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CS3002 Information Security

Theoretical Models of Access Control

Source: Stallings chap 27

Why Theoretical Models

- Providing security in a large-scale system is extremely complex
  - Firstly, your product design should incorporate security
  - Secondly, the design implementation should be flawless
    - Too much room for making mistakes in both steps
- A theoretical model can aid in achieving fool proof security.
  - Our design and implementation can then be tested against that model

Multi-Level Security

- An environment where information or assets are classified at different levels of security
- For example in military, classifications are:
  - Top secret (most sensitive)
  - Secret
  - Confidential
  - Restricted
  - Unclassified (least sensitive)

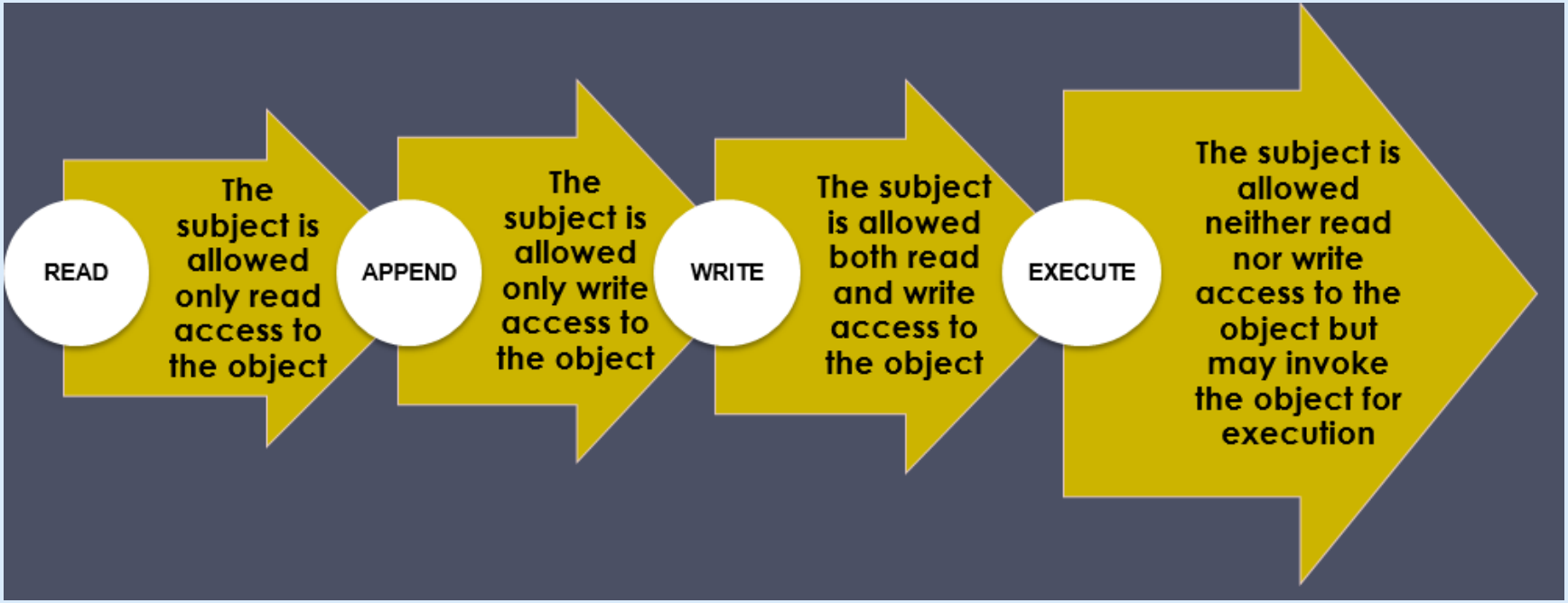
Bell LaPadula (BLP) Model

- Goal: prevent the unauthorized disclosure of information
  - ONLY deals with confidentiality of information flow
- Bell-LaPadula Model is basis for many, or most, of the other theoretical models
- Proposed in 1970s, in the era of mainframe computers

BLP Model

- A formal model for access control
- Objects (assets) are assigned a security classification
  - Form a hierarchy and are referred to as security levels
  - e.g. top secret > secret > confidential > unclassified
- Subjects have a security clearance
- Security classes control the manner by which a subject may access an object

Access Privileges



BLP Properties (to enforce)

