Access control models

Access types

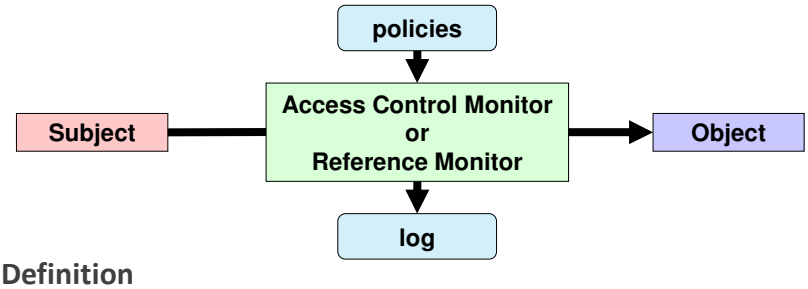
Physical access

- Physical contact between a subject and the object of interest
  - Facility, room, network, computer, storage device, authentication token, etc.
- Out of scope of this course …

Informatic or electronic access

- Information-oriented contact between a subject and the object of interest
  - Contact through request-response dialogs
- Contact is mediated by
  - Computers and networks
  - Operating systems, applications, middleware, devices, etc.

Access control



Definition

- Policies and mechanisms that mediate the access of a subject to an object

Normal requirements

- Authentication
  - With some Level of Assurance (LoA)
- Authorization policies
- Accountability ➔ logging

AAA

Access control

Subjects and objects: Both digital entities

Subjects are something exhibiting activity:

- Processes
- Computers
- Networks

Objects are the target of an action:

- Stored data
- CPU time
- Memory
- Processes
- Computers
- Networks

An entity can be both subject and object

Least privilege principle

Every program and every user of the system should operate using the least set of privileges necessary to complete the job

J. H. Saltzer, M. D. Schroeder,
The protection of information in computer systems, Proc. of the IEEE, 63(9) 1975

Privilege:

- Authorization to perform a given task
- Similar to access control clearance

Each subject should have, at any given time, the exact privileges required to the assigned tasks

- Less privileges than the required create unsurpassable barriers
- More privileges than the required create vulnerabilities
  - Damage resulting from accidents or errors
  - Potential interactions among privileged programs
  - Misuse of a privileges
  - Unwanted information flows
    - "need-to-know" military restrictions

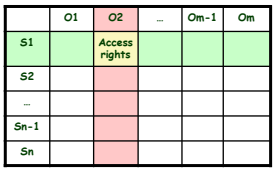
Access control models

	O1	O2	…	Om-1	Om
S1		Access rights			
S2					
…					
Sn-1					
Sn					

Access control matrix

- Matrix with all access rights for subjects relatively to objects
- Conceptual organization

Access control models



ACL-based mechanisms

- ACL: Access Control List
- Matrix column

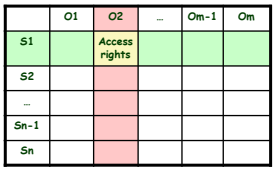
List of access rights for specific subjects

- Access rights can be positive or negative
- Default subjects may often be used

Usually, ACLs are stored along with objects

- e.g., for file system objects

Access control models



Capability-based mechanisms

- Capability: unforgeable authorization token
- Matrix row
- Contains object references and access rights

Access granting

- Transmission of capabilities between subjects
- Mediated / non-mediated

Usually, capabilities are kept by subjects

- e.g., OAuth 2.0 access tokens

Access control kinds: MAC and DAC

Mandatory access control (MAC)

- Fixed access control policy implemented by the access control monitor
- Access control rights cannot be tailored by subjects or object owners

Discretionary access control (DAC)

- Some subjects can update rights granted or denied to other subjects for a given object
- Usually this is granted to object owners and system administrators

Access control kinds: Role-Based Access Control (RBAC)

D.F. Ferraiolo and D.R. Kuhn, "**Role Based Access Control**",
15th National Computer Security Conference, Baltimore, October 1992

Not DAC or MAC

- Roles are dynamically assigned to subjects
- For access control it matters the role played by the subject and not the subject's identity
  - Identity is mostly relevant for role access and logging

Access control binds roles to (meaningful) operations

- Operations are complex, meaningful system transactions
  - Not the ordinary, low-level read/write/execute actions on individual objects
- Operations can involve many individual lower-level objects

Access control kinds: RBAC rules (1/2)

Role assignment:

- All subject activity on the system is conducted through transactions
  - And transactions are allowed to specific roles
  - Thus, all active subjects are required to have some active role
- A subject can execute a transaction **iff** it has selected or been assigned a role which can use the transaction

Access control kinds: RBAC rules (2/2)

