TEL AVIV UNIVERSITY

Introduction to Information Security

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Lecture 3:

Access control (2/2)

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Access Control

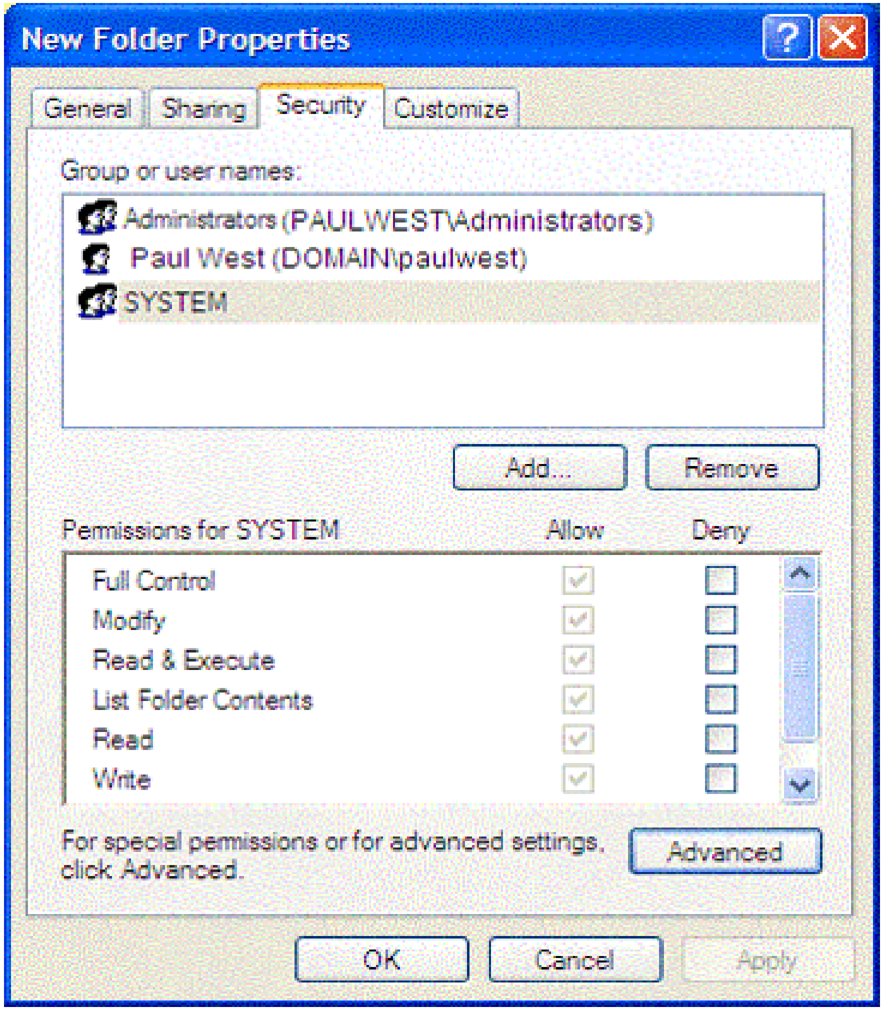
Windows

Access control in Windows (since NTFS)

- Some basic functionality similar to Unix
  - Specify access for groups and users
    - Read, modify, change owner, delete
- Some additional concepts
  - Tokens
  - Security attributes
- Generally
  - More flexibility than Unix
    - Can define new permissions
    - Can give some but not all administrator privileges

Identify subject using SID

- Security ID (SID)
  - Identity (replaces UID)
    - SID revision number
    - 48-bit authority value
    - variable number of Relative Identifiers (RIDs), for uniqueness
  - Users, groups, computers, domains, domain members all have SIDs