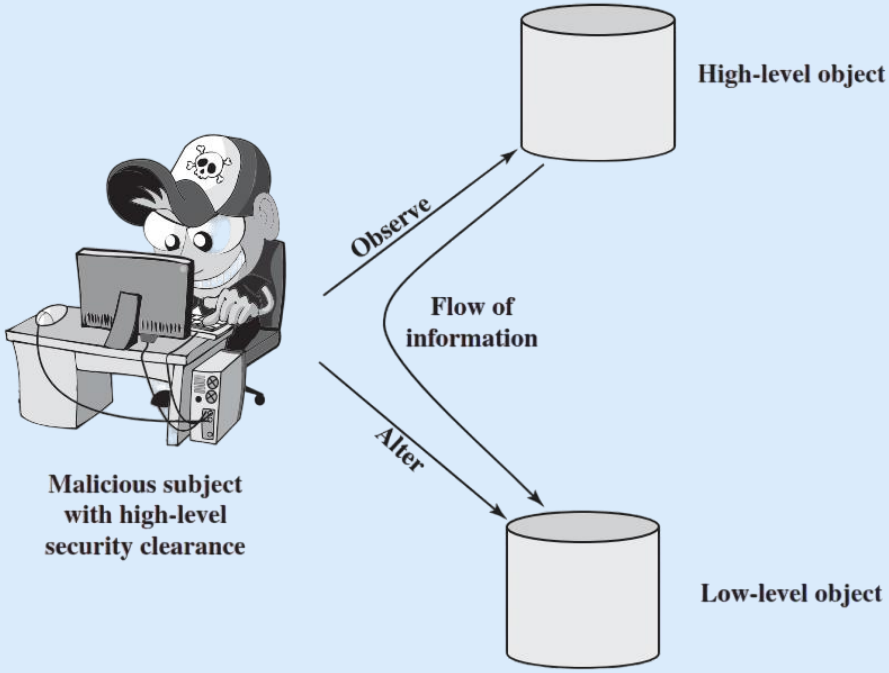
Subject at a high level may not convey info to a subject at a non-comparable level:

1) Simple security (ss) property:

- A subject can only read an object of less or equal security level
- No read up

2) * (star) property:

- A subject can only write into an object of greater or equal security level
- No write down



Breach of confidentiality: prevented by BLP star property

BLP ss-property Example

Security level	***Subject***	***Object***
Top Secret	Tamim	Personnel Files
Secret	Sohail	E-Mail Files
Confidential	Kaleem	Activity Logs
Unclassified	Jamal	Telephone Lists

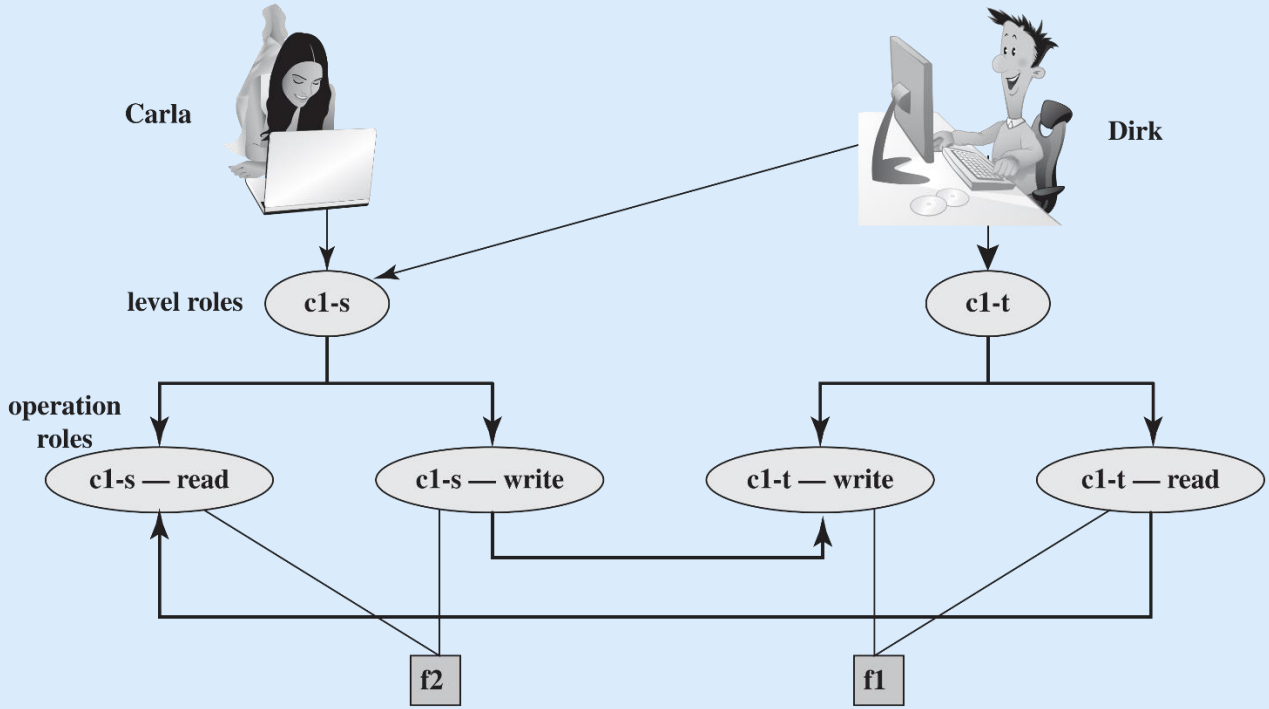
- Tamim can read all files
- Kaleem cannot read Personnel or E-Mail Files
- Jamal can only read Telephone Lists

