# ECS 235B Module 31
# Role-Based Access Control

# Role-Based Access Control

- Access depends on function, not identity
  - Example:
    - Allison, bookkeeper for Math Dept, has access to financial records.
    - She leaves.
    - Betty hired as the new bookkeeper, so she now has access to those records
  - The role of “bookkeeper” dictates access, not the identity of the individual.

# Definitions

- Role *r*: collection of job functions
  - *trans*(*r*): set of authorized transactions for *r*
- Active role of subject *s*: role *s* is currently in
  - *actr*(*s*)
- Authorized roles of a subject *s*: set of roles *s* is authorized to assume
  - *authr*(*s*)
- *canexec*(*s*, *t*) iff subject *s* can execute transaction *t* at current time

# Axioms

Let $S$ be the set of subjects and $T$ the set of transactions.

- *Rule of role assignment*: $(\forall s \in S)(\forall t \in T)\ [canexec(s, t) \rightarrow actr(s) \neq \varnothing]$.
  - If *s* can execute a transaction, it has a role
  - This ties transactions to roles
- *Rule of role authorization*: $(\forall s \in S)\ [actr(s) \subseteq authr(s)]$.
  - Subject must be authorized to assume an active role (otherwise, any subject could assume any role)

# Axiom

- *Rule of transaction authorization*:

$$(\forall s \in S)(\forall t \in T)\ [canexec(s, t) \rightarrow t \in trans(actr(s))].$$

  - If a subject *s* can execute a transaction, then the transaction is an authorized one for the role *s* has assumed

# Containment of Roles

- Trainer can do all transactions that trainee can do (and then some). This means role $r$ contains role $r'$ ($r > r'$). So:
  - $(\forall s \in S)[\, r \in authr(s) \land r > r' \rightarrow r' \in authr(s)\, ]$

# Separation of Duty

- Let $r$ be a role, and let $s$ be a subject such that $r \in auth(s)$. Then the predicate $meauth(r)$ (for mutually exclusive authorizations) is the set of roles that $s$ cannot assume because of the separation of duty requirement.
- Separation of duty:

$$(\forall r_1, r_2 \in R)\ [\ r_2 \in meauth(r_1) \rightarrow [\ (\forall s \in S)\ [\ r_1 \in authr(s) \rightarrow r_2 \notin authr(s)\ ]\ ]\ ]$$

# RBAC Hierarchy

- $RBAC_0$: basic model (you just saw it)
- $RBAC_1$: adds role hierarchies to $RBAC_0$
- $RBAC_2$: adds constraints to $RBAC_0$
- $RBAC_3$: adds both role hierarchies, constraints to $RBAC_0$
  - It combines $RBAC_1$ and $RBAC_2$

# $RBAC_0$, Formally

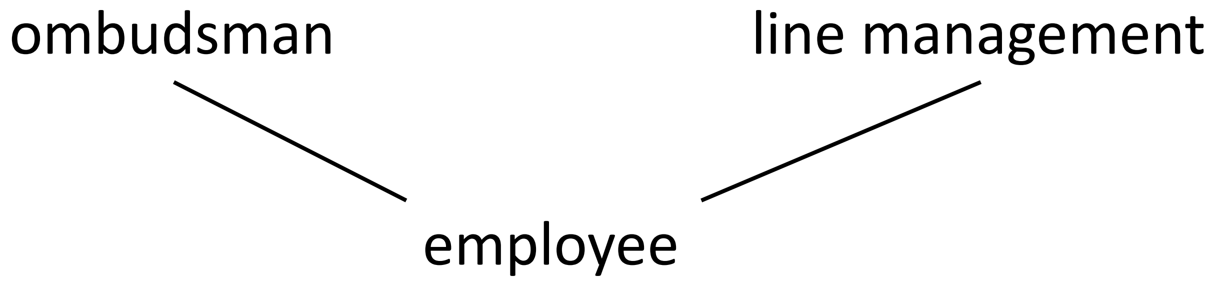
- Set of users $U$, roles $R$, permissions $P$, sessions $S$
- Relation $PA \subseteq P \times R$ mapping permissions to roles
- Relation $UA \subseteq U \times R$ mapping users to roles
- Function *user*: $S \rightarrow U$ mapping each session to a user
- Function *roles*: $S \rightarrow 2^R$ mapping each session $s \in S$ to a set of roles $roles(s) \subseteq \{ r \in R \mid (user(s), r) \in UA \}$, where $s$ has permissions

$$\cup_{r \in roles(s)} \{ p \in P \mid (p, r) \in PA \}$$

  - When a user assumes role *r* during session, *r* and hence the user assuming *r* gets the set of permissions associated with *r*

# $RBAC_1$, Intuitively

- Add containment of roles to $RBAC_0$ (this is the hierarchy)
  - It's a partial ordering
- Each role less powerful than its containing role
  - Containing role contains job functions (permissions) of the contained role
- Can define *private roles* in which one role is subordinate to two others, and those two are not related



# RBAC$_1$, Formally

- Set of users $U$, roles $R$, permissions $P$, sessions $S$
- Partial order $RH \subseteq R \times R$
  - Write $(r_1, r_2) \in R$ as $r_1 \geq r_2$
- Relation $PA \subseteq P \times R$ mapping permissions to roles
- Relation $UA \subseteq U \times R$ mapping users to roles
- Function *user*: $S \rightarrow U$ mapping each session to a user
- Function *roles*: $S \rightarrow 2^R$ mapping each session s $\in S$ to a set of roles $roles(s) \subseteq \{ \text{r} \in \text{R} \mid (\exists r' \geq r)(user(s), r') \in UA \}$, where $s$ has permissions

$$\bigcup_{r \in roles(s)} \{ p \in P \mid (\exists r'' \geq r)( p, r'') \in PA \}$$

  - When a user assumes role *r* with subordinate role *r'* during session, *r* and hence the user assuming *r* gets the set of permissions associated with *r*, and hence with *r'*

# $RBAC_2$ and $RBAC_3$

- $RBAC_2$ adds constraints on values that components can assume to $RBAC_0$
  - Example: user can be in only one role at a time
  - Example: make 2 roles mutually exclusive
- $RBAC_3$ provides both role hierarchies and constraints that determine allowable values for relations and functions
  - Combines $RBAC_1$ and $RBAC_2$
- Can be extended to manage role and privilege assignments
  - A set of administrative roles *AR* and permissions *AP* defined disjointly from *R* and *P*
  - Constraints allow $ap \in AP$ to be assigned to $ar \in AR$ only, and $p \in P$ to $r \in R$ only

# Role Engineering

- *Role engineering*: defining roles and determining needed permissions
- Often used when two organizations using RBAC merge
  - Roles in one organization rarely overlap with roles in other
  - Job functions often do overlap
- *Role mining*: analyzing existing roles, permission assignments to determine optimal assignment of permissions to roles
  - *NP*-complete, but in practice optimal solutions can be approximated or produced