Access Control

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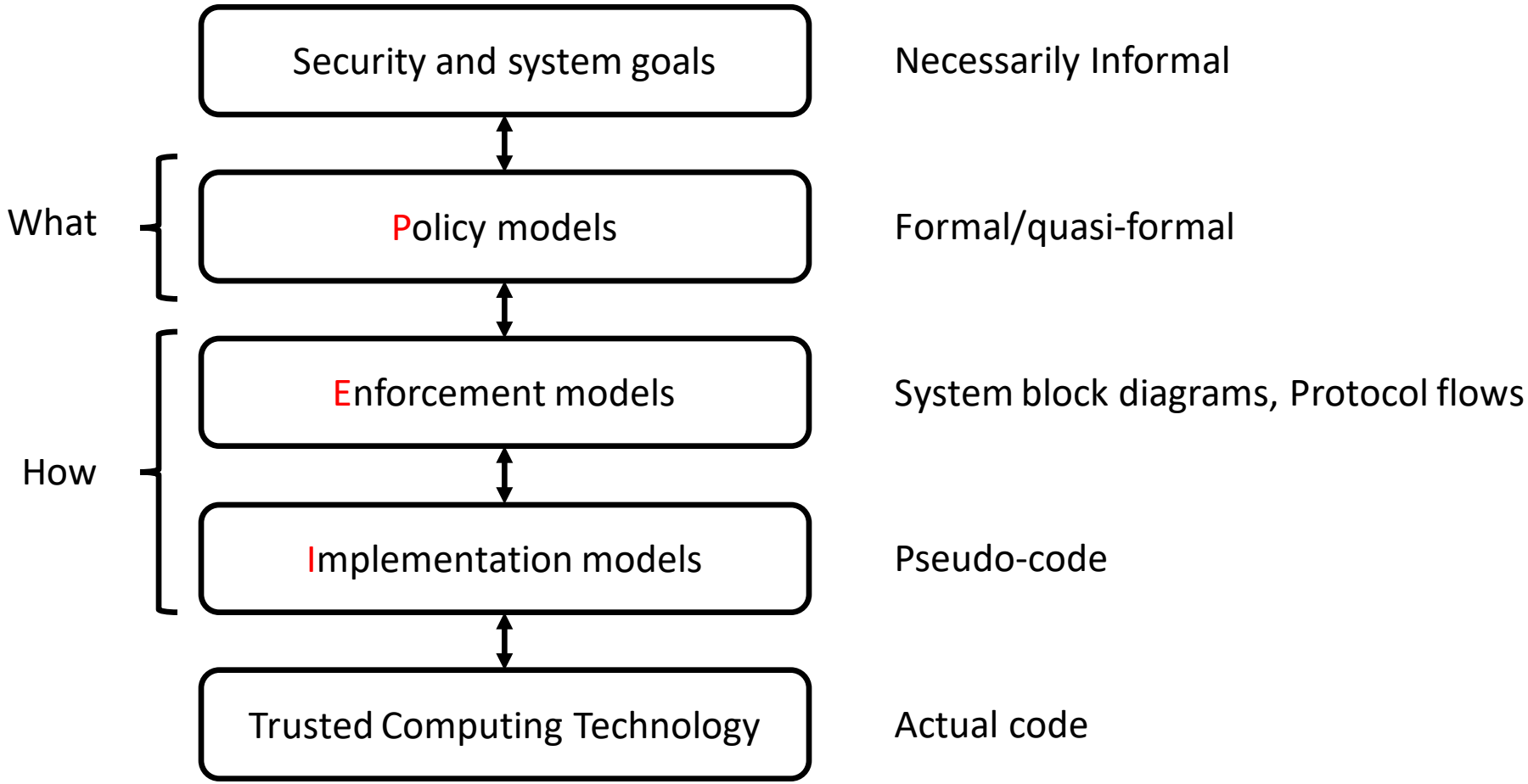
Examples of Access Control

- Social Networks: Access to personal information.
- Web Browsers: Javascript - same origin policy.
- Operating Systems: One user cannot arbitrarily access/kill another user's files/processes.
- Memory Protection: Code in one region (for example, in Ring 3), cannot access the data in another more privileged region (e.g. Ring 0).
- Firewalls: If a packet matches with certain conditions, it will be dropped.

