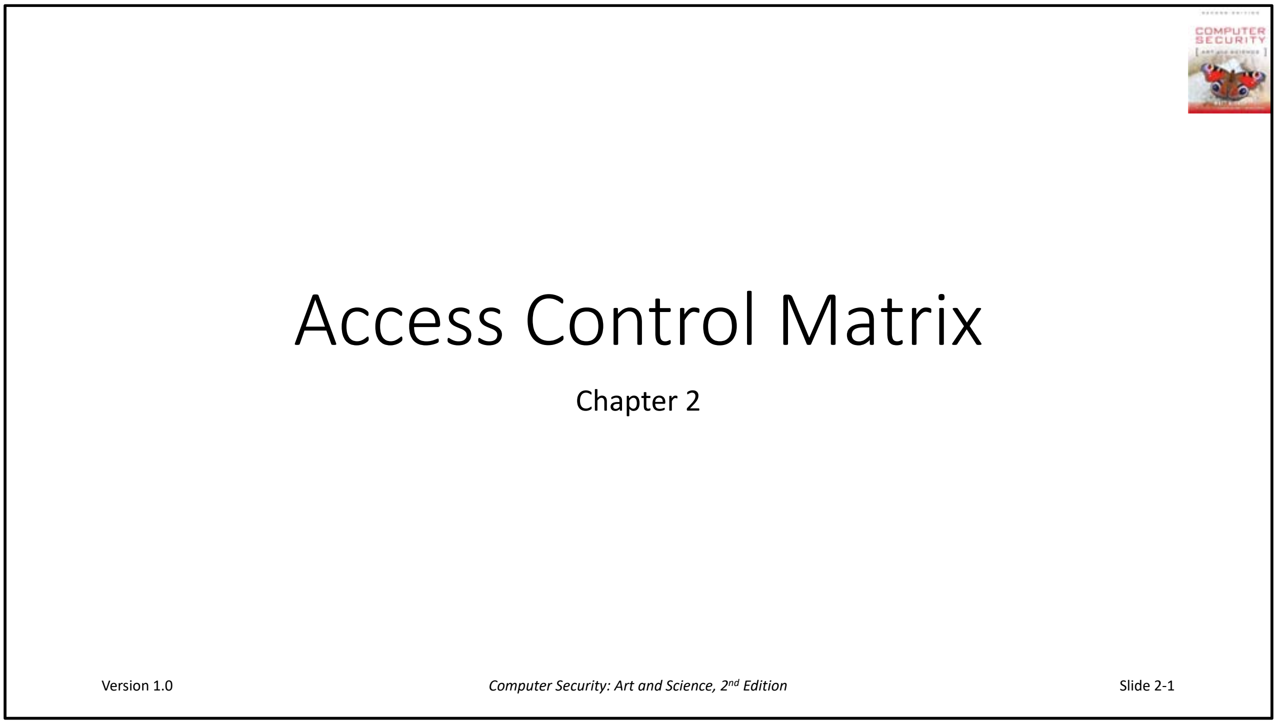
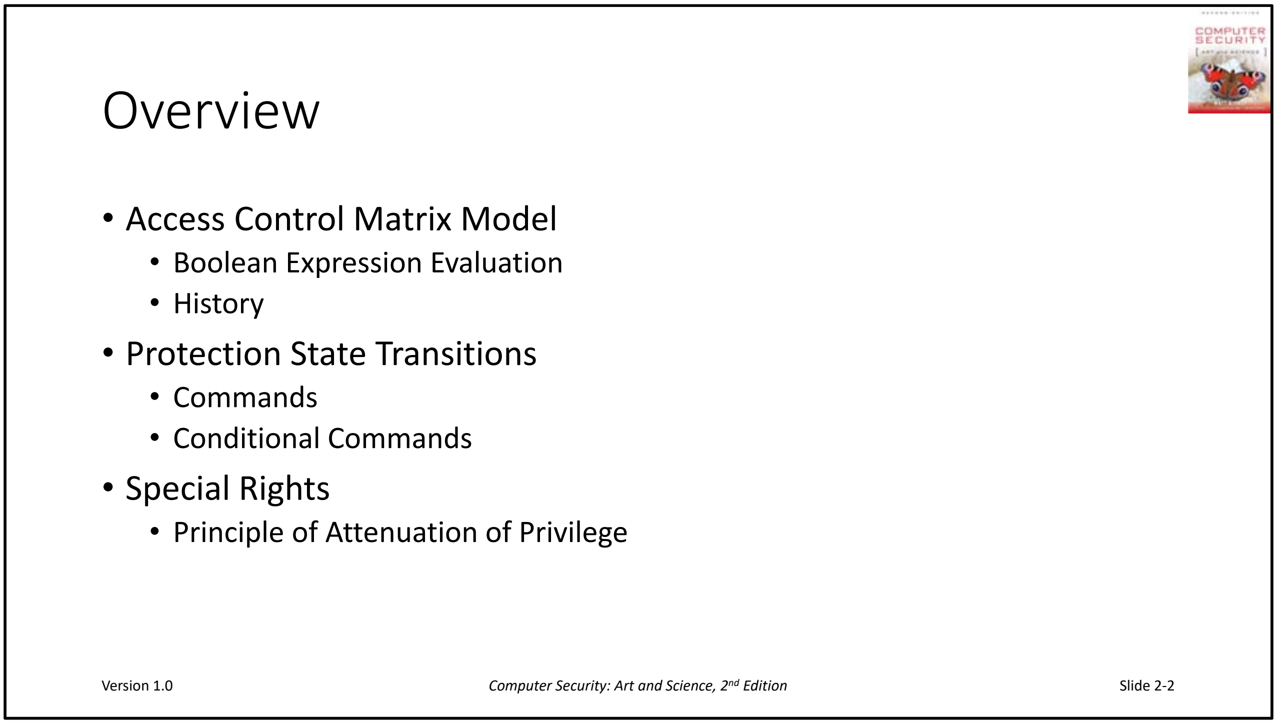


