Information Security
CS 3002

Dr. Haroon Mahmood

Assistant Professor

NUCES Lahore

Disclaimer: The contents of these slides have been taken from the book of Computer Security by William Stallings.

Confidentiality Policy

- **Goal: prevent the unauthorized disclosure of information**
  - **Deals with information flow**
  - **Integrity incidental**

- **Multi-level security models are best-known examples**
  - **Bell-LaPadula Model basis for many, or most, of these**

Bell-LaPadula (BLP) Model

- Security levels arranged in linear ordering
  - Top Secret: highest
  - Secret
  - Confidential
  - Unclassified: lowest

- Levels consist of security clearance L(s)
- Objects have security classification L(o)

Bell-LaPadula (BLP) Model

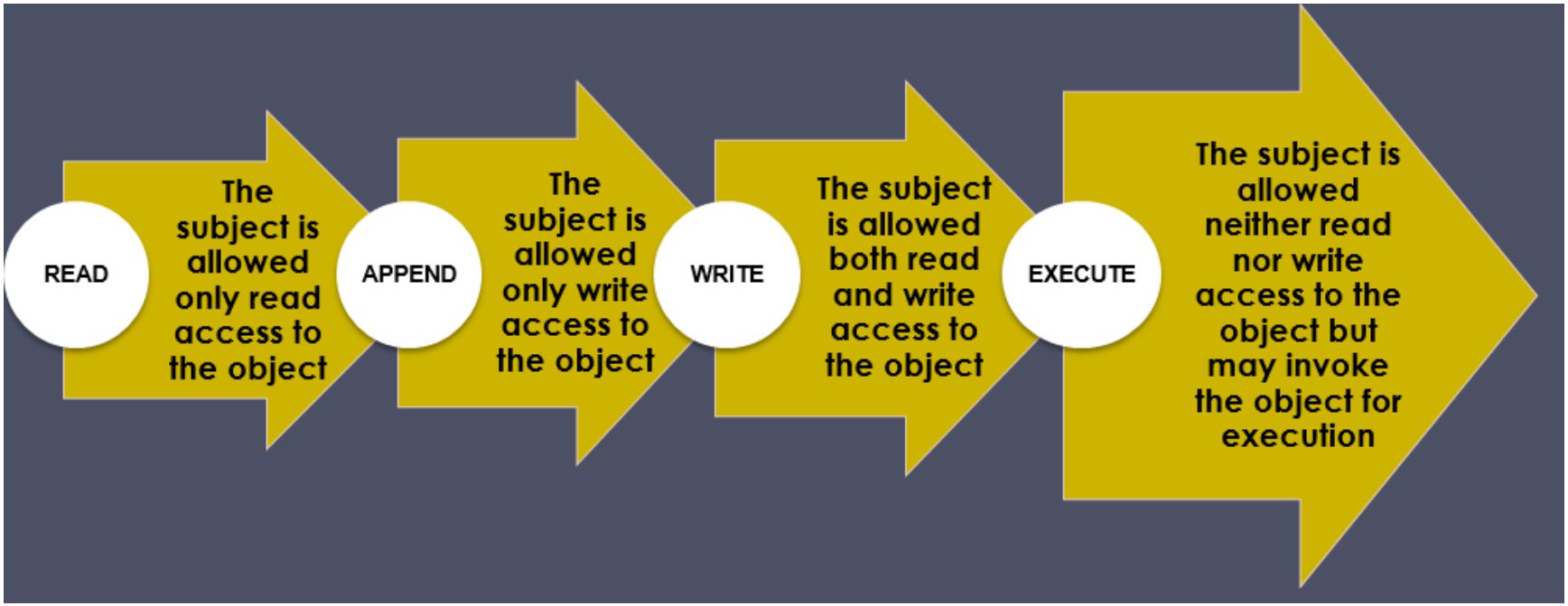
- Formal model for access control
- Subjects and objects are assigned a security class
- Form a hierarchy and are referred to as security levels
- A subject has a security clearance
- An object has a security classification
- Security classes control the manner by which a subject may access an object

