

IT Security

Multilevel Databases

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All infos about the database part in this lecture

<http://dbresearch.uni-salzburg.at/teaching/2016ws/its/>

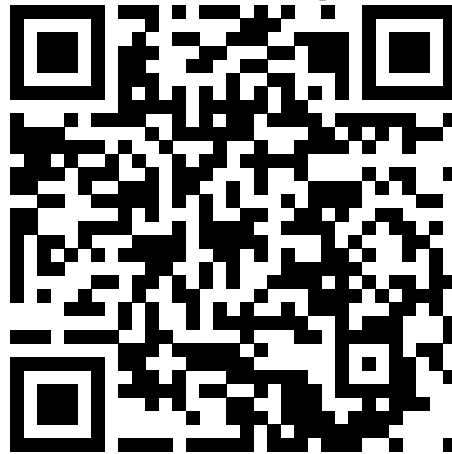


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Mandatory Access Control (MAC)

- Why is discretionary access control (DAC) not enough?
 - users have the freedom to give other users access to data
 - all users see the same data (if they have access)
 - security policies cannot be centrally enforced
- Some applications need multilevel security
 - government, military, intelligence service
 - many industrial and corporate applications
- MAC is implemented in some DBMS (e.g., Oracle Label Security since 2009) or special versions of DBMS (e.g., SE-PostgreSQL)
- also operating systems implement MAC (SE-Linux, Windows Vista and later)

MAC Basics

- Security classes: levels of trust
 - TS (top secret) > S (secret) > C (confidential) > U (unclassified, public)
- Subjects s
 - users, roles, accounts, programs
 - clearance $clear(s)$ is the trustworthiness of s
 - $clear(s)$ is a security class
- Objects o :
 - data objects (e.g., relation, tuple, attribute values)
 - classification $class(o)$ is the sensitivity of the data object
 - $class(o)$ is a security class

Bell LaPadula

- Example of MAC used in database (and many other) systems
- Named after developers D. E. Bell and L. J. LaPadula
- Access control rules
 - **no read-up**: s is allowed to read o only if $clear(s) \geq class(o)$
 - **no write-down**: s is allowed to write o only if $clear(s) \leq class(o)$
(also called *-property)
 - **respect DAC**: respect discretionary access control rules
- **Trusted subjects**
 - must be trustworthy according to security policy
 - not restricted by the *-property
 - can transfer data from higher to lower sensitivity

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Multilevel Model

- Multilevel relation

- each attribute and each tuple in $R(A_1, A_2, \dots, A_n)$ are classified
- $C_i = \text{class}(A_i)$ is an attribute classification
- $TC \geq \max\{C_i \mid 1 \leq i \leq n\}$ is the tuple classification
- the schema of the multilevel relation is

$$R(A_1, C_1, A_2, C_2, \dots, A_n, C_n, TC)$$

Reading from Multilevel Relations

- Security requirement
 - users should not even know which data they cannot access
 - system should not reject requests for non-authorized data
 - but still the user should see a consistent view of the table
- Each clearance class c sees a different instance R^c of R :

$$R^c = (A_1^c, C_1^c, A_2^c, C_2^c, \dots, A_n^c, C_n^c, TC^c)$$

- Attributes A_i^c visible by s with $clear(s) = c$:
 - $A_i^c = A_i$ if $C_i \leq c$
 - $A_i^c = \text{NULL}$ if $C_i > c$
- Classifications C_i^c and TC^c :
 - $C_i^c = \min\{C_i, c\}$
 - $TC^c = \min\{TC, c\}$

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How to Deal with Updates?

- Problem:
 - subject with low clearance sees NULL value and tries to change it
 - but this NULL value is due to the low clearance
- Option 1 (bad): update value
 - values of subjects with higher clearance get lost
 - writers do not even realize that they are doing something harmful
- Option 2 (bad): reject update
 - writing subject can infer that there is a sensitive non-NULL value
 - can be systematically exploited
- Option 3 (good): Polyinstantiation
 - maintain multiple versions of tuples
 - versioned tuples must differ by sensitivity class TC
 - new model for integrity is required!

Integrity in Multi-Level Databases

- Entity integrity
- Null integrity
- Inter-instance integrity
- Polyinstantiation integrity

Entity Integrity

- Keys in instance R^c are called **apparent key**
- **Entity integrity**: for each R^c and for each tuple in R^c
 1. key values must not be NULL
 2. all key attributes must have identical sensitivity class
 3. non-keys must be at least as sensitive as key

Null Integrity

- Null integrity: for each R^c
 1. NULL values always have sensitivity of key
 2. freedom of subsumption (= no unnecessary tuples)

Inter Instance Integrity

- **Inter instance integrity:** for any pair $R^c, R^{c'}$ with $c' < c$

$$R^{c'} = f(R^c)$$

where f is called **filter**.

- The filter has the following properties
 1. for each tuple in R^c with key visible by c' a tuple must exist in $R^{c'}$
 2. no other tuples exist in $R^{c'}$
 3. subsumed tuples are eliminated

Polyinstantiation Integrity

- Polyinstantiation integrity: uniqueness of tuples in R
 - functional dependency

$$(key, C_{key}, C_i) \rightarrow A_i$$

must hold for any A_i in instance R^c

Implementation of Multilevel Databases

- integrity constraints allow implementation on top of “normal” relational system
- multilevel relation is fragmented into normal relations
- user queries compute answer from fragmented relations

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Example: Oracle Label Security/1

- Label security provides MAC for Oracle DBMS
- Each tuple and each user has a label
- Labels consist of
 - level (class / clearance)
 - compartments: segregate data within a given level
 - groups: segregate data within level using organizational hierarchy
- subject s can access object o if
 - label of s must be at least level of o
 - s must have at least one compartments of o
 - s must have at least one group or supergroup of o

User labels

- User labels
 - max read clearance
 - min write clearance
 - default clearance (at login)
 - row level: default for inserted tuples
 - read and write compartments
 - read and write groups
- Trusted users / stored procedures
 - read / writeup / writedown
 - write across: change compartment and group
 - profile access: become other user (like Unix 'su')