Access Control Matrix

Chapter 2

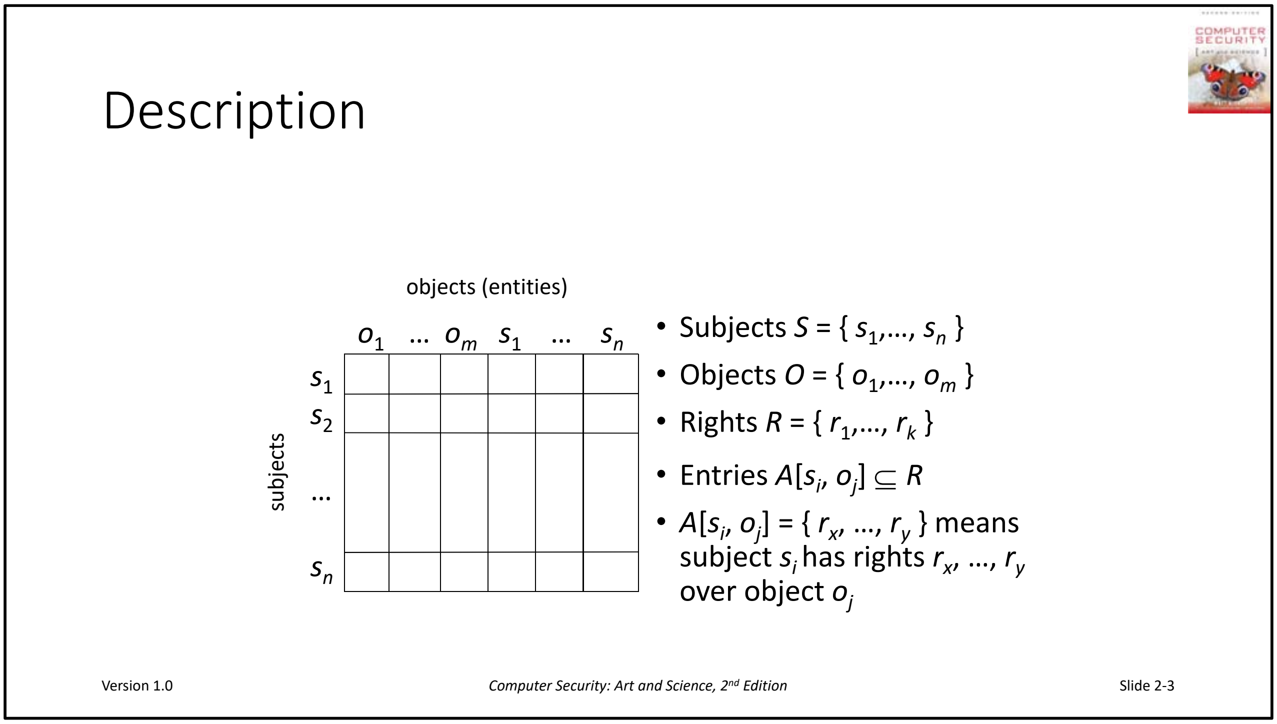


Overview

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

Section 2.1

A subject is an active entity



Description

objects (entities)

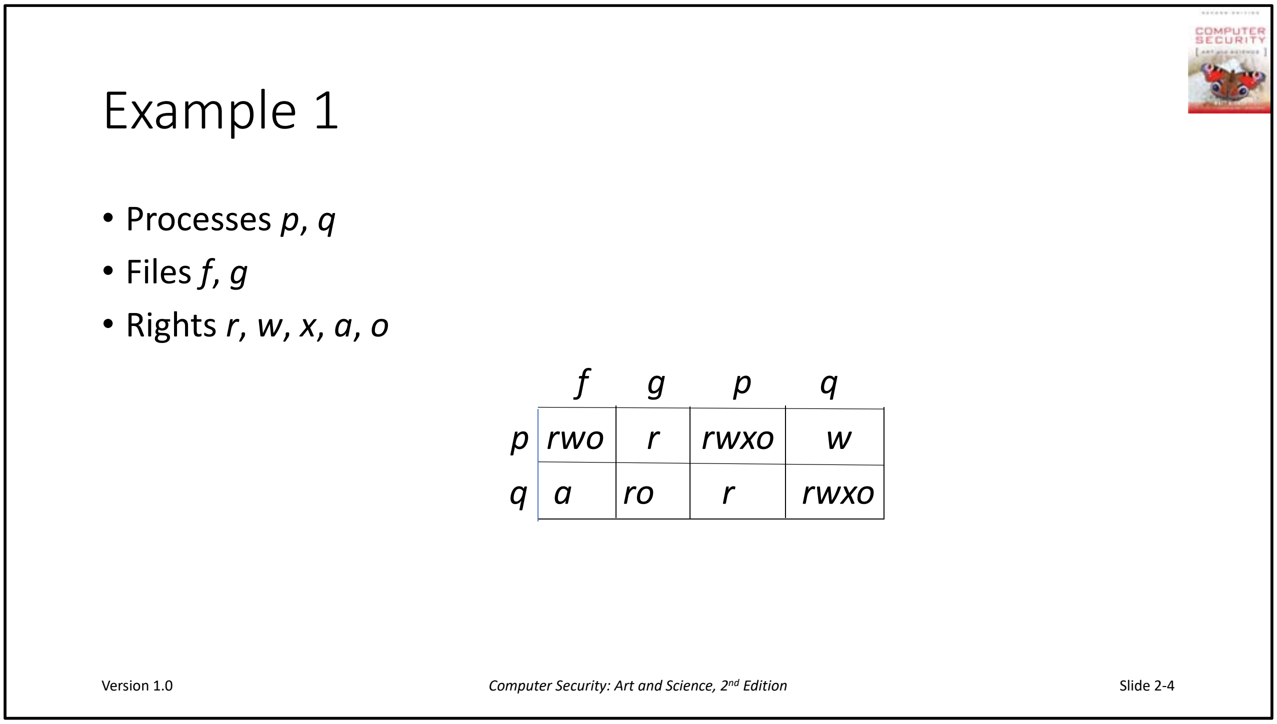
subjects

$$\begin{array}{c|c|c|c|c|c|c|}
 & o_1 & \ldots & o_m & s_1 & \ldots & s_n \\ \hline
s_1 & & & & & & \\ \hline
s_2 & & & & & & \\ \hline
\ldots & & & & & & \\ \hline
s_n & & & & & & \\ \hline
\end{array}$$

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

Section 2.2

Note the way “object” is used here; it means “any entity”, not a “passive entity” as is usually the case. An object that is passive cannot take any actions, of course.