A BLP Example

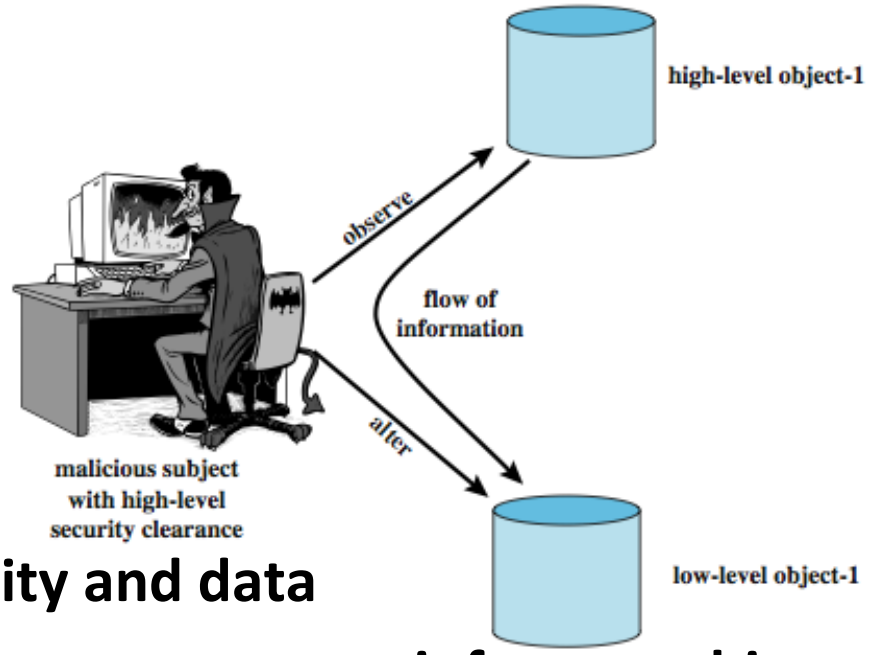
Security level	*Subject*	*Object*
Top Secret	Tamim	Personnel Files
Secret	Sohail	E-Mail Files
Confidential	Kaleem	Activity Logs
Unclassified	Jamal	Telephone Lists

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

Access Privileges



Multilevel Security



- Multiple levels of security and data
- Subject at a high level may not convey info to a subject at a non-comparable level:
  - No read up (ss-property): a subj can only read an obj of less or equal sec level
  - No write down (*-property): a subj can only write into an obj of greater or equal sec level

BLP Formal Description

- **Based on current state of system (*b*, *M*, *f*, *H*):**
  - **Current access set *b (subj, objs, access-mode);* it is the *current* access (not permanent)**
  - **Access matrix *M* (Si is permitted to acces Oj)**
  - **Level function *f: assigns sec level to each subj and obj;* a subject may operate at that or lower level**
  - **Hierarchy *H: a directed tree whose nodes are objs:***
    - ***Sec level of an obj must dominate (must be greater than) its parents***

BLP Properties

- **Three BLP properties:** *(c = current)*
  1. **ss-property: (S_i, O_j, read) has $f_c(S_i) \geq f_o(O_j)$**
  2. ***-property: (S_i, O_j, append) has $f_c(S_i) \leq f_o(O_j)$ and (S_i, O_j, write) has $f_c(S_i) = f_o(O_j)$**
  3. **ds-property: (S_i, O_j, A_x) implies $A_x \in M[S_i,O_j]$**

- **BLP give formal theorems**
  - **Theoretically possible to prove system is secure**

