CREATE MATERIALIZED VIEW *lecture10* AS
SELECT *lecture*
FROM

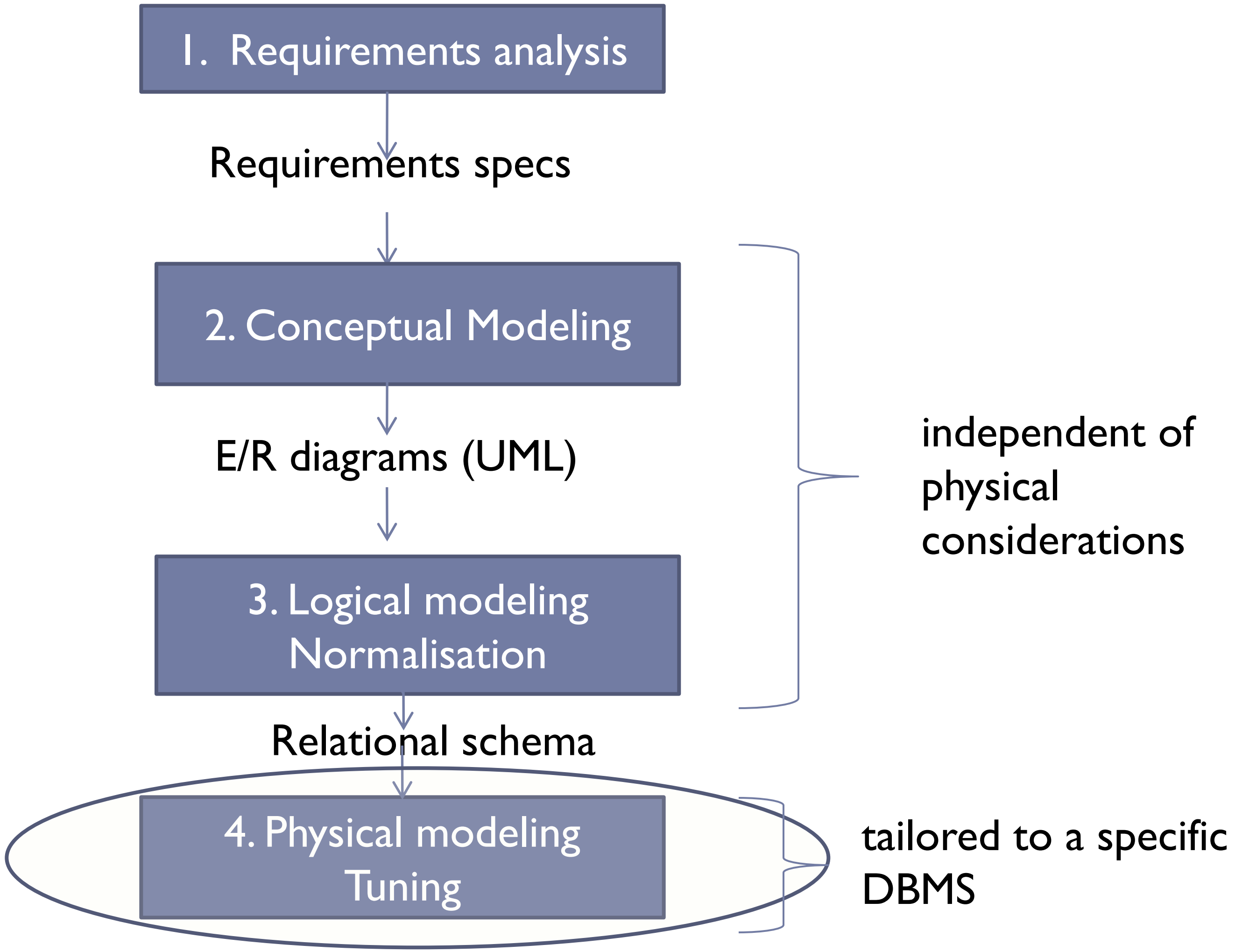
Databases

WHERE *topic* = ' Physical Design ';

INSERT INTO *lecture10* VALUES ('Constraints, Triggers, Views');

Mihaela Elena Breabăn

Relational Database Design Methodology



Outline

- Declaring integrity constraints
- Triggers
- Views

Static integrity constraints (1)