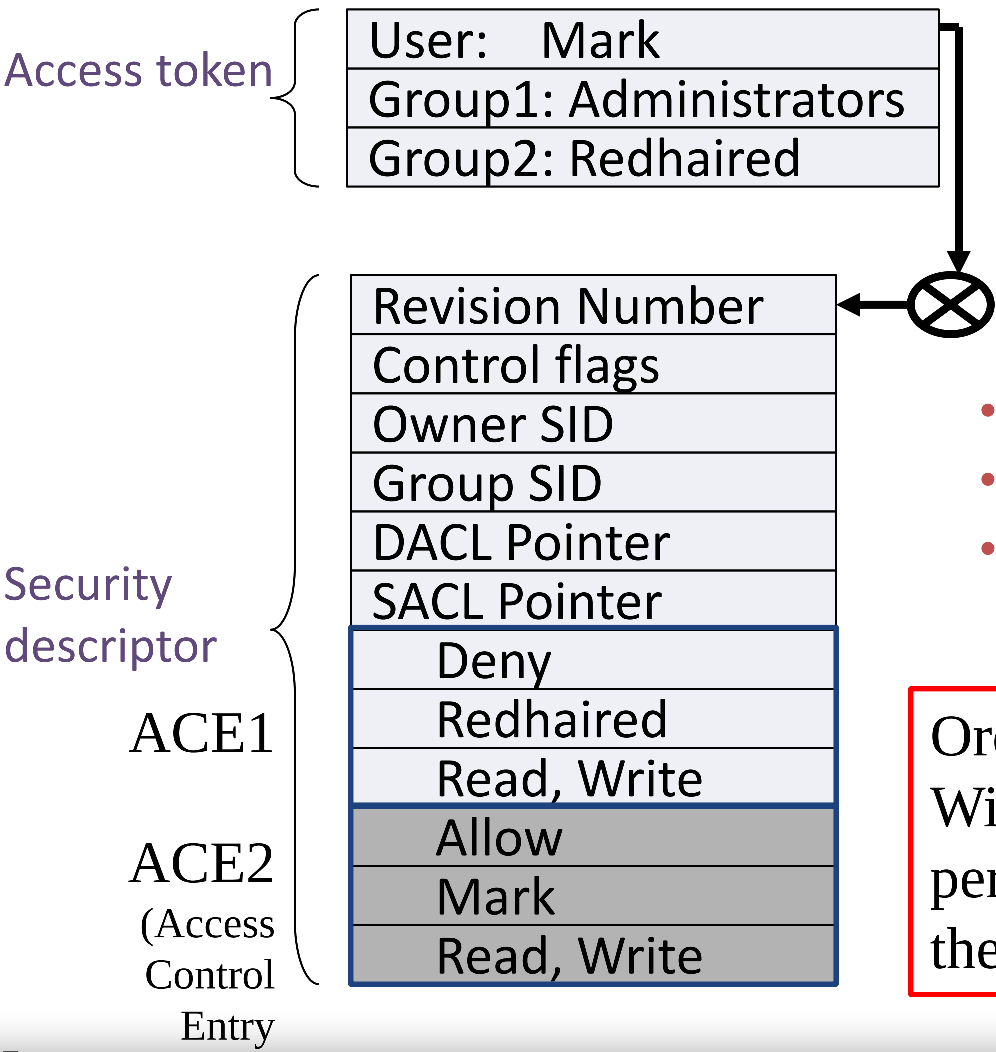
Each process has set of tokens

- Security context
  - Privileges, accounts, and groups associated with the process or thread
  - Presented as set of tokens
- Reference Monitor
  - Uses tokens to identify the security context of a process or thread
- Impersonation token
  - Used temporarily to adopt a different security context, usually of another user

Each object has security descriptor

- Security descriptor, associated with an object, specifies who can perform what actions on the object
- Fields:
  - Header
    - Descriptor revision number
    - Control flags, attributes of the descriptor
      - E.g., memory layout of the descriptor
  - SID of the object's owner
  - SID of the primary group of the object
  - Two attached optional lists:
    - Discretionary Access Control List (DACL) controls access by users, groups, …
    - System Access Control List (SACL) controls logging of access to system logs

Example access request



Access request: write
Action: denied

- User Mark requests write permission
- Descriptor denies permission to group
- Reference Monitor denies request

Order of ACEs in ACL matters. Windows reads ACL until permission is Granted or Denied, then stops.

Impersonation Tokens (compare to setuid)

- Process adopts security attributes of another
  - Client passes impersonation token to service
- Client specifies impersonation level of service
  - Anonymous
    - The service can impersonate the client but the impersonation token does not contain any information about the client.
  - Identification
    - The service can get the identity of the client and use this information in its own security mechanism, but it cannot impersonate the client.
  - Impersonation
    - The service can impersonate the client (on local computers).
  - Delegation
    - The service can impersonate the client on local and remote computers.