PEI Model [Sandhu, 2006]



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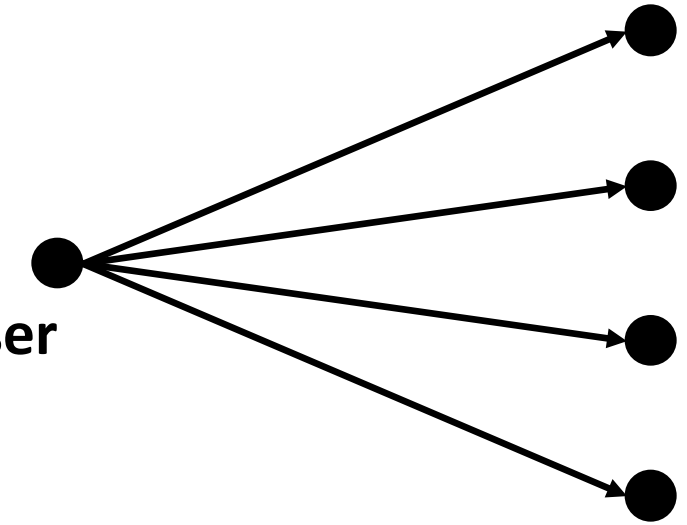
Vocabulary

- Basic abstractions:
  - Subjects
  - Objects
  - Rights

- A **subject** is an entity who wishes to access a certain **object**, which is some kind of resource, e.g., a file or directory. The different modes of access (e.g., reading, writing) are called **permissions**.

