

# IS 2150 / TEL 2810

## Information Security & Privacy



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Security Policies  
Confidentiality Policies

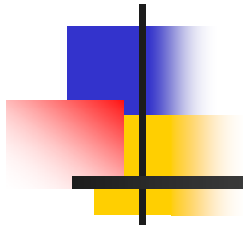
Lecture 4  
Feb 3, 2016



# Objectives

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- Understanding/defining security policy and nature of trust
- Overview of different policy models
- Define/Understand existing Bell-LaPadula model of confidentiality
  - how lattice helps?
- Understand the Biba integrity model



# Security Policies



# Security Policy

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- Defines what it means for a system to be secure
- Formally: Partitions a system into
  - Set of secure (authorized) states
  - Set of non-secure (unauthorized) states
- Secure system is one that
  - Starts in authorized state
  - Cannot enter unauthorized state



# Confidentiality Policy

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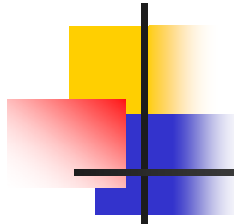
- Also known as *information flow*
  - Transfer of rights
  - Transfer of information without transfer of rights
  - Temporal context
- Model often depends on trust
  - Parts of system where information *could* flow
  - Trusted entity must participate to enable flow
- Highly developed in Military/Government



# Integrity Policy

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- Defines how information can be altered
  - Entities allowed to alter data
  - Conditions under which data can be altered
  - Limits to change of data
- Examples:
  - Purchase over \$1000 requires signature
  - Check over \$10,000 must be approved by one person and cashed by another
    - *Separation of duties* : for preventing fraud
- Highly developed in commercial world



# Trust

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- Theories and mechanisms rest on some trust assumptions
- Administrator installs patch
  1. Trusts patch came from vendor, not tampered with in transit
  2. Trusts vendor tested patch thoroughly
  3. Trusts vendor's test environment corresponds to local environment
  4. Trusts patch is installed correctly



# Trust in Formal Verification

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- Formal verification provides a formal mathematical proof that given input  $i$ , program  $P$  produces output  $o$  as specified
- Suppose a security-related program  $S$  formally verified to work with operating system  $O$
- What are the assumptions during its installation?





# Security Model

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- A model that represents a particular policy or set of policies
  - Abstracts details relevant to analysis
  - Focus on specific characteristics of policies
    - E.g., Multilevel security focuses on information flow control



# Security policies

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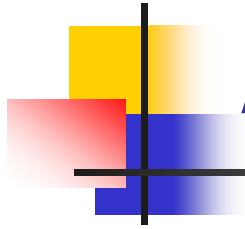
- Military security policy
  - Focuses on confidentiality
- Commercial security policy
  - Primarily Integrity
  - Transaction-oriented
    - Begin in consistent state
      - “Consistent” defined by specification
    - Perform series of actions (*transaction*)
      - Actions cannot be interrupted
      - If actions complete, system in consistent state
      - If actions do not complete, system reverts to beginning (consistent) state



# Access Control

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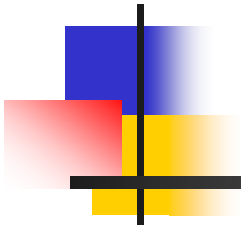
- Discretionary Access Control (DAC)
  - Owner determines access rights
  - Typically *identity-based access control*: Owner specifies other users who have access
- Mandatory Access Control (MAC)
  - Rules specify granting of access
  - Also called *rule-based access control*



# Access Control

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- Originator Controlled Access Control (ORCON)
  - Originator controls access
  - *Originator need not be owner!*
- Role Based Access Control (RBAC)
  - Identity governed by role user assumes



# Confidentiality Policies



# Confidentiality Policy

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- Also known as information flow policy
  - Integrity is secondary objective
  - Eg. Military mission “date”
- Bell-LaPadula Model
  - Formally models military requirements
    - Information has sensitivity levels or classification
    - Subjects have clearance
    - Subjects with clearance are allowed access
  - Multi-level access control or mandatory access control



# Bell-LaPadula: Basics

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- Mandatory access control
  - Entities are assigned security levels
  - Subject has security clearance  $L(s) = l_s$
  - Object has security classification  $L(o) = l_o$
  - Simplest case: Security levels are arranged in a linear order  $l_i < l_{i+1}$
- Example

