Access Control Models

SIO

deti universidade de aveiro
departamento de eletrónica, telecomunicações e informática

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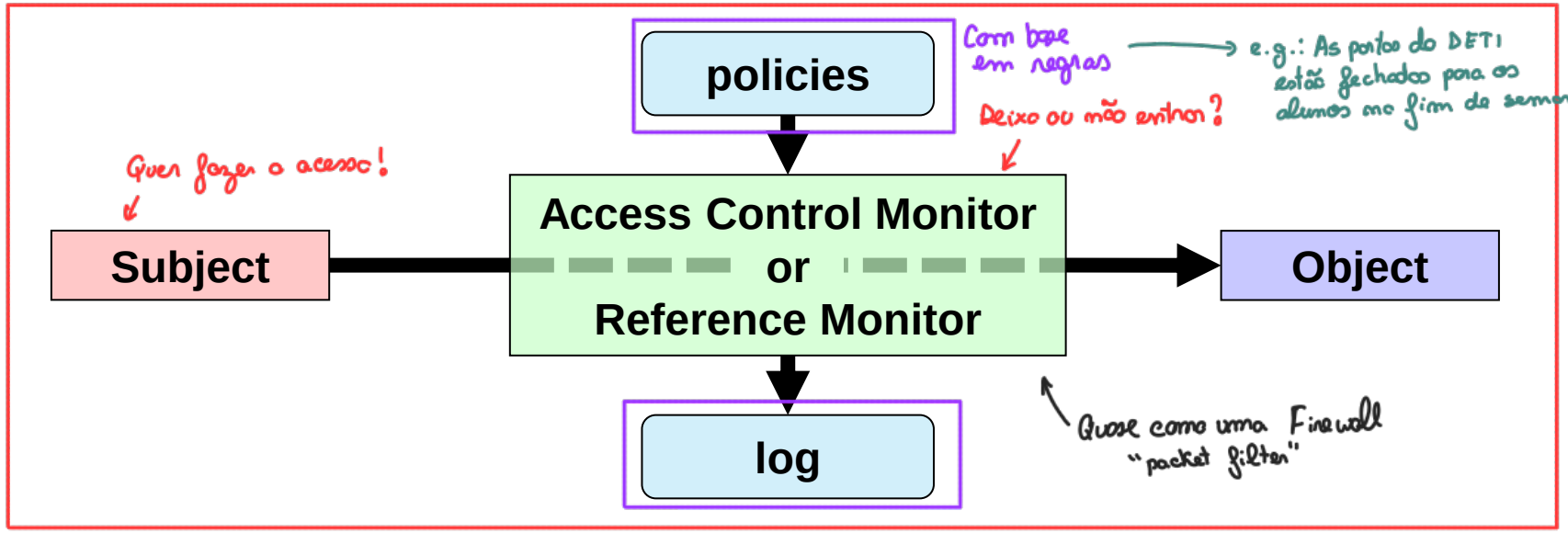
Access types

- 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 ← Quem está a fazer o pedido
    - With some Level of Assurance (LoA)
  - Authorization policies
  - Accountability → logging

Regras: são a passagem para algo escrito (concreto) de uma política!

Políticos: decisões de alto nível, não definem como fazer!

→ AAA

Access control: Subjects and Objects

- Both are digital entities

- Subjects are something exhibiting activity:
  - Processes
  - Computers
  - Network elements

- Objects are targets of actions (resources):
  - Stored data
  - CPU time
  - Memory
  - Processes
  - Computers
  - Networks

Fork bomb já não manda o PC a baixo ...

- An entity can be both subject & object

Least privilege principle

Princípio do privilégio mínimo

"Every program and every user of the system should operate using the least set of privileges necessary to complete the job" → Nunca devemos trabalhar com privilégios superiores aos que precisamos!

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

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

- Subjects should have, at any time, the exact privileges required to their 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

e.g.: Trabalhando sempre com o root perigoso... é possível acabar com a máquina...

Não deve saber coisas que não precisa...

Access control models

"por objetos": ACLs

"por sujeitos": Capacidades

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

Apenas o conceito! (matrix conceptual)

OBJETOS

SUJEITOS

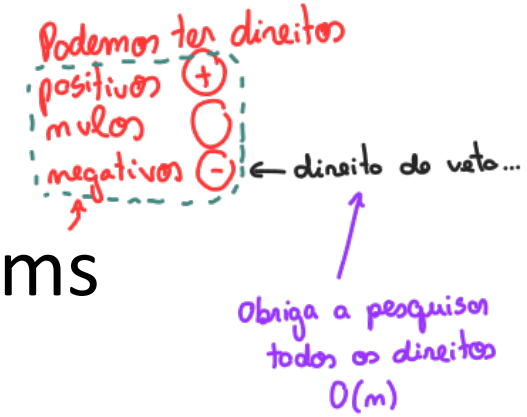
	O1	O2	...	Om-1	Om
S1		Access rights			
S2					
...					
Sn-1					
Sn					

Normalmente os direitos associados a um objeto são uma ACL
Access Control List

DIREITOS
positivos / nulos / negativos

Capacidade!
(guardado no token)
no Auth 2.0 vai no token...