Example 1

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

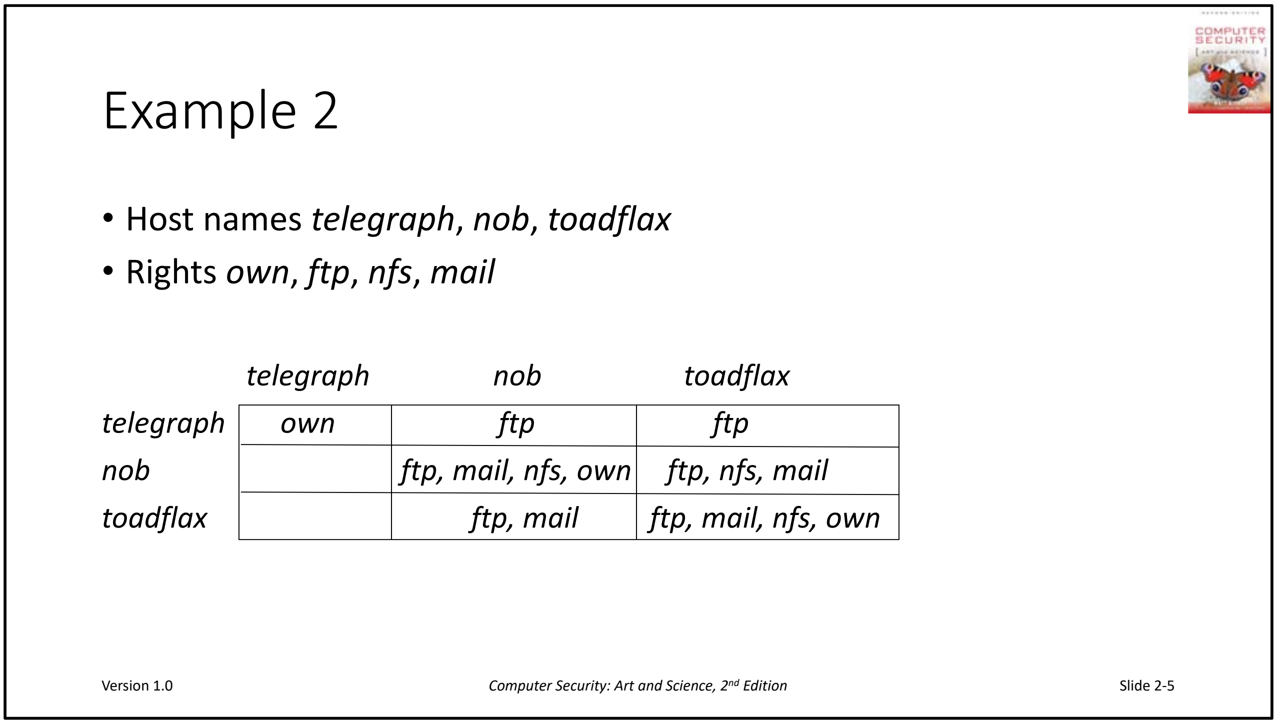
	f	*g*	*p*	*q*
p	*rwo*	*r*	*rwxo*	*w*
q	*a*	*ro*	*r*	*rwxo*

Figure 2-1, slightly redone

The change here is to use the letters r, w, o, x, a to mean read, write, own, execute, and append respectively (Figure 2-1 spells them out)

Own is often treated specially, though (it can alter rights in the column, not row, in which it lies)

Note interpretation of rights is not relevant here; “x” can mean execute (as with a UNIX file) or “search” (as with a UNIX directory)



Example 2

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

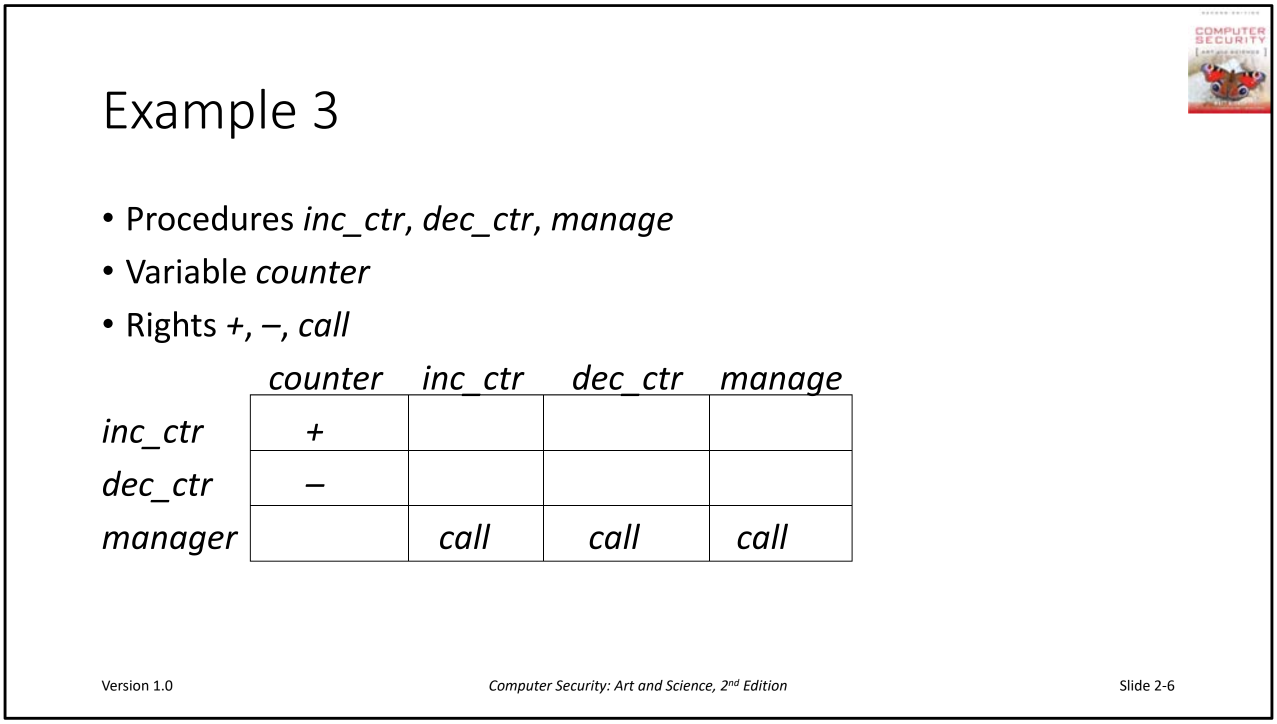
	telegraph	*nob*	*toadflax*
telegraph	*own*	*ftp*	*ftp*
nob		*ftp, mail, nfs, own*	*ftp, nfs, mail*
toadflax		*ftp, mail*	*ftp, mail, nfs, own*