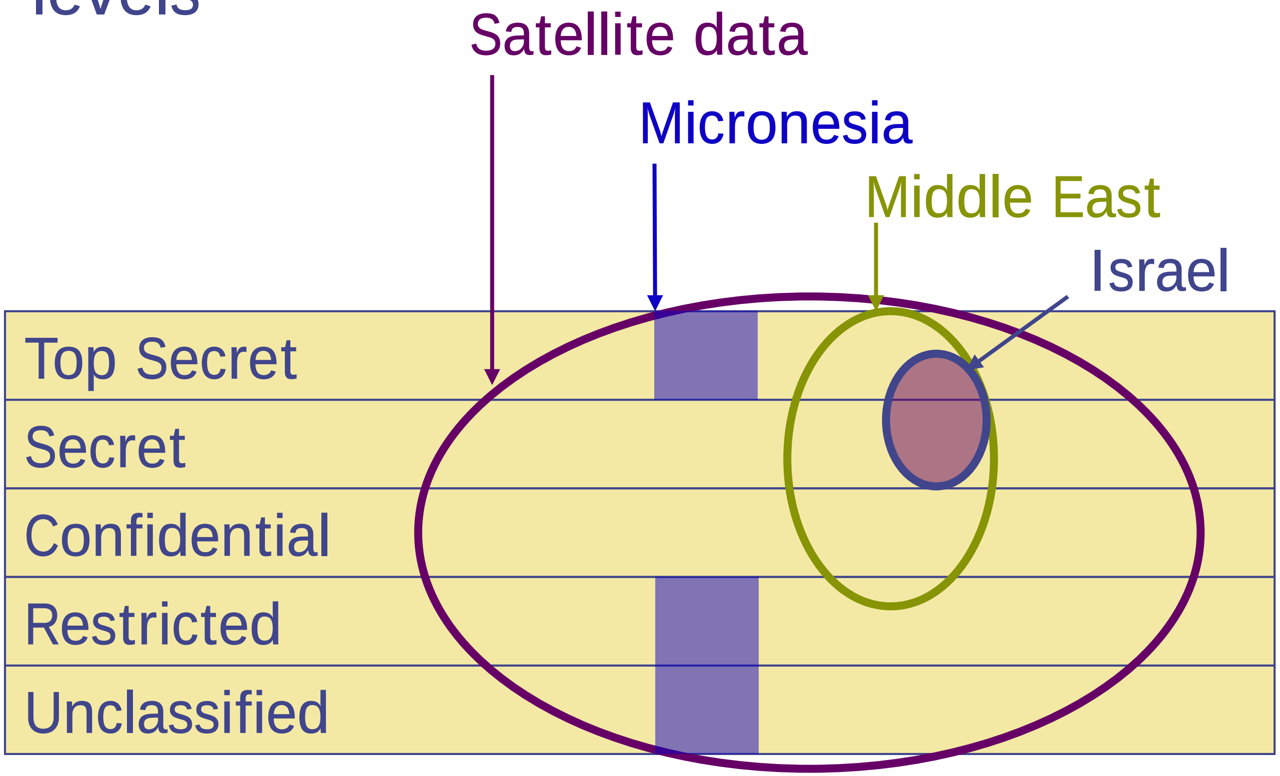
Access control policies

Multi-Level Security (MLS) Concepts

- Military security policy
  - Classification involves sensitivity levels, compartments
  - Do not let classified information leak to unclassified files
- Group individuals and resources
  - Use some form of hierarchy to organize policy
- Other policy concepts
  - Separation of duty
  - “Chinese Wall” Policy (managing conflicts of interests)