Access control models



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

Para 1 objeto as permissões para os sujeitos

- 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

Este sujeito, tem vários permissões...

Nas linhas

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

- 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

Pode ir no token :)

Access control models: MAC and DAC

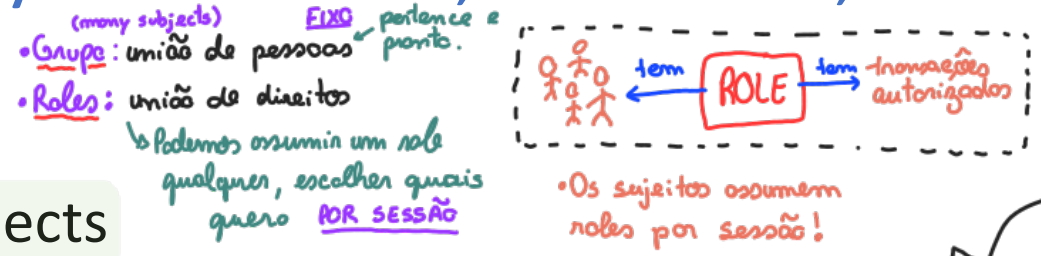
- Mandatory access control (MAC)
  - Fixed access control policy implemented by the access control monitor
  - Access control rights cannot be tailored by subjects or object owners
- Discretionary access control (DAC)
  - Some subjects can update rights granted or denied to other subjects for a given object
  - Usually this is granted to object owners and system administrators

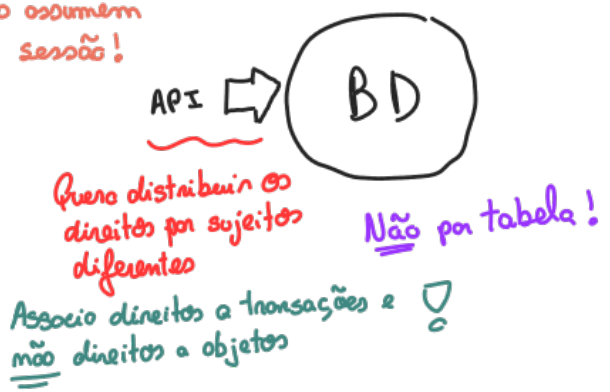
Access control models: Role-Based Access Control (RBAC)

Role-Based Access Control

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

- Not DAC or MAC
  - Roles are dynamically assigned to subjects
  - For access control what matters is 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

Não queremos redundância!

Access control models: RBAC 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

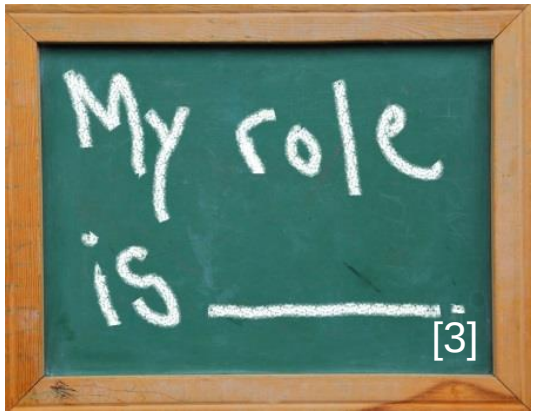
Access control models: RBAC role authorization

se ele pertencer à role ...

- A subject's active role must be authorized for the subject
  - In that case, the subject may assume the role

- 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

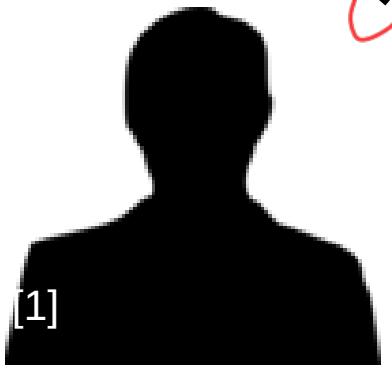


1 - Role assignment

2 - Role authorization

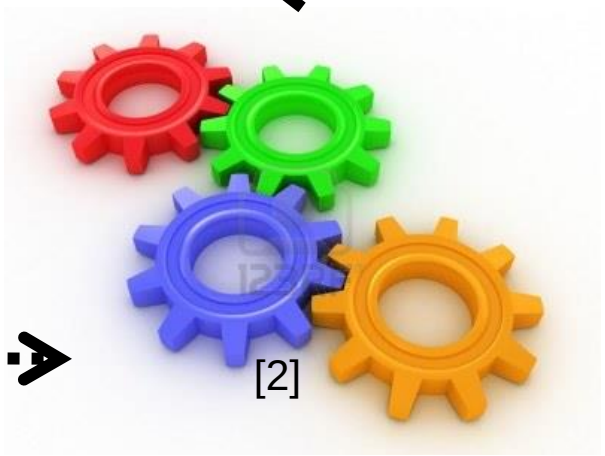
3 - Transaction authorization

Posso ficar com a role??


