

ECS 235B Module 17

Confidentiality Policies and the Bell-LaPadula Model

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 Model, Step 1

- Security levels arranged in linear ordering
 - Top Secret: highest
 - Secret
 - Confidential
 - Unclassified: lowest
- Levels consist are called *security clearance* $L(s)$ for subjects and *security classification* $L(o)$ for objects

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 all files
- Claire cannot read Personnel or E-Mail Files
- Ulaley can only read Telephone Lists

Reading Information

- Information flows *up*, not *down*
 - “Reads up” disallowed, “reads down” allowed
- Simple Security Condition (Step 1)
 - Subject s can read object o iff $L(o) \leq L(s)$ 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

- Information flows up, not down
 - “Writes up” allowed, “writes down” disallowed
- *-Property (Step 1)
 - Subject s can write object o iff $L(s) \leq L(o)$ 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

Basic Security Theorem, Step 1

- If a system is initially in a secure state, and every transition of the system satisfies the simple security condition, step 1, and the *-property, step 1, then every state of the system is secure
 - Proof: induct on the number of transitions

Bell-LaPadula Model, Step 2

- Expand notion of security level to include categories
- Security level is (*clearance, category set*)
- Examples
 - (Top Secret, { NUC, EUR, ASI })
 - (Confidential, { EUR, ASI })
 - (Secret, { NUC, ASI })

Levels and Lattices

- $(A, C) \text{ dom } (A', C')$ iff $A' \leq A$ and $C' \subseteq C$
- Examples
 - $(\text{Top Secret}, \{\text{NUC}, \text{ASI}\}) \text{ dom } (\text{Secret}, \{\text{NUC}\})$
 - $(\text{Secret}, \{\text{NUC}, \text{EUR}\}) \text{ dom } (\text{Confidential}, \{\text{NUC}, \text{EUR}\})$
 - $(\text{Top Secret}, \{\text{NUC}\}) \not\text{dom } (\text{Confidential}, \{\text{EUR}\})$
- Let C be set of classifications, K set of categories. Set of security levels $L = C \times K$, dom form lattice
 - $\text{lub}(L) = (\max(A), C)$
 - $\text{glb}(L) = (\min(A), \emptyset)$

Levels and Ordering

- Security levels partially ordered
 - Any pair of security levels may (or may not) be related by *dom*
- “dominates” serves the role of “greater than” in step 1
 - “greater than” is a total ordering, though

Reading Information

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 - Subject s can read object o iff $L(s) \text{ dom } L(o)$ and s has permission to read o
 - Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)
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Writing Information

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 - Sometimes called “no writes down” rule

Basic Security Theorem, Step 2

- If a system is initially in a secure state, and every transition of the system satisfies the simple security condition, step 2, and the *-property, step 2, then every state of the system is secure
 - Proof: induct on the number of transitions
 - In actual Basic Security Theorem, discretionary access control treated as third property, and simple security property and *-property phrased to eliminate discretionary part of the definitions — but simpler to express the way done here.

Problem

- Colonel has (Secret, {NUC, EUR}) clearance
- Major has (Secret, {EUR}) clearance
 - Major can talk to colonel (“write up” or “read down”)
 - Colonel cannot talk to major (“read up” or “write down”)
- Clearly absurd!

Solution

- Define maximum, current levels for subjects
 - $maxlevel(s) \text{ dom } curlevel(s)$
- Example
 - Treat Major as an object (Colonel is writing to him/her)
 - Colonel has $maxlevel$ (Secret, { NUC, EUR })
 - Colonel sets $curlevel$ to (Secret, { EUR })
 - Now $L(\text{Major}) \text{ dom } curlevel(\text{Colonel})$
 - Colonel can write to Major without violating “no writes down”
 - Does $L(s)$ mean $curlevel(s)$ or $maxlevel(s)$?
 - Formally, we need a more precise notation

Example: Trusted Solaris

- Provides mandatory access controls
 - Security level represented by *sensitivity label*
 - Least upper bound of all sensitivity labels of a subject called *clearance*
 - Default labels ADMIN_HIGH (dominates any other label) and ADMIN_LOW (dominated by any other label)
- S has controlling user U_S
 - S_L sensitivity label of subject
 - $privileged(S, P)$ true if S can override or bypass part of security policy P
 - $asserted(S, P)$ true if S is doing so

