CS590U

Access Control: Theory and Practice

Lecture 11 (February 15)

Role Based Access Control

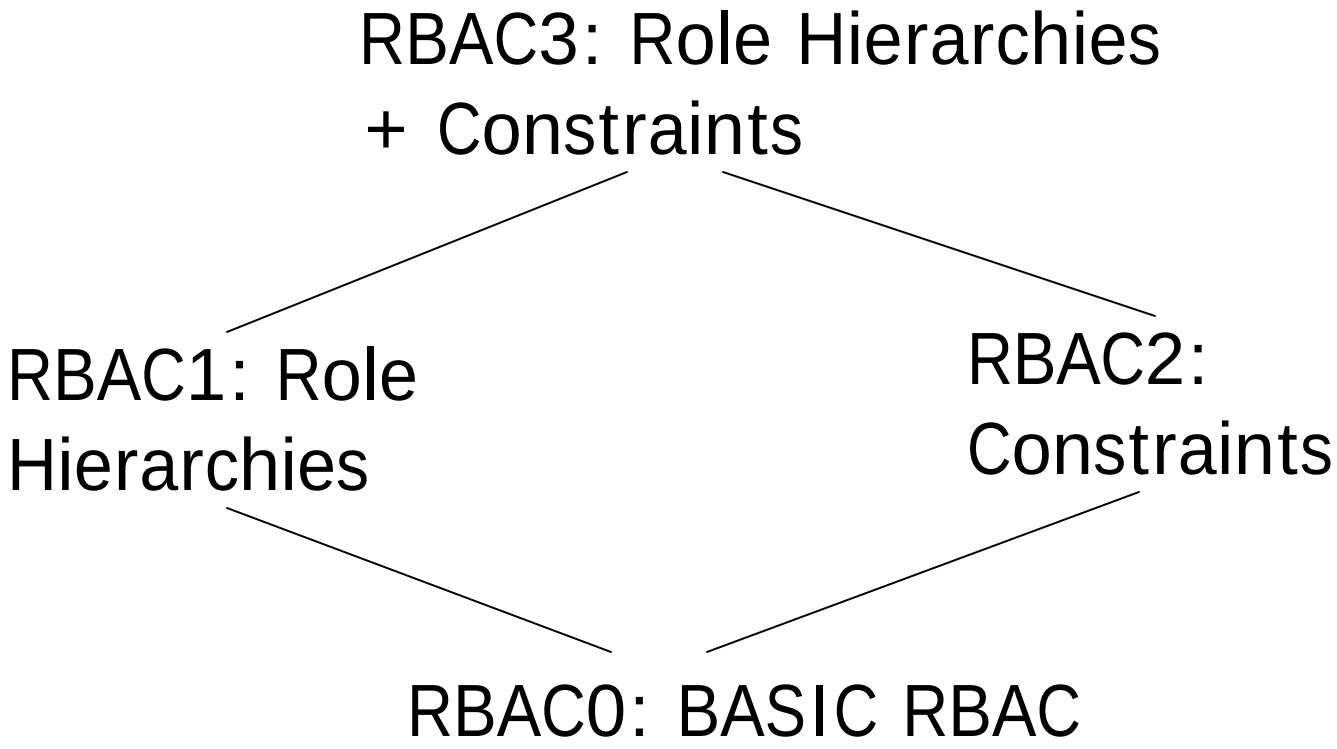
Role-Based Access Control Models.

R.S. Sandhu, E.J. Coyne, H.L. Feinstein, and C.E. Youman.