Vocabulary – Users and Principals

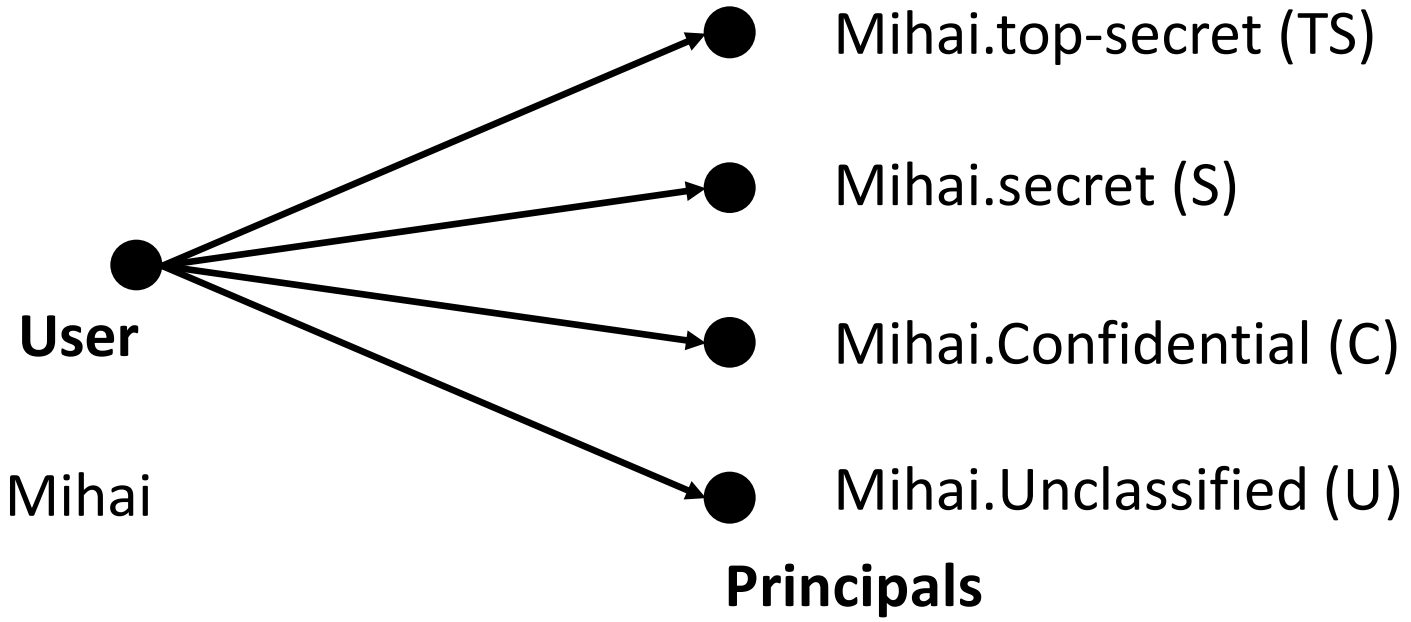


Real World **User**

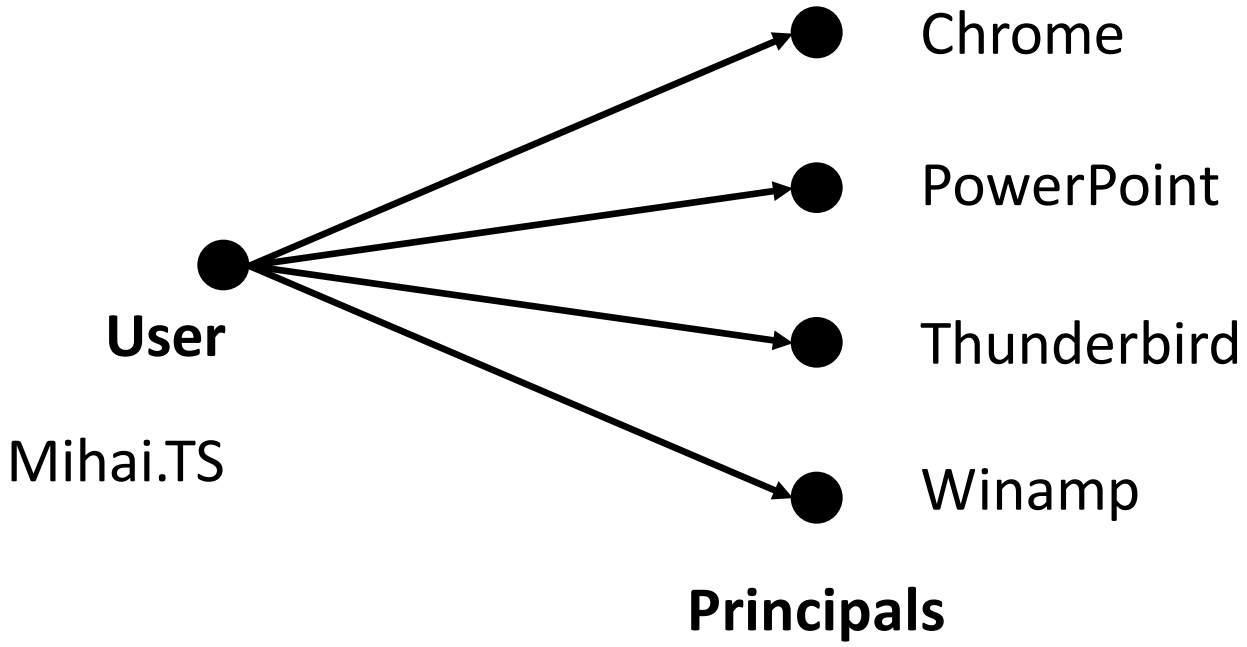
Principals - Unit of Access Control and Authorization

- A Principal is an User authenticated in a context

Vocabulary – Users and Principals



Vocabulary – Principals and subjects



- A subject is a program executing on behalf of a principal

Vocabulary

- The relation between Users and Principals is One-To-Many
  - Allows accountability of user's actions
  - Don't share your passwords!!!

- For simplicity, a principal and subject can be treated as identical concepts.

Vocabulary - Objects

- An object is anything on which a subject can perform operations (mediated by rights)
- Usually objects are passive, for example:
  - File
  - Directory (or Folder)
  - Memory segment
- But, subjects can also be objects, with operations
  - kill
  - suspend
  - resume

Access control models

Access control enforcement

- **Discretionary access controls (DAC)** – the access of objects (or subjects) can be propagated from one subject to another. Possession of an access right by a subject is sufficient to allow access to the object.
- **Mandatory access controls (MAC)** – the access of subjects to objects is based on a system-wide policies (based on security labels) that can be changed only by the administrator.
- **Role-Based Access Control (RBAC)** – can be configured as both MAC or DAC, access to objects is based on roles.

Discretionary access controls

DAC

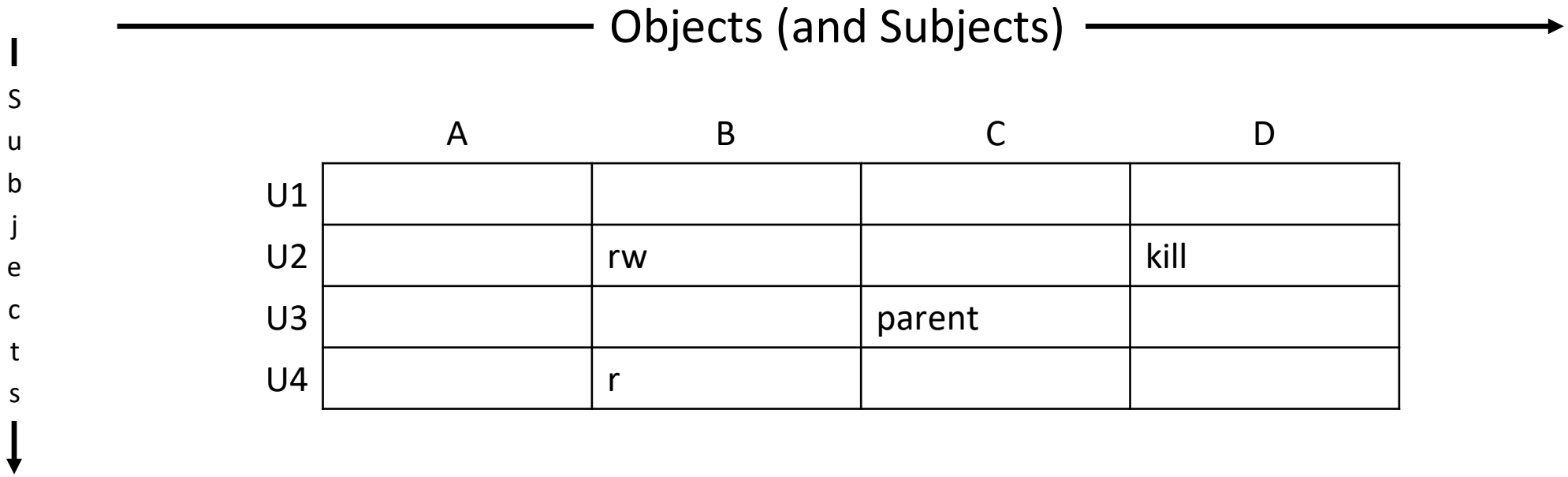
- No precise definition.
- Basically, DAC allows access rights to be propagated at subject's discretion
  - often has the notion of owner of an object
  - used in UNIX, Windows, etc.