[1]

Transaction execution request (on behalf of a given role)

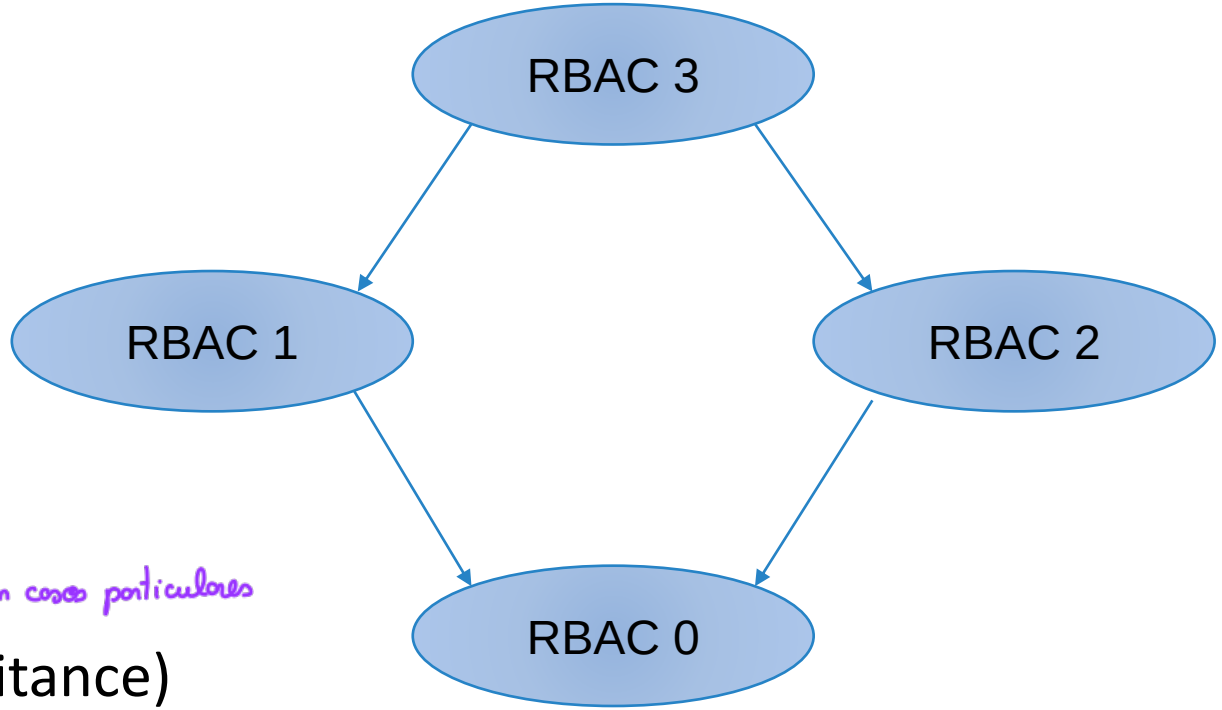
tenho permissão para esta transação


[2]

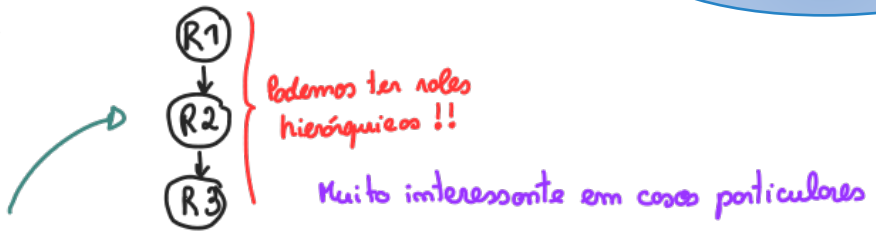
[1] From http://www.clker.com/clipart-24011.html
[2] From http://www.123rf.com/photo_12115593_three-dimensional-colored-toothed-wheels.html
[3] From http://www1.yorksolutions.net/Portals/115255/images/MyRoleIs.jpg

RBAC variants

Role-Based Access Control



- 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)

separação de deveres

Quem tem uma role não tem outra!

Separar os papeis entre todos os roles!
Evitar uma entidade a manipular a outra

- RBAC 3
  - RBAC 1 + RBAC 2

Hierarquia + Separação de deveres

"Quase como criar uma classe para cada conjunto de permissões e garantir condições"

Cashier / Auditor → A user cannot have both the "Cashier" and "Auditor" roles.

NIST RBAC model

TESTE ?

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

Poder de verificar qual a role que um utilizador tem, e quais pode assumir!

Revisão de 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

Separação de deveres

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

Dada uma permissão quais roles têm, e quais permissões tem uma role

Revisão de Permissão

"utilizador - papel"

User-role review

Which users can have a role?

Role $\xrightarrow{?}$ users

Which roles can a user have?

User $\xrightarrow{?}$ roles

"direito - papel"

Permission-role review

Which permissions has a role?

Role $\xrightarrow{?}$ permissions

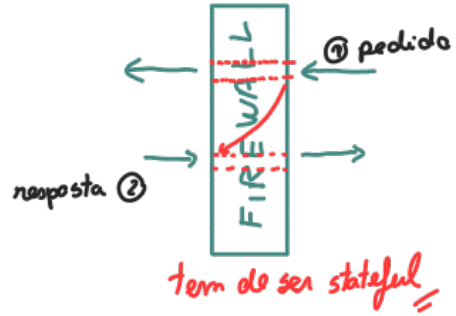
Which roles have a permission?