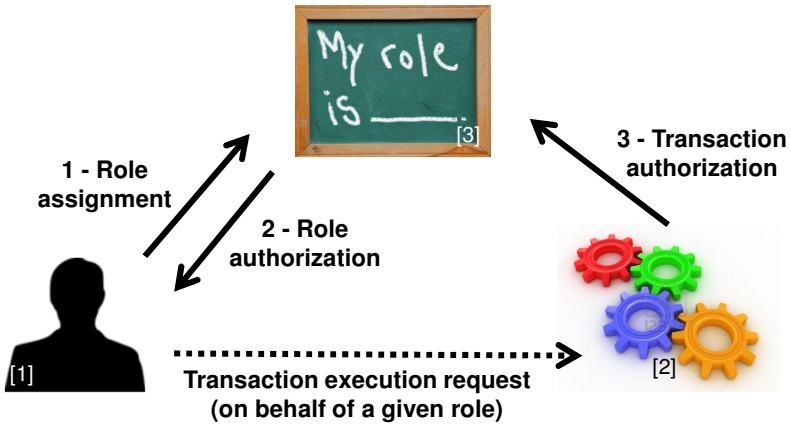
Role authorization:

- A subject's active role must be authorized for the subject

Transaction authorization:

- A subject can execute a transaction **iff**
  - the transaction is authorized through the subject's role memberships
- and
  - there are no other constraints that may be applied across subjects, roles, and permissions

RBAC rules



[1] From http://www.clker.com/clipart-24011.html
[2] From http://www.123rf.com/photo_12115593_three-dimensional-colored-toothed-wheels.html
[3] From http://www1.yorksolutions.net/Portals/115255/images/MyRoleIs.jpg

RBAC: Roles vs groups

Roles are a collection of permissions

- The permissions are granted to the subjects that, at a given instant, play the role
- A subject can (should) only play a role at a given time

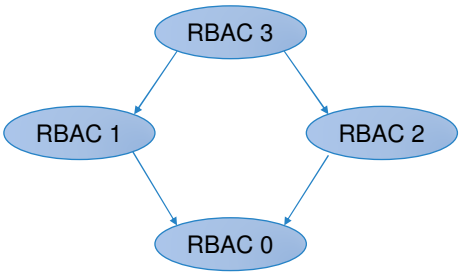
Groups are a collection of users

- And permissions can be granted both to users and groups
- A subject can belong to many groups at a given time

The session concept

- Role assignment is like a session activation
- Group membership is ordinarily a static attribute

RBAC variants



RBAC 0
- No role hierarchies
- No role constraints

RBAC 1
- RBAC 0 w/ role hierarchies (privilege inheritance)

RBAC 2
- RBAC 0 w/ role constraints (separation of duties)

RBAC 3
- RBAC 1 + RBAC 2

NIST RBAC model

Flat RBAC
- Simple RBAC model w/ **user-role review**

User-role review
Which users can have a role?
Role $\xrightarrow{?}$ users
Which roles can a user have?
User $\xrightarrow{?}$ roles

Hierarchical RBAC
- Flat RBAC w/ role hierarchies (DAG or tree)
- General and restricted hierarchies

Constraint RBAC
- RBAC w/ role constraints for separation of duty

Symmetric RBAC
- RBAC w/ **permission-role review**

Permission-role review
Which permissions has a role?
Role $\xrightarrow{?}$ permissions
Which roles have a permission?
Permission $\xrightarrow{?}$ roles

Access control kinds:

Context-Based Access Control (CBAC)

Access rights have an historical context

- The access rights cannot be determined without reasoning about past access operations
- Example:
  - Stateful packet filter firewall

Chinese Wall policy

- Conflict groups
- Access control policies need to address past accesses to objects in different members of conflict groups

D.F.C. Brewer and M.J. Nash,
"**The Chinese Wall Security Policy** ",
IEEE Symposium on Security and Privacy, 1989

Access control kinds:

Attribute-Based Access Control (ABAC)

Access control decisions are made based on attributes associated with relevant entities

OASIS XACML architecture

- Policy Administration Point (PAP)
  - Where policies are managed
- Policy Decision Point (PDP)
  - Where authorization decisions are evaluated and issued
- Policy Enforcement Point (PEP)
  - Where resource access requests are intercepted and confronted with PDP's decisions
- Policy Information Point (PIP)
  - Where the PDP gets external information