Rules

C_L clearance of S , S_L sensitivity label of S , U_S controlling user of S , and O_L sensitivity label of O

1. If $\neg\text{privileged}(S, \text{"change } S_L\text{"})$, then no sequence of operations can change S_L to a value that it has not previously assumed
2. If $\neg\text{privileged}(S, \text{"change } S_L\text{"})$, then $\neg\text{privileged}(S, \text{"change } S_L\text{"})$
3. If $\neg\text{privileged}(S, \text{"change } S_L\text{"})$, then no value of S_L can be outside the clearance of U_S
4. For all subjects S , named objects O , if $\neg\text{privileged}(S, \text{"change } O_L\text{"})$, then no sequence of operations can change O_L to a value that it has not previously assumed

Rules (*con't*)

C_L clearance of S , S_L sensitivity label of S , U_S controlling user of S , and O_L sensitivity label of O

5. For all subjects S , named objects O , if $\neg\text{privileged}(S, \text{"override } O\text{'s mandatory read access control"})$, then read access to O is granted only if $S_L \text{ dom } O_L$
 - Instantiation of simple security condition
6. For all subjects S , named objects O , if $\neg\text{privileged}(S, \text{"override } O\text{'s mandatory write access control"})$, then write access to O is granted only if $O_L \text{ dom } S_L$ and $C_L \text{ dom } O_L$
 - Instantiation of *-property

Initial Assignment of Labels

- Each account is assigned a label range [clearance, minimum]
- On login, Trusted Solaris determines if the session is single-level
 - If clearance = minimum, single level and session gets that label
 - If not, multi-level; user asked to specify clearance for session; must be in the label range
 - In multi-level session, can change to any label in the range of the session clearance to the minimum

Writing

- Allowed when subject, object labels are the same or file is in downgraded directory D with sensitivity label D_L and all the following hold:
 - $S_L \text{ dom } D_L$
 - S has discretionary read, search access to D
 - $O_L \text{ dom } S_L$ and $O_L \neq S_L$
 - S has discretionary write access to O
 - $C_L \text{ dom } O_L$
- Note: subject cannot read object

Directory Problem

- Process p at MAC_A tries to create file $/tmp/x$
- $/tmp/x$ exists but has MAC label MAC_B
 - Assume MAC_B dom MAC_A
- Create fails
 - Now p knows a file named x with a higher label exists
- Fix: only programs with same MAC label as directory can create files in the directory
 - Now compilation won't work, mail can't be delivered

Multilevel Directory

- Directory with a set of subdirectories, one per label
 - Not normally visible to user
 - p creating $/tmp/x$ actually creates $/tmp/d/x$ where d is directory corresponding to MAC_A
 - All p 's references to $/tmp$ go to $/tmp/d$
- p cd 's to $/tmp$
 - System call $stat(".", \&buf)$ returns information about $/tmp/d$
 - System call $lstat(".", \&buf)$ returns information about $/tmp$