Permission $\xrightarrow{?}$ roles

Access control models: 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

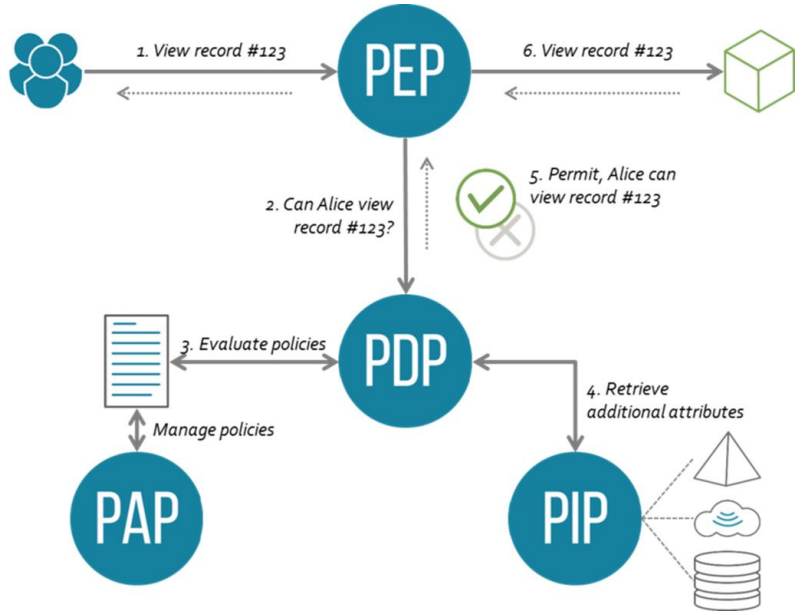


- Example: Chines Wall policy
  - Conflict groups
  - Access control policies need to address past accesses to objects from members of conflict groups

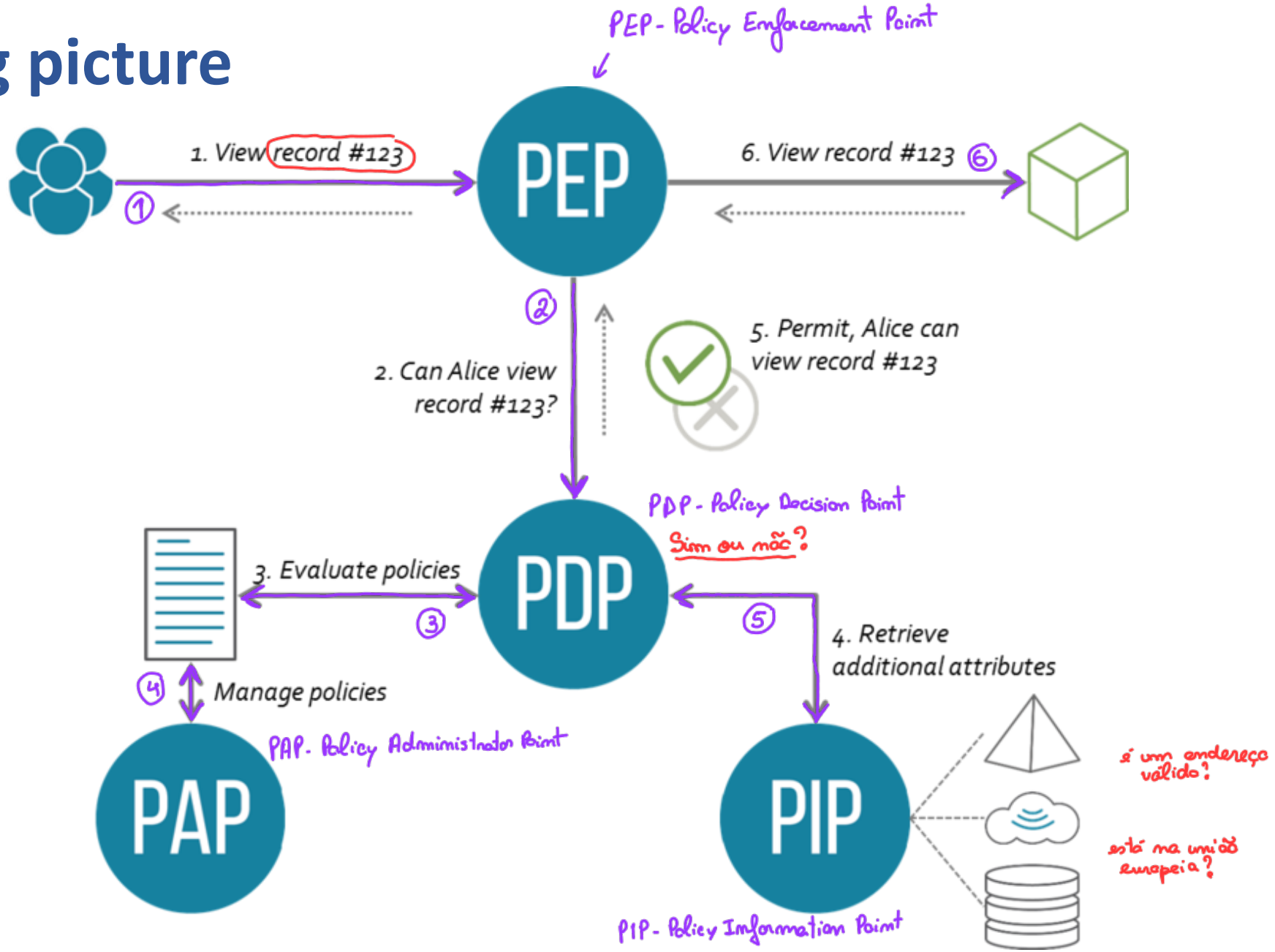
D.F.C. Brewer and M.J. Nash,
"The Chinese Wall Security Policy ",
IEEE Symposium on Security and Privacy, 1989