- Restrict the possible states of the database
  - Describe conditions that every instance of a database must satisfy
  - Avoid erroneous insertions, updates, deletions
  - Enforce data consistency
  - Tell the DBMS information that is useful for data storing and retrieval (query optimization)

- Types
  - Domain constraints
  - Non-null constraints
  - Keys – unique constraints
  - Referential integrity
  - General constraints at tuple level
  - Assertions

Static integrity constraints (2)

- Declaration
  - At (table) creation(CREATE TABLE)
  - After (table) creation (ALTER TABLE)

- Validation
  - At every DML statement
  - At the end of the transaction

Integrity constraints over 1 attribute *Inline* declaration

CREATE TABLE *table_name* (

a1 type **not null**, -- does not allow null entries

a2 type **unique**, --candidate key consisting of one attribute

a3 type **primary key**, -- primary key consisting of one attribute, implies {not null, unique}

a4 type **references** *table_name2 (b1)*, --foreign key consisting of one attribute

a5 type **check** (*condition*) – the condition is a Boolean expression built with attribute a5: (a5<11 and a5>4), (a5 between 5 and 10), (a5 in (5,6,7,8,9,10))…

)

Integrity constraints over several attributes
Out-of-line declaration

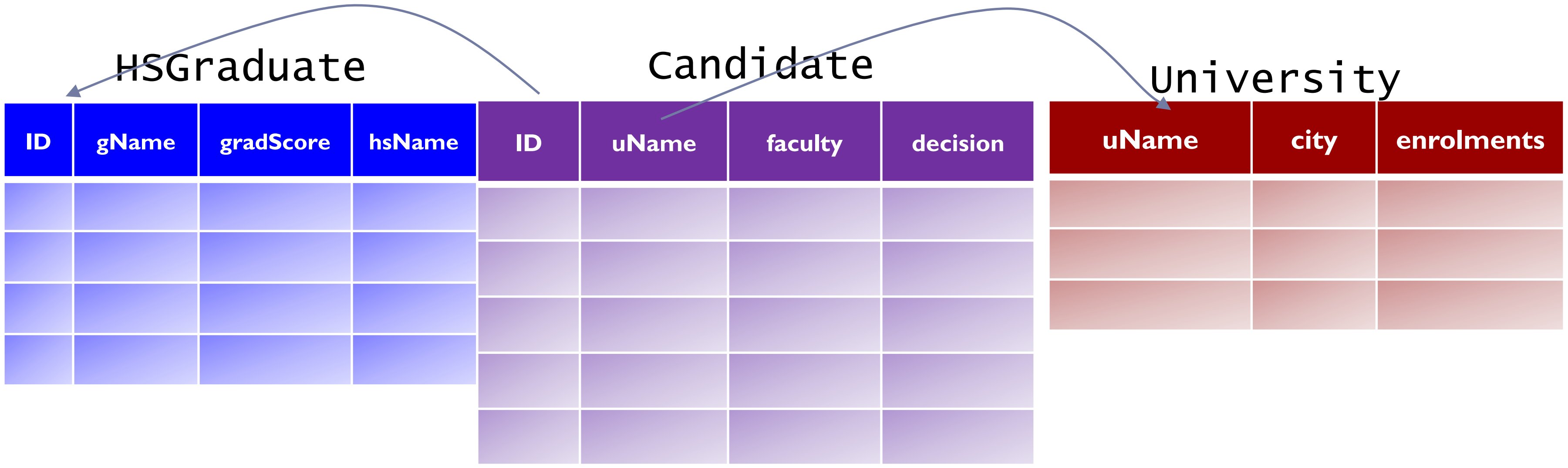
```
CREATE TABLE table_name (
a1 type,
a2 type,
a3 type,
a4 type,

primary key (a1,a2), -- primary key consisting of two (or more )attributes

unique(a2,a3), -- candidate key consisting of two (or more )attributes

check (condiție), -- a Boolean expression built over several attributes: ((a1+a3)/2>=5)
foreign key (a3,a4) references table_name2(b1,b2) – multi-valued foreign key
)
```

Referential integrity
Definitions



- *Referential integrity from R.A to S.B:*
  - Every value in column A of table R must appear in column B of table S
  - A is called a foreign key
  - B must be declared as primary key or unique for table S
- There may exist multi-valued foreign keys

