Systems Security

COMSM1500

University of BRISTOL

Access Control

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Access Control

- Physical access control
  - Physical enforcement to access to areas
- Digital access control
  - Restrict access to resources and interactions

Subjects and Objects

- Object
  - – Passive entity that contains information
  - – e.g. file, record, memory location etc.
- Access
  - – Ability to perform an action on/interact with an object
  - – Flow of information between a subject and an object
- Subject
  - – Active entity requesting access to an object or data within an object
  - – Different subjects have different access levels
  - – e.g. users, processes etc.

Access Control

- Concerned with authorisation: what a subject is allowed to do
- Mediates a subject access to object
- Enforces a security policy, limiting which actions are allowed

Complete mediation

- That is our aim
- Trusted computing base: all hardware and software that is responsible for enforcing the policy
  - For example, OS kernel, all trusted processes, and the PC hardware. A fault in one can compromise security (we have seen many examples).
- Complete mediation is important (if it can be subverted, then use is limited)
- Reference monitor concept (all access through it)

Subject → Reference Monitor → Object

Protection state

- Security context: security identity information used to inform authorisation decision.
  - For example, UID and GID associated with a process
- The protection state is made up of the security sensitive actions every entity is able to do
  - For example, when a user change identity the protection state has changed
- Transition between protection state need to be tightly controlled (e.g. setgid)

Access Control Matrix

- Simplest way to represent the protection state of a system
- A table representing every subjects and objects, and the permitted type of actions between them

	File 1	File 2	File 3
User A	Read, Write, Own	Read, Write	Read, Write, Own
User B	Append	Read, Write, Own	Read, Write

What’s the fundamental issue here?

Access Control Matrix

- Could in theory express any possible access control policy
- Only useful in theory…
- In any practical systems there is too many subjects and objects
- … but any protection state can be expressed this way

	File 1	**File 2**	**File 3**
User A	Read, Write, Own	Read, Write	Read, Write, Own
User B	Append	Read, Write, Own	Read, Write

Access control policy

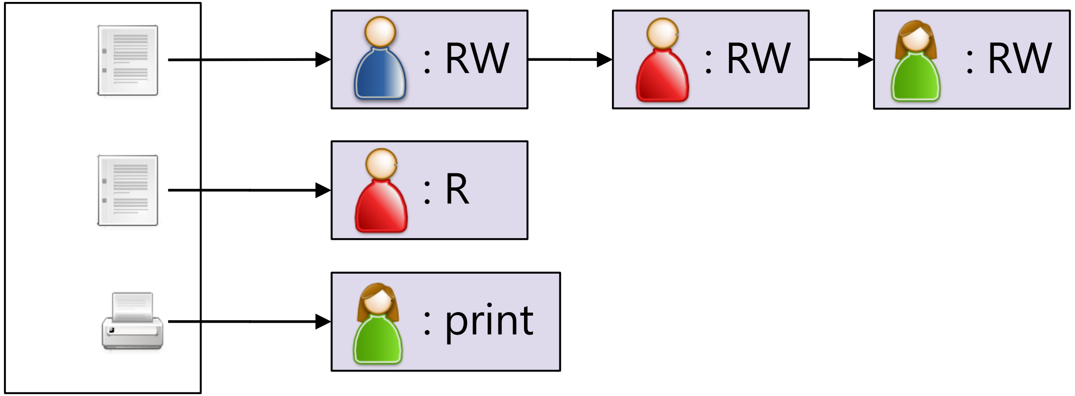
- Express formally or informally what is allowed
- Generally express confidentiality/integrity requirements

	File 1	File 2	File 3
User A	Read, Write, Own	Read, Write	Read, Write, Own
User B	Append	Read, Write, Own	Read, Write