Access control models: 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 big picture



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)
  - With some subject's attributes
- 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)

Access control models: Break-the-glass

Emergência!

"eu quero ultrapassar a limitação"

"uma razão de força maior"

Políticos break-the-glass

- In some scenarios it may be required to overcome the established access limitations
  - e.g., in a life-threatening situation

um médico encontra uma pessoa desmaiada, precisa de ver o seu relatório clínico //

Ignorar a não permissão em casos excepcionais...

- 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 RBAC 2

- 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

Matrix de segregação de deveres

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.

Pode

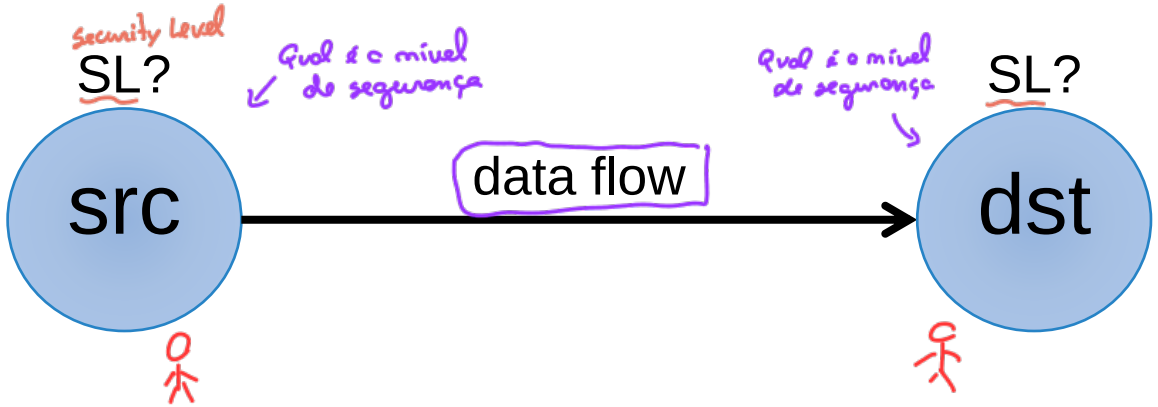
Não pode ser!

Information flow models

Quando falamos de MAC - Mandatory Access control pensamos misto:

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

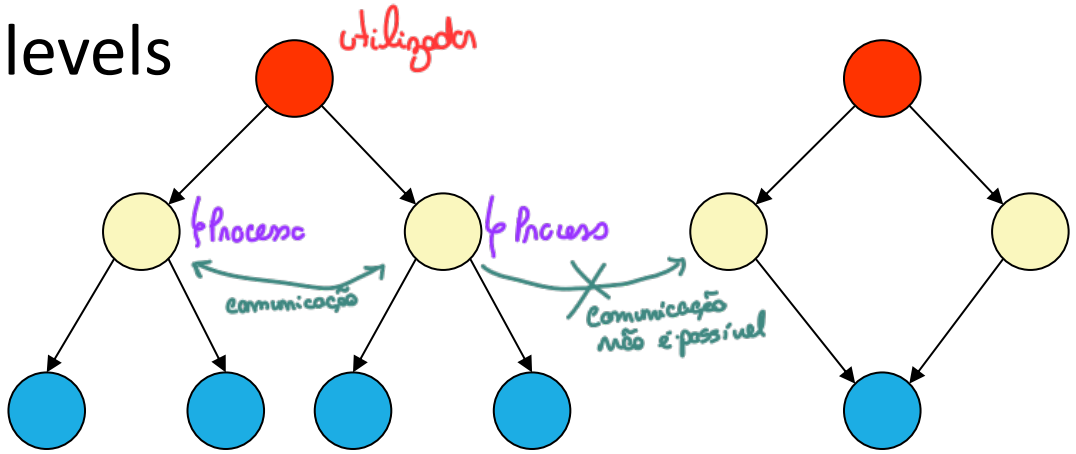
e.g.: Materia classificada em Portugal
→ Só podem ser acedidos por pessoas autorizadas
• Só pessoas com um determinado nível podem aceder!