Military security policy

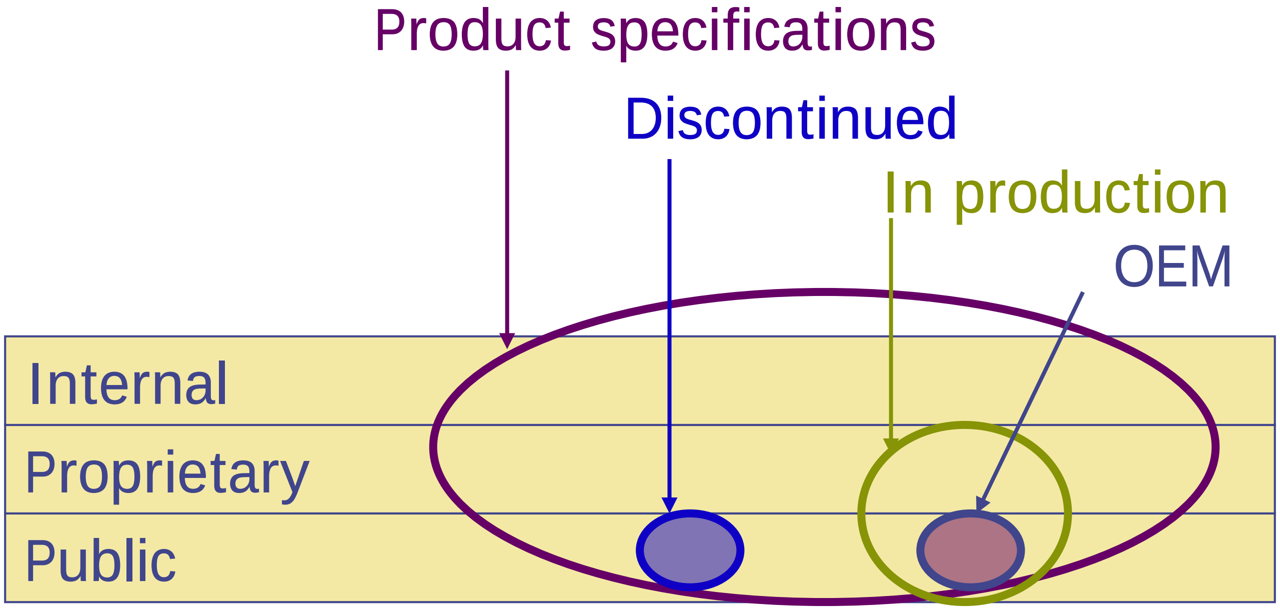
- Sensitivity levels
- Compartments



Example: military security policy

- Classification of personnel and data
  - Class = ⟨rank, compartment⟩
- Dominance relation
  - $C_1 \leq C_2$ iff $rank_1 \leq rank_2$
    and $compartment_1 \subseteq compartment_2$
  - Example: ⟨Restricted, Israel⟩ ≤ ⟨Secret, Middle East⟩
- Applies to
  - Subjects – users or processes
  - Objects – documents or resources

