Computer Security
CS 426
Lecture 21

The Bell LaPadula Model

Annoucements

- October 15: Guest lecture by Prof. Steve Elliott on biometrics

- October 22: Mid-term exam

Bell-LaPadula Model: A MAC Model for Achieving Multi-level Security

- Introduce in 1973

- Air Force was concerned with security in time-sharing systems
  - Many OS bugs
  - Accidental misuse

- Main Objective:
  - Enable one to formally show that a computer system can securely process classified information

What is a Security Model?

- A model describes the system
  - e.g., a high level specification or an abstract machine description of what the system does
- A security policy
  - defines the security requirements for a given system
- Verification shows that a policy is satisfied by a system
- System Model + Security Policy = Security Model

Security Goal of BLP

- There are security classifications or security levels
  - Users/principals/subjects have security clearances
  - Objects have security classifications
- Example
  - Top Secret
  - Secret
  - Confidential
  - Unclassified
- In this case Top Secret > Secret > Confidential > Unclassified
- Security goal (confidentiality): ensures that information do not flow to those not cleared for that level

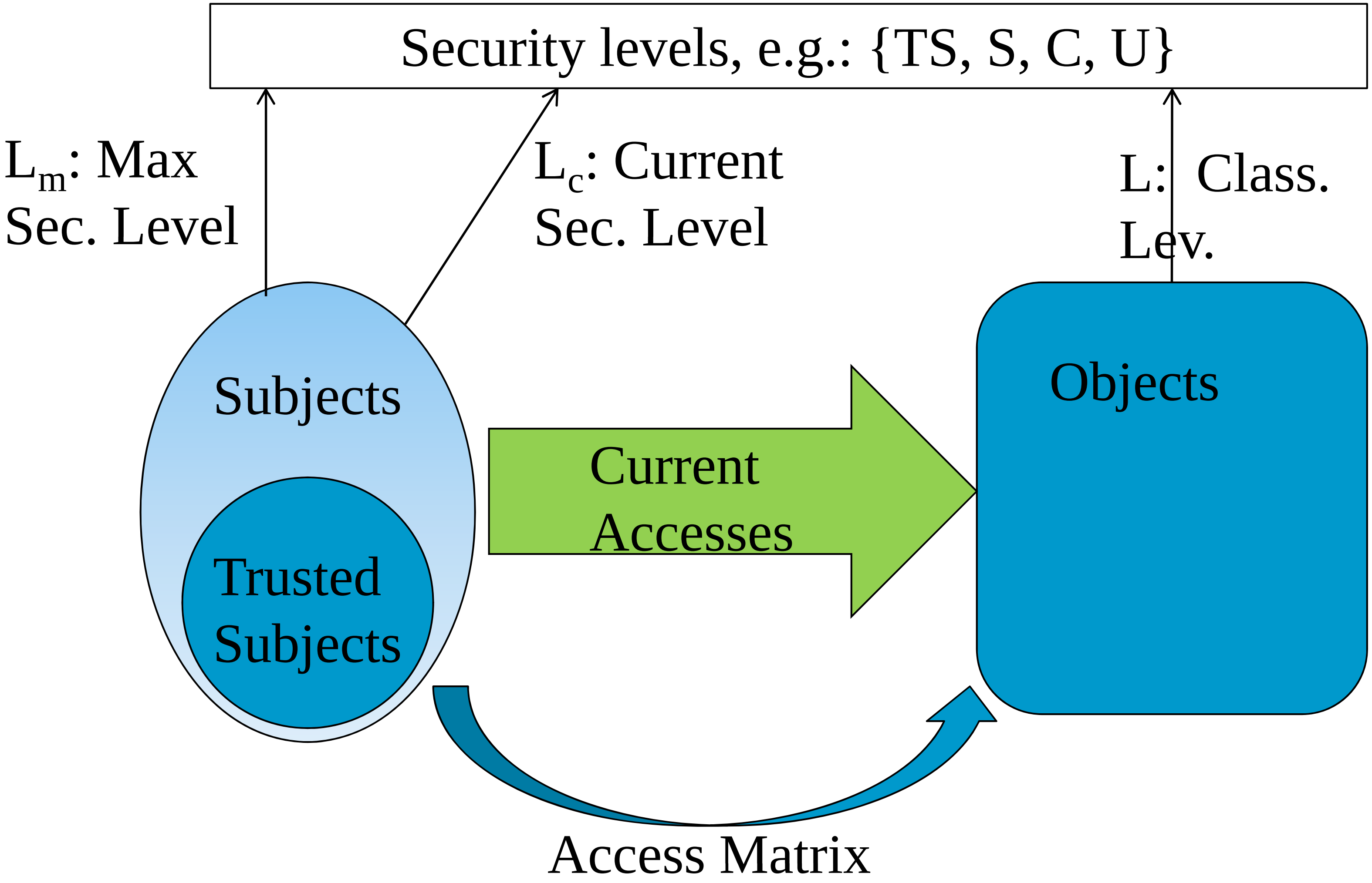
Approach of BLP

- Use state-transition systems to describe computer systems
- Define a system as secure iff. every reachable state satisfies 3 properties
  - simple-security property, *-property, discretionary-security property
- Prove a Basic Security Theorem (BST)
  - so that one can prove a system is secure by proving things about the system description