- 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

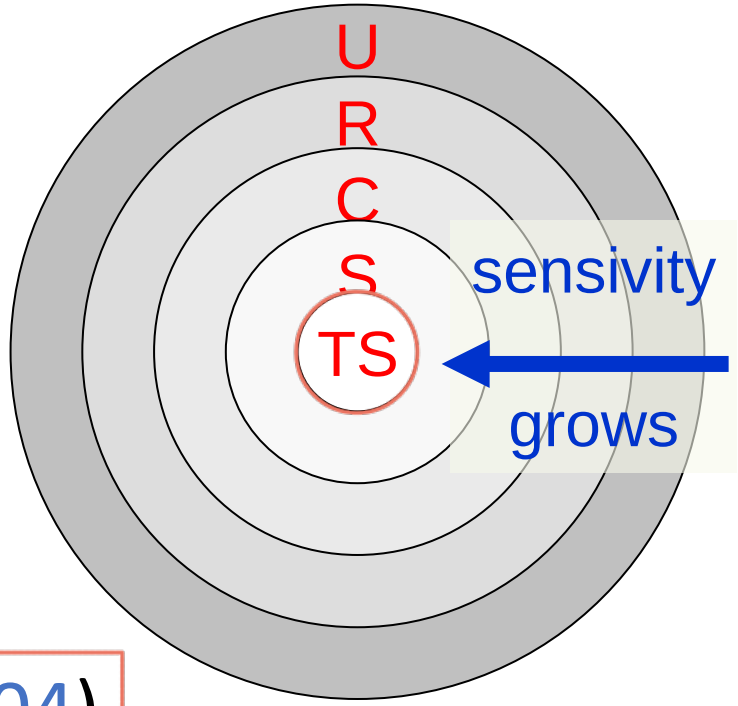


- Levels are used as attributes of subjects and objects
  - Subjects: security level clearance → credenciação
  - Objects: security classification
    ↑ Documentos físicos

- Information flows & security levels
  - Same security level → authorized
    - Still, restricted to a “need to know”
  - Different security levels → controlled

MS levels: Military / Intelligence organizations

- Typical levels
  - Top secret
  - Secret
  - Confidential
  - Restricted
  - Unclassified



Marca

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

Marca

- Portugal (NTE01, NTE04)
  - Muito Secreto
  - Secreto
  - Confidencial
  - Reservado

Quanto mais o dono no país.

• Cada Marca tem a sua hierarquia ...

Marca

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

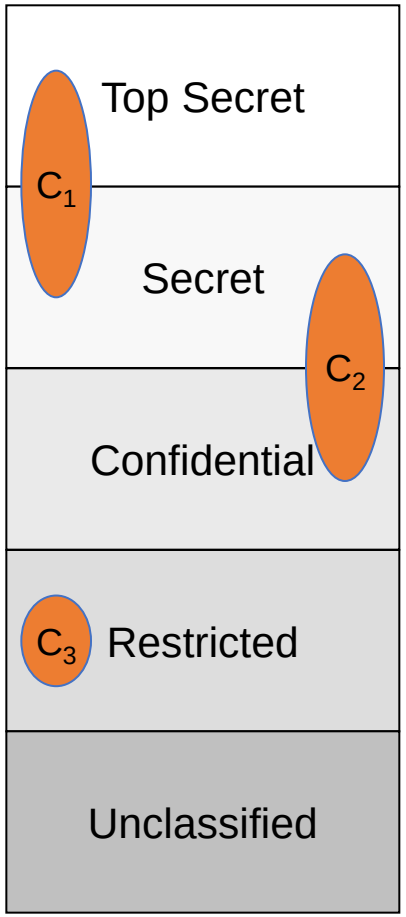
Security categories (or compartments)

sub-divisão dos níveis de segurança

- Self-contained information environments
  - May span several security levels
- Military environments
  - Military branches, military units
- Civil environments
  - Departments, organizational units

eu tenho um nível por categoria:

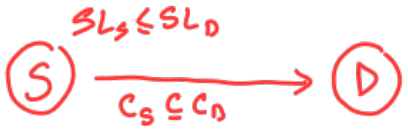
TOP SECRET MARINHA
SECRET CYBER ↑
↑ security label!
(...)



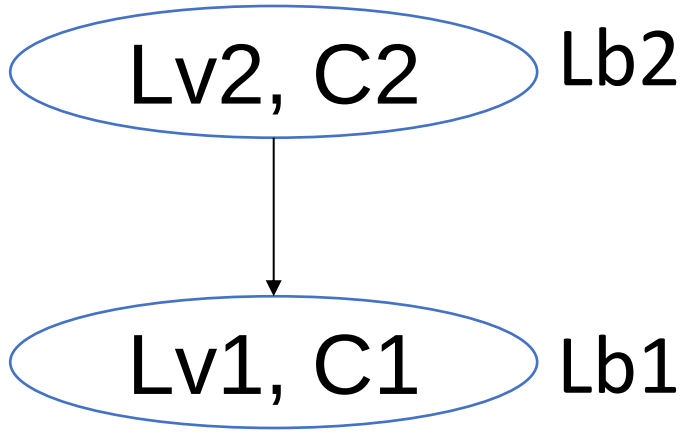
- An object can belong to different compartments and have a different security classification in each of them
  - (top-secret, crypto), (secret, weapon)