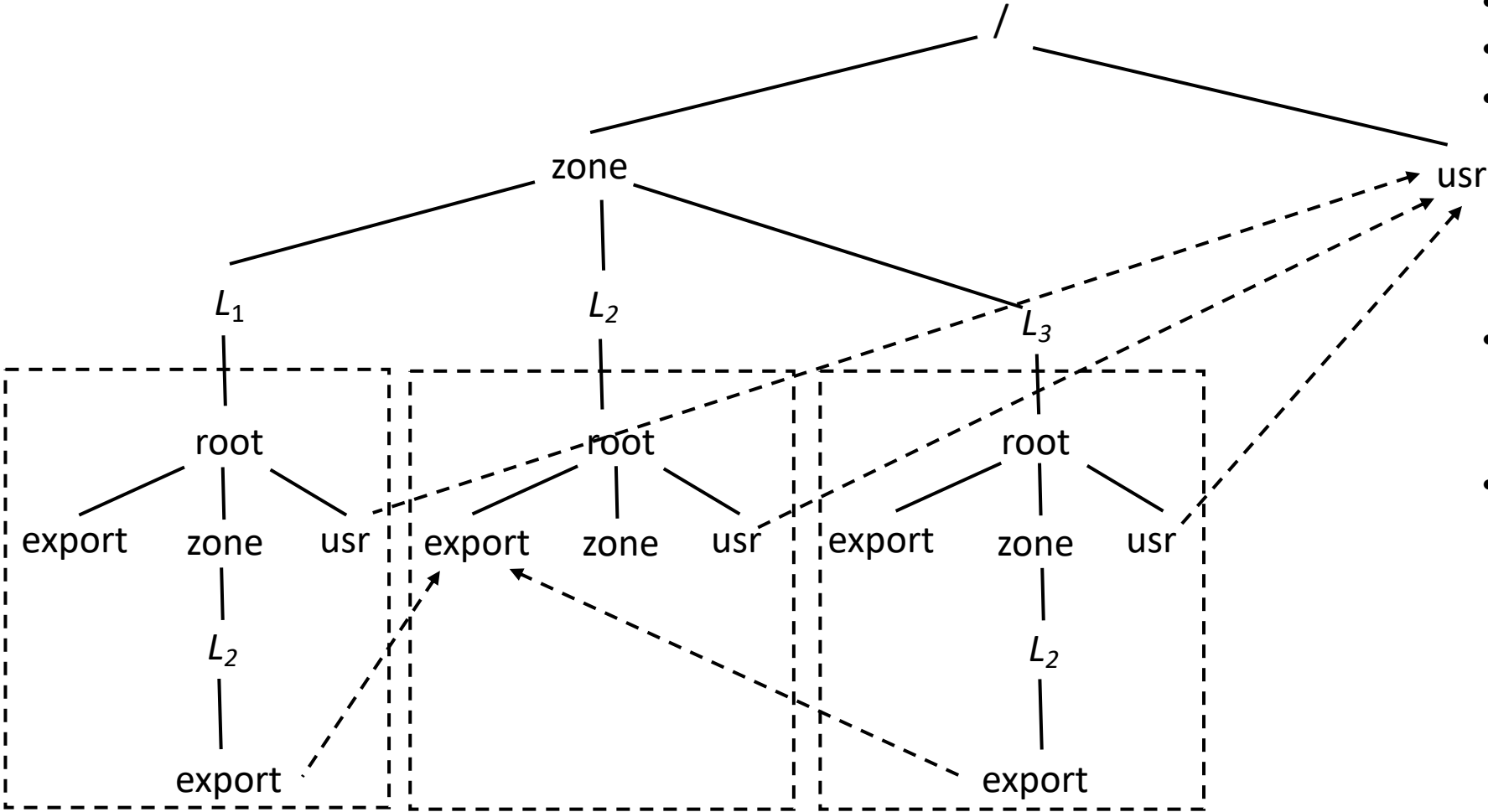
Labeled Zones

- Used in Trusted Solaris Extensions, various flavors of Linux
- *Zone*: virtual environment tied to a unique label
 - Each process can only access objects in its zone
- *Global zone* encompasses everything on system
 - Its label is ADMIN_HIGH
 - Only system administrators can access this zone
- Each zone has a unique root directory
 - All objects within the zone have that zone's label
 - Each zone has a unique label

More about Zones

- Can import (mount) file systems from other zones provided:
 - If importing *read-only*, importing zone's label must dominate imported zone's label
 - If importing *read-write*, importing zone's label must equal imported zone's label
 - So the zones are the same; import unnecessary
 - Labels checked at time of import
- Objects in imported file system retain their labels

Example



- $L_1 \text{ dom } L_2$
- $L_3 \text{ dom } L_2$
- Process in L_1 can read any file in the export directory of L_2 (assuming discretionary permissions allow it)
- L_1, L_3 disjoint
 - Do not share any files
- System directories imported from global zone, at ADMIN_LOW
 - So can only be read

Quiz

In a system implementing the Bell-LaPadula model, Tom's file f is in the compartment $SC_f = (secret, \{a, b\})$. He wants Tina, whose process is in the compartment $SC_{Tina} = (confidential, \{a\})$ to be able to read the file, so he sets turns on the discretionary permission *read* for Tina. Can Tina now read Tom's file?

- Yes, because Tom has set the discretionary permissions to allow this.
- Yes, because $SC_f \text{ dom } SC_{Tina}$, and reads up are allowed.
- No, because $SC_f \text{ dom } SC_{Tina}$ and reads up are not allowed.
- No, because $SC_f \text{ dom } SC_{Tina}$, so Tom must set the special discretionary right that allows the discretionary right *read* to override the mandatory controls, and he has not done so.