Referential integrity
Validation

- Statements that may generate violations:
  - Insertions in R
  - Deletions in S
  - Updates of R.A or S.B

- Special actions that can be enforced:
  - At deletions in S:

ON DELETE RESTRICT (by default) | SET NULL | CASCADE

  - At updates on S.B:

ON UPDATE RESTRICT (by default) | SET NULL | CASCADE

Referential integrity
egg or chicken?

```
CREATE TABLE chicken (cID INT PRIMARY KEY,
                      eID INT REFERENCES egg(eID));
CREATE TABLE egg(eID INT PRIMARY KEY,
                      cID INT REFERENCES chicken(cID));
```

Referential integrity
egg or chicken?

```
CREATE TABLE chicken (cID INT PRIMARY KEY,
                      eID INT REFERENCES egg(eID));
CREATE TABLE egg(eID INT PRIMARY KEY,
                      cID INT REFERENCES chicken(cID));
```

```
CREATE TABLE chicken(cID INT PRIMARY KEY,  eID INT);
CREATE TABLE egg(eID INT PRIMARY KEY,   cID INT);
```

```
ALTER TABLE chicken ADD CONSTRAINT chickenREFegg
     FOREIGN KEY (eID) REFERENCES egg(eID)
      DEFERRABLE INITIALLY DEFERRED;  -- Oracle

ALTER TABLE egg ADD CONSTRAINT eggREFchicken
     FOREIGN KEY (cID) REFERENCES chicken(cID)
      DEFERRABLE INITIALLY DEFERRED; -- Oracle
```

```
INSERT INTO chicken VALUES(1, 2);
INSERT INTO egg VALUES(2, 1);
COMMIT;
```

How do you solve insertions if the constraints are validated at each statement?
What about table drops?

Asertions
-defined in the SQL standard -

```
create assertion Key
check ((select count(distinct A) from T) =
       (select count(*) from T)));
```

```
create assertion ReferentialIntegrity
check (not exists (select * from Candidate
                   where ID not in (select ID from HSGraduate)));
```

Integrity constraints
DBMS implementations

- Postgres, SQLite, Oracle, MySQL(innodb) implement and validate all constraints above
- No DBMS allows queries in the check constraint (deviation from the SQL standard)
- No DBMS implements assertions – their functionality can be provided by triggers

…DEMO…

(file *constraints.sql*)

Triggers
Dynamic constraints

- Monitor all the changes in a database, check conditions and initiate actions

- *Event-condition-action* rules
  - Bring within the DBMS elements from the application logic
  - Enforce constraints that cannot be expressed otherwise
  - Are expressive
  - May implement repairing actions

  - The implementation may differ among DBMSs, the examples in the presentation are in accordance with the SQL standard

Triggers
Implementation

Create Trigger *name*
Before|After|Instead Of *event*
[*Referenced-variables*]
[For Each Row] -- the action is executed for each row altered by the event (row vs. statement types)
[When (*condition* **)]** – a boolean expression – exactly as within the WHERE clause in SQL queries
action – in the SQL standard it's just a SQL statement, but in DBMSs implementing procedural extensions it may be a procedural block

- *event:*
  - INSERT ON *table*
  - DELETE ON *table*
  - UPDATE [OF *a1,a2,…*] ON *table*
- *Referenced-variabiles* (they are declared and then used in *condition* and *action*):
  - OLD TABLE AS *var*
  - NEW TABLE AS *var*
  - OLD ROW AS *var* – *only for DELETE, UPDATE*
  - NEW ROW AS *var* –*only for INSERT, UPDATE*

Only for ROW triggers

Triggers Example

- Referential integrity from R.A to S.B implementing cascade deletes

```
Create Trigger Cascade_Deletes
After Delete On S
Referencing Old Row As O
For Each Row
[ no conditions ]
Delete From R Where A = O.B
```

```
Create Trigger Cascade_Deletes
After Delete On S
Referencing Old Table As OT
[ For Each Row ]
[ no condition ]
Delete From R Where
    A in (select B from OT)
```

Triggers
Problems to consider

- Several triggers are activated simultaneously: which one is the first to be executed?
- The trigger action activates other triggers: chaining that can create cycles