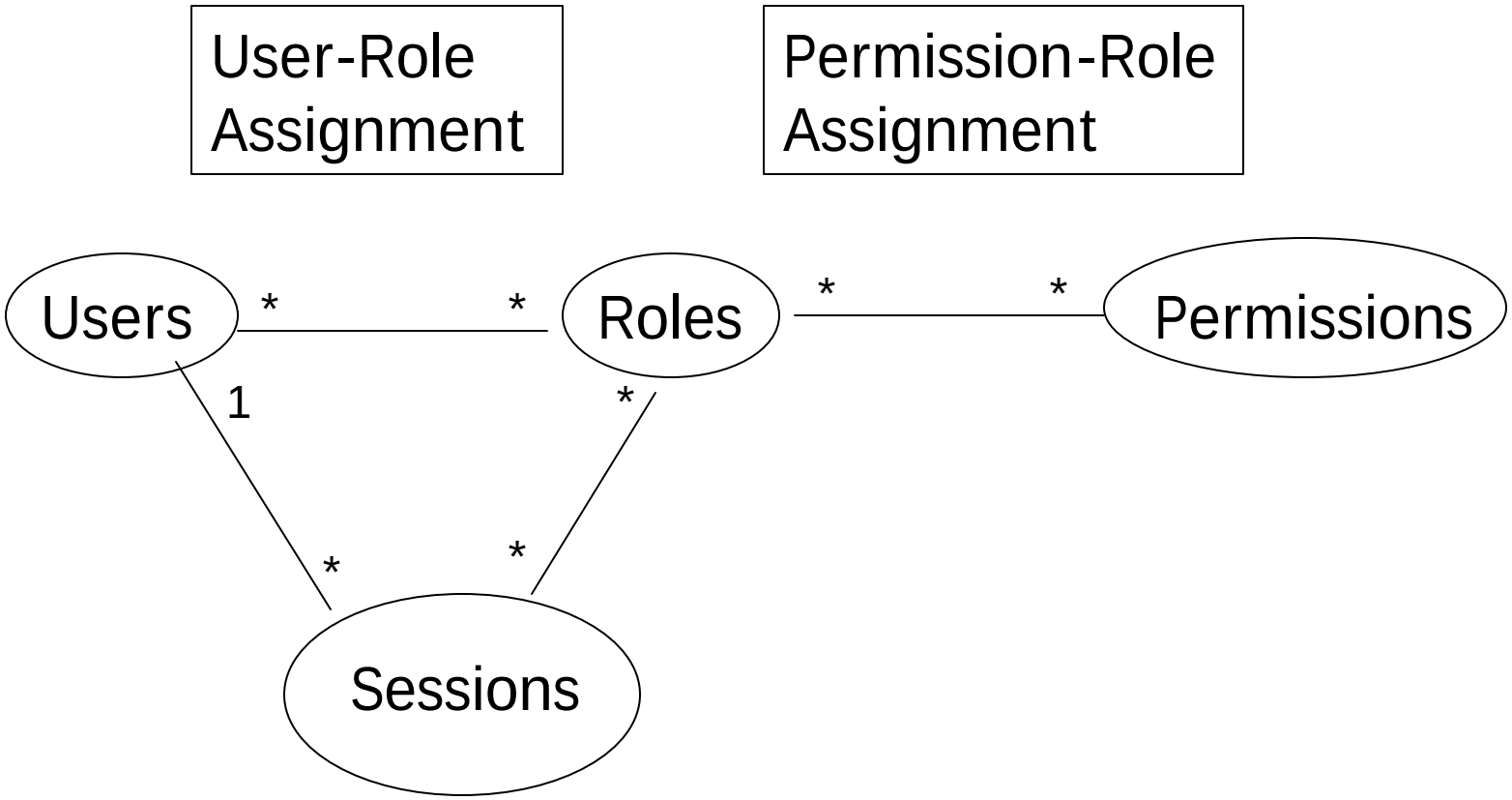
IEEE Computer, 29(2):38--47, February 1996.

- The most cited paper in access control
  - 691 citations on google scholar

RBAC96 Family of Models



RBAC0


User-Role Assignment
Permission-Role Assignment
Users
Roles
Permissions
Sessions
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RBAC0: Formal Model

- U, R, P, S (users, roles, permissions, and sessions)
- $PA \subseteq P \times R$ (permission assignment)
- $UA \subseteq U \times R$ (user assignment)
- user: $S \rightarrow U$
- roles: $S \rightarrow 2^R$
  - requires $roles(s) \subseteq \{ r \mid (user(s), r) \in UA \}$