Top secret > Secret > Confidential > Unclassified



# “No Read Up”

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- Information is allowed to flow *up*, not *down*
- *Simple security property:*
  - $s$  can read  $o$  if and only if
    - $l_o \leq l_s$  and
    - $s$  has discretionary read access to  $o$
  - Combines mandatory (*security levels*) and discretionary (*permission required*)
  - Prevents subjects from reading objects at higher levels (*No Read Up rule*)

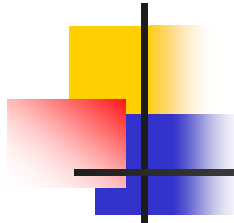




# “No Write Down”

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- Information is allowed to flow *up*, not *down*
- *\*property*
  - $s$  can write  $o$  if and only if
    - $I_s \leq I_o$  and
    - $s$  has write access to  $o$
  - Combines mandatory (*security levels*) and discretionary (*permission required*)
  - Prevents subjects from writing to objects at lower levels (*No Write Down rule*)



# Example

<i>security level</i>	<i>subject</i>	<i>object</i>
Top Secret	Tamara	Personnel Files
Secret	Samuel	E-Mail Files
Confidential	Claire	Activity Logs
Unclassified	Ulaley	Telephone Lists

- Tamara can *read* which objects? And *write*?
- Claire cannot read which objects? And *write*?
- Ulaley can *read* which objects? And *write*?



# Access Rules

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- Secure system:
  - One in which both the properties hold
- Theorem:
  - Let  $\Sigma$  be a system with secure initial state  $\sigma_0$ ,
  - $T$  be a set of state transformations
  - If every element of  $T$  follows rules, every state  $\sigma_i$  secure
  - Proof - induction



# Categories

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- Total order of classifications not flexible enough
  - Alice cleared for missiles; Bob cleared for warheads; Both cleared for targets
- Solution: Categories
  - Use set of compartments (from power set of compartments)
  - Enforce "*need to know*" principle
  - Security levels (security level, category set)
    - (Top Secret, {Nuc, Eur, Asi})
    - (Top Secret, {Nuc, Asi})



# Lattice of categories

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- Combining with clearance:
  - $(L, C) \text{ dominates } (L', C') \Leftrightarrow L' \leq L \text{ and } C' \subseteq C$
  - Induces lattice of security levels
- Examples of levels
  - (Top Secret, {Nuc, Asi}) *dom* (Secret, {Nuc}) ?
  - (Secret, {Nuc, Eur}) *dom* (Topsecret, {Nuc, Eur}) ?
  - (Top Secret, {Nuc}) *dom* (Confidential, {Eur}) ?

Exercise: Hesse diagram for:  
compartments: NUC, US,  
EU;

Exercise: Hesse diagram for:  
Security levels: TS, S, C  
Compartments US, EU;



# Access Rules

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- *Simple Security Condition*:  $S$  can read  $O$  if and only if
  - $S$  dominate  $O$  and
  - $S$  has read access to  $O$
- *\*-Property*:  $S$  can write  $O$  if and only if
  - $O \text{ dom } S$  and
  - $S$  has write access to  $O$
- Secure system: One with above properties
- Theorem: Let  $\Sigma$  be a system with secure initial state  $\sigma_0$ ,  $T$  be a set of state transformations
  - If every element of  $T$  follows rules, every state  $\sigma_i$  secure



# Communication across level

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- Communication is needed between
  - Subject at higher level and a subject at the lower levels
    - Need write down to a lower object
- One mechanism
  - Subjects have *max* and *current* levels
    - *max* must dominate *current*
  - Subjects decrease clearance level



# Read & write

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- Conventional use
  - “Read” – allowing information to flow from object being read to the subject reading
    - Read includes Execute
  - “Write” – allowing information to flow from the subject writing to the object being written
    - Write includes Append
- Could change based on the requirement and the model instantiated based on that.





# Problem: No write-down

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*Cleared subject can't communicate to non-cleared subject*

- Any write from  $l_i$  to  $l_k$ ,  $l_i > l_k$ , would violate \*-property
  - Subject at  $l_i$  can only write to  $l_i$  and above
- Any read from  $l_k$  to  $l_i$ ,  $l_k < l_i$ , would violate simple security property
  - Subject at  $l_k$  can only read from  $l_k$  and below
- Subject at level  $l_i$  can't write something readable by subject at  $l_k$ 
  - Not very practical



# Principle of Tranquility

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- Should we change classification levels?
- Raising object's security level
  - Information once available to some subjects is no longer available
  - Usually assumes information has already been accessed
  - Simple security property violated? Problem?