ss-property: simple security

***-property: pronounced star**

ds-property: discretionary security

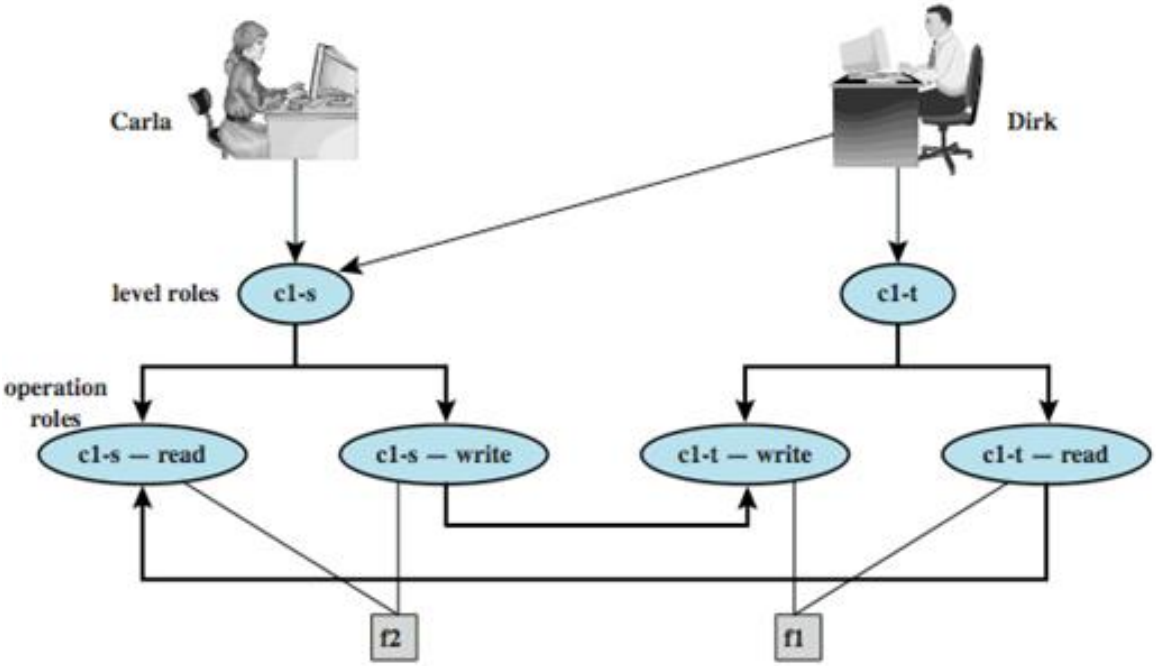
BLP Operations

1. get access: add (subj, obj, access-mode) to b
   - used by a subj to initiate an access to an object
2. release access: remove (subj, obj, access-mode)
3. change object level
4. change current level (subject)
5. give access permission: Add an access mode to M
   - used by a subj to grant access to on an obj
6. rescind access permission: reverse of 5
7. create an object
8. delete a group of objects

BLP Example

- A role-based access control system
- Two users: Carla (student) and Dirk (teacher)
  - Carla (Class: s)
  - Dirk (Class: T); can also login as a students thus (Class: s)
- A student role has a lower security clearance
- A teacher role has a higher security clearance

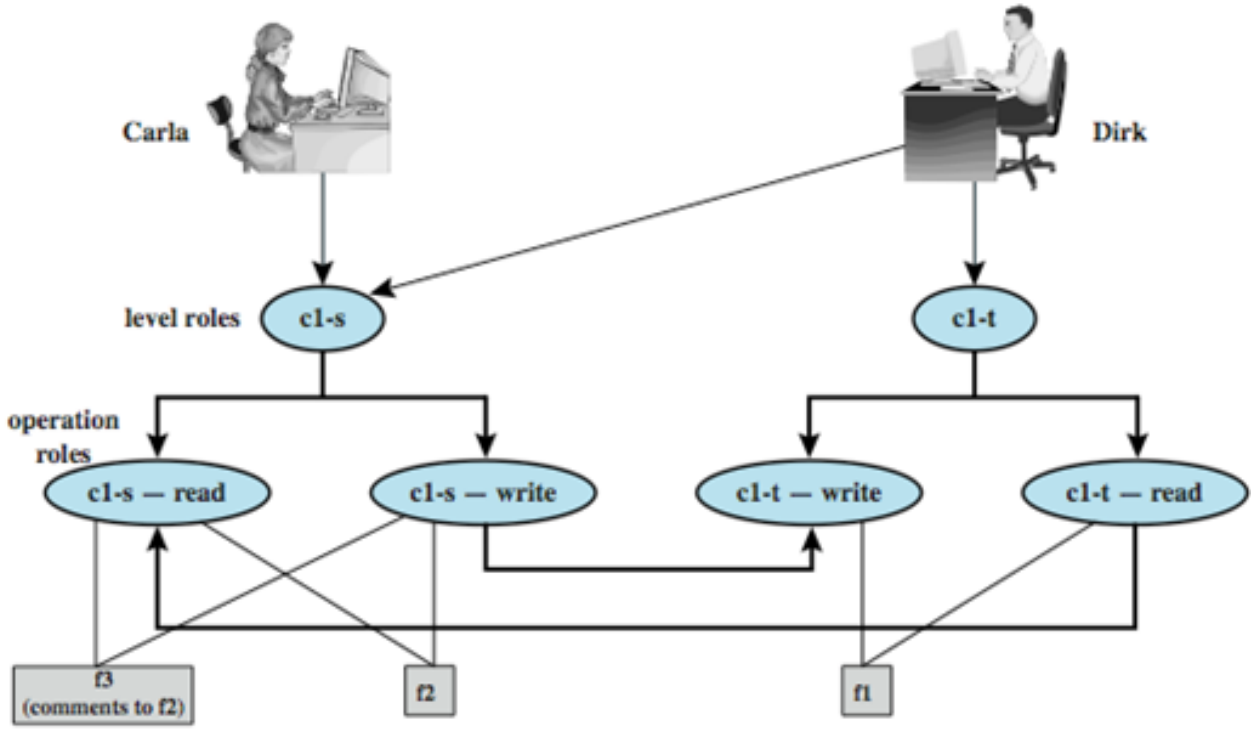
BLP Example



(a) Two new files are created: f1: c1-t; f2: c1-s

- Dirk creates f1; Carla creates f2
- Carla can read/write to f2 but cant read f1
- Dirk can read/write f1 and f2 (if perm)
- Dirk can read/write f2 only as a student

