ECS 235B Module 19
Applying the Bell-LaPadula Model

Rule

- $\rho: R \times V \rightarrow D \times V$
- Takes a state and a request, returns a decision and a (possibly new) state
- Rule ρ *ssc-preserving* if for all $(r, v) \in R \times V$ and v satisfying *ssc rel f*, $\rho(r, v) = (d, v')$ means that v' satisfies *ssc rel f'*.
  - Similar definitions for *-property, ds-property
  - If rule meets all 3 conditions, it is *security-preserving*

Unambiguous Rule Selection

- Problem: multiple rules may apply to a request in a state
  - if two rules act on a read request in state *v* …
- Solution: define relation $W(\omega)$ for a set of rules $\omega = \{ \rho_1, …, \rho_m \}$ such that a state $(r, d, v, v') \in W(\omega)$ iff either
  - $d = \underline{\mathrm{i}}$; or
  - for exactly one integer j, $\rho_j(r, v) = (d, v')$
- Either request is illegal, or only one rule applies

Rules Preserving *SSC*

- Let ω be set of *ssc*-preserving rules. Let state z_0 satisfy simple security condition. Then $\Sigma(R, D, W(\omega), z_0)$ satisfies simple security condition

  Proof: by contradiction.

  - Choose $(x, y, z) \in \Sigma(R, D, W(\omega), z_0)$ as state not satisfying simple security condition; then choose $t \in N$ such that (x_t, y_t, z_t) is first appearance not meeting simple security condition
  - As $(x_t, y_t, z_t, z_{t-1}) \in W(\omega)$, there is unique rule $\rho \in \omega$ such that $\rho(x_t, z_{t-1}) = (y_t, z_t)$ and $y_t \neq \underline{\text{i}}$.
  - As ρ ssc-preserving, and z_{t-1} satisfies simple security condition, then z_t meets simple security condition, contradiction.

Adding States Preserving *SSC*

- Let $v = (b, m, f, h)$ satisfy simple security condition. Let $(s, o, p) \notin b$, $b' = b \cup \{ (s, o, p) \}$, and $v' = (b', m, f, h)$. Then v' satisfies simple security condition iff:

  1. Either p = e or p = a; or
  2. Either p = r or p = w, and $f_c(s)$ *dom* $f_o(o)$

  Proof:

  1. Immediate from definition of simple security condition and v' satisfying *ssc rel f*
  2. v' satisfies simple security condition means $f_s(s)$ *dom* $f_o(o)$, and for converse, $(s, o, p) \in b'$ satisfies *ssc rel f*, so v' satisfies simple security condition

Rules, States Preserving *-Property

- Let ω be set of *-property-preserving rules and initial state z_0 satisfies the *-property. Then $\Sigma(R, D, W(\omega), z_0)$ satisfies *-property
- Let $v = (b, m, f, h)$ satisfy *-property. Let $(s, o, p) \notin b$, $b' = b \cup \{ (s, o, p) \}$, and $v' = (b', m, f, h)$. Then v' satisfies *-property iff one of the following holds:
  1. p = $\underline{\text{a}}$ and $f_o(o)$ *dom* $f_c(s)$
  2. p = $\underline{\text{w}}$ and $f_c(s) = f_o(o)$
  3. p = $\underline{\text{r}}$ and $f_c(s)$ *dom* $f_o(o)$

Rules, States Preserving ds-Property

- Let ω be set of ds-property-preserving rules, state z_0 satisfies ds-property. Then $\Sigma(R, D, W(\omega), z_0)$ satisfies ds-property
- Let $v = (b, m, f, h)$ satisfy ds-property. Let $(s, o, p) \notin b$, $b' = b \cup \{ (s, o, p) \}$, and $v' = (b', m, f, h)$. Then v' satisfies ds-property iff $p \in m[s, o]$.

Combining

- Let ρ be a rule and $\rho(r, v) = (d, v')$,

  where $v = (b, m, f, h)$ and $v' = (b', m', f', h')$.

Then:

1. If $b' \subseteq b$, $f' = f$, and v satisfies the simple security condition, then v' satisfies the simple security condition
2. If $b' \subseteq b$, $f' = f$, and v satisfies the *-property, then v' satisfies the *-property
3. If $b' \subseteq b$, $m[s, o] \subseteq m'[s, o]$ for all $s \in S$ and $o \in O$, and v satisfies the ds-property, then v' satisfies the ds-property

Proof

1. Suppose v satisfies simple security property.
   a) $b' \subseteq b$ and $(s, o, \underline{\text{r}}) \in b'$ implies $(s, o, \underline{\text{r}}) \in b$
   b) $b' \subseteq b$ and $(s, o, \underline{\text{w}}) \in b'$ implies $(s, o, \underline{\text{w}}) \in b$
   c) So $f_s(s)$ *dom* $f_o(o)$
   d) But $f' = f$
   e) Hence $f'_s(s)$ *dom* $f'_o(o)$
   f) So v' satisfies simple security condition