BLP Example (1/6)

- A role-based access control system
- Two users: Carla (student) and Dirk (teacher) in a course c1
  - Carla (Class: c1-s)
  - Dirk (Class: c1-t)
    - can also login as a student (Class: c1-s)
- A student role has a lower security clearance
- A teacher role has a higher security clearance

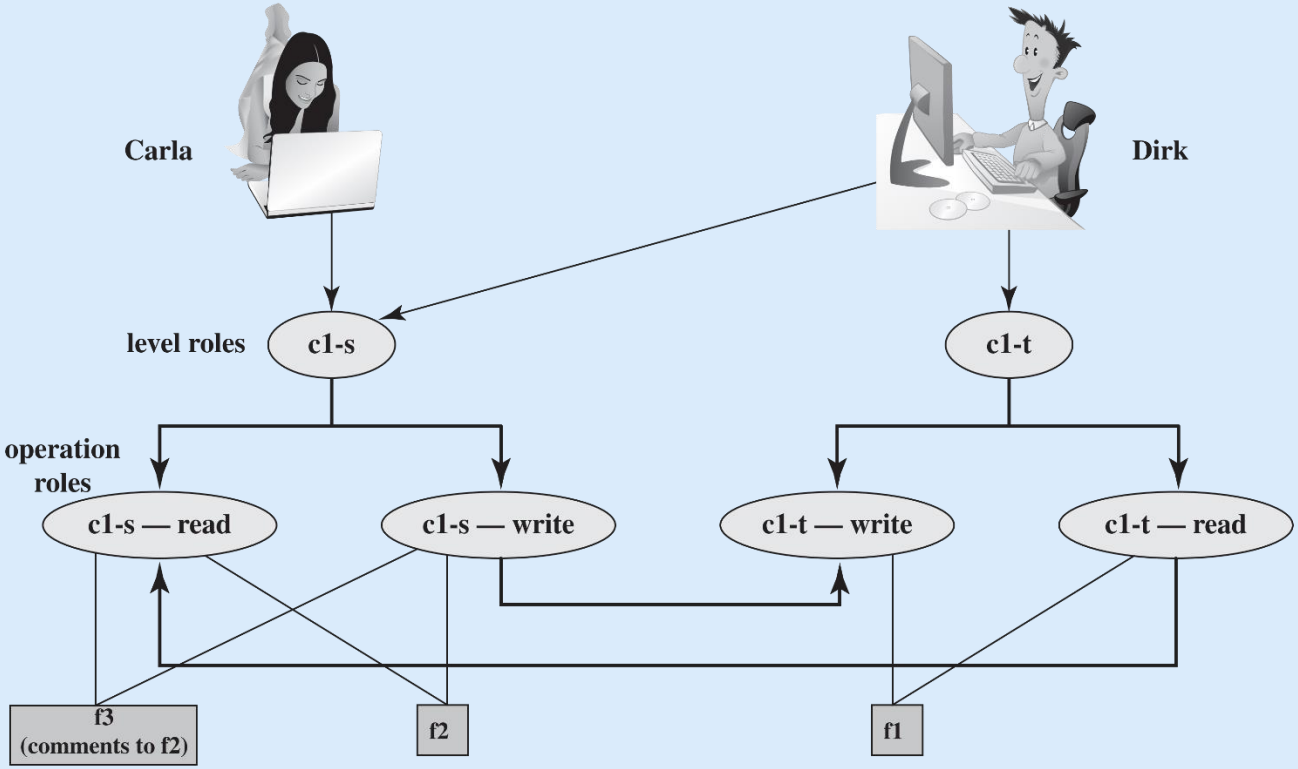
BLP Example (2/6)

- Dirk creates file f1 (e.g. personal notes)
- Carla creates file f2 (e.g. an assignment attempt)
- Carla can read/write to f2 but can not read f1
- Dirk can read/write f1 but f2 is read-only as teacher (if Carla permits)
- Dirk can write to f2 only as a student