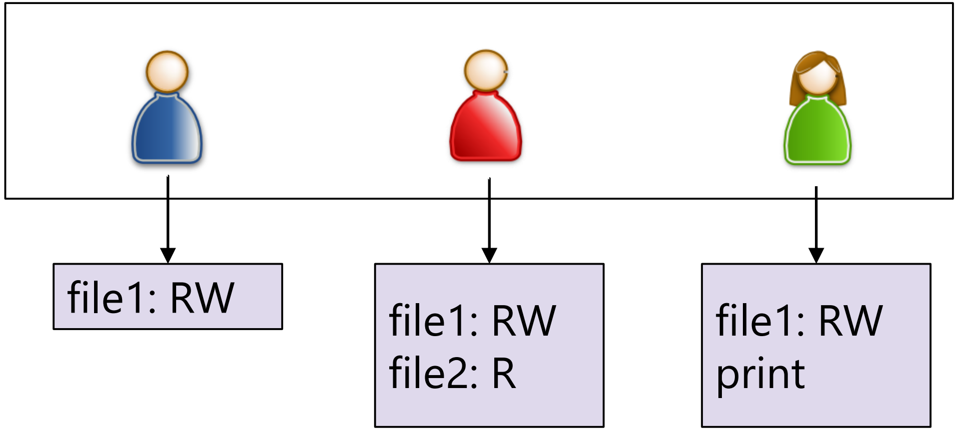
Mechanisms and Models

- A mechanism how the policy is enforced (think of softwared/hardware implementation)
  - e.g. SELinux, AppArmor on Linux distributions
- A model how to represent policies
  - e.g. access control matrix (this is not a good idea)

Access Control List



Capabilities



Access Control List/Capabilities

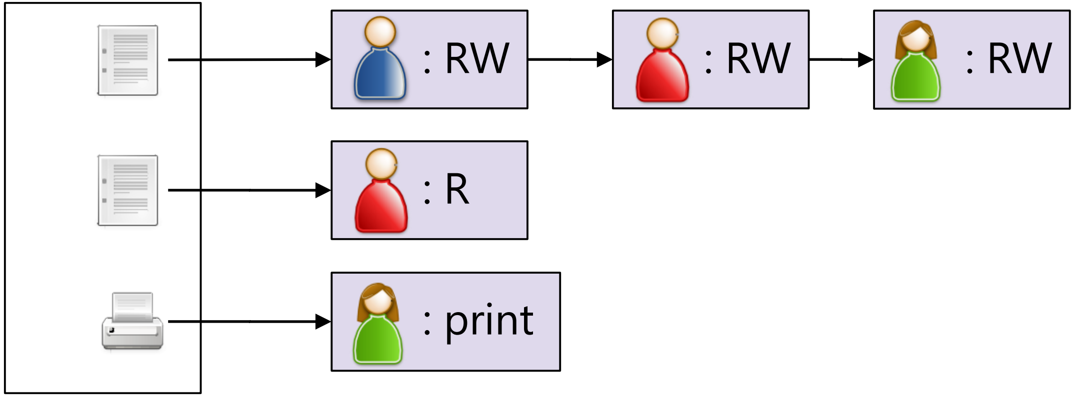
- Access Control List
  - Object centric
- Capabilities
  - Subject centric

Discretionary / Mandatory

- Discretionary: owner of a resource defines/delegates right
  - Requires the notion of owner
  - Most systems
  - Resource owner define associated policy

- Mandatory: policies centrally set by an administrator
  - Notion of owner optional
  - Well suited when an organization own the data (e.g. military government)

Access Control List



Access Control List

- On Windows work more or less like this (virtually unlimited list)
- On UNIX: 3 entries Owner, Group, World
- By default owner=creator
- Inheritance rules (objects inherit rules of containers)
  - e.g. files inherit folders permission
- Owner can revoke access
- DAC