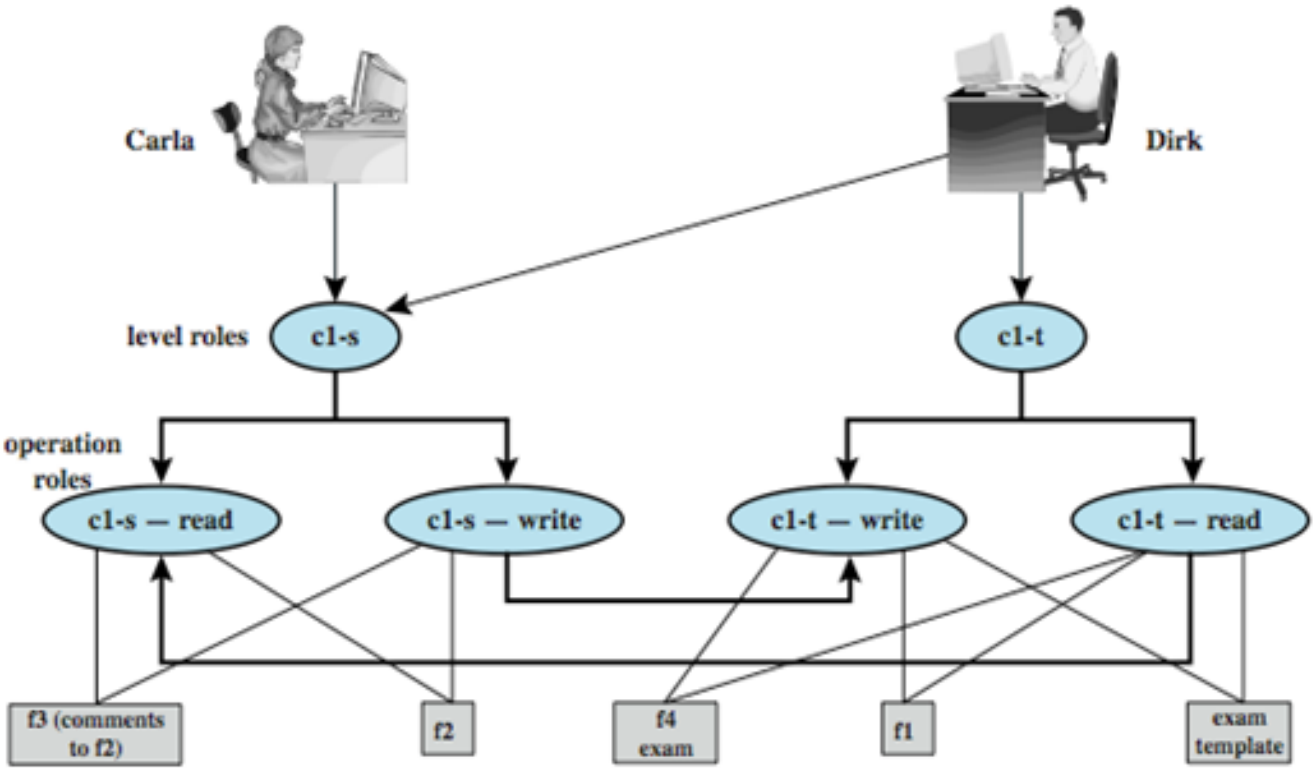
BLP Example cont.



(b) A third file is added: f3: c1-s

- Dirk reads f2; want to create f3 (comments)
- Dirk signs in as a stu (so Carla can read)
- As a teacher, Dirk cannot create a file at stu classification