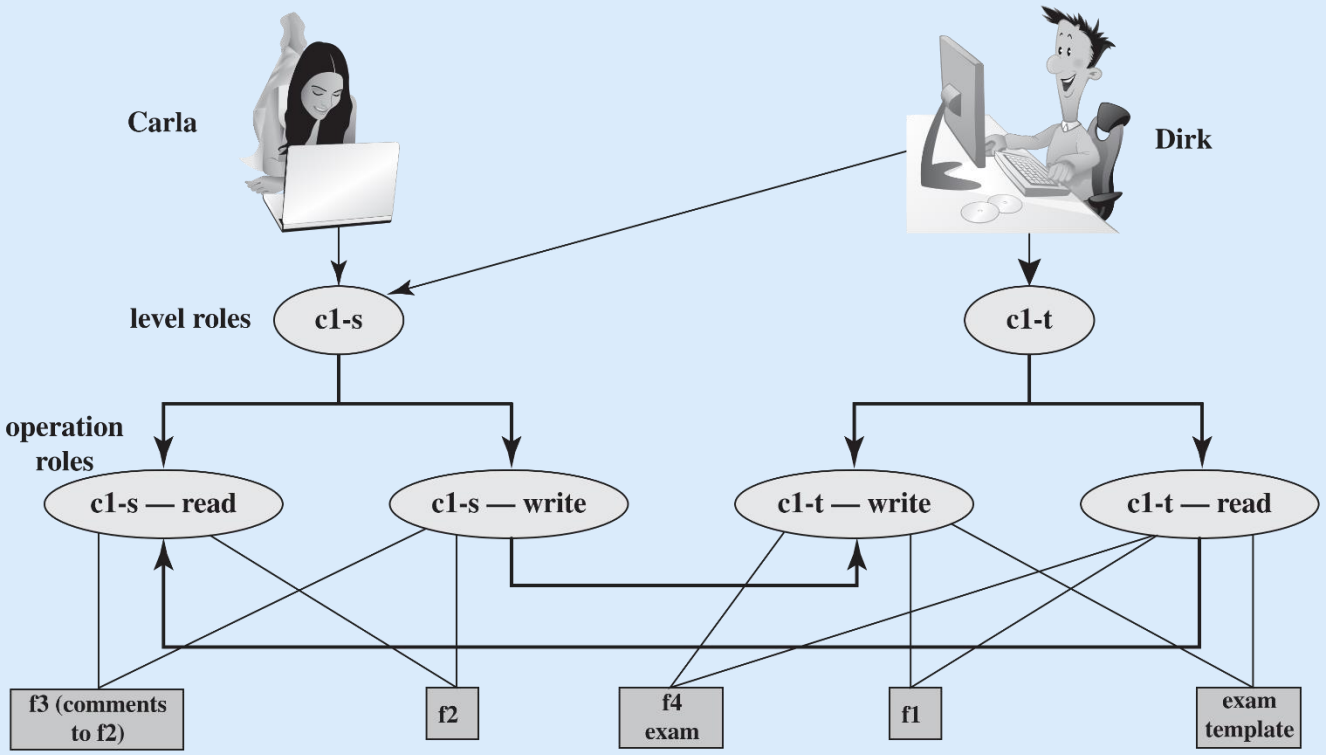
BLP Example (3/6)

- Dirk reads f2; want to create f3 (comments on Carla's submission)
- Dirk signs in as a student to create f3 (so that Carla can read)
  - As a teacher, Dirk cannot create a file at student classification



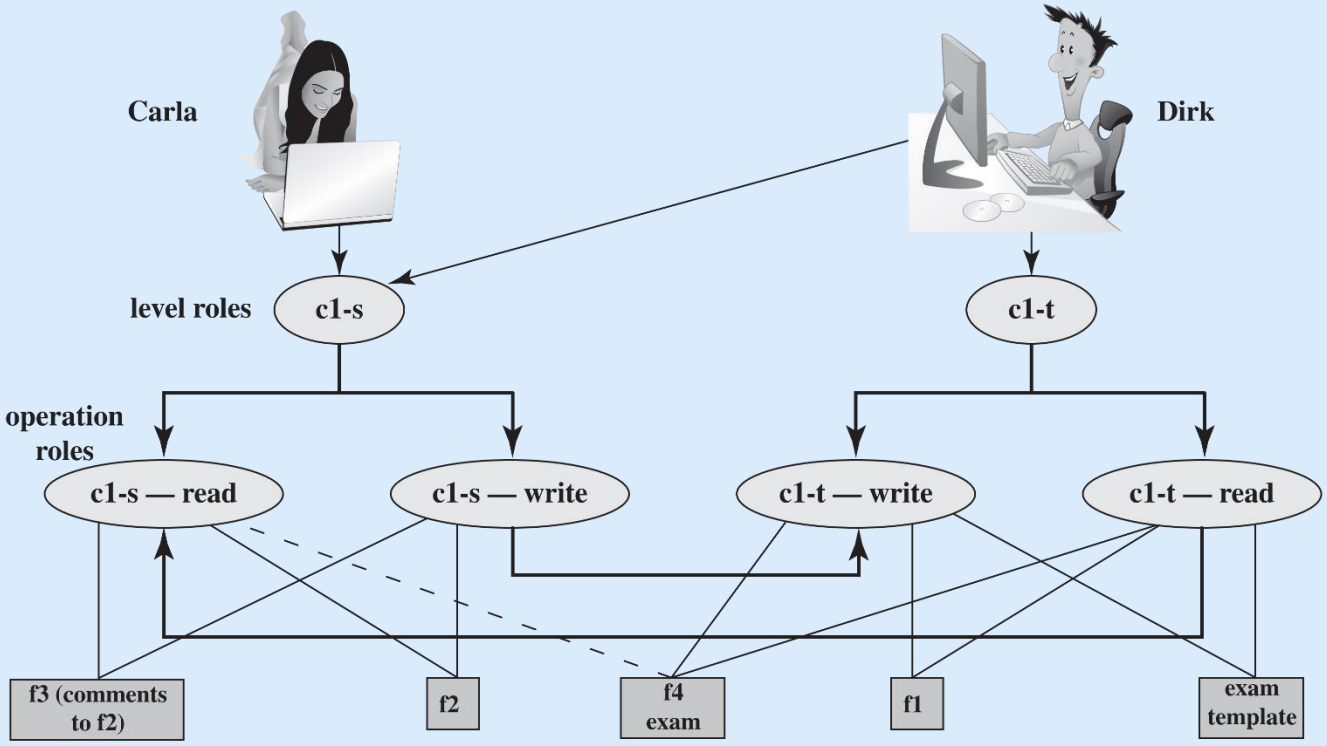
BLP Example (4/6)