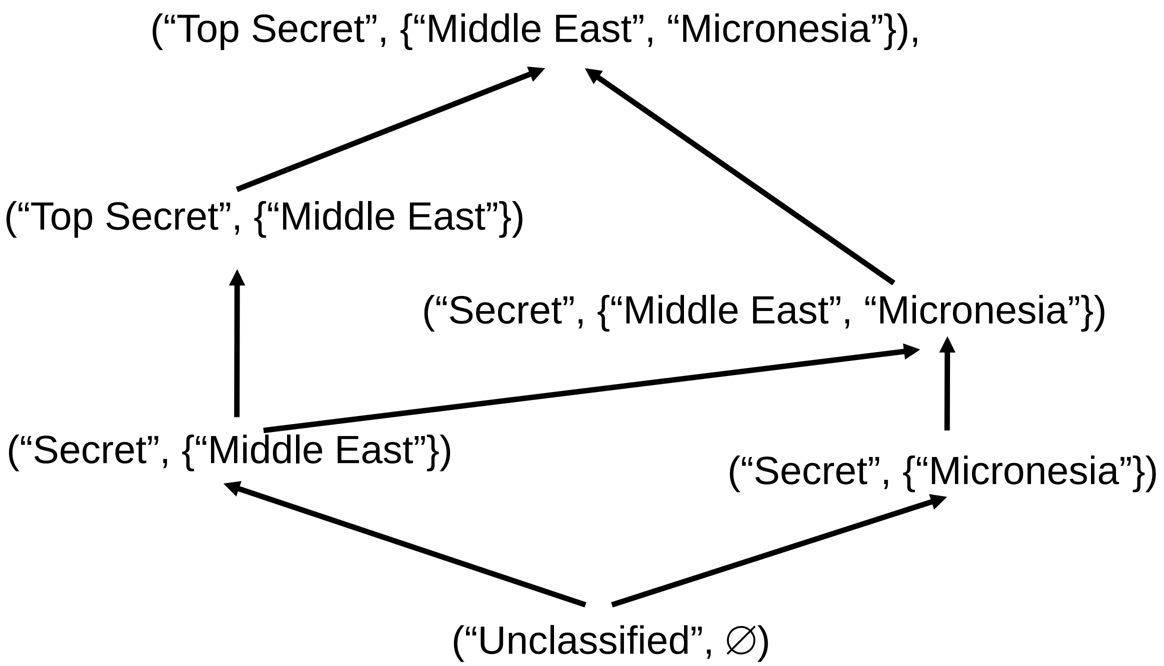
Example: commercial policy



Generalizing: lattices

- A dominance relationship that is transitive and antisymmetric defines a lattice
- For two levels a and b, maybe neither $a \geq b$ nor $b \geq a$
- However, for every a and b, there is a lowest upper bound u for which u ≥ a and $u \geq b$, and
  a greatest lower bound l for which a ≥ l and $b \geq l$
- There are also two elements U and L that dominate/are dominated by all levels
  - In next slide's example,
    U = ("Top Secret", {"Middle East", "Micronesia"})
    L = ("Unclassified", $\emptyset$)