UNIX

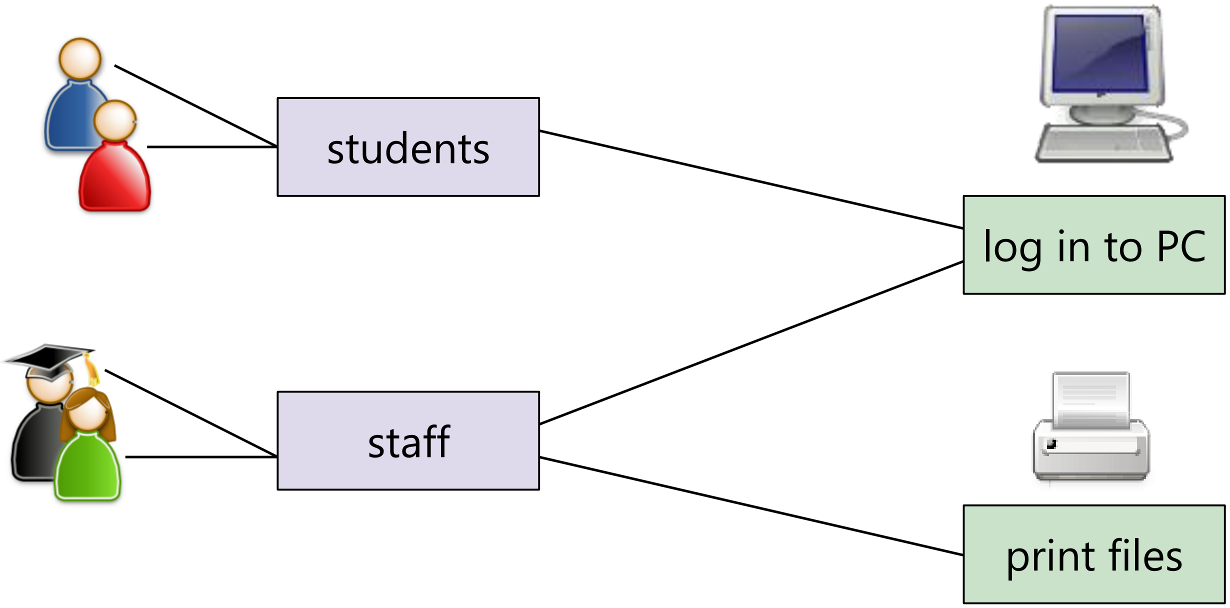
```
~/syssec/2017$ ls -l
-rw-r--r-- csxdb cosc ... accesscontrol.pdf
-rw-r--r-- csxdb cosc ... systems.pdf
-rw------- csxdb cosc ... exam.pdf
-rwxr-x--- csxdb cosc ... slides.sh
```

owner group

owner	group	other
read	write	exec

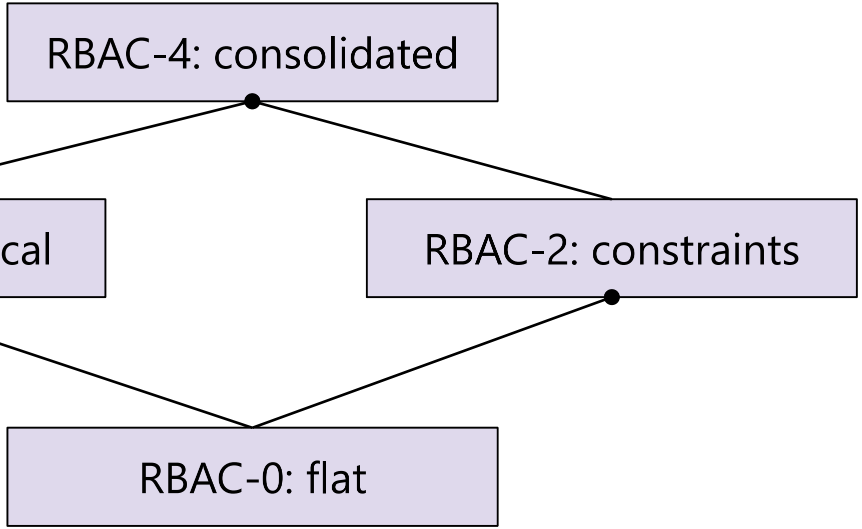
Role-based Access Control

Groups / Roles



RBAC (NIST)

- RBAC 0: users have a role, role have permission
- RBAC 1: roles can be inherited



- RBAC 2: allows for separation of duties
- RBAC 4: all of the above

Information Flow Control

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IFC

- read: receiving information from another entity
- write: sending information from another entity

- Concept emerges from US military

IFC- Bell Lapadula

Top-secret (2)
Secret (1)
Unclassified (0)

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- read: $f_s(s) >= f_o(o)$
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Problem with this naïve approach?