- Dirk as a teacher creates an exam (f4)
- Must log in as a teacher to read exam template



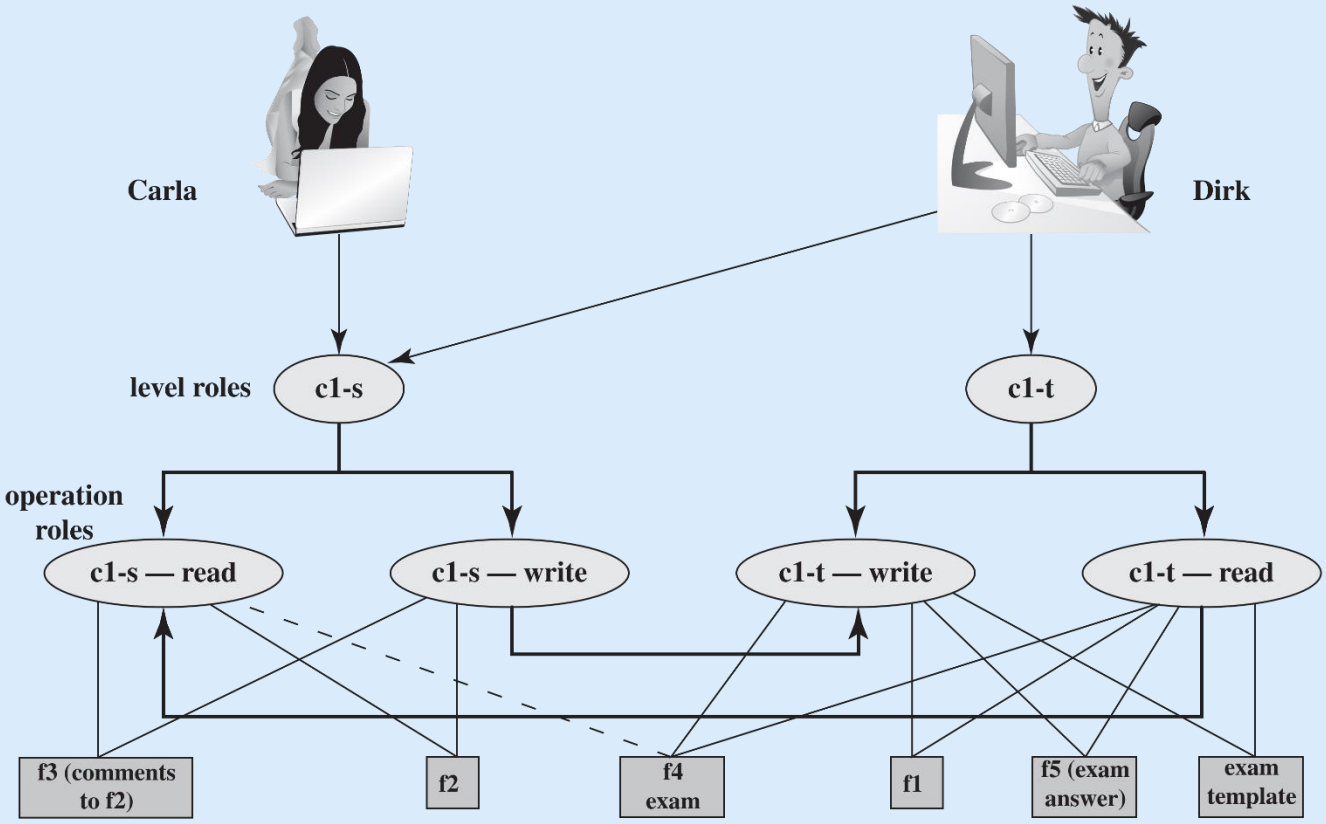
BLP Example (5/6)