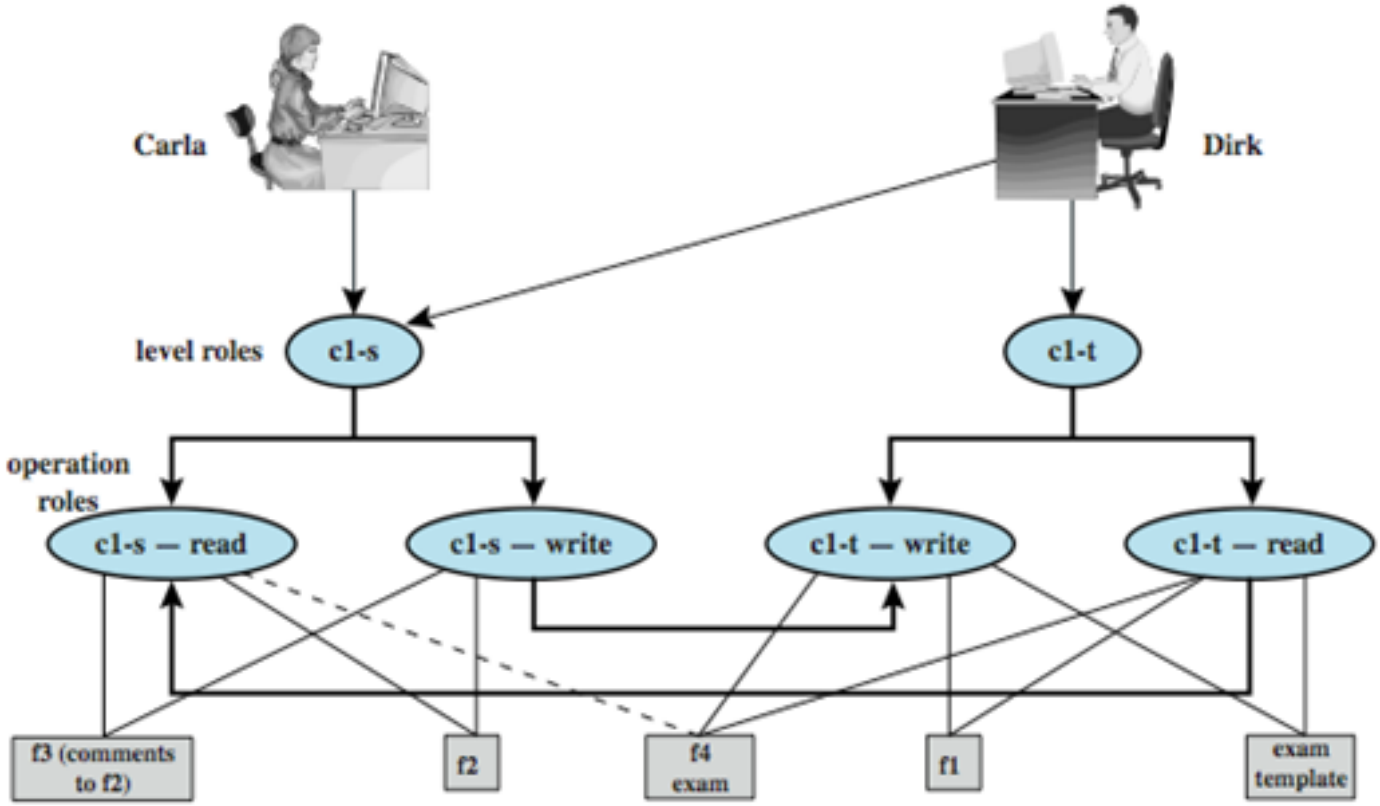
BLP Example cont.



(c) An exam is created based on an existing template: f4: c1-t

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

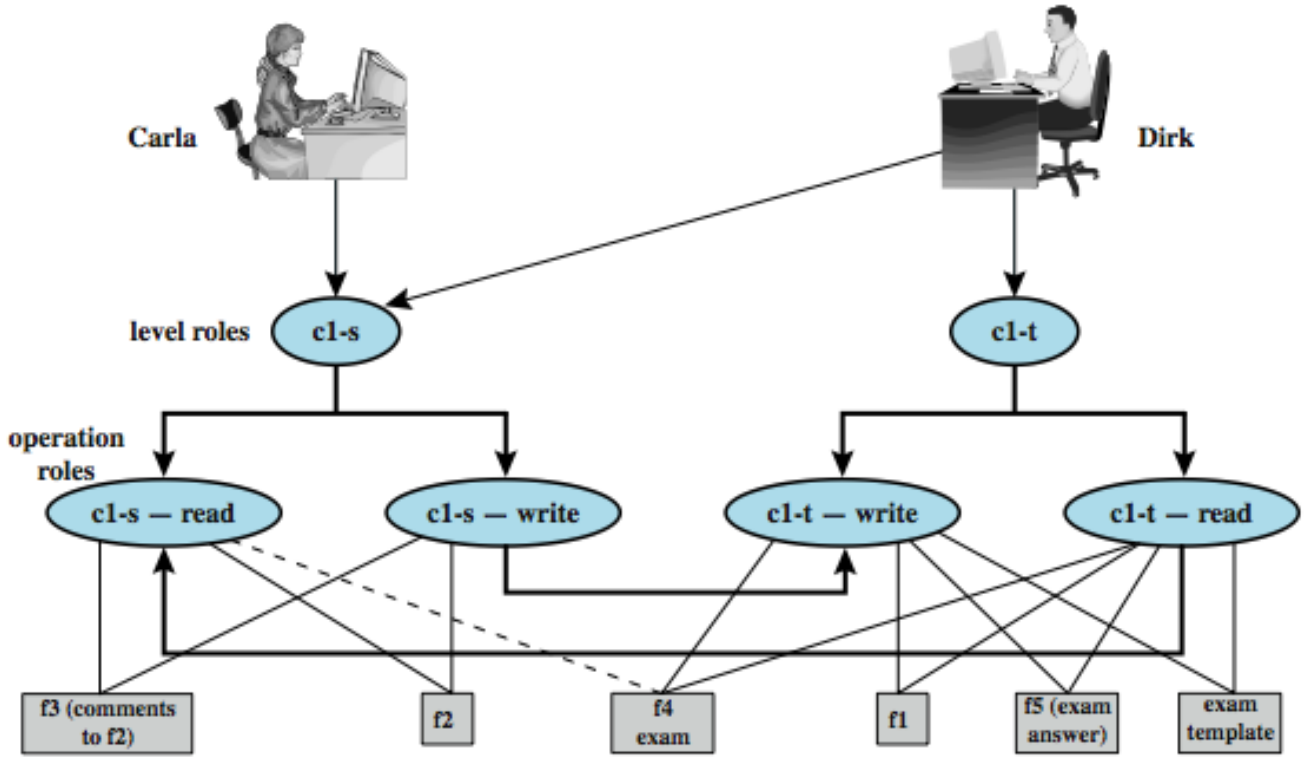
BLP Example cont.