Version 1.0 *Computer Security: Art and Science, 2nd Edition* Slide 2-5

Figure 2-3

This is a data module to increment and decrement a counter

Note manager can call itself, so it’s recursive



Example 3

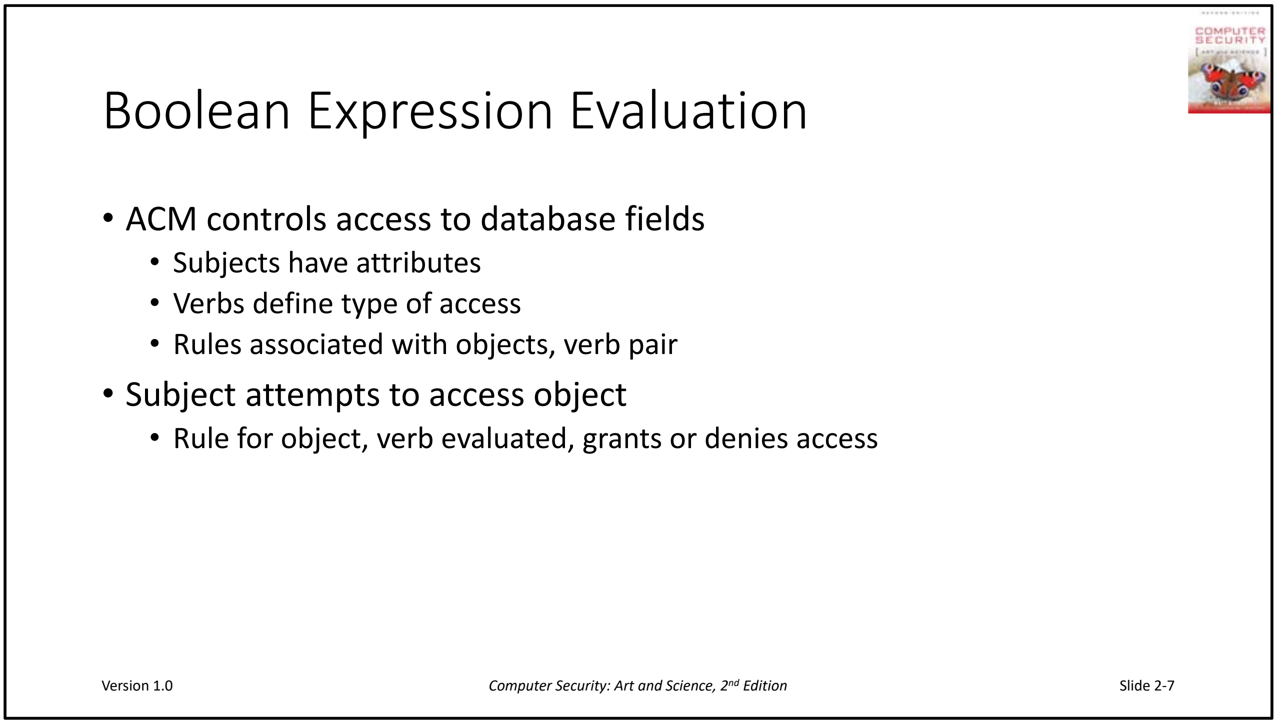
- Procedures *inc_ctr*, *dec_ctr*, *manage*
- Variable *counter*
- Rights *+*, *–*, *call*

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

Figure 2-3

This is a data module to increment and decrement a counter

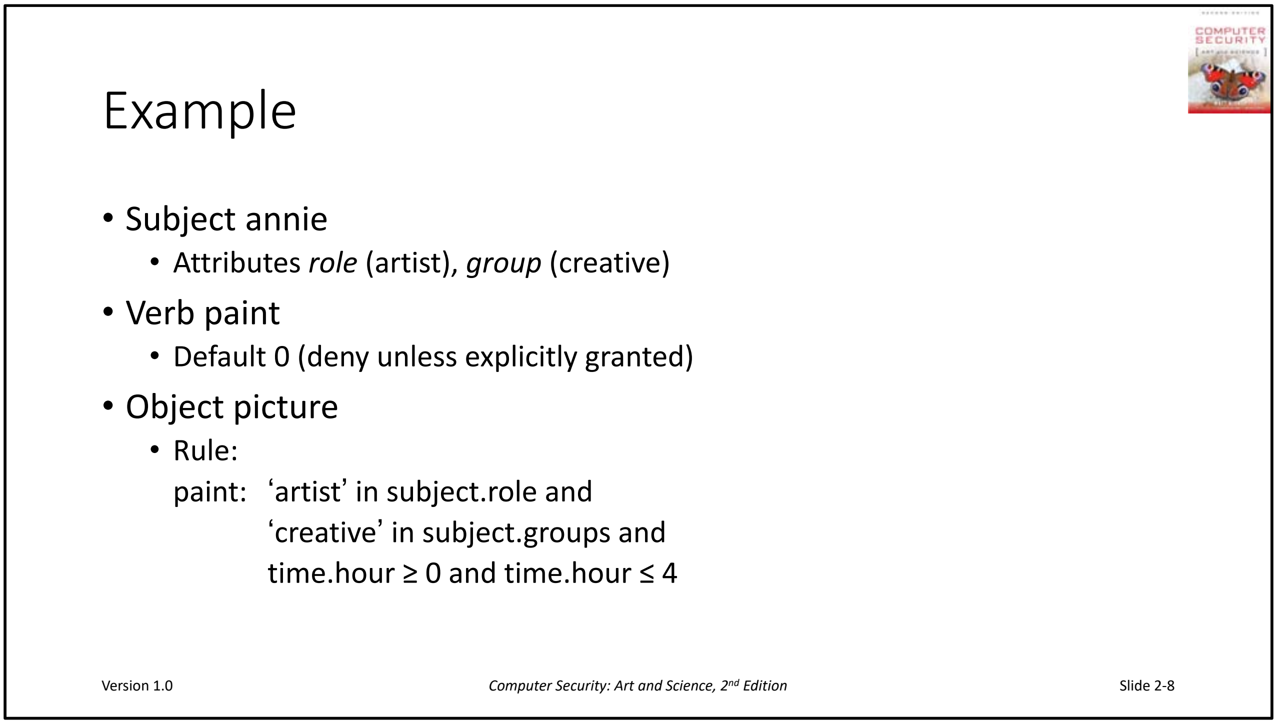
Note manager can call itself, so it's recursive



Boolean Expression Evaluation

- ACM controls access to database fields
  - Subjects have attributes
  - Verbs define type of access
  - Rules associated with objects, verb pair
- Subject attempts to access object
  - Rule for object, verb evaluated, grants or denies access

Section 2.2.1

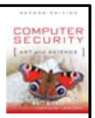


Example

- Subject annie
  - Attributes *role* (artist), *group* (creative)
- Verb paint
  - Default 0 (deny unless explicitly granted)
- Object picture
  - Rule:

```
paint:  'artist' in subject.role and
        'creative' in subject.groups and
        time.hour ≥ 0 and time.hour ≤ 4
```