The BLP Security Model

- A computer system is modeled as a state-transition system
  - There is a set of subjects; some are designated as trusted.
  - Each state has objects, an access matrix, and the current access information.
  - There are state transition rules describing how a system can go from one state to another
  - Each subject s has a maximal sec level $L_m(s)$, and a current sec level $L_c(s)$
  - Each object has a classification level

Elements of the BLP Model



The BLP Security Model

- A state is secure if it satisfies
  - Simple Security Condition (no read up):
    - S can read O iff $L_m(S) \geq L(O)$
  - The Star Property (no write down): for any S that is not trusted
    - S can read O iff $L_c(S) \geq L(O)$
    - S can write O iff $L_c(S) \leq L(O)$
  - Discretionary-security property
    - every access is allowed by the access matrix
- A system is secure if and only if every reachable state is secure.

STAR-PROPERTY

- Applies to subjects (principals) not to users
- Users are trusted (must be trusted) not to disclose secret information outside of the computer system
- Subjects are not trusted because they may have Trojan Horses embedded in the code they execute
- Star-property prevents overt leakage of information and does not address the covert channel problem

Is BLP Notion of Security Good?

- The objective of BLP security is to ensure
  - a subject cleared at a low level should never read information classified high
- The ss-property and the *-property are sufficient to stop such information flow at any given state.
- What about information flow across states?

BLP Security Is Not Sufficient!

- Consider a system with s_1,s_2,o_1,o_2
  - $f_S(s_1)=f_C(s_1)=f_O(o_1)$=high
  - $f_S(s_2)=f_C(s_2)=f_O(o_2)$ =low
- And the following execution
  - s_1 gets access to o_1, read something, release access, then change current level to low, get write access to o_2, write to o_2
- Every state is secure, yet illegal information exists
- Solution: tranquility principle: subject cannot change current levels

Main Contributions of BLP

- The overall methodology to show that a system is secure
  - adopted in many later works
- The state-transition model
  - which includes an access matrix, subject security levels, object levels, etc.
- The introduction of *-property
  - ss-property is not enough to stop illegal information flow

Other Issues with BLP

- Deal only with confidentiality,
  - does not deal with integrity at all
- Does not deal with information flow through covert channels

Overt (Explicit) Channels vs. Covert Channels

- Security objective of MLS in general, BLP in particular
  - high-classified information cannot flow to low-cleared users
- Overt channels of information flow
  - read/write an object
- Covert channels of information flow
  - communication channel based on the use of system resources not normally intended for communication between the subjects (processes) in the system

Examples of Covert Channels

- Using file lock as a shared boolean variable
- By varying its ratio of computing to input/output or its paging rate, the service can transmit information to a concurrently running process
- Covert channels are often noisy
- However, information theory and coding theory can be used to encode and decode information through noisy channels

More on Covert Channels

- Covert channels cannot be blocked by *-property
- It is generally very difficult, if not impossible, to block all cover channels
- One can try to limit the bandwidth of covert channels
- Military requires cryptographic components be implemented in hardware
  - to avoid trojan horse leaking keys through covert channels

More on MLS: Security Levels

- Used as attributes of both subjects & objects
  - clearance & classification
- Typical military security levels:
  - top secret $\geq$ secret $\geq$ confidential $\geq$ unclassified
- Typical commercial security levels
  - restricted $\geq$ proprietary $\geq$ sensitive $\geq$ public