(d) Carla, as student, is permitted acess to the exam: f4: c1-s

- 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 cont.



(e) The answers given by Carla are only accessible for the teacher: f5: c1-t

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

Reading Information - New

- **"Reads up" disallowed, "reads down" allowed**

- **Simple Security Condition**
  - **Subject *s* can read object *o* iff *L*(*s*) *dom L*(*o*) and *s* has permission to read *o***
    - **Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)**
  - **Sometimes called "no reads up" rule**

Writing Information - New

- Information flows up, not down
  - "Writes up" allowed, "writes down" disallowed

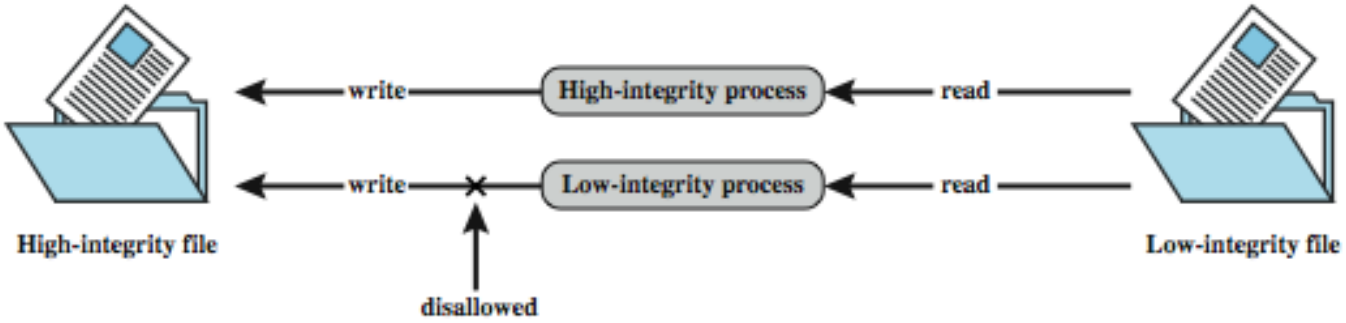
- *-Property (Step 2)
  - Subject *s* can write object *o* iff *L*(*o*) *dom L*(*s*) and *s* has permission to write *o*
    - Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)
  - Sometimes called "no writes down" rule

Limitation of BLP model

- Incompatibility of confidentiality and integrity
- Classification of data changes over time
- If data needs to migrate to higher security classification, a trusted user has to be downgraded!
- In the presence of shared resources, *-property may not be enforced
- A bit complex to implement

Biba Integrity Model

- Deals with integrity and deal with the case where data must be visible at multiple security levels but should be modified in a controlled ways.
- Strict integrity policy:
  - Simple integrity: *modify only if* $I(S) \geq I(O)$
  - Integrity confinement: *read only if* $I(S) \leq I(O)$
  - Invocation property: *invoke/comm only if* $I(S_1) \geq I(S_2)$