DAC Implementation

- Let *S* be the set of all subjects, *O* the set of all objects, and P the set of all permissions. The description of access control can be given by a set $A \subseteq S \times O \times P$.
- When new permissions are added, triplets are added to A; when they are removed (revoked), triplets are deleted.

Access control – Representation

- An access control matrix is a matrix (Ms,o) whose rows are subjects and columns are objects. Element (Ms,o) ⊆ P is the set of permissions that subject **S** is authorized for object o.



	A	B	C	D
U1				
U2		rw		kill
U3			parent	
U4		r		

Access Control Lists (ACL)

- An access control list is a set {Ao | o ∈ O}, one element for each **object**. The elements of the list are the pairs (s, p) of **subjects** s who have **permission** p to that object.

B
U2: rw
U4: r

C
U3: parent

D
U2: Kill

Capabilities

- Storing capabilities means giving to each subject tokens which give them access to the permissions they are entitled.

U1	
U2	B/rw, D/kill
U3	C/parent
U4	B/r

ACL vs. Capabilities

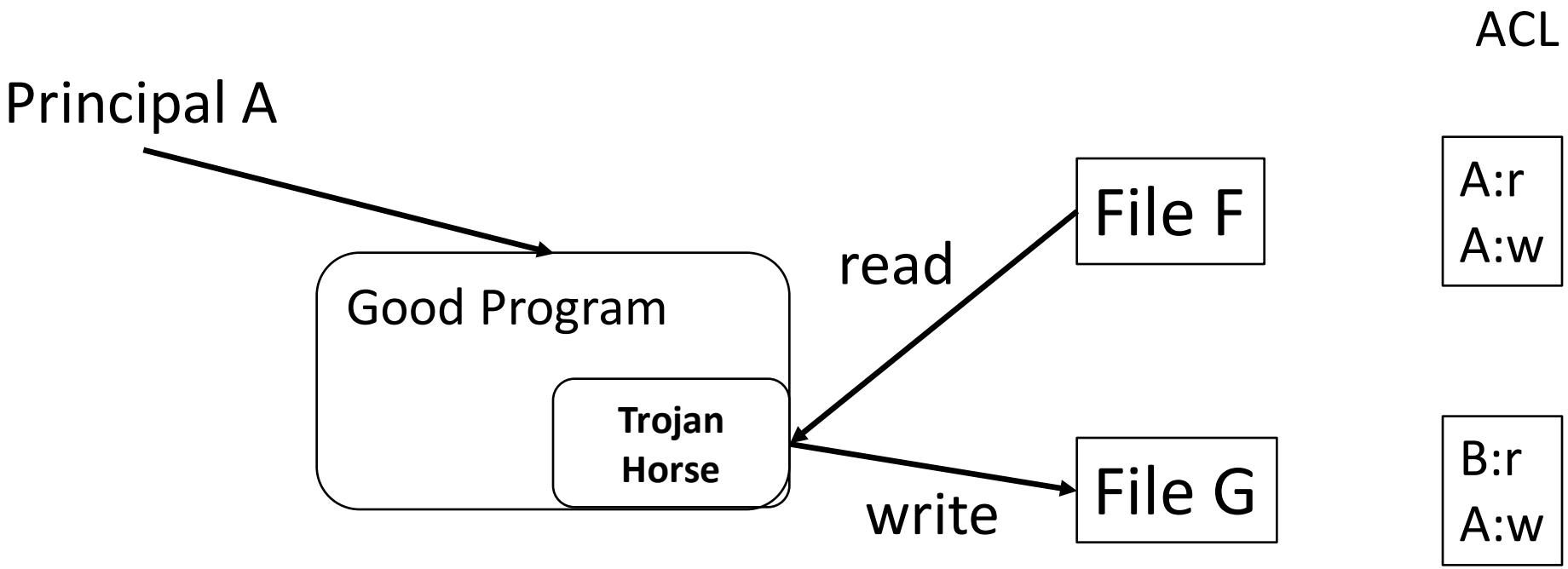
- ACL require authentication of subjects
- Capabilities do not require authentication of subjects, but do require unforgeability and control of propagation of capabilities. Usually implemented trough cryptography.