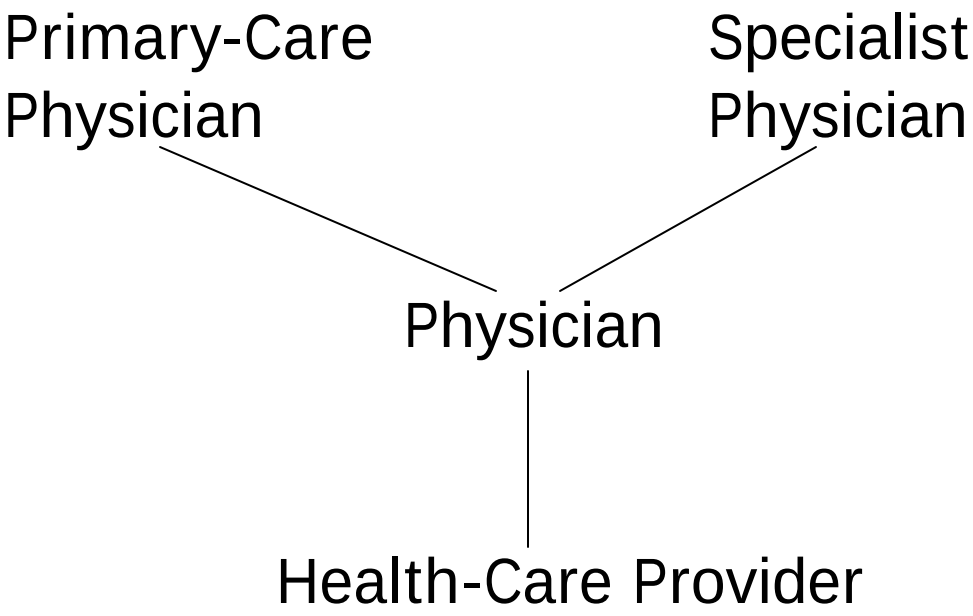
Session s has permissions

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

Why RBAC

- Fewer relationships to manage
  - from O(mn) to O(m+n), where m is the number of users and n is the number of permissions
- Roles add a useful level of indirection

RBAC1: RBAC0+ Role Hierarchies



RBAC1: Formal Model

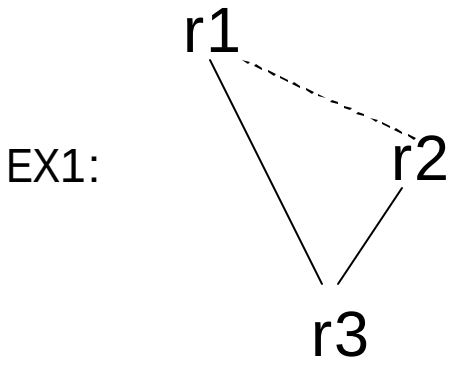
- U, R, R, S, PA, UA, and user unchanged from RBAC0
- RH $\subseteq$ R × R : a partial order on R, written as $\geq$
- roles: S $\rightarrow 2^R$
  - requires roles(s) $\subseteq$
    { r | $\exists$ r' [(r' $\geq$ r) & (user(s), r') $\in$ PA] }

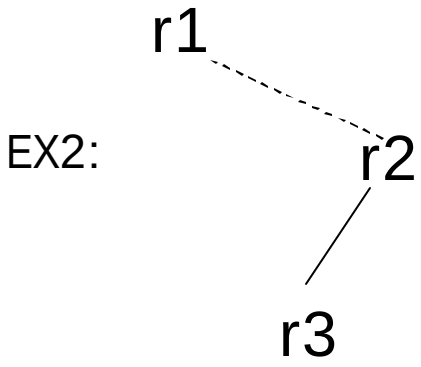
Session s has permissions

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

On Modeling Role Hierarchy As A Partial Order

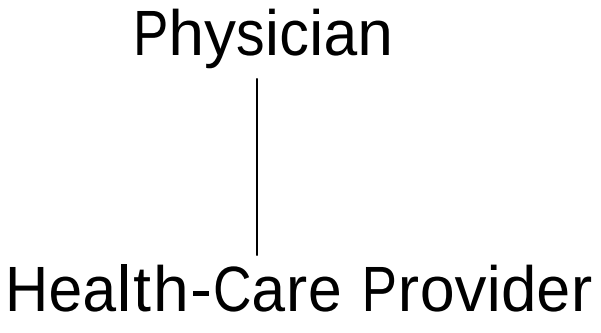
- Modeling RH as a partial order may miss some important information
- Consider the two examples to the right
  - where the dashed edge is added and removed
- Better approach seems to remember the base edges and then compute their transitive and reflexive closure





Semantics of Role Hierarchies

- User inheritance
  - r1≥r2 means every user that is a member of r1 is also a member of r2
- Permission inheritance
  - r1≥r2 means every permission that is authorized for r2 is also authorized r1
- Activation inheritance
  - r1≥r2 means that activating r1 will also activate r2



RBAC2: RBAC0 + Constraints

- No formal model specified
- A list of examples are given

Static Mutual Exclusion Constraints

- Two mutually exclusive roles: cannot both have the same user as members
- Two mutually exclusive roles: cannot both have the same permissions
  - why?
- Two mutually exclusive permissions: one role cannot have both permissions
  - why?