Biba Integrity Model

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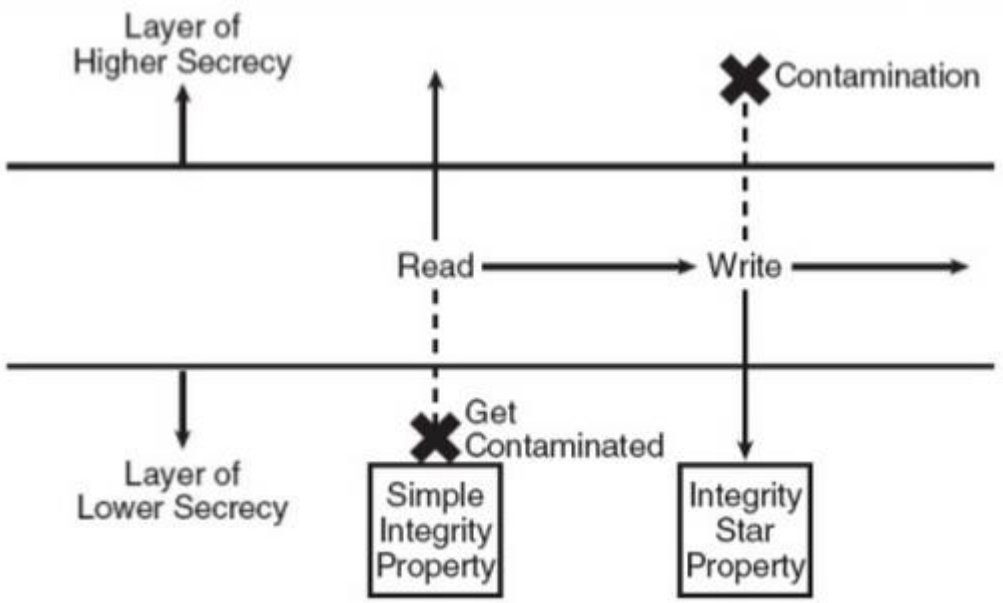


Clark-Wilson Integrity Model

- Two concepts
  - Well-formed transactions: a user can manipulate data in constrained ways
  - Separation of duty: one can create a transaction but not execute it

- CDI: constrained data items (loan app; checks)
- UDI: unconstrained items
- IVPs: procedures that assure all CDIs conform to integrity/consistency rules
- TPs: transactions that change CDIs
- Very practical; used in commercial world