The next two slides are similar to the example in Section 2.2.1, but use painting rather than a file



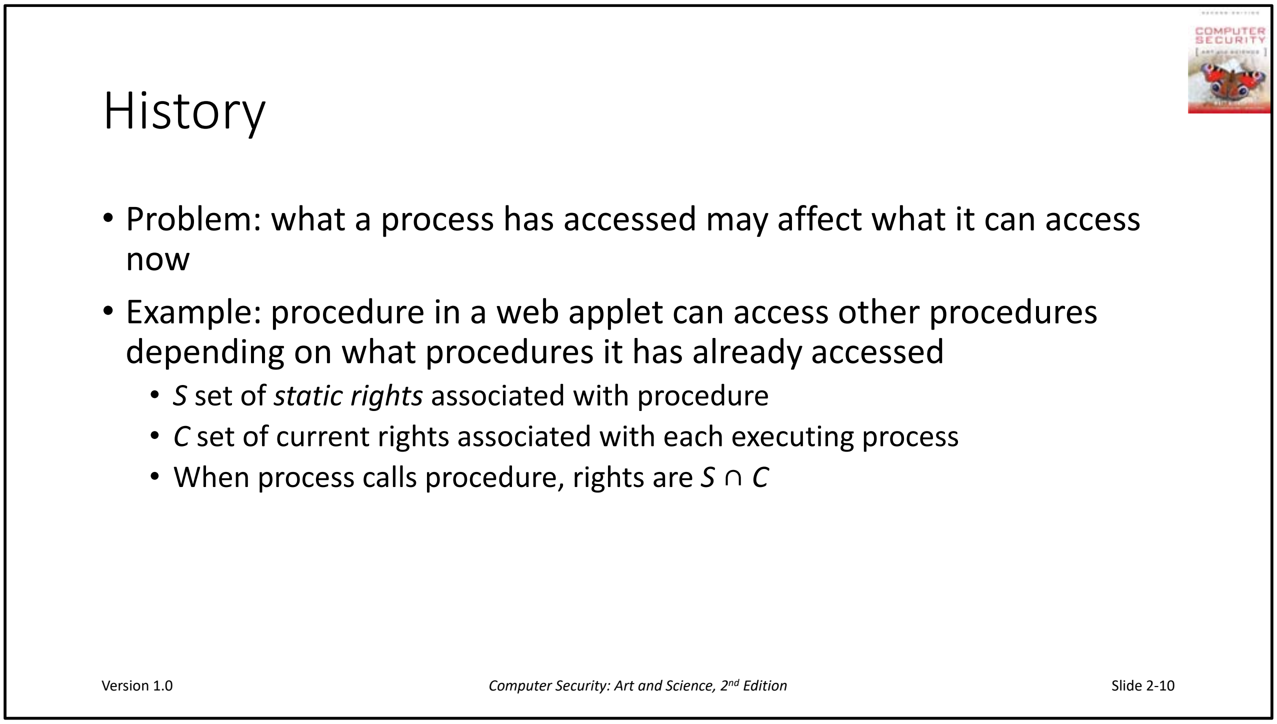
ACM at 3AM and 10AM

At 3AM, time condition met
ACM is:

	…	picture	…
…			
annie		paint	
…			

At 10AM, time condition not met
ACM is:

	…	picture	…
…			
annie			
…			



History

- Problem: what a process has accessed may affect what it can access now
- Example: procedure in a web applet can access other procedures depending on what procedures it has already accessed
  - *S* set of *static rights* associated with procedure
  - *C* set of current rights associated with each executing process
  - When process calls procedure, rights are $S \cap C$

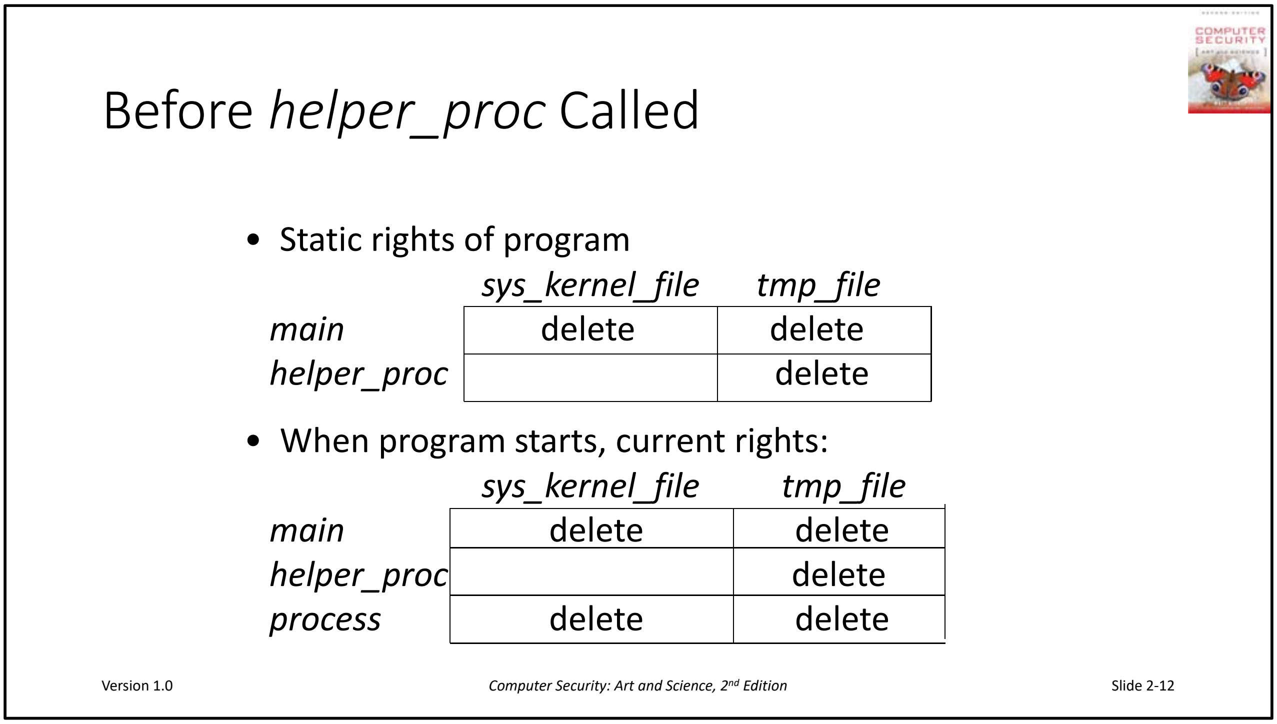
Example Program

```
// This routine has no filesystem access rights
// beyond those in a limited, temporary area
procedure helper_proc()
        return sys_kernel_file

// But this has the right to delete files
program main()
        sys_load_file(helper_proc)
        tmp_file = helper_proc()
        sys_delete_file(tmp_file)
```