- Dirk wants to give Carla access to read f4
- Dirk can't do that; an admin must do
  - An admin downgrades f4 class to c1-s



BLP Example (6/6)

- Carla writes answers to f5 at teacher level (c1-t)
- An example of write up (allowed in BLP)
- Dirk can read f5



BLP – Reading Information

- "Reads up" disallowed, "reads down" allowed
- Simple Security Property
  - Subject s can read object o
  - iff $Level_s$ dominates $Level_o$
  - and s has permission to read o
    - Note: It combines mandatory control (relationship of security levels) and discretionary control (the required permission)
  - Sometimes called "no reads up" rule

BLP – Writing Information

- Information flows up, not down
  - "Writes up" allowed, "writes down" disallowed
- *-property
  - Subject s can write object o
  - iff $Level_o$ dominates $Level_s$
  - and s has permission to write o
    - Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)
  - Sometimes called "no writes down" rule

Limitations of BLP Model

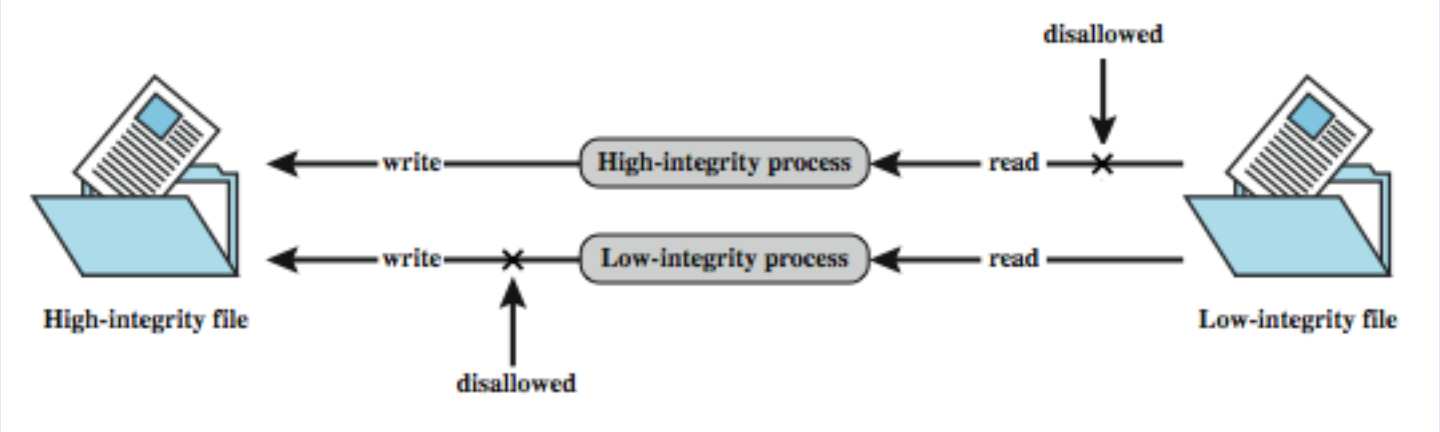
- Incompatibility of confidentiality and integrity
- Classification of data changes over time
  - BLP has no provision to manage the downgrade of objects
- In the presence of shared resources, *-property may not be enforced
- A bit complex to implement

Biba Integrity Model

- Another model from 1970s.
- Deals with information integrity only
  - the case where data must be visible at multiple security levels but should be modified in a controlled ways.
  - Prevent unauthorized modifications
- Like BLP, it also works with subjects and objects
- Each subject and object is assigned an integrity level
  - Denoted by I(S) and I(O)
  - Levels should be hierarchical
    - e.g. measure data accuracy as extreme > high > medium > low
- There are four access modes
  - modify, observe, execute, invoke
  - invoke means to communicate information b/w subjects

Biba Integrity Model

- Strict integrity policy: Prevent low integrity data from **contaminating** the high integrity data
  - Simple integrity: modify only if I(S) ≥ I(O)
    - i.e. can write down, but **no write up**
  - Integrity confinement: read only if I(S) ≤ I(O)
    - i.e. can read up, but **no read down**
  - Invocation property: invoke/comm only if $I(S_1) \geq I(S_2)$



Clark-Wilson Integrity Model

- More practical integrity model from 1987
- Aimed at commercial world (instead of military)
- Goals
  - Prevent unauthorized users from making modifications
  - Prevent authorized users from making improper modifications
    - Biba model addressed the first goal only
- Two concepts
  - Well-formed transactions: a user can manipulate data in constrained ways only
  - Separation of duty: one can create a transaction but not execute it

Clark-Wilson Integrity Model

- Main components
  - Users
  - CDI: constrained data items (whose integrity should be preserved)
  - UDI: unconstrained items
  - IVPs: integrity verification procedures that assure all CDIs conform to integrity/consistency rules
  - TPs: transaction procedures that change CDIs
- Example: In a banking system, CDIs could be account balance, loan application, cheques etc. TPs are deposit, withdraw etc. One UDI could be user's input at ATM pin keypad

- In CW model, a security officer needs to define **access triples** (subject, TP, objects). This ensures that even authorized users can not take malicious actions.