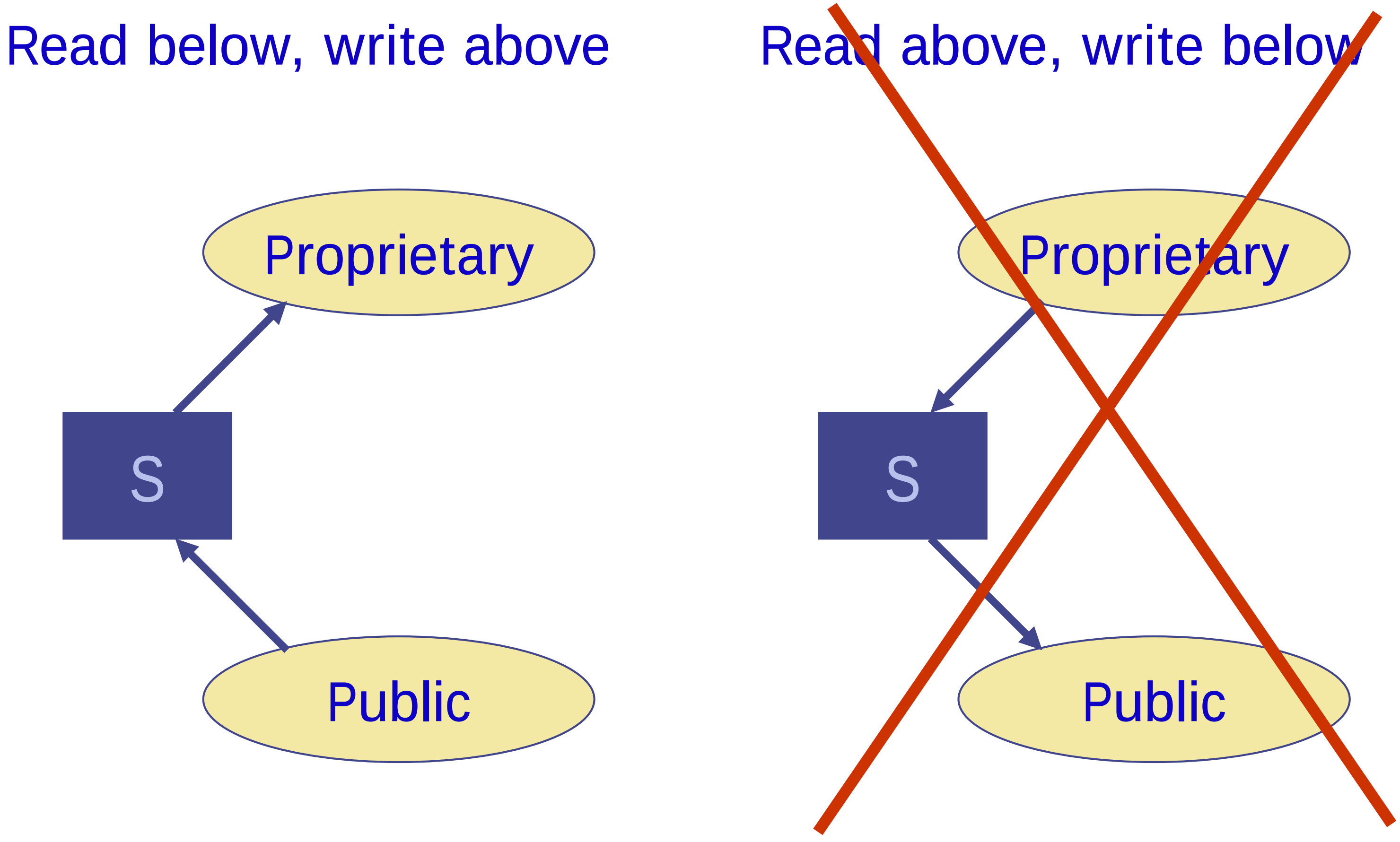
Example Lattice



Bell-LaPadula Confidentiality Model

- When is it OK to release information?
- Two properties
  - No read up
    - A subject S may read object O only if $C(O) \leq C(S)$
  - No write down
    - A subject S with read access to O may write to object P only if $C(O) \leq C(P)$
- You may only *read below* your classification
  and *write above your classification*
- Mandatory Access Control: protect even against malicious software / users / trojan horses
  who try to violate policy.
  (by contrast: Discretionary Access Control)

Picture: Confidentiality



Biba Integrity Model

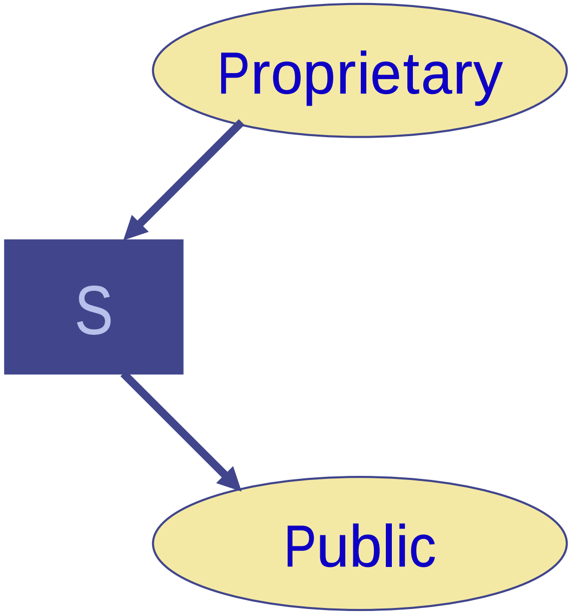
- Rules that preserve integrity of information (dual to confidentiality)
- Two properties
  - No write up
    - A subject S may write object O only if $C(S) \geq C(O)$

      (Only trust S to modify O if S has higher rank …)
  - No read down
    - A subject S with read access to O may write object P only if $C(O) \geq C(P)$

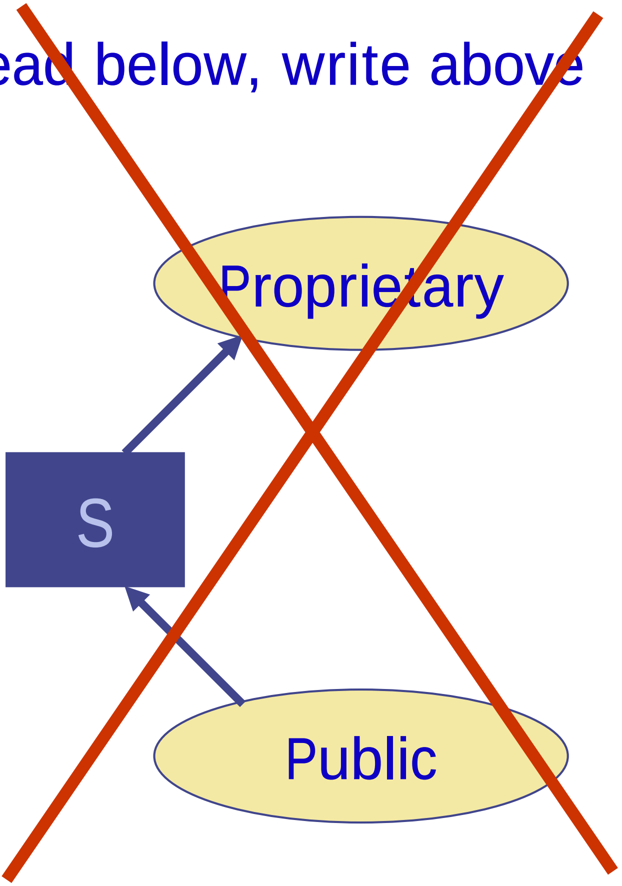
      (Only move info from O to P if O is more trusted than P)
- You may only *write below* your classification and *read above your classification*