- The Confused Deputy Problem [1986]
  - Example: Cross-Site Scripting (XSS)
  - Solution: Use Capabilities Implementation

DAC Problems

- The underlying philosophy in DAC is that subjects can determine who has access to their objects.
  - There is a difference, though, between trusting a person and trusting a program.
- The copies of file are not controlled
- The Trojan Horse attack [1970]
  - Solution: use MAC ☺

Trojan Horse attack



Principal B cannot read file F

Buggy software can become Trojan Horses

- When a buggy software is exploited, it executes the code/ intention of the attacker, while using the privileges of the user who started it

- This means that computers with only DAC cannot be trusted to process information classified at different levels

Mandatory access controls

Modeling Access Control

- Assigning access rights based on regulations by a central authority
- Implemented using a *"reference monitor"*
  - Small Trusted Computing Base (TCB) [John Rushby, 1981, OSP]
- Implemented using Virtualization
- TOCTTOU problem
  - Time of check to time of use

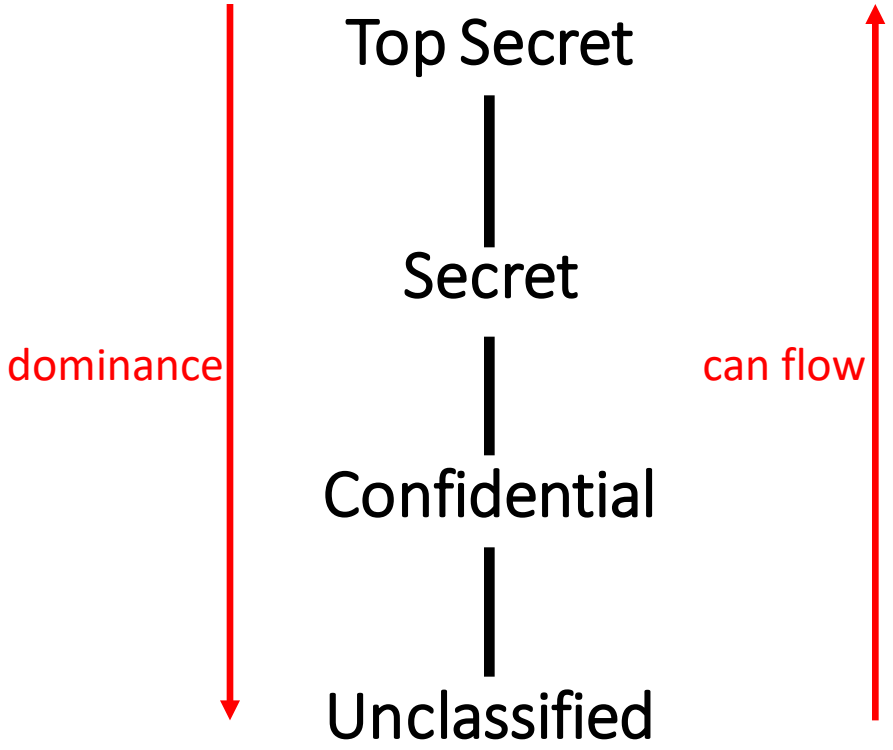
Modeling Access Control

- Multi-level security (MLS)
  - Bell-Bell-LaPadula (BLP)
  - Biba Model
- Chinese Wall

Multi-level security (MLS)

- The capability of a computer system to carry information with different sensitivities

- Bell-LaPadula (BLP) Model [1973]
- Biba Model



BLP Model

- Aims to capture confidentiality (read) requirements only
- The system is modelled as transitions through a set of states, starting from an initial state.
  - State = Object, access matrix, current access information
- State transition rules describe how a system can go from one state to another
- Each subject s has a maximal security level Lm(s), and a current security level Lc(s)
- Each object has a classification level

BLP Model

- A state is secure if:
  - A) Simple Security Property (SS): no subject may read data at a higher level
  - B) The *-Property (SP): no subject may write data at a lower level
    - (due to the fear of Trojan Horse)

- A system is secure if and only if every reachable state is secure.