- *sys_kernel_file* contains system kernel

- *tmp_file* is in limited area that *helper_proc*() can access



Before *helper_proc* Called

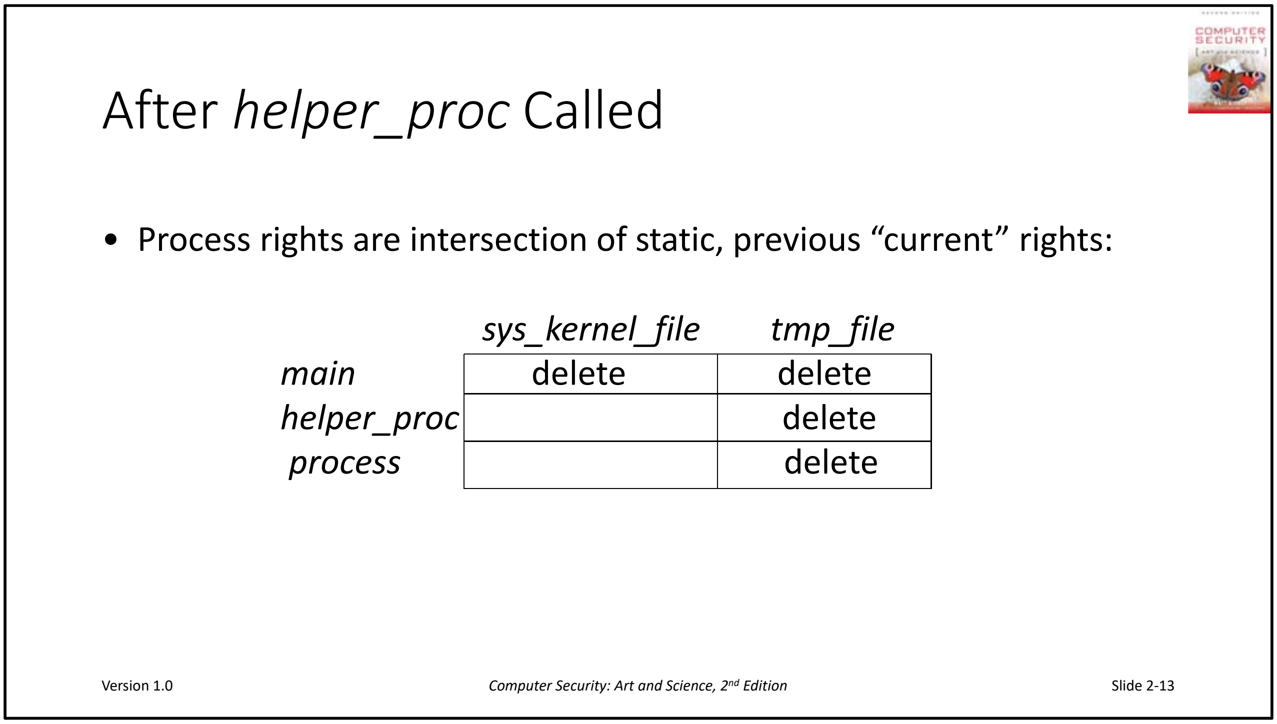
- Static rights of program

	sys_kernel_file	*tmp_file*
main	delete	delete
helper_proc		delete

- When program starts, current rights:

	sys_kernel_file	*tmp_file*
main	delete	delete
helper_proc		delete
process	delete	delete

In "current rights", *helper_proc*() is not yet loaded

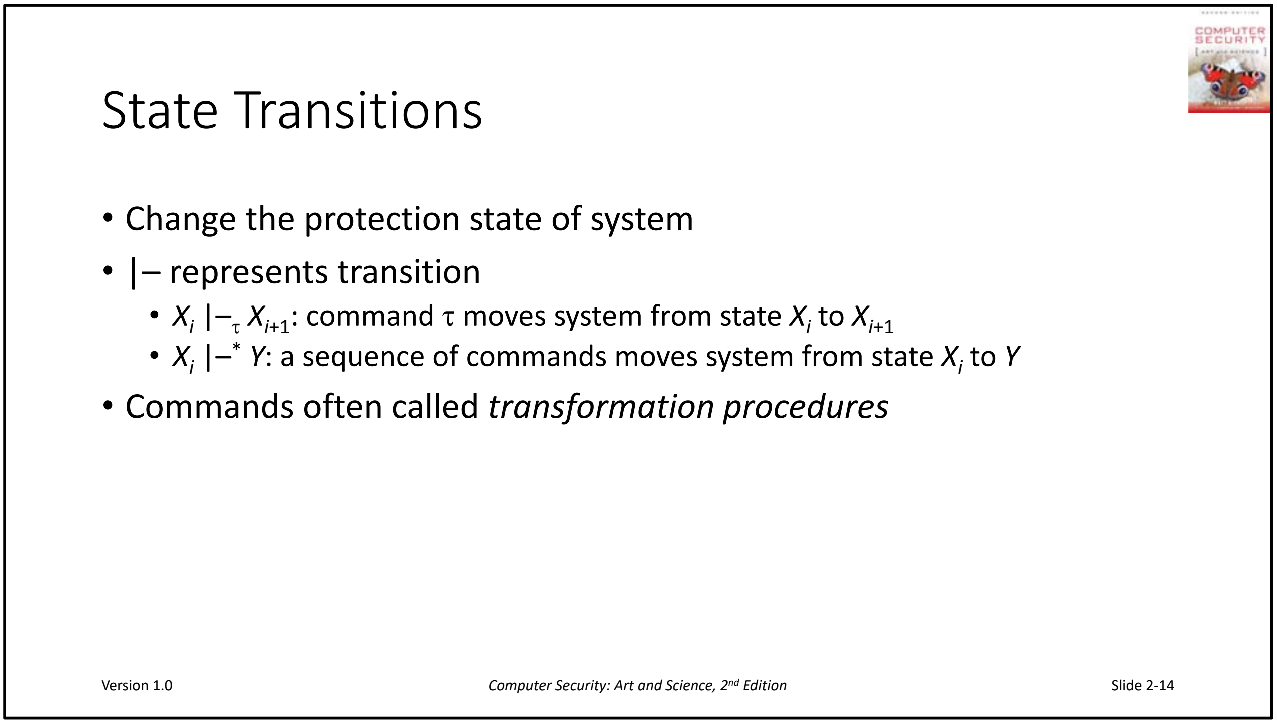


After *helper_proc* Called

- Process rights are intersection of static, previous “current” rights:

	sys_kernel_file	*tmp_file*
main	delete	delete
helper_proc		delete
process		delete