Picture: Integrity

Read above, write below



Read below, write above



Problems

- Covert channels
- Declassification (when OK to violate strict policy?)
- Composability (e.g, one-time-pad)
  - Aggregation (many “low” facts may enable deduction of “high” information)
- Overclassification (label creep)
- Incompatibilies (e.g., upgraded files “disappear”)
- Polyinstantiation (maintaining consistency when different users have different view of the data, and perhaps even see “cover stories”)

Other policy concepts

- Separation of duty
  - If amount is over $10,000, check is only valid if signed by two authorized people
  - Two people must be *different*
  - Policy involves role membership and ≠
- Chinese Wall Policy
  - Lawyers L1, L2 in same firm
  - If company C1 sues C2,
    - L1 and L2 can each work for either C1 or C2
    - No lawyer can work for opposite sides in any case
  - Permission depends on use of other permissions

These policies cannot be represented using access matrix

Access control in web browsers

Operating system

- Objects:
  - System calls
  - Processes
  - Disk
  - File
- Principals:
  - Users
- Discretionary access control
- Vulnerabilities
  - Buffer overflow
  - Root exploit

Web browser

- Objects:
  - Document object model
  - Frames
  - Cookies / localStorage
- Principals : “Origins”
- Mandatory access control
- Vulnerabilities
  - Cross-site scripting
  - Universal scripting

Components of browser security policy

- Frame-Frame relationships
  - canScript(A,B)
    - Can Frame A execute a script that manipulates arbitrary/nontrivial DOM elements of Frame B?
  - canNavigate(A,B)
    - Can Frame A change the origin of content for Frame B?
- Frame-principal relationships
  - readCookie(A,S), writeCookie(A,S)
    - Can Frame A read/write cookies from site S?

Policies: further reading

- Anderson, Stajano, Lee, *Security Policies*
  https://www.cl.cam.ac.uk/~rja14/Papers/security-policies.pdf
- Levy, *Capability-Based Computer Systems*
  http://www.cs.washington.edu/homes/levy/capabook

Information Flow Control

Information Flow Control

- An information flow policy describes authorized paths along which information can flow
- For example, Bell-La Padula describes a lattice-based information flow policy

Program-level IFC

- Input and output variables of program each have a (lattice-based) security classification S() associated with them
- For each program statement, compiler verifies whether information flow is secure
- For example, `x = y + z` is secure only if S(x) ≥ lub(S(y), S(z)), where lub() is lowest upper bound
- Program is secure if each of its statements is secure