IFC - Bell Lapadula

Top-secret (2)
Secret (1)
Unclassified (0)

- Need to add categories! (DAC)
- (c, s)
  - c classification
  - s categories
- $f_s(s)$ dominates $f_o(o)$
  - if $c_s >= c_o$ MAC
    - e.g. top-secret >= secret
  - if $s_s \supseteq s_o$ DAC
    - e.g. {Iraq, Syria} ⊇ {Iraq}

IFC- Bell Lapadula

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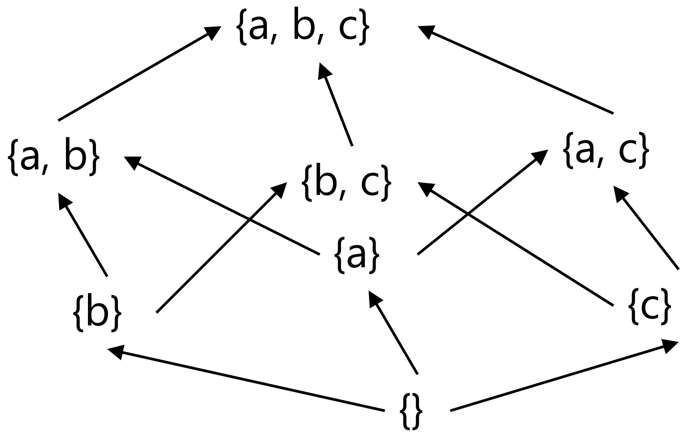
- SELinux variant
  - Level per category

IFC - Bell Lapadula

- Categories have a partial order.
- Form a lattice



IFC - Biba Model (similar idea for integrity)

Fact (2)
Belief (1)
Rumor (0)

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- Similarly we can add DAC categories

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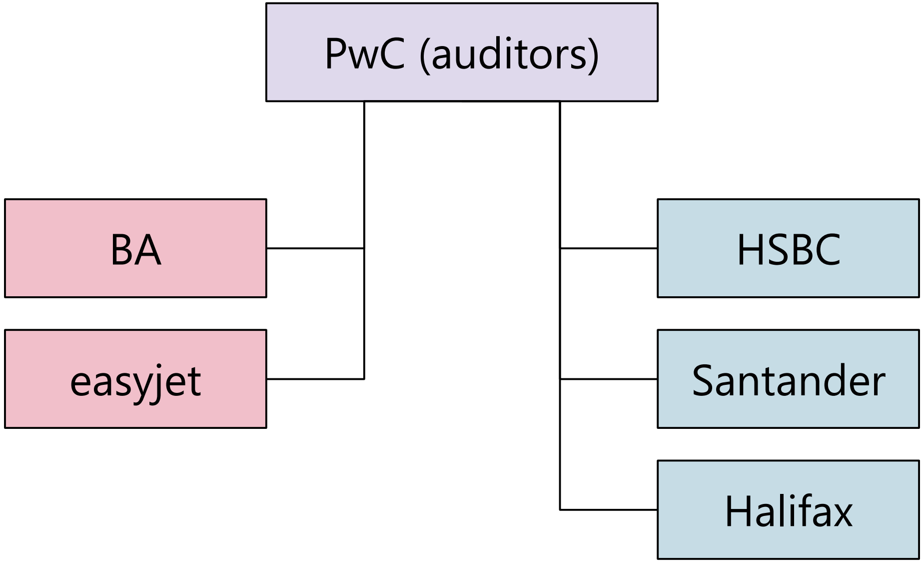
Brewer and Nash Model

