ECS 235B Module 30
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:

  $(\forall s \in S)[\ r \in authr(s) \wedge r > r' \rightarrow r' \in authr(s)\ ]$

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

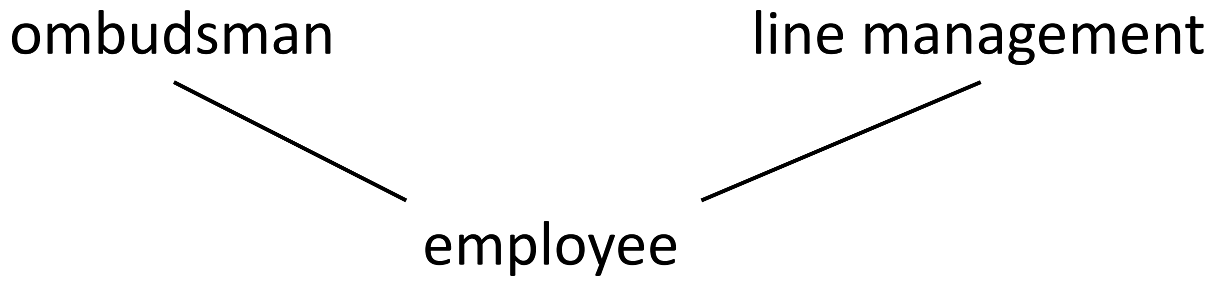
- Set of users U, roles R, permissions P, sessions S
- Relation $PA \subseteq P \times R$ mapping permissions to roles
- Relation $UA \subseteq U \times R$ mapping users to roles
- Function *user*: $S \rightarrow U$ mapping each session to a user
- Function *roles*: $S \rightarrow 2^R$ mapping each session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

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

  - 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 $roles(s) \subseteq \{ \mathrm{r} \in \mathrm{R} \mid (\exists r' \geq r)(user(s), r') \in UA \}$, where s has permissions

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

  - 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

Quiz

Which of the following best describes the difference between roles and the notion of user groups?

1. Roles are tied to job functions; user groups are tied to specific projects
2. There is no difference; the two are the same
3. Roles are tied to specific projects; user groups can include any user
4. Roles are tied to job functions; user groups are not