BLP Problems

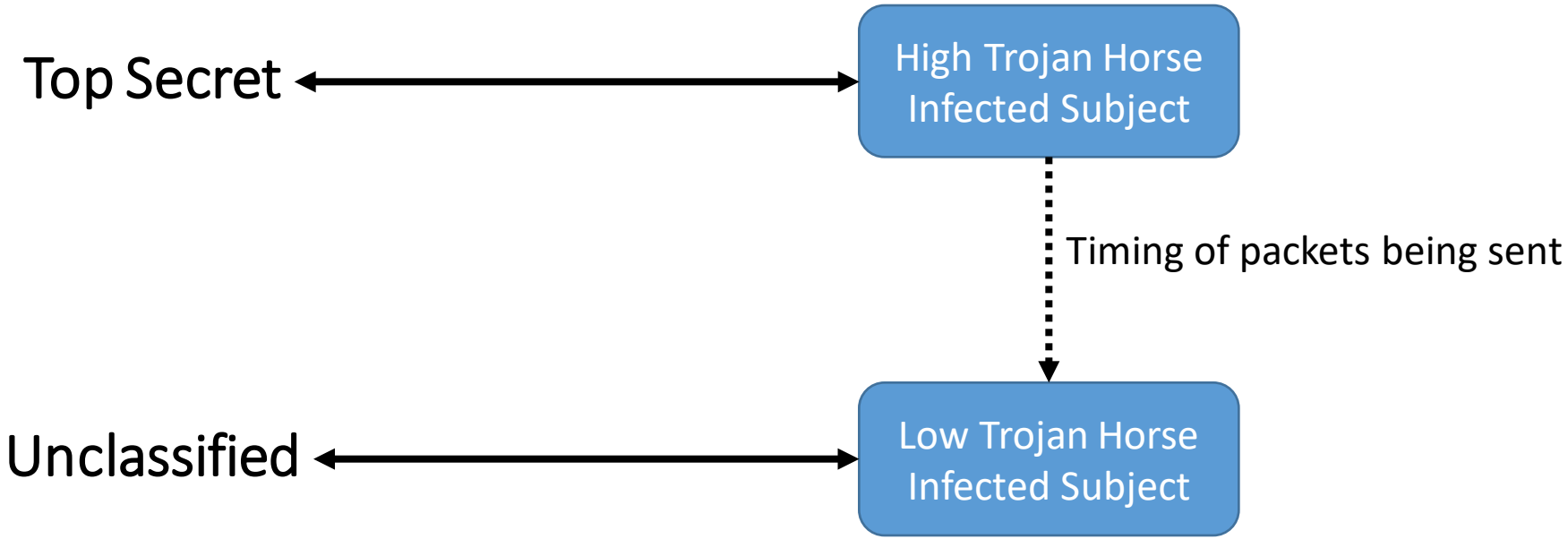
- Consider a system with subjects s1, s2, and objects o1, o2
  - Lm(s1) = Lc(s1) = L(o1) = high
  - Lm(s2) = Lc(s2) = L(o2) = low
- And the following execution
  - s1 gets access to o1, reads something, releases access, then changes current level to low, gets write access to o2, writes to o2
- Every state is secure, yet illegal information exists
- Solution: **tranquility** principle: subject cannot change current levels, or cannot drop to below the highest level read so far

BLP Problems

- There is no ACK from High to Low
- Not all system components can be enforced by BLP, e.g., memory management must have access to all levels
  - Called *“trusted subjects”*
- Can overwrite high and more important files

BLP Problems

- Covert channels cannot be blocked by star-property



Biba Model

- Integrity is also very important
- Each subject (process) has an integrity level; Each object has an integrity level ; Integrity levels are totally ordered