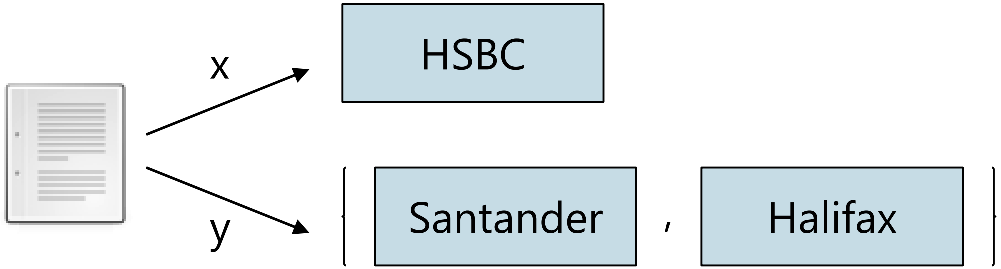
a.k.a Chinese Wall

Chinese Wall Model



Chinese Wall Model

O = objects (clients' files)
C = clients
CoI(o) = Conflict of Interest Group
x(o): owner, y(o): conflict class CoI(o) – x(o)



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  - For all o’ such that n(s, o’)=true, y(o) = y(o’) or y(o) $\not\ni$ x(o’)
  - o is from the same company as previously read objects or o belong to a different conflict of interest class

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  - You can’t write client data if reading anyone else data, unless other data have been sanitized
  - Need sanitization/declassification policy
    - Simple example owner can declassify objects they own
    - Authority may declassify audit report etc.

Clark-Wilson Model

Integrity

Clark-Wilson Model

- Bank-like context
- Integrity defined as a set of constraints
  - Data in a valid state when it meet constraints
  - Example
    - YB: Yesterday Balance, TD: today deposit, TW: today withdrawal, TB: today balance
    - TB = YB + TD – TW
- Well formed transactions
  - Move system to one consistent state to another
- Require separation of duty
  - Who certify transactions
  - Who verify constraints

Clark-Wilson Model

CDI	constrained data item
UDI	unconstrained data item
TP	transformation procedure
IVP	integrity verification procedure

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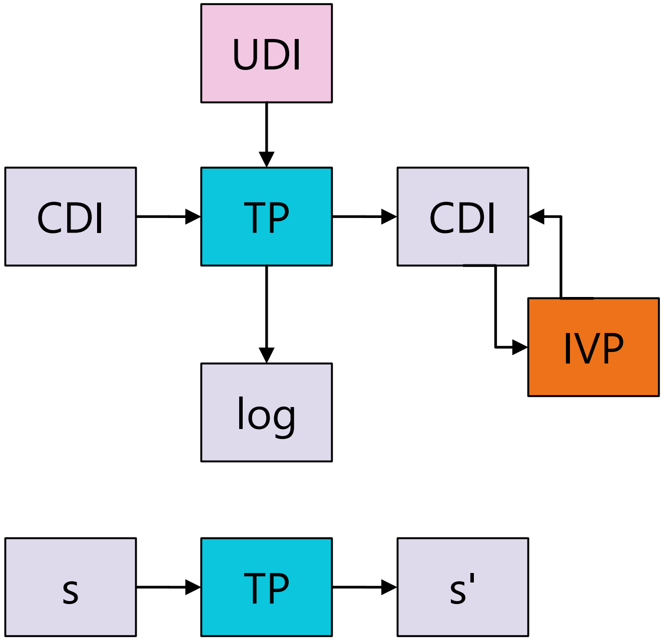
- Permission as a triple
  - (user, TP, {CDIs})
- e.g. (bob, transfer, hisaccount)
- transfer(CDI:account, UDI:accountref)

Clark-Wilson Model



Certification rules
C1: CDI state validated by IVP
C2: TPs preserve valid state
C3: separation of duty
C4: TPs write to log
C5: UDIs are validated by TPs

Enforcement rules
E1: Only TPs change CDIs
E2: TPs require authorisation
E3: All users are authenticated
E4: only authorised people can change permissions

Summary

- Many models for different objectives
- … and there is many more
  - attribute-based access control
  - provenance-based access control
  - etc..
- Different model for different objectives (in theory you could obtain the same access control matrix from two different models)
- They have led to programming pattern
- In practice hard to implement
  - Many secure OS attempts (yet nothing widely available)
  - Real world is full of exception and edge cases
  - May get in the way of business

Thank you

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