XACML:
Access control with PEP and PDP

A subject sends a request

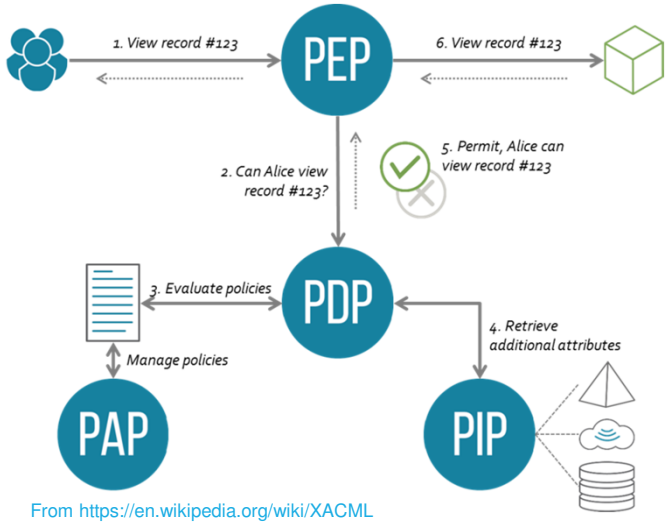
- Which is intercepted by the Policy Enforcement Point (PEP)
- The PEP sends an authorization request to the Policy Decision Point (PDP)

The PDP evaluates the authorization request against its policies and reaches a decision

- Which is returned to the PEP

- Policies are retrieved from a Policy Retrieval Point (PRP)
- Useful attributes are fetched from Policy Information Points (PIP)
- Policies are managed by the Policy Administration Point (PAP)

XACML big picture



From https://en.wikipedia.org/wiki/XACML

Break-the-glass access control model

In some scenarios it may be required to overcome the established access limitations

- e.g., in a life-threatening situation

In those cases, the subject may be presented with a break-the-glass decision upon a deny

- Can overcome the deny at their own responsibility
- Logging is fundamental to prevent abuses

Separation of duties

R.A. Botha, J.H.P. Eloff, "Separation of duties for access control enforcement in workflow environments", IBM Systems Journal, 2001

Fundamental security requirement for fraud and error prevention

- Dissemination of tasks and associated privileges for a specific business process among multiple subjects
- Often implemented with RBAC

Damage control

- Segregation of duties helps reducing the potential damage from the actions of one person
- Some duties should not be combined into one position

Segregation of duties:
ISACA (Inf. Systems Audit and Control Ass.) matrix guideline

Exhibit 2.9—Segregation of Duties Control Matrix

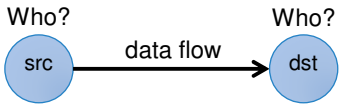
	Control Group	Systems Analyst	Application Programmer	Help Desk and Support Manager	End User	Data Entry	Computer Operator	Database Administrator	Network Administrator	Systems Administrator	Security Administrator	Systems Programmer	Quality Assurance
Control Group		X	X	X		X	X	X	X	X		X	
Systems Analyst	X			X	X		X				X		X
Application Programmer	X			X	X	X	X	X	X	X	X	X	X
Help Desk and Support Manager	X	X	X		X	X		X	X	X		X	
End User		X	X	X			X	X	X			X	X
Data Entry	X		X	X			X	X	X	X	X	X	
Computer Operator	X	X	X		X	X		X	X	X	X	X	
Database Administrator	X		X	X	X	X	X		X	X		X	
Network Administrator	X		X	X	X	X	X	X					
System Administrator	X		X	X		X	X	X				X	
Security Administrator		X	X			X	X					X	
Systems Programmer	X		X	X	X	X	X	X		X	X		X
Quality Assurance		X	X		X							X	

X—Combination of these functions may create a potential control weakness.

Information flow models

Authorization is applied to data flows

- Considering the data flow source and destination
- Goal: avoid unwanted/dangerous information flows



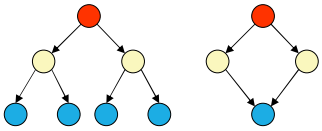
Src and Dst security-level attributes

- Information flows should occur only between entities with given security level (SL) attributes
- Authorization is given based on the SL attributes

Multilevel security

Subjects (or roles) act on different security levels

- Levels do not intersect themselves
- Levels have some partial order
  - Hierarchy
  - Lattice



Levels are used as attributes of subjects and objects

- Subjects: security level clearance
- Objects: security classification

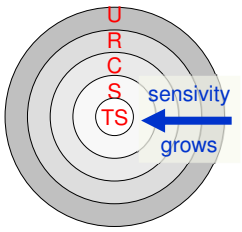
Information flows & security levels

- Same security level → authorized
  - Still, subject to a "need to know"
- Different security levels → controlled

Multilevel security levels: Military / Intelligence organizations

Typical levels

- Top secret
- Secret
- Confidential
- Restricted
- Unclassified



Portugal (NTE01, NTE04)