↳ Pode ser os 2 categorias

Security labels



- Label = Category + Level

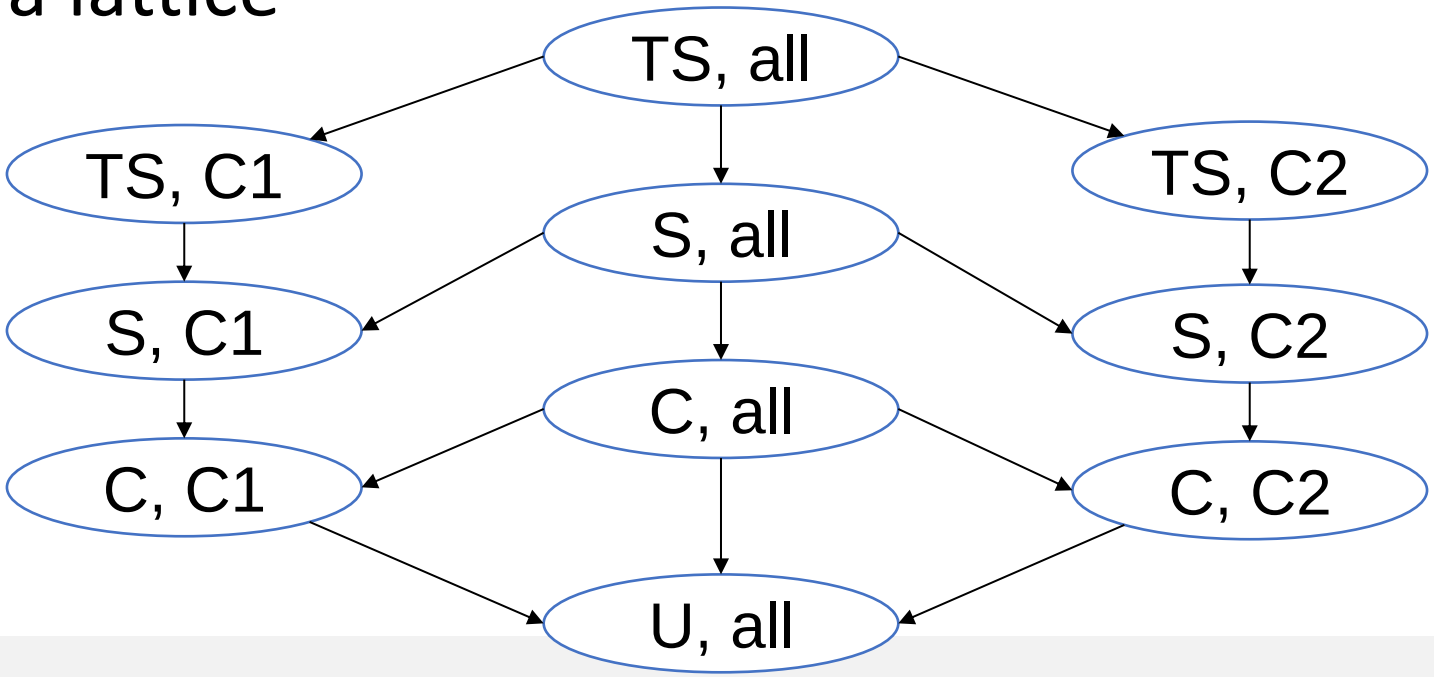


- Relative order between labels
  - Lb1 ≤ Lb2 ⇒ C1 ⊆ C2 ∧ Lv1 ≤ Lv2

contida ou igual

nível de segurança for menor ou igual

- Labels form a lattice



Bell-La Padula MLS Model

Confidencialidade

D. Elliott Bell, Leonard J. La Padula, "Secure Computer Systems: Mathematical Foundations", MITRE Tech. Report 2547, Vol. 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
- Combines access control matrixes with MLS

Consideramos o SECRETISMO

IDEA

- Os níveis menos seguros podem produzir informação para os níveis mais seguros
- Os níveis mais seguros NÃO podem produzir informação para os níveis mais seguros

Bell-La Padula MLS Model: secure state transitions

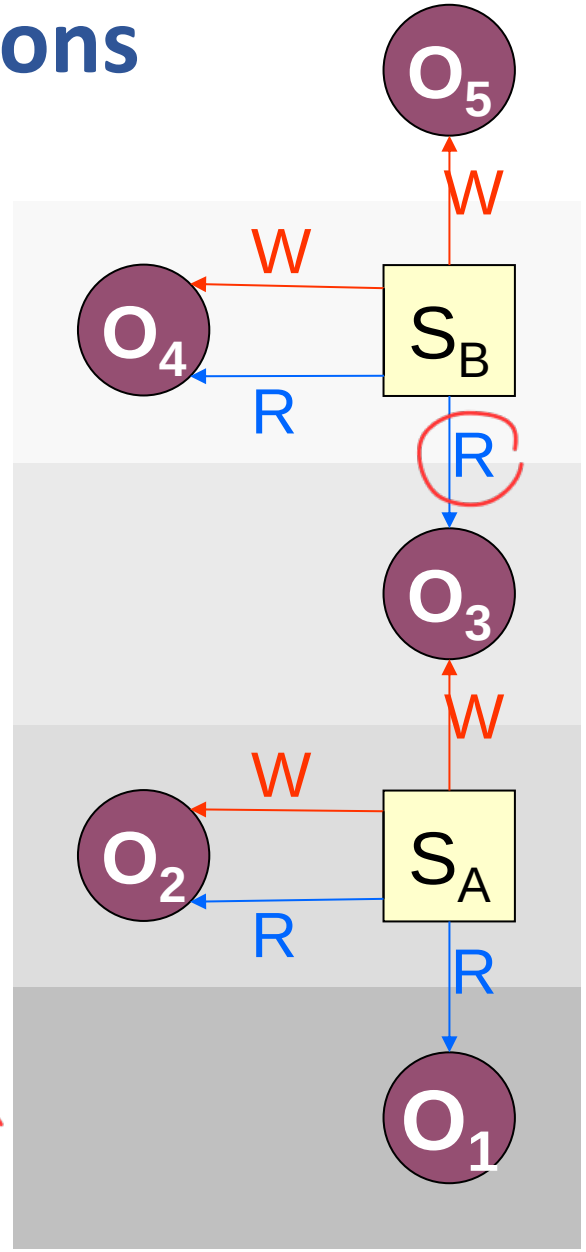
- Simple security condition (no read up)
  - S can read O iff L(S) ≥ L(O)