- NO read down; NO write up
  - BLP upside down

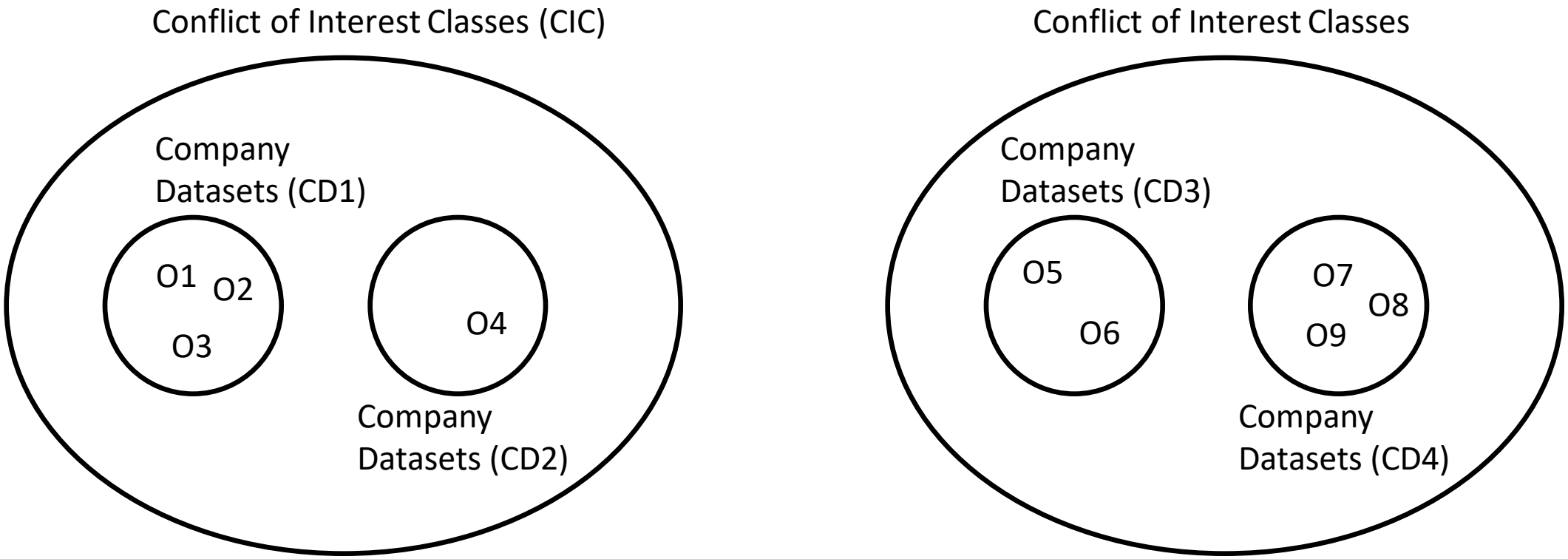
- The integrity of an object is the lowest level of all the objects that contributed to its creation

Biba Model

- Used by Windows

- E.g., A Internet Explorer Browser can download a file (with Low priority) and read everything in the system. It cannot write to it.

Chinese Wall [1989]



Chinese Wall

- S can read O only if
  - O is in the same company dataset as some object previously read by S (i.e., O is within the wall)

  or
  - O belongs to a conflict of interest class within which S has not read any object (i.e., O is in the open)
- S can write O only if
  - S can read O by the simple security rule

  and
  - no object can be read which is in a different company dataset to the one for which write access is request

Chinese Wall

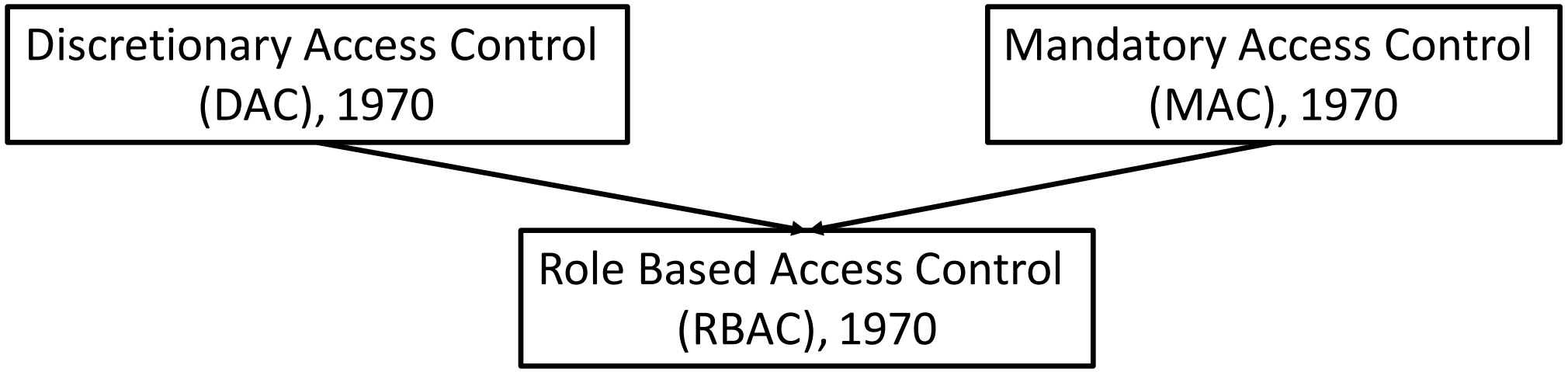
- Once a subject reads two objects from different CDs, that subject may never write any object.

- S1 reads information from an object in CD1.
- S1 writes that information to object O6 in CD3.
- S2 reads that information from O6.
- At the end of this sequence, S2 would have read information pertaining to both CD1 and CD2, which would violate the Chinese Wall policy since both CDs are in the same CIC.

Role-Based Access Control

Role-Based Access Control

- In the real world, security policies are dynamic.
- E.g., a user promotes at his job, therefore his rights must change (deleted, added, etc.)



