Confidentiality Policies

ECS 153 Spring Quarter 2021

Module 9

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

security level	*subject*	*object*
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 $L(s) \le L(o)$ 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) *dom* (A', C') iff $A' \le A$ and $C' \subseteq C$
- Examples
  - (Top Secret, {NUC, ASI}) *dom* (Secret, {NUC})
  - (Secret, {NUC, EUR}) *dom* (Confidential,{NUC, EUR})
  - (Top Secret, {NUC}) $\neg$*dom* (Confidential, {EUR})
- Let C be set of classifications, K set of categories. Set of security levels $L = C \times K$, *dom* form lattice
  - $lub(L) = (max(A), C)$
  - $glb(L) = (min(A), \varnothing)$

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

- Information flows *up*, not *down*
  - "Reads up" disallowed, "reads down" allowed
- Simple Security Condition (Step 2)
  - 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

- Information flows up, not down
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- *-Property (Step 2)
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    - Note: combines mandatory control (relationship of security levels) and discretionary control (the required permission)
  - 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*) *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*(Major) *dom curlevel*(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 ¬*privileged*(*S*, "change S_L"), then no sequence of operations can change S_L to a value that it has not previously assumed
2. If ¬*privileged*(*S*, "change S_L"), then ¬*privileged*(*S*, "change S_L")
3. If ¬*privileged*(*S*, "change S_L"), then no value of S_L can be outside the clearance of U_S
4. For all subjects *S,* named objects *O*, if ¬*privileged*(*S*, "change O_L"), 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 ¬*privileged*(*S*, "override *O*'s mandatory read access control"), then read access to *O* is granted only if S_L *dom* O_L
   - Instantiation of simple security condition
6. For all subjects *S,* named objects *O*, if ¬*privileged*(*S*, "override *O*'s mandatory write access control"), then write access to *O* is granted only if O_L *dom* S_L and C_L *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 *dom* D_L
  - *S* has discretionary read, search access to *D*
  - O_L *dom* S_L and $O_L \neq S_L$
  - *S* has discretionary write access to *O*
  - C_L *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 mldstat(".", &buf) returns information about*/tmp*

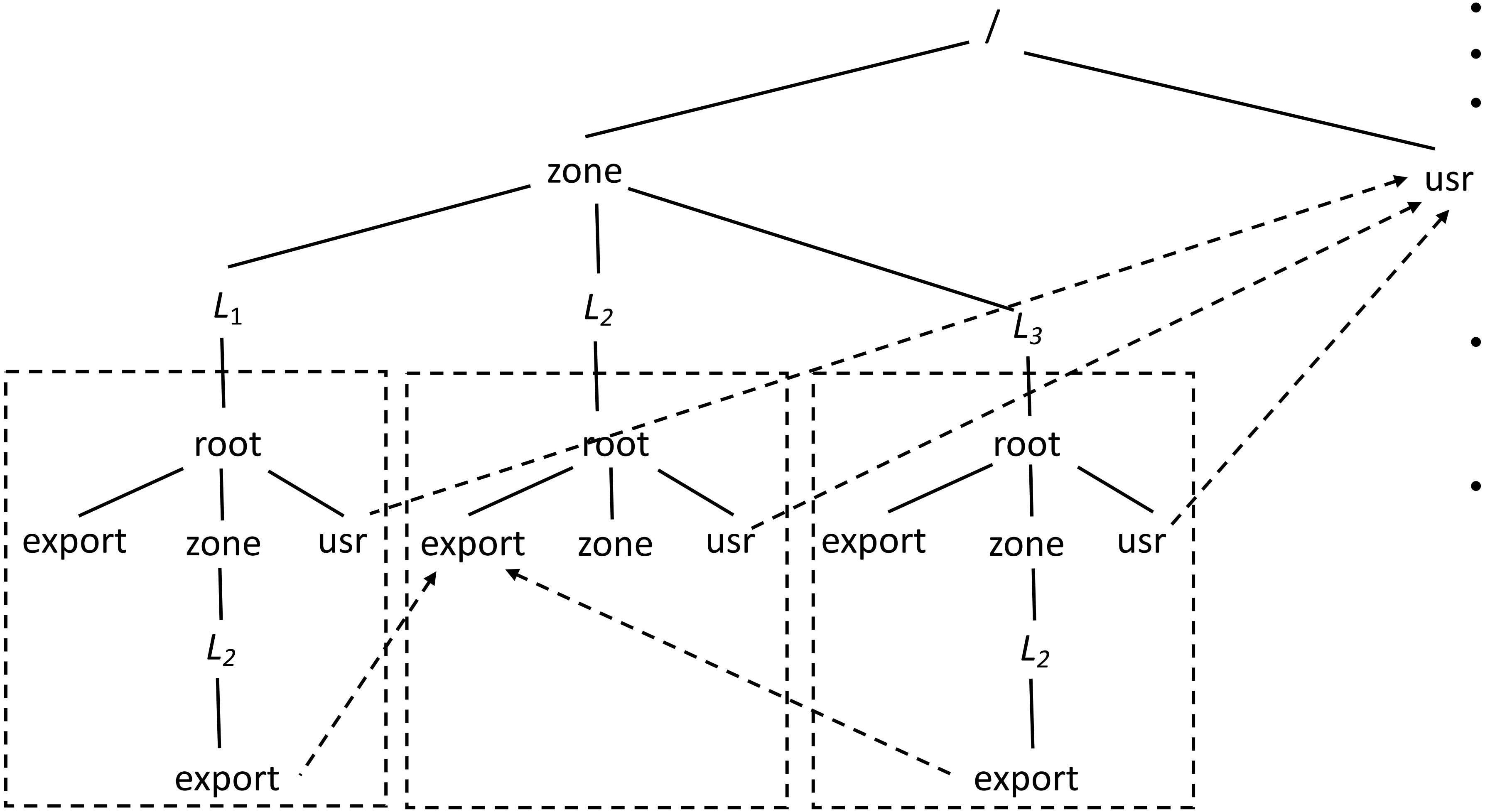
Labeled Zones

- 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 *dom* L_2
- L_3 *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

Principle of Tranquility

- Raising object's security level
  - Information once available to some subjects is no longer available
  - Usually assume information has already been accessed, so this does nothing
- Lowering object's security level
  - The *declassification problem*
  - Essentially, a "write down" violating *-property
  - Solution: define set of trusted subjects that *sanitize* or remove sensitive information before security level lowered

Types of Tranquility

- 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: Trusted Solaris

- Security administrator can provide specific authorization for a user to change the MAC label of a file
  - “downgrade file label” authorization
  - “upgrade file label” authorization
- User requires additional authorization if not the owner of the file
  - “act as file owner” authorization

Principles of Declassification

- Principle of Semantic Consistency
  - As long as semantics of components that do not do declassification do not change, the components can be altered without affecting security
- Principle of Occlusion
  - A declassification operation cannot conceal an *improper* declassification
- Principle of Conservativity
  - Absent any declassification, the system is secure
- Principle of Monotonicity of Release
  - When declassification is performed in an authorized manner by authorized subjects, the system remains secure