
- Bill copies it
- Who breached security?
    - Anne, Bill, or both?

Answer Part 1

- Bill clearly breached security
    - Policy forbids copying homework assignment
    - Bill did it
    - System entered unauthorized state (Bill having a copy of Anne's assignment)
- If not explicit in computer security policy, certainly implicit
    - Not credible that a unit of the university allows something that the university as a whole forbids, unless the unit explicitly says so

Answer Part 2

- Anne didn’t protect her homework
    - Not required by security policy
- She didn’t breach security
- If policy said students had to read-protect homework files, then Anne did breach security
    - She didn’t do this

Types of Security Policies

- Military (governmental) security policy
    - Policy primarily protecting confidentiality
- Commercial security policy
    - Policy primarily protecting integrity
- Confidentiality policy
    - Policy protecting only confidentiality
- Integrity policy
    - Policy protecting only integrity

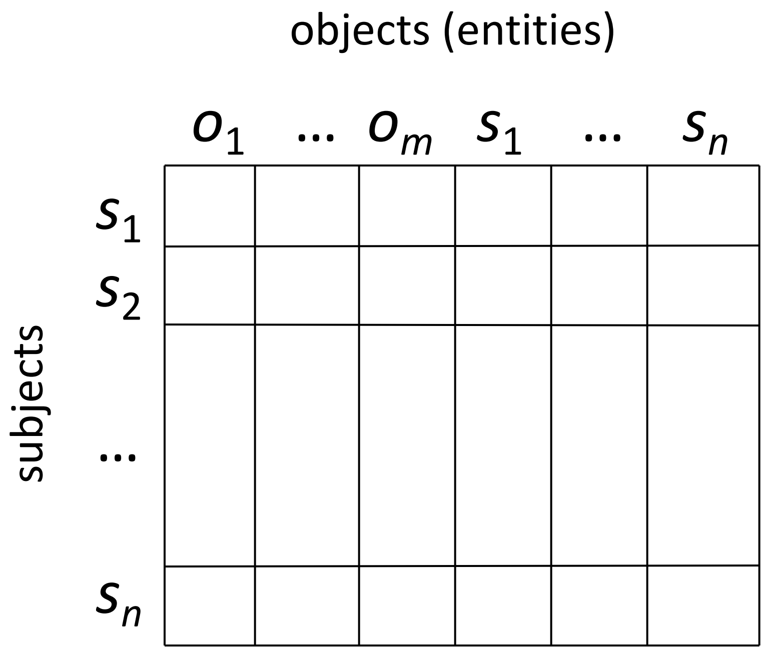
Types of Access Control

- Discretionary Access Control (DAC, IBAC)
  - individual user sets access control mechanism to allow or deny access to an object
- Mandatory Access Control (MAC)
  - system mechanism controls access to object, and individual cannot alter that access
- Originator Controlled Access Control (ORCON)
  - originator (creator) of information controls who can access information

Access Control Matrix

- Access Control Matrix Model
- Protection State Transitions
  - Commands
  - Conditional Commands
- Special Rights
- Principle of Attenuation of Privilege

Description



- Subjects $S = \{ s_1,…, s_n \}$
- Objects $O = \{ o_1,…, o_m \}$
- Rights $R = \{ r_1,…, r_k \}$
- Entries $A[s_i, o_j] \subseteq R$
- $A[s_i, o_j] = \{ r_x, …, r_y \}$ means subject s_i has rights $r_x, …, r_y$ over object o_j

Example 1

- Processes *p*, *q*
- Files *f*, *g*
- Rights *r*, *w*, *x*, *a*, *o*

	f	*g*	*p*	*q*
p	*rwo*	*r*	*rwxo*	*w*
q	*a*	*ro*	*r*	*rwxo*

Example 2

- Host names *telegraph*, *nob*, *toadflax*
- Rights *own*, *ftp*, *nfs*, *mail*

	telegraph	*nob*	*toadflax*
telegraph	*own*	*ftp*	*ftp*
nob		*ftp, mail, nfs, own*	*ftp, nfs, mail*
toadflax		*ftp, mail*	*ftp, mail, nfs, own*

Example 3

- Procedures *inc_ctr*, *dec_ctr*, *manage*
- Variable *counter*
- Rights *+*, *–*, *call*

	counter	*inc_ctr*	*dec_ctr*	*manage*
inc_ctr	*+*			
dec_ctr	*–*			
manager		*call*	*call*	*call*

State Transitions

- Change the protection state of system
  - Protection state is the triple (*S*, *O*, *A*), where S is the set of subjects, *O* is the set of entities (not the set of passive entities, so $S \subseteq O$) and *A* is the access control matrix
- |– represents transition
  - $X_i \vdash_\tau X_{i+1}$: command τ moves system from state X_i to X_{i+1}
  - $X_i \vdash^* Y$: a sequence of commands moves system from state X_i to Y
- Commands often called *transformation procedures*