Cardinality Constraints

- On User-Role Assignment
  - at most k users can belong to the role
  - at least k users must belong to the role
  - exactly k users must belong to the role
- On activation
  - at most k users can activate a role
  - ...

Why Using Constraints?

- For laying out higher level organization policy
  - simply a convenience when admin is centralized
  - a tool to enforce high-level policies when admin is decentralized

RBAC3

- RBAC0 + Role Hierarchies + Constraints

Some Issues in RBAC

Whether to Allow Multiple Roles to be Activated?

- RBAC96 allows this
- [Baldwin'90] does not
- Observations:
  - one can define new role to achieve the effect of activating multiple roles
  - dynamic constraints are implicit when only one role can be activated in a session

What is a Role?

- A set of users
- A set of permissions (named protection domains)
- A set of users and permissions
- Also affects how to interpret role hierarchies
- Maybe it is useful to have both roles and groups?

Roles vs. Groups

- What are the differences?
  - Answer 1: groups are sets of users, and roles are sets of users as well as permissions
    - doesn’t seem to be true.
  - Answer 2: one can activate and deactivate roles, but cannot deactivate groups
    - seems unimportant unless there is negative authorization
  - Answer 3: one can enumerate permissions that a role has
    - seems an implementation issue

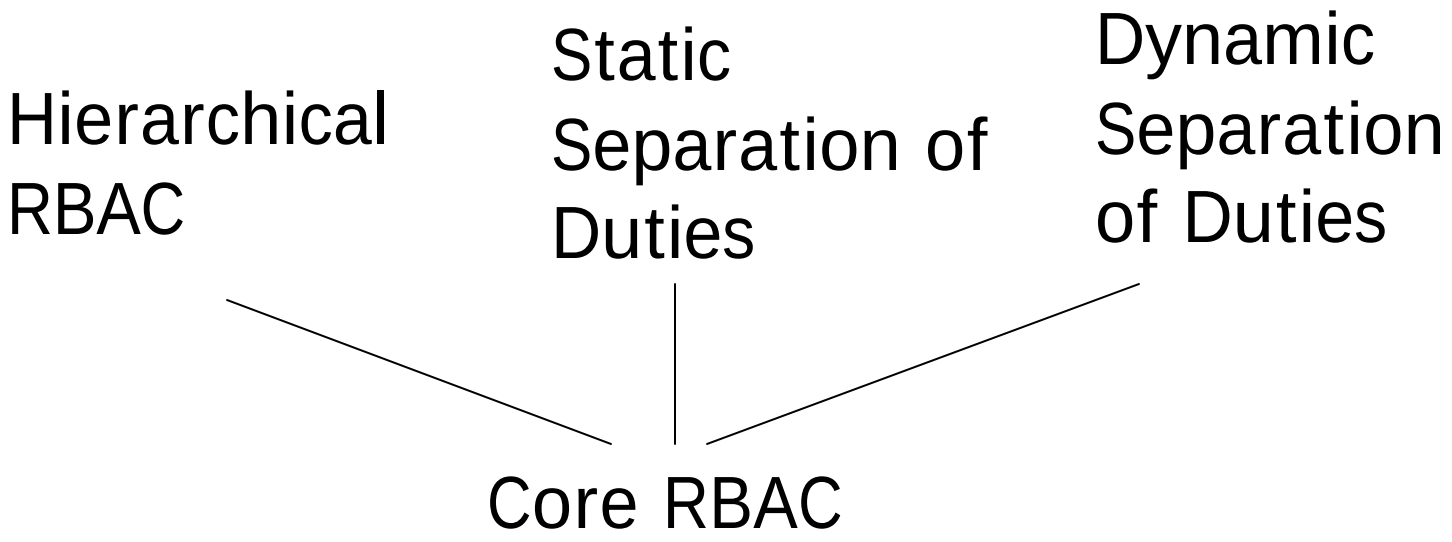
Everything as an attribute?