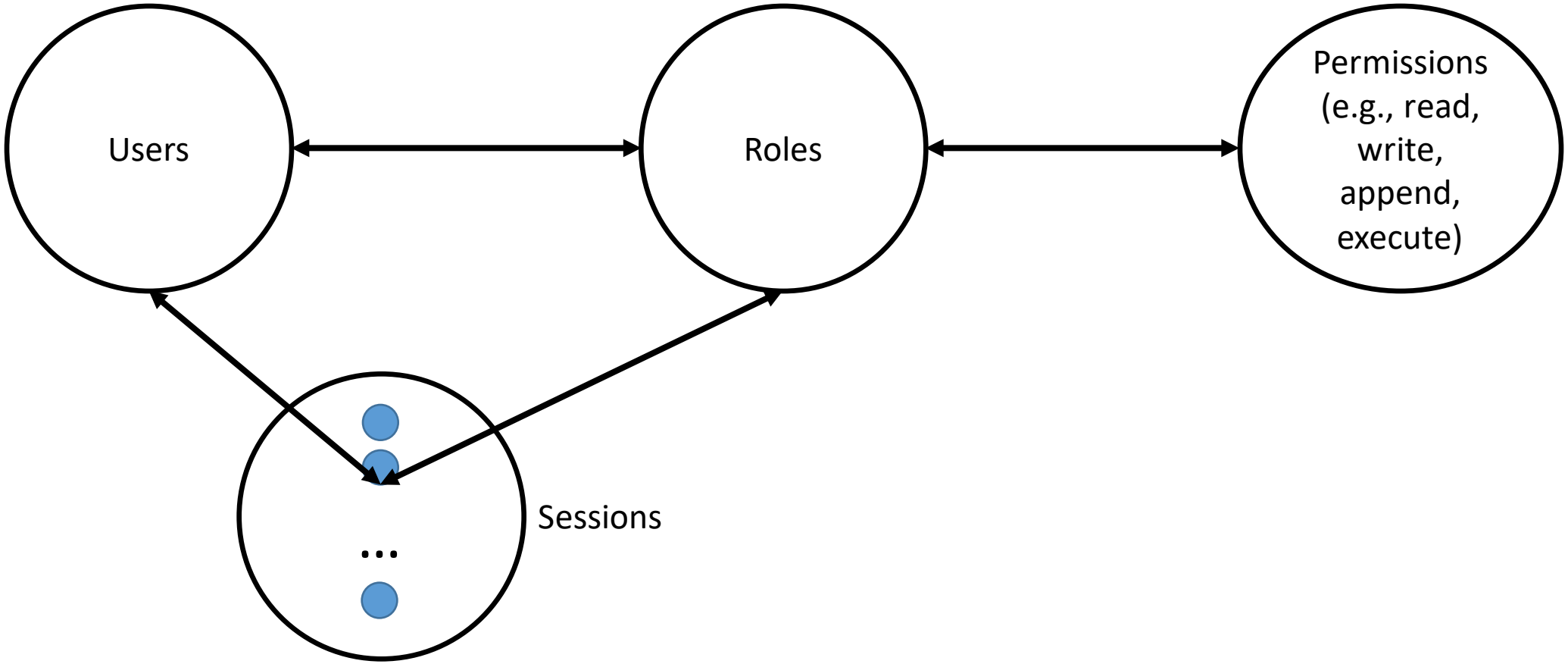
Role-Based Access Control

- Can be configured to do MAC
  - roles simulate clearances (ESORICS 96)
- Can be configured to do DAC
  - roles simulate identity (RBAC98)

Role-Based Access Control

- Changes the underlying subject--object model
  - a policy is a relation on roles, objects, and rights
- Subjects are now assigned to roles;
  - *role assignment*
- Roles are hierarchical

Role-Based Access Control



Roles as policy

- A role brings together
  - a collection of users and
  - a collection of permissions a collection of permissions
- These collections will vary over time
- A user can be a member of many roles
- Each role can have many users as Each role can have many users as members

Implementation

- Using a access matrix

RBAC Shortcomings

- Role granularity is not adequate leading to role explosion
- Role design and engineering is difficult and expensive
- Assignment of users/permissions to roles is cumbersome
- Adjustment based on local/global situational factors is difficult

Future Access Control

Attribute-Based Access Control (ABAC)

- Attributes are name:value pairs
  - possibly chained
  - values can be complex data structures
- Associated with
  - users
  - subjects
  - objects
  - contexts
- Converted by policies into rights just in time
  - policies specified by security architects
  - attributes maintained by security administrators
  - ordinary users morph into architects and administrators

Resources

- [Sandhu, 2006] http://www.profsandhu.com/confrnc/asiaccs/asiaccs06-pei.pdf
- http://www.cs.cornell.edu/courses/cs5430/2011sp/NL.accessControl.html
- http://cnitarot.github.io/courses/cs526_Spring_2015/s2014_526_ac.pdf