Certification & Enforcement of Rules

These rules ensure the integrity of data items.
'Certification' preformed by a security officer.

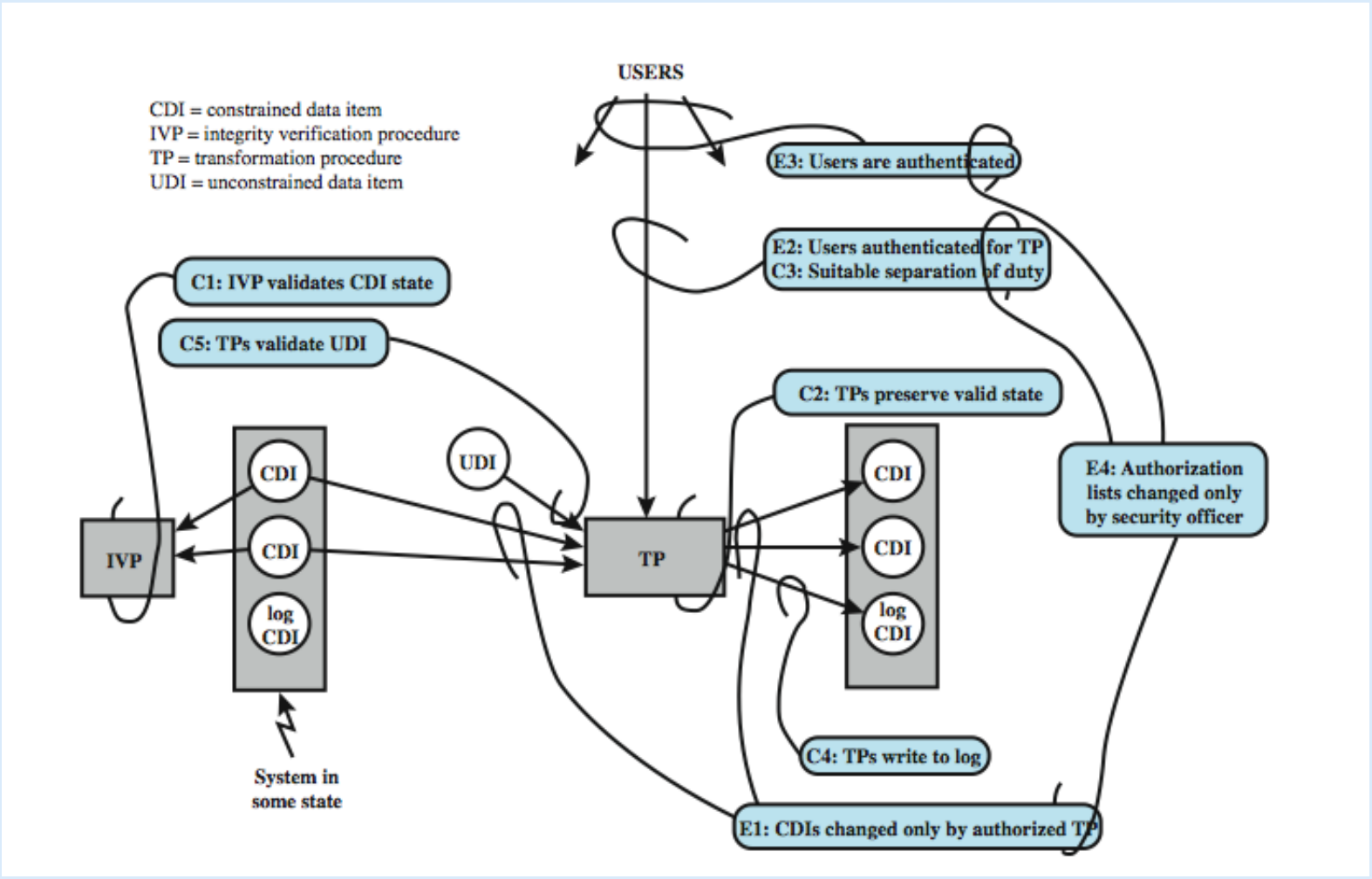
'Enforcement' done by the system

- C1: IVPs must ensure that all CDIs are in valid states
- C2: All TPs must be certified (must take a CDI from a valid initial state to a valid final state)
  - A certified TP looks like: TPi (CDIa, CDIb, CDIc, …)
- E1: The system must maintain a list of relations specified in C2
- E2: The system must maintain a list of allowed (User, TPi, (CDIa, CDIb, …)) combinations, i.e. access triples