Implicit information flow

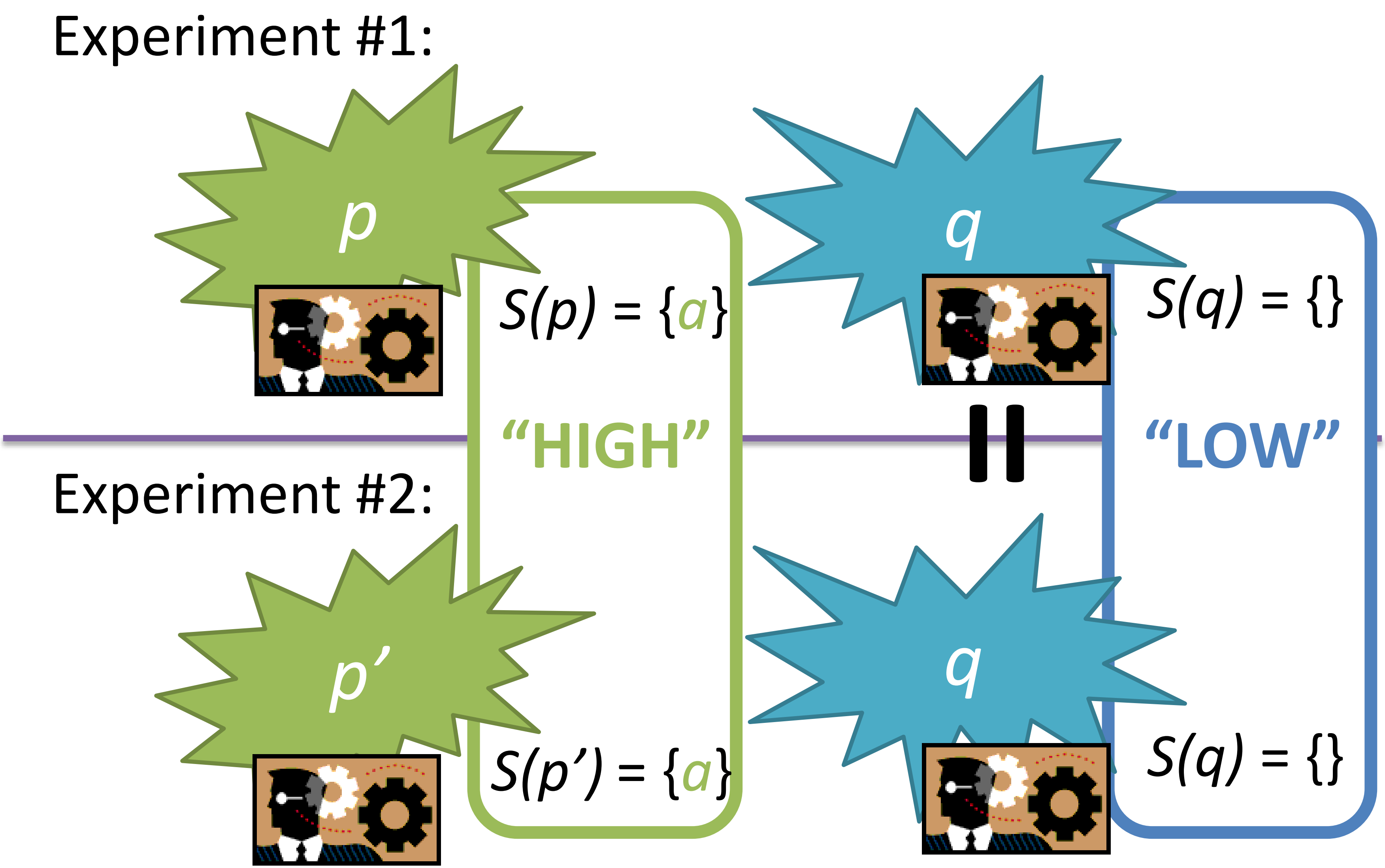
Conditional branches carry information about the condition:

```
secret bool a;
public bool b;
…
~~b = a;~~
if (a) {
    b = 1;
} else {
    b = 0;
}
```

Possible solution: assign label to program counter and include it in every operation. (Too conservative!)

IFC security notion: non-interference

Many variants and formalizations. At very high level: [Goguen Meseguer 1982]



IFC: Implementation approaches

- Language-based IFC (JIF & others)
  – Compile-time tracking for Java, Haskell
  – Static analysis
  – Provable security
  – Label creep (false positives)
- Dynamic analysis
  – Language / bytecode / machine code
  – Tainting
  – False positives, false negatives
  – Performance
  – Hybrid solutions
- OS-based DIFC (Asbestos, HiStar, Flume)
  – Run-time tracking enforced by a trusted kernel
    - Works with any language, compiled or scripting, closed or open

Difficulties with Information Flow Control

- Label creep
  Examples:
  - Branches
  - Logically-false flows
  - “Doesn’t really matter”
- Declassification
  - Example: encryption
- Catching all flows
  - Exceptions (math division by 0, null pointer, out of bounds access…)
  - Signals
  - Covert channels