Security Categories

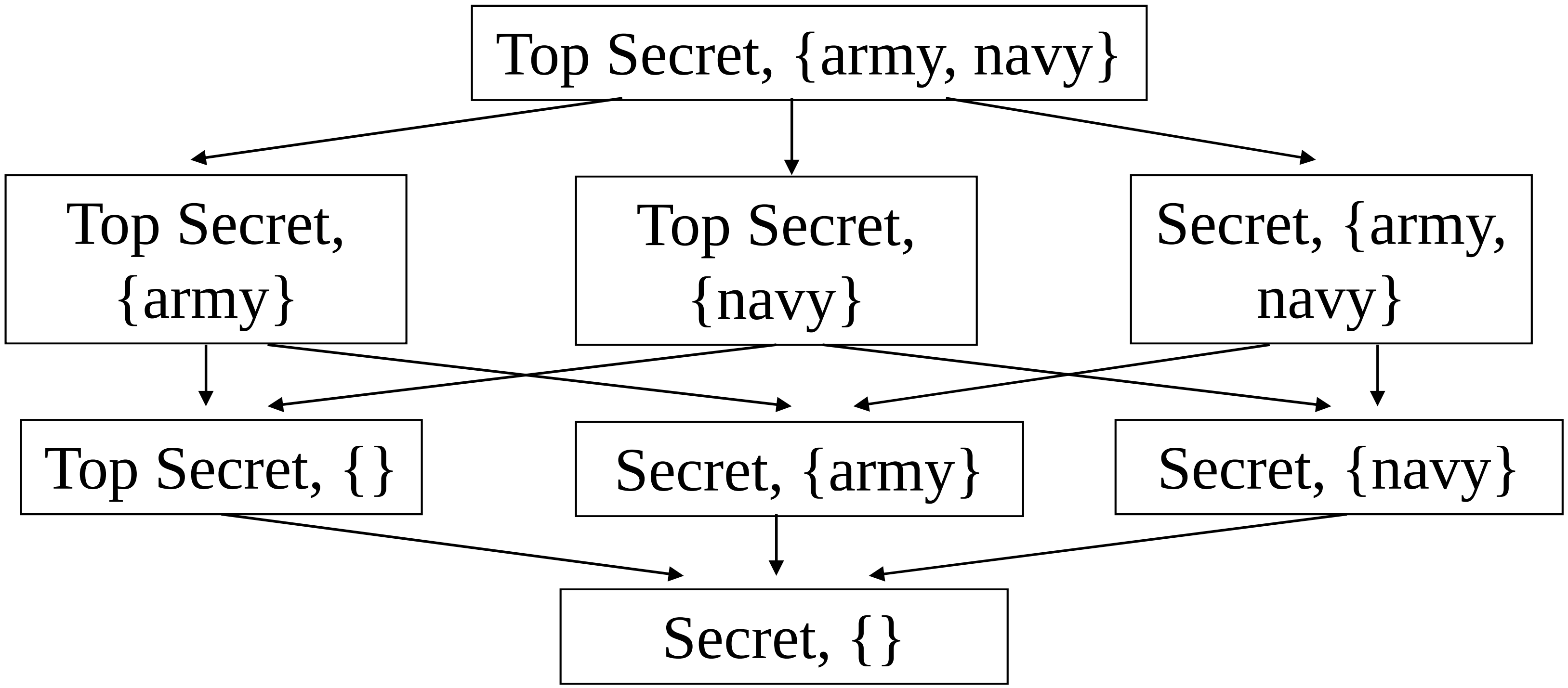
- Also known as compartments
- Typical military security categories
  - army, navy, air force
  - nato, nasa, noforn
- Typical commercial security categories
  - Sales, R&D, HR
  - Dept A, Dept B, Dept C

Security Labels

- Labels = Levels $\times$ P (Categories)
- Define an ordering relationship among Labels
  - (e1, C1) $\leq$ (e2, C2) iff. e1 $\leq$e2 and C1 $\subseteq$ C2
- This ordering relation is a partial order
  - reflexive, transitive, anti-symmetric
  - e.g., $\subseteq$
- All security labels form a lattice

An Example Security Lattice

- levels={top secret, secret}
- categories={army,navy}

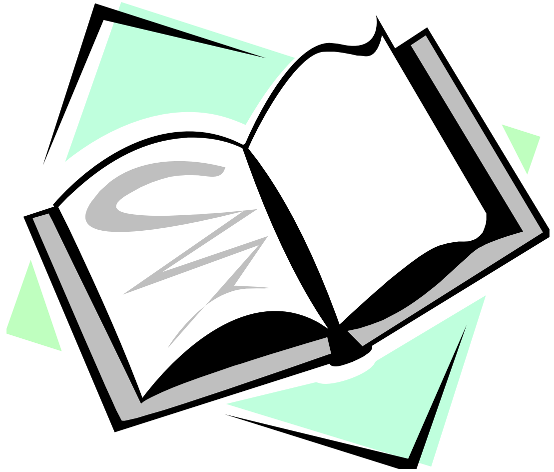


The need-to-know principle

- Even if someone has all the necessary official approvals (such as a security clearance) to access certain information they should not be given access to such information unless they have a *need to know*: that is, unless access to the specific information necessary for the conduct of one's official duties.
- Can be implemented using categories and or DAC

Readings for This Lecture

- Wikipedia
  - Bell-LaPadula model
- David E. Bell: Looking Back at the *Bell*-La Padula Model



Coming Attractions …

- Trusted Operating Systems and Assurance