In “current rights”, *helper_proc*() is not yet loaded

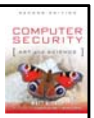


State Transitions

- Change the protection state of system
- |– represents transition
  - $X_i \mid\!-_{\tau} X_{i+1}$: command τ moves system from state X_i to X_{i+1}
  - $X_i \mid\!-^{*} Y$: a sequence of commands moves system from state X_i to Y
- Commands often called *transformation procedures*

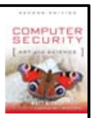
Section 2.3

State is the triple (S, O, A), where O here means the set of entities, not the set of passive entities (so O ⊆ S)



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*

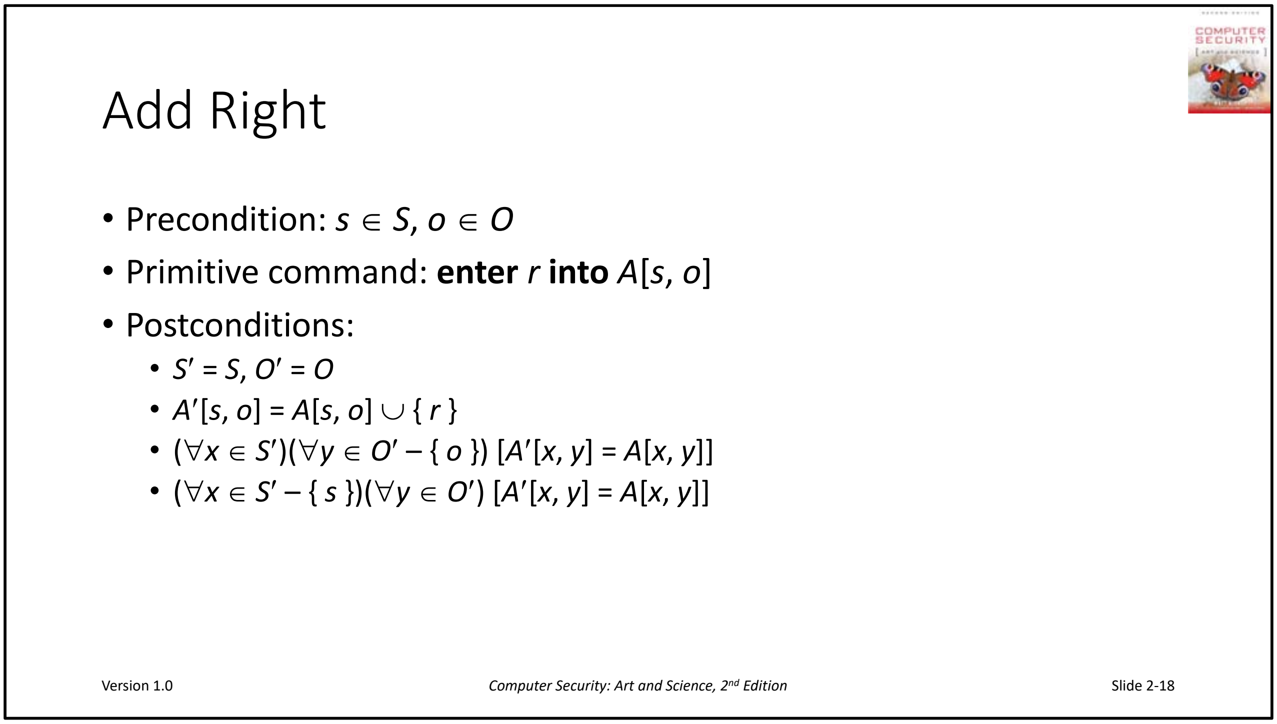


Create Subject

- Precondition: $s \notin S$
- Primitive command: **create subject** *s*
- Postconditions:
  - $S' = S \cup \{ s \}, O' = O \cup \{ s \}$
  - $(\forall y \in O')\ [A'[s, y] = \varnothing], (\forall x \in S')\ [A'[x, s] = \varnothing]$
  - $(\forall x \in S)(\forall y \in O)\ [A'[x, y] = A[x, y]]$

Create Object

- Precondition: $o \notin O$
- Primitive command: **create object** *o*
- Postconditions:
  - $S' = S$, $O' = O \cup \{ o \}$
  - $(\forall x \in S') [A'[x, o] = \varnothing]$
  - $(\forall x \in S)(\forall y \in O) [A'[x, y] = A[x, y]]$

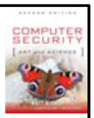


Add Right

- Precondition: $s \in S$, $o \in O$
- Primitive command: **enter** *r* **into** $A[s, o]$
- Postconditions:
  - $S' = S$, $O' = O$
  - $A'[s, o] = A[s, o] \cup \{ r \}$
  - $(\forall x \in S')(\forall y \in O' - \{ o \})\ [A'[x, y] = A[x, y]]$
  - $(\forall x \in S' - \{ s \})(\forall y \in O')\ [A'[x, y] = A[x, y]]$

Delete Right

- Precondition: $s \in S$, $o \in O$
- Primitive command: **delete** *r* **from** $A[s, o]$
- Postconditions:
  - $S' = S$, $O' = O$
  - $A'[s, o] = A[s, o] - \{ r \}$
  - $(\forall x \in S')(\forall y \in O' - \{ o \})\ [A'[x, y] = A[x, y]]$
  - $(\forall x \in S' - \{ s \})(\forall y \in O')\ [A'[x, y] = A[x, y]]$



Destroy Subject

- Precondition: $s \in S$
- Primitive command: **destroy subject** *s*
- Postconditions:
  - $S' = S - \{ s \}$, $O' = O - \{ s \}$
  - $(\forall y \in O')\ [A'[s, y] = \varnothing]$, $(\forall x \in S')\ [A'[x, s] = \varnothing]$
  - $(\forall x \in S')(\forall y \in O')\ [A'[x, y] = A[x, y]]$

Destroy Object

- Precondition: $o \in O$
- Primitive command: **destroy object** *o*
- Postconditions:
  - $S' = S$, $O' = O - \{ o \}$
  - $(\forall x \in S')\ [A'[x, o] = \varnothing]$
  - $(\forall x \in S')(\forall y \in O')\ [A'[x, y] = A[x, y]]$

Creating File

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

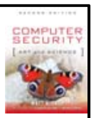
```
command create•file(p, f)
    create object f;
    enter own into A[p, f];
    enter r into A[p, f];
    enter w into A[p, f];
end
```