- Muito Secreto
- Secreto
- Confidencial
- Reservado

EU example

- EU TOP SECRET
- EU SECRET
- EU CONFIDENTIAL
- EU RESTRICTED
- EU COUNCIL / COMMISSION

NATO example

- COSMIC TOP SECRET (CTS)
- NATO SECRET (NS)
- NATO CONFIDENTIAL (NC)
- NATO RESTRICTED (NR)

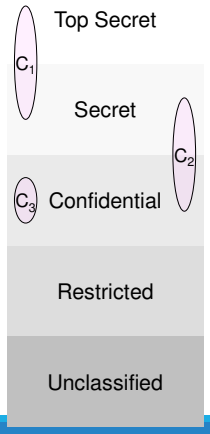
Security categories (or compartments)

Self-contained information environments
- May span several security levels

Military environments
- Military branches, military units

Civil environments
- Departments, organizational units

An object can belong to different compartments and have a different security classification in each of them
- (top-secret, crypto), (secret, weapon)

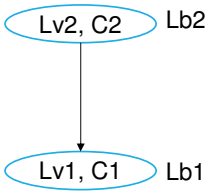


Security labels

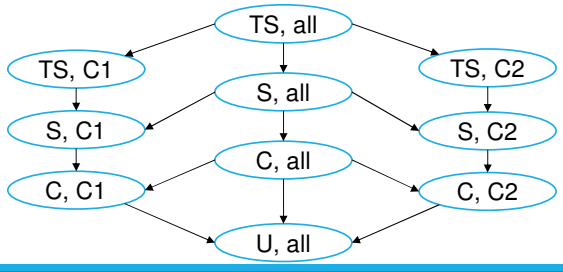
Label = Category + Level

Relative order between labels

$Lb1 \leq Lb2 \Rightarrow C1 \subseteq C2 \wedge Lv1 \leq Lv2$



Labels form a lattice



Bell-La Padula MLS Model

D. Elliott Bell, Leonard J. La Padula, "**Secure Computer Systems: Mathematical Foundations**", MITRE Tech. Report 2547, Volume I, 1973

Access control policy for controlling information flows
- Addresses data confidentiality and access to classified information
- Addresses disclosure of classified information
  - Object access control is not enough
  - One needs to restrict the flow of information from a source to authorized destinations

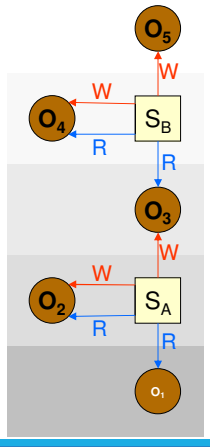
Uses a state-transition model
- In each state there are subjects, objects, an access matrix and the current access information
- State transition rules
- Security levels and clearances
  - Objects have a security labels
  - Subjects have security clearances
  - Both refer to security levels (e.g., CONFIDENTIAL)

Bell-La Padula MLS Model: Secure state-transition model

Simple security condition (no read up)
- S can read O iff L(S) ≥ L(O)

***-property (no write down)**
- S can write O iff L(S) ≤ L(O)
- aka confinement property

Discretionary Security Property
- DAC-based access control



Biba Integrity Model

K. J. Biba, "**Integrity Considerations for Secure Computer Systems**", MITRE Technical Report 3153, The Mitre Corporation, April 1977

Access control policy for controlling information flows

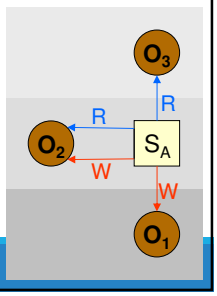
- For enforcing data integrity control
- Uses integrity levels, not security levels
- Similar to Bell-La Padula, with inverse rules

Simple Integrity Property (no read down)

- S can read O iff I(S) ≤ I(O)

Integrity *-Property (no write up)

- S can write O iff I(S) ≥ I(O)



Windows mandatory integrity control

Allows mandatory (priority and critical) access control enforcement prior to evaluate DACLs

- If access is denied, DACLs are not evaluated
- If access is allowed, DACLs are evaluated

Integrity labels

- Untrusted
- Low (or AppContainer)
- Medium
- Medium Plus
- High
- System
- Protected Process

Windows mandatory integrity control

Users

- Medium: standard users
- High: elevated users

Process integrity level

- The minimum associated to the owner and the executable file
- User processes usually are Medium or High
  - Except if executing Low-labeled executables
- Service processes: High

Windows mandatory integrity control

Securable objects mandatory label

- NO_WRITE_UP (default)
- NO_READ_UP
- NO_EXECUTE_UP