ECS 235B Module 48 Introduction to Information Flow

Basics

- Bell-LaPadula Model embodies information flow policy
  - Given compartments *A*, *B*, info can flow from *A* to *B* iff *B dom A*
- So does Biba Model
  - Given compartments *A*, *B*, info can flow from *A* to *B* iff *A dom B*
- Variables *x*, *y* assigned compartments $\underline{x}$, $\underline{y}$ as well as values
  - Confidentiality (Bel-LaPadula): if $\underline{x}$ = *A*, $\underline{y}$ = *B*, and *B dom A*, then *y* := *x* allowed but not *x* := *y*
  - Integrity (Biba): if $\underline{x}$ = *A*, $\underline{y}$ = *B*, and *A dom B*, then *x* := *y* allowed but not *y* := *x*
- For now, focus on confidentiality (Bell-LaPadula)
  - We'll get to integrity later

Entropy and Information Flow

- Idea: information flows from *x* to *y* as a result of a sequence of commands *c* if you can deduce information about *x* before *c* from the value in *y* after *c*
- Formally:
  - *s* time before execution of *c*, *t* time after
  - $H(x_s \mid y_t) < H(x_s \mid y_s)$
  - If no *y* at time *s*, then $H(x_s \mid y_t) < H(x_s)$

Example 1

- Command is $x := y + z$; where:
  - x does not exist initially (that is, has no value)
  - $0 \le y \le 7$, equal probability
  - $z = 1$ with probability 1/2, $z = 2$ or 3 with probability 1/4 each
- s state before command executed; t, after; so
  - $H(y_s) = H(y_t) = -8(1/8) \lg (1/8) = 3$
- You can show that $H(y_s \mid x_t) = (3/32) \lg 3 + 9/8 \approx 1.274 < 3 = H(y_s)$
  - Thus, information flows from y to x

Example 2

- Command is

  if $x = 1$ **then** $y := 0$ **else** $y := 1$;

  where x, y equally likely to be either 0 or 1
- $H(x_s) = 1$ as x can be either 0 or 1 with equal probability
- $H(x_s \mid y_t) = 0$ as if $y_t = 1$ then $x_s = 0$ and vice versa
  - Thus, $H(x_s \mid y_t) = 0 < 1 = H(x_s)$
- So information flowed from x to y

Implicit Flow of Information

- Information flows from *x* to *y* without an *explicit* assignment of the form *y* := *f*(*x*)
  - *f*(*x*) an arithmetic expression with variable *x*
- Example from previous slide:

if *x* = 1 **then** *y* := 0 **else** *y* := 1;

- So must look for implicit flows of information to analyze program

Notation

- $\underline{x}$ means class of x
  - In Bell-LaPadula based system, same as “label of security compartment to which x belongs”
- $\underline{x} \leq \underline{y}$ means “information can flow from an element in class of x to an element in class of y
  - Or, “information with a label placing it in class $\underline{x}$ can flow into class $\underline{y}$”