Certification & Enforcement of Rules

- C3: The list of relations in E2 must be certified to meet separation of duties
- E3 The system must authenticate each user when executing a TP
- C4: All TPs must be certified to write their details to a log file
- C5: Any TP that takes UDI as in input value must be certified to perform only valid transactions
- E4: Only the agent permitted to certify entities is allowed to do so

Clark-Wilson Integrity Model



C: Certification rules
E: Enforcement rules

The Chinese Wall Model

- Also called Brewer and Nash model.
- Not a general purpose security model, it is meant for a very specific commercial concern
- Addresses the conflict of interest (CI or CoI) problem.
- Think law firms, accounting firms, and other consultancy services, providing services to several of clients. Some of those clients might be competitor to each other.

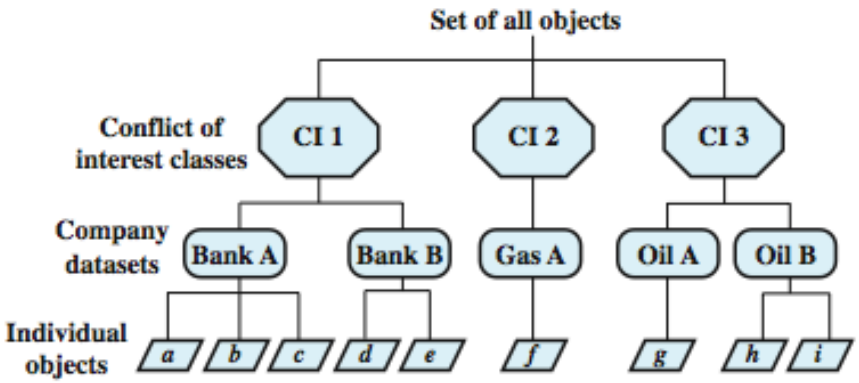
The Chinese Wall Model

- Model elements
  - subjects: active entities interested in accessing protected objects
  - information
    - objects: individual data items, each about a corporation
    - datasets (DS): all objects concerning one corporation
    - CI class: datasets whose corporation are in competition (conflict of interest or CI)
  - access rules: rules for reading/writing data

The Chinese Wall Model

- Not a true multilevel security model
  - the history of a subject's access determines access control
- Subjects are only allowed access to info that is not held to conflict with any other info they already possess
- Once a subject accesses info from one dataset, a wall is set up to protect info in other datasets in the same CI

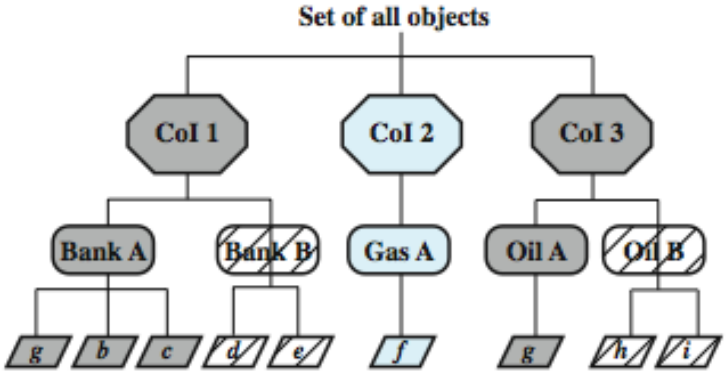
The Chinese Wall Model



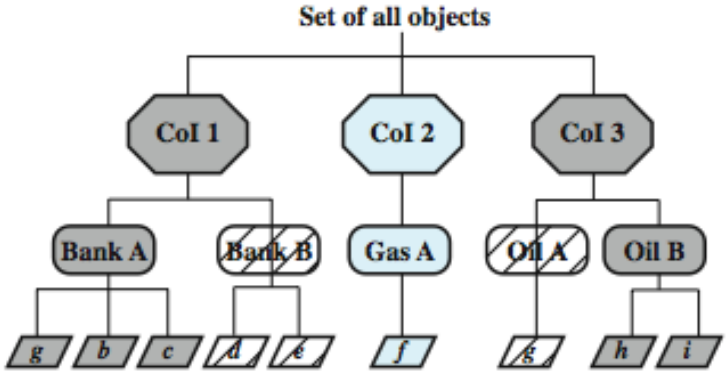
(a) Example set

simple security rule (read): S can read O if O is in the same DS as an object already accessed by S **OR** O belongs to a CI from which S has not yet accessed any info

***-property rule (write):** S can write O only if S can read O **AND** all objects that S can read are in the same DS as O.



(b) John has access to Bank A and Oil A



(c) Jane has access to Bank A and Oil B

Question: what can John write to?
what about Jane?

Chinese Wall vs BLP

- CW is based on access history, BLP is history-less
- BLP can capture CW state at any time, but cannot track changes over time
  - BLP security levels would need to be updated each time an access is allowed