- Some attributes are more intrinsic about properties of a user
- Some attributes are more intrinsic about job functionalities

The NIST Standard

- Proposed NIST Standard for Role-Based Access Control. David F. Ferraiolo, Ravi S. Sandhu, Serban I. Gavrila, D. Richard Kuhn, and Ramaswamy Chandramouli. TISSEC, August 2001.
- ANSI Standard

Overview of the NIST Standard for RBAC



Core RBAC (1)

- *USERS*
- *ROLES*
- *OBS*
- *OPS*
- $PRMS = 2^{(OPS \times OBS)}$
  - $Op : (p: PRMS) \rightarrow 2^{OPS}$
  - $Ob : (p: PRMS) \rightarrow 2^{OBS}$

Core RBAC (2)

- $UA \subseteq USERS \times ROLES$
  - $assigned\_users : (r : Roles) \rightarrow 2^{USERS}$
- $PA \subseteq PRMS \times ROLES$
  - $assigned\_permissions : (r : Roles) \rightarrow 2^{PRMS}$

Core RBAC (3)

- *SESSIONS*
- *session_users* : (*s* :*SESSIONS*) $\rightarrow$*USERS*
  - *user_sessions* : (*u* :*USERS*) $\rightarrow 2^{SESSIONS}$
- *session_roles* : (*s* :*SESSIONS*) $\rightarrow 2^{ROLES}$
  - *avail_session_perms* : (*s* :*SESSIONS*) $\rightarrow 2^{PRMS}$

Hierarchical RBAC: Generalized Role Hierarchies

- $RH \subseteq ROLES \times ROLES$
  - user inheritance & permission inheritance
  - we say r_1 inherits r_2 if $r_1 \geq r_2$
- $authorized\_users : (r : Roles) \rightarrow 2^{USERS}$
- $authorized\_permissions : (r : Roles) \rightarrow 2^{PRMS}$

Hierarchical RBAC: Limited Role Hierarchies

- Role Hierarchies with the limitation that each role has at most one immediate senior
  - Role hierarchies form a forest

Constrained RBAC: Motivations

- Example of SoD
  - The following duties shall be performed by different individuals:
    1. Check request reviewer
    2. Check preparer
    3. Check issuer
    4. Check deliverer
    5. Ledger reviewer

Constrained RBAC: Static SoD

- $SSD \subseteq (2^{ROLES} \times \mathrm{N})$ is a collection of pairs (rs, n)
  - rs: a role set
  - n: $n \geq 2$ is a natural number
- For each (rs, n), no user is authorized for n or more roles in rs

SoD with Role Hierarchies

- Two roles can be mutually exclusive only if neither one inherits the other
- If two roles are mutually exclusive, no role can inherit from both
- If two roles are mutually exclusive, there can be no “root” or “super user”.

Constrained RBAC: Dynamic SoD

- $DSD \subseteq (2^{ROLES} \times \mathrm{N})$ is a collection of pairs (rs, n)
  - rs: a role set
  - n: $n \geq 2$ is a natural number
- For each (rs, n), no user is allowed to activate n or more roles in rs in one session

Functional Specifications

- Administrative functions
- Supporting system functions
- Review functions

Old Slides From Fall 2003

SoD and Permission Assignments (1)

- Mutually exclusive roles is a means rather than an end
- SoD is the goal:
  - no single user possesses all the permissions needed to accomplish a sensitive task

SoD and Permission Assignments (2)

- A permission assignment problem
  - Giving a set of tasks where each task requires a set of permissions, assign permissions to roles such that no single role has access to all permissions required by any task
  - Graph coloring problem

A Project Topic (1)

- How do we know SoD goals has been achieved by constraints?
  - sensitive tasks and the permissions they require need to be identified
- SoD may be more complicated
  - a sensitive task may be completed by a user having some property

A Project Topic (2)

- Tasks:
  - Design a language to specify SoD objectives.
  - Given SoD objectives and permission assignments, verify that constraints satisfy the objectives.
  - Assume a fixed permission assignments, generate mutually exclusive constraints to satisfy the SoD objectives.

Next Lecture

- On SSoD policies and SMER constraints