2, 3 proved similarly

Example Instantiation: Multics

- 11 rules affect rights:
  - set to request, release access
  - set to give, remove access to different subject
  - set to create, reclassify objects
  - set to remove objects
  - set to change subject security level
- Set of "trusted" subjects $S_T \subseteq S$
  - *-property not enforced; subjects trusted not to violate it
- $\Delta(\rho)$ domain
  - determines if components of request are valid

get-read Rule

- Request $r = (get, s, o, \underline{\mathrm{r}})$
  - s gets (requests) the right to read o
- Rule is $\rho_1(r, v)$:

if $(r \neq \Delta(\rho_1))$ **then** $\rho_1(r, v) = (\underline{\mathrm{i}}, v)$;

else if $(f_s(s)\ dom\ f_o(o)$ **and** $[s \in S_T$ **or** $f_c(s)\ dom\ f_o(o)]$ **and** $r \in m[s, o])$

then $\rho_1(r, v) = (\underline{\mathrm{y}}, (b \cup \{ (s, o, \underline{\mathrm{r}}) \}, m, f, h))$;

else $\rho_1(r, v) = (\underline{\mathrm{n}}, v)$;

Security of Rule

- The get-read rule preserves the simple security condition, the *-property, and the ds-property

  Proof:

  - Let v satisfy all conditions. Let $\rho_1(r, v) = (d, v')$. If $v' = v$, result is trivial. So let $v' = (b \cup \{ (s_2, o, \underline{\mathrm{r}}) \}, m, f, h)$.

Proof

- Consider the simple security condition.
  - From the choice of v', either $b' - b = \varnothing$ or $\{ (s_2, o, \underline{r}) \}$
  - If $b' - b = \varnothing$, then $\{ (s_2, o, \underline{r}) \} \in b$, so $v = v'$, proving that v' satisfies the simple security condition.
  - If $b' - b = \{ (s_2, o, \underline{r}) \}$, because the *get-read* rule requires that $f_s(s)$ *dom* $f_o(o)$, an earlier result says that v' satisfies the simple security condition.

Proof

- Consider the *-property.
  - Either $s_2 \in S_T$ or $f_c(s)$ *dom* $f_o(o)$ from the definition of *get-read*
  - If $s_2 \in S_T$, then s_2 is trusted, so *-property holds by definition of trusted and S_T.
  - If $f_c(s)$ *dom* $f_o(o)$, an earlier result says that v' satisfies the *-property.

Proof

- Consider the discretionary security property.
  - Conditions in the *get-read* rule require $\underline{\mathrm{r}} \in m[s, o]$ and either $b' - b = \varnothing$ or $\{ (s_2, o, \underline{\mathrm{r}}) \}$
  - If $b' - b = \varnothing$, then $\{ (s_2, o, \underline{\mathrm{r}}) \} \in b$, so $v = v'$, proving that v' satisfies the simple security condition.
  - If $b' - b = \{ (s_2, o, \underline{\mathrm{r}}) \}$, then $\{ (s_2, o, \underline{\mathrm{r}}) \} \notin b$, an earlier result says that v' satisfies the ds-property.

give-read Rule

- Request $r = (s_1, give, s_2, o, \underline{r})$
  - s_1 gives (request to give) s_2 the (discretionary) right to read o
  - Rule: can be done if giver can alter parent of object
    - If object or parent is root of hierarchy, special authorization required
- Useful definitions
  - $root(o)$: root object of hierarchy h containing o
  - $parent(o)$: parent of o in h (so $o \in h(parent(o))$)
  - $canallow(s, o, v)$: s specially authorized to grant access when object or parent of object is root of hierarchy
  - $m \wedge m[s, o] \leftarrow \underline{r}$: access control matrix m with $\underline{r}$ added to $m[s, o]$

give-read Rule

- Rule is $\rho_6(r, v)$:

  if $(r \neq \Delta(\rho_6))$ **then** $\rho_6(r, v) = (\underline{\text{i}}, v)$;

  else if $([o \neq root(o)$ **and** $parent(o) \neq root(o)$ **and** $parent(o) \in b(s_1{:}\underline{\text{w}})]$ **or**

  $[parent(o) = root(o)$ **and** $canallow(s_1, o, v)\ ]$ **or**

  $[o = root(o)$ and $canallow(s_1, o, v)\ ])$

  then $\rho_6(r, v) = (\underline{\text{y}}, (b, m \wedge m[s_2, o] \leftarrow \underline{\text{r}}, f, h))$;

  else $\rho_1(r, v) = (\underline{\text{n}}, v)$;

Security of Rule

- The *give-read* rule preserves the simple security condition, the *-property, and the ds-property

  Proof:

  - Let v satisfy all conditions. Let $\rho_1(r, v) = (d, v')$.
  - If $v' = v$, result is trivial.
  - So let $v' = (b, m[s_2, o] \leftarrow \underline{r}, f, h)$.
  - Then $b' = b$, $f' = f$, $m[x, y] = m'[x, y]$ for all $x \in S$ and $y \in O$ such that $x \neq s$ and $y \neq o$, and $m[s, o] \subseteq m'[s, o]$.
  - And by earlier result, v' satisfies the simple security condition, the *-property, and the ds-property.