Primitive Operations

- **create subject** *s*; **create object** *o*
  - Creates new row, column in ACM; creates new column in ACM
- **destroy subject** *s*; **destroy object** *o*
  - Deletes row, column from ACM; deletes column from ACM
- **enter** *r* **into** *A*[*s*, *o*]
  - Adds *r* rights for subject *s* over object *o*
- **delete** *r* **from** *A*[*s*, *o*]
  - Removes *r* rights from subject *s* over object *o*

Creating File

- Process *p* creates file *f* with *r* and *w* permission

```
command create•file(p, f)
    create object f;
    enter own into A[p, f];
    enter r into A[p, f];
    enter w into A[p, f];
end
```

Mono-Operational Commands

- Make process *p* the owner of file *g*

```
command make•owner(p, g)
    enter own into A[p, g];
end
```

- Mono-operational command
    - Single primitive operation in this command

Conditional Commands

- Let *p* give *q* *r* rights over *f*, if *p* owns *f*

```
command grant•read•file•1(p, f, q)
    if own in A[p, f]
    then
         enter r into A[q, f];
end
```

- Mono-conditional command
    - Single condition in this command

Multiple Conditions

- Let *p* give *q* *r* and *w* rights over *f*, if *p* owns *f* and *p* has *c* rights over *q*

```
command grant•read•file•2(p, f, q)
    if own in A[p, f] and c in A[p, q]
    then
         enter r into A[q, f];
         enter w into A[q, f];
end
```

Multiple Conditions: No `or`

- Let *p* give *q* *r* rights over *f*, if *p* owns *f* **or** *p* has *c* rights over *q*

```
command grant•read•file•3(p, f, q)
    if own in A[p, f]
    then
        enter r into A[q, f];
end
command grant•read•file•4(p, f, q)
    if c in A[p, q]
    then
        enter r into A[q, f];
end
```

Multiple Conditions: No `or`

- Let *p* give *q* *r* rights over *f*, if *p* owns *f* **or** *p* has *c* rights over *q*
- Now run:

```
grant•read•file•3(p, f, q)
grant•read•file•4(p, f, q)
```

- If either is true, then *r* is entered into *A*[*q*, *f*], as required

Copy Flag and Right

- Allows possessor to give rights to another
- Often attached to a right (called a *flag*), so only applies to that right
  - *r* is read right that cannot be copied
  - *rc* is read right that can be copied
- Is copy flag copied when giving *r* rights?
  - Depends on model, instantiation of model

Own Right

- Usually allows possessor to change entries in ACM column
  - So owner of object can add, delete rights for others
  - May depend on what system allows
    - Can’t give rights to specific (set of) users
    - Can’t pass copy flag to specific (set of) users

Attenuation of Privilege

- Principle says you can’t increase your rights, or give rights you do not possess
  - Restricts addition of rights within a system
  - Usually *ignored* for owner
    - Why? Owner gives themselvs rights, gives them to others, deletes their rights.

What Is “Secure”?

- Adding a generic right *r* where there was not one is “leaking”
  - In what follows, a right leaks if it was not present *initially*
  - Alternately: not present *in the previous state* (not discussed here)
- If a system *S*, beginning in initial state s_0, cannot leak right *r*, it is *safe with respect to the right r*
  - Otherwise it is called *unsafe with respect to the right r*

Safety Question

- Does there exist an algorithm for determining whether a protection system *S* with initial state s_0 is safe with respect to a generic right *r*?
  - Here, “safe” = “secure” for an abstract model

Mono-Operational Commands

- Answer: *yes*
- Sketch of proof:

  Consider minimal sequence of commands $c_1, \ldots, c_k$ to leak the right.

  - Can omit **delete**, **destroy**
  - Can merge all **create**s into one

  Worst case: insert every right into every entry; with s subjects and o objects initially, and n rights, upper bound is $k \leq n(s+1)(o+1)$

General Case

- Answer: *no*
- Sketch of proof:

  Reduce halting problem to safety problem
  - Map head motion of Turing machine into entering, deleting rights in the access control matrix
  - Turing machine symbols mapped into rights
  - Head position, end of tape indicated by special rights
  - Head motion represented by commands; two sets for R motion
    - One for mid-tape, one for end of tape
  - So protection system simulates a Turing machine *exactly*
  - TM halts when it enters state q_f; this means right has leaked

Confidentiality Models

- Overview
  - What is a confidentiality model
- Bell-LaPadula Model
  - General idea
  - Informal description of rules
- Tranquility
- Declassification

Confidentiality Policy

- 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, Step 1

- Security levels arranged in linear ordering
  - Top Secret: highest
  - Secret
  - Confidential
  - Unclassified: lowest
- Levels consist are called *security clearance* $L(s)$ for subjects and *security classification* $L(o)$ for objects

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 (Step 1)
  - Subject s can read object o iff $L(o) \leq L(s)$ 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 (Step 1)
  - Subject *s* can write object *o* iff $L(s) \leq L(o)$ 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, Step 1

- If a system is initially in a secure state, and every transition of the system satisfies the simple security condition, step 1, and the *-property, step 1, then every state of the system is secure
  - Proof: induct on the number of transitions