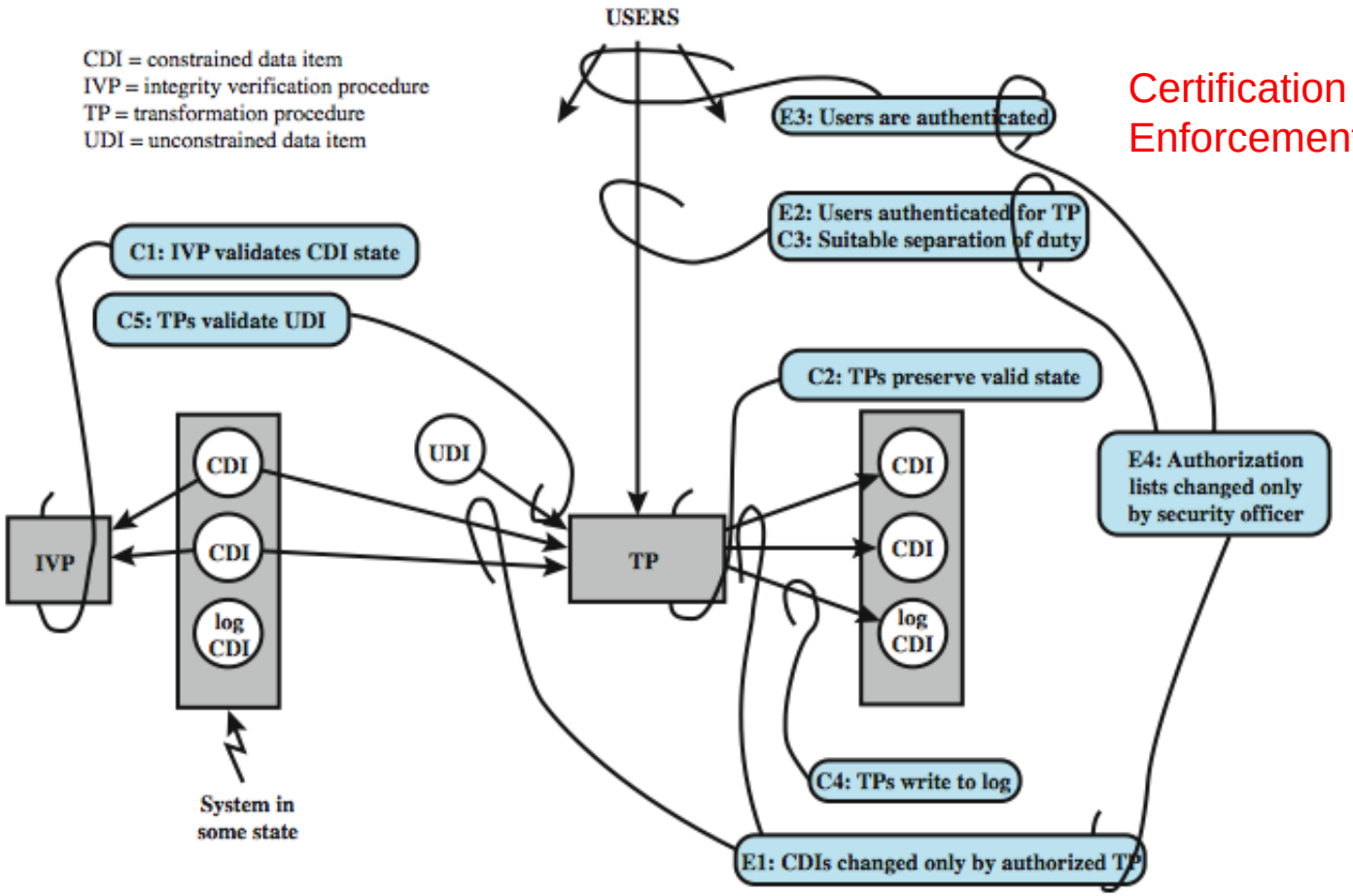
Certified and Enforcement Rules

- **C1: IVPs must ensure that all CDIs are in valid states**
- **C2: All TPs must be certified (must take a CDI from a valid state to a valid final state)**
  - **(Tpi, CDIa, CDIb, CDIc, …)**
- **E1: The system must maintain a list of relations specified in C2**
- **E2: The system must maintain a list of (User, Tpi, (CDIa, CDIb, …))**

Certified and Enforcement 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**
- **C5: Any TP that takes UDI as in input value must be certified to perform valid transaction**
- **E4: Only the agent permitted to certify entitles is allowed to do so**

Clark-Wilson Integrity Model



Certification (C) and Enforcement (E) rules

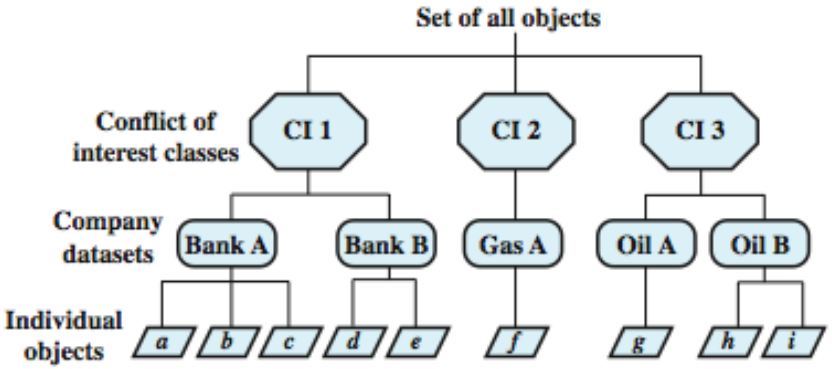
The Chinese Wall Model

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

The Chinese Wall Model

- Not a true multilevel secure 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

Chinese Wall Model

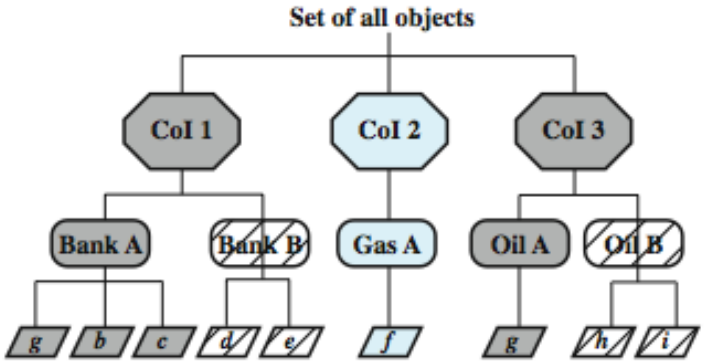


(a) Example set

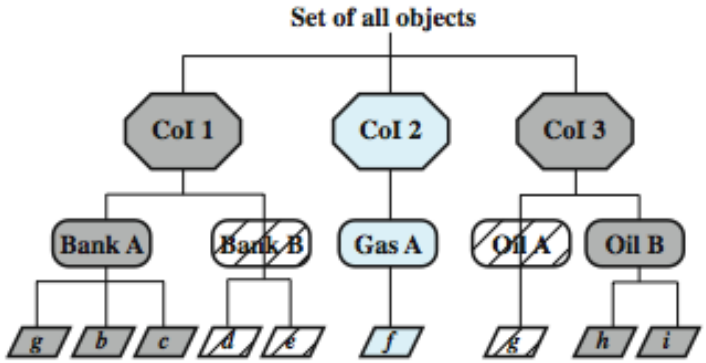
Simple sec rule (read): S can read O if O is in the same DS as an object already accessed by S OR O belongs to a CoI from which S has not yet accessed any info

***-property (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.

Question: what can John or Jane write to?



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



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

Compare CW to Bell-LaPadula

- 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