# Principle of Tranquility

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- Lowering object's security level
  - Simple security property violated?
  - The *declassification problem*
  - Essentially, a “write down” violating \*-property
  - Solution: define set of trusted subjects that *sanitize* or remove sensitive information before security level is lowered



# Types of Tranquility

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- Strong Tranquility
  - The clearances of subjects, and the classifications of objects, do not change during the lifetime of the system
- Weak Tranquility
  - The clearances of subjects, and the classifications of objects, do not change in a way that violates the simple security condition or the \*-property during the lifetime of the system



# Example

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- DG/UX System
  - Only a trusted user (security administrator) can lower object's security level
  - In general, process MAC labels cannot change
    - If a user wants a new MAC label, needs to initiate new process
    - Cumbersome, so user can be designated as able to change process MAC label within a specified range



# DG/UX Labels

- Lowest upper bound: IMPL\_HI
- Greatest lower bound: IMPL\_LO

Hierarchy levels	↑	A&A database, audit	Administrative Region
		User data and applications	User Region
VP-1		Site executables	Virus Prevention Region
VP-2		Trusted data	
VP-3		Executables not part of the TCB	
VP-4		Executables part of the TCB	
VP-5		Reserved for future use	
		Categories	



- Once you login
  - MAC label that of user in Authorization and Authentication (A&A) Databases
- When a process begins
  - It gets its parent's MAC label
- Reading up and writing up not allowed

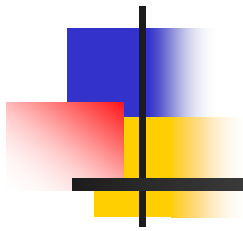


- S:MAC\_A creates O
  - If O:MAC\_B already exists
    - Fails if MAC\_B dom MAC\_A
- Creating files in a directory
  - Only programs with the same level as the directory can create files in the directory
  - Problems with /tmp and /var/mail
  - **Solution:** use multilevel directory:
    - a directory with a subdirectory for each level (hidden)
    - If process with MAC\_A creates a file – put in subdirectory with label MAC\_A
    - Reference to parent directory of a file refers to the hidden directory





- Provides a range of MAC labels
  - Called MAC Tuples: [Lower, Upper]
    - [(S, {Europe}), (TS, {Europe})]
    - [(S,  $\emptyset$ ), (TS, {Nuclear, Europe, Asia})]
  - Objects can have a tuple as well as a required MAC label
    - Tuple overrides
  - A process can *read* an object if its MAC label grants it read access to the upper bound
  - A process can *write* an object if its MAC label grants it write access to any label in the MAC tuple range



# Integrity Policies



# Biba's Integrity Policy Model

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- Based on Bell-LaPadula
  - Subject, Objects have
    - Integrity Levels with dominance relation
  - Higher levels
    - more reliable/trustworthy
    - More accurate



# Biba's model

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- Strict Integrity Policy (dual of Bell-LaPadula)
  - $s$  can **read**  $o \leftrightarrow \ell(s) \leq \ell(o)$  (no read-down)
    - Why?
  - $s$  can **write**  $o \leftrightarrow \ell(o) \leq \ell(s)$  (no write-up)
    - Why?
  - $s_1$  can **execute**  $s_2 \leftrightarrow \ell(s_2) \leq \ell(s_1)$ 
    - Why?



# Low-water-mark

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- Low-Water-Mark Policy
  - $s$  can **write**  $o \leftrightarrow \ell(o) \leq \ell(s)$ 
    - Why?
  - $s$  **reads**  $o \rightarrow \ell'(s) = \min(\ell(s), \ell(o))$ 
    - $\ell'(s)$  is the integrity level of  $s$  after “read” op
    - Why?
  - $s_1$  can **execute**  $s_2 \leftrightarrow \ell(s_2) \leq \ell(s_1)$



# Summary

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- Trust assumptions should be properly understood
- Lattice structure provides basis for representing information flow or confidentiality policies
  - Need to know