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

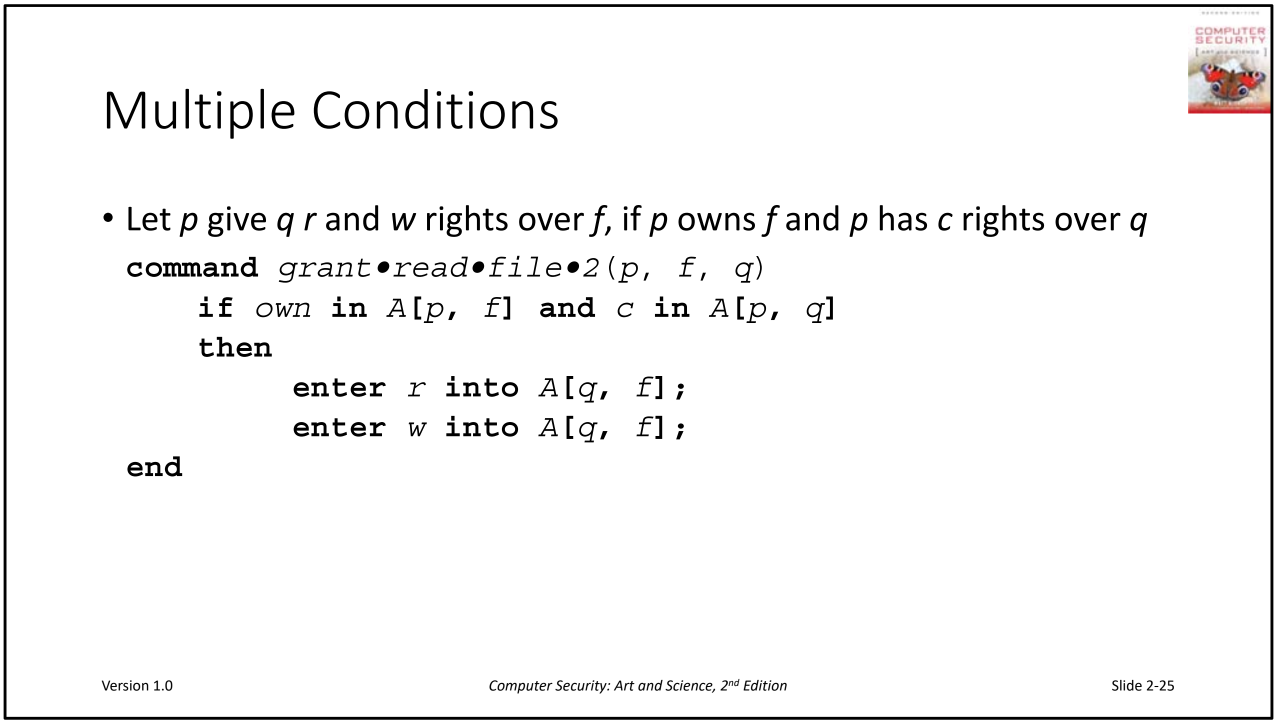


Conditional Commands

- 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
```

Copy Flag and Right

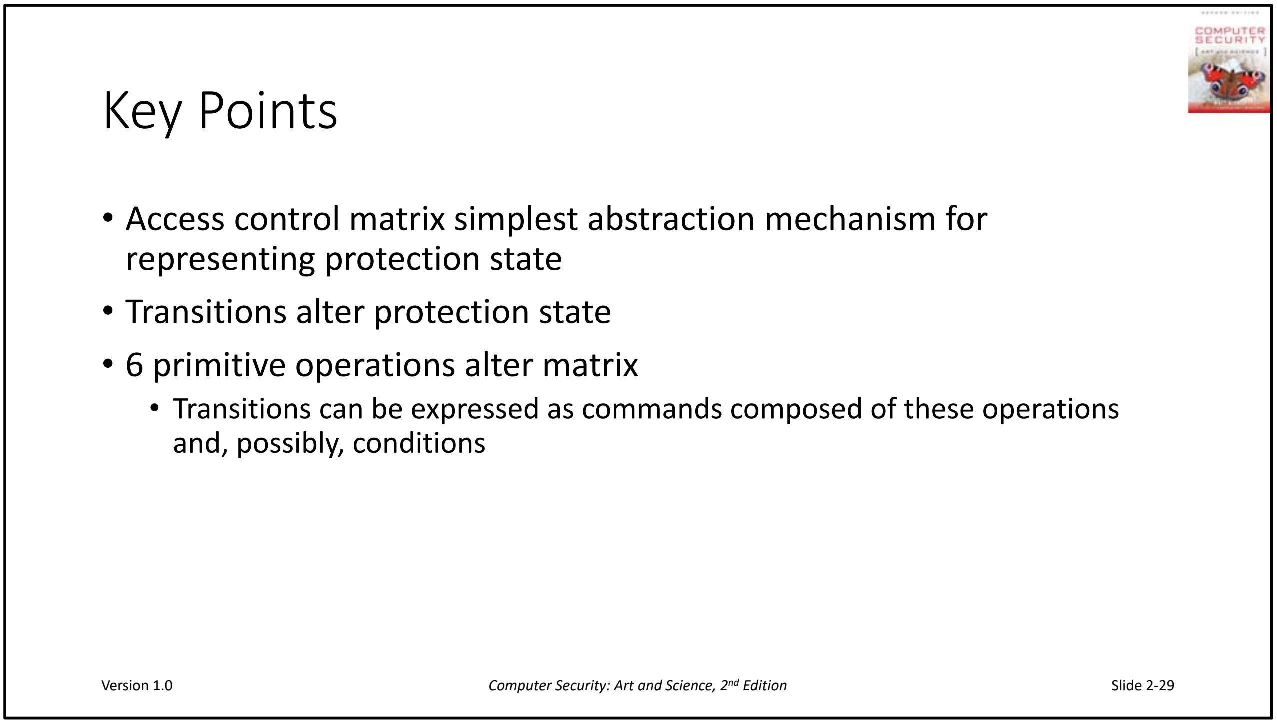
- Allows possessor to give rights to another
- Often attached to a right (called a *flag*), so only applies to that right
  - *r* is read right that cannot be copied
  - *rc* is read right that can be copied
- Is copy flag copied when giving *r* rights?
  - Depends on model, instantiation of model

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 herself rights, gives them to others, deletes her rights.



Key Points

- Access control matrix simplest abstraction mechanism for representing protection state
- Transitions alter protection state
- 6 primitive operations alter matrix
  - Transitions can be expressed as commands composed of these operations and, possibly, conditions