Top secret ⟶ Secret
Top secret ⟵ Secret

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

Só podemos fluir a informação para cima
Mas posso ler de baixo...

- Discretionary Security Property
  - DAC-based access control within the same security level



Biba Integrity Model

oposto do anterior ...

Só confiamos nos níveis de integridade superiores //

↳ Consideramos a INTEGRIDADE

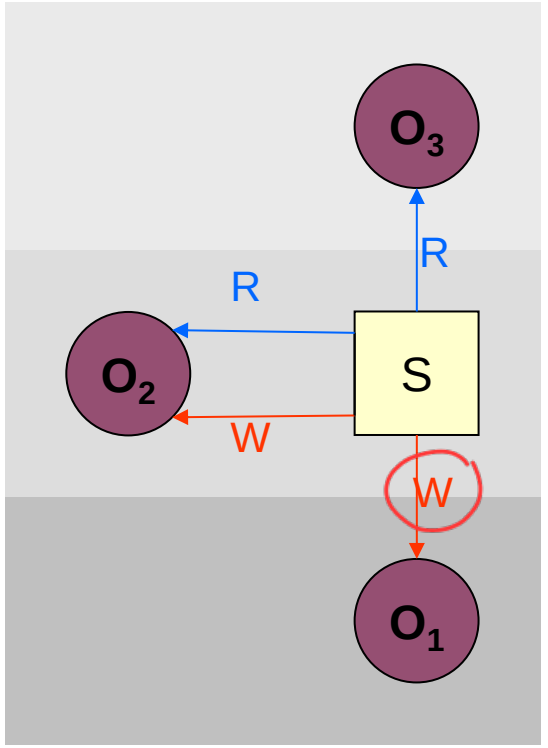
K. J. Biba, "Integrity Considerations for Secure Computer Systems", MITRE Technical Report 3153, The Mitre Corporation, April 1977

- Access control policy for enforcing integrity control over data flows
  - Uses integrity levels, not security levels
  - Similar to Bell-La Padula, with inverse rules

Não considera o SECRETISMO //

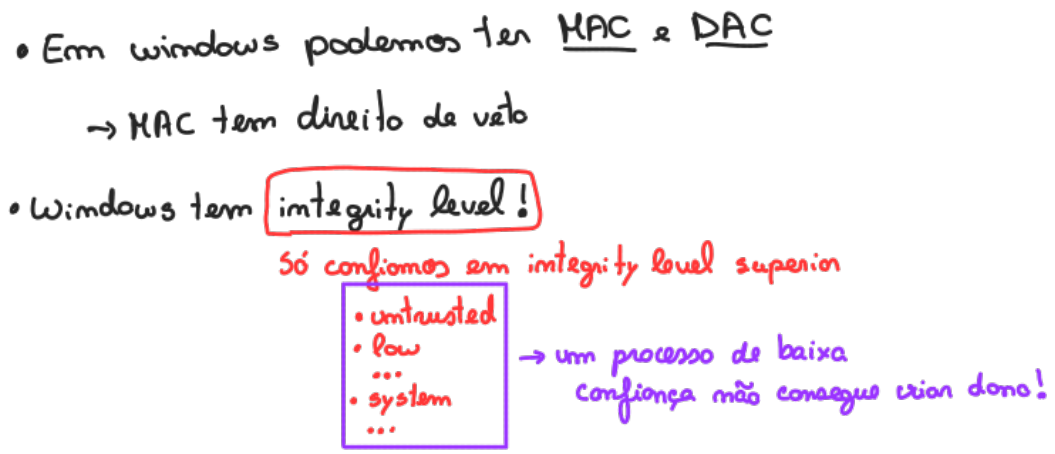
- Simple Integrity Property (no read down)
  - S can read O iff I(S) ≤ I(O)

- 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



Windows mandatory integrity control: integrity labels

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

No gestor de tarefas do windows conseguimos ver isto ...

Windows mandatory integrity control: users and processes

- User integrity level
  - 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) } Biba Integrity Model //
  - NO_READ_UP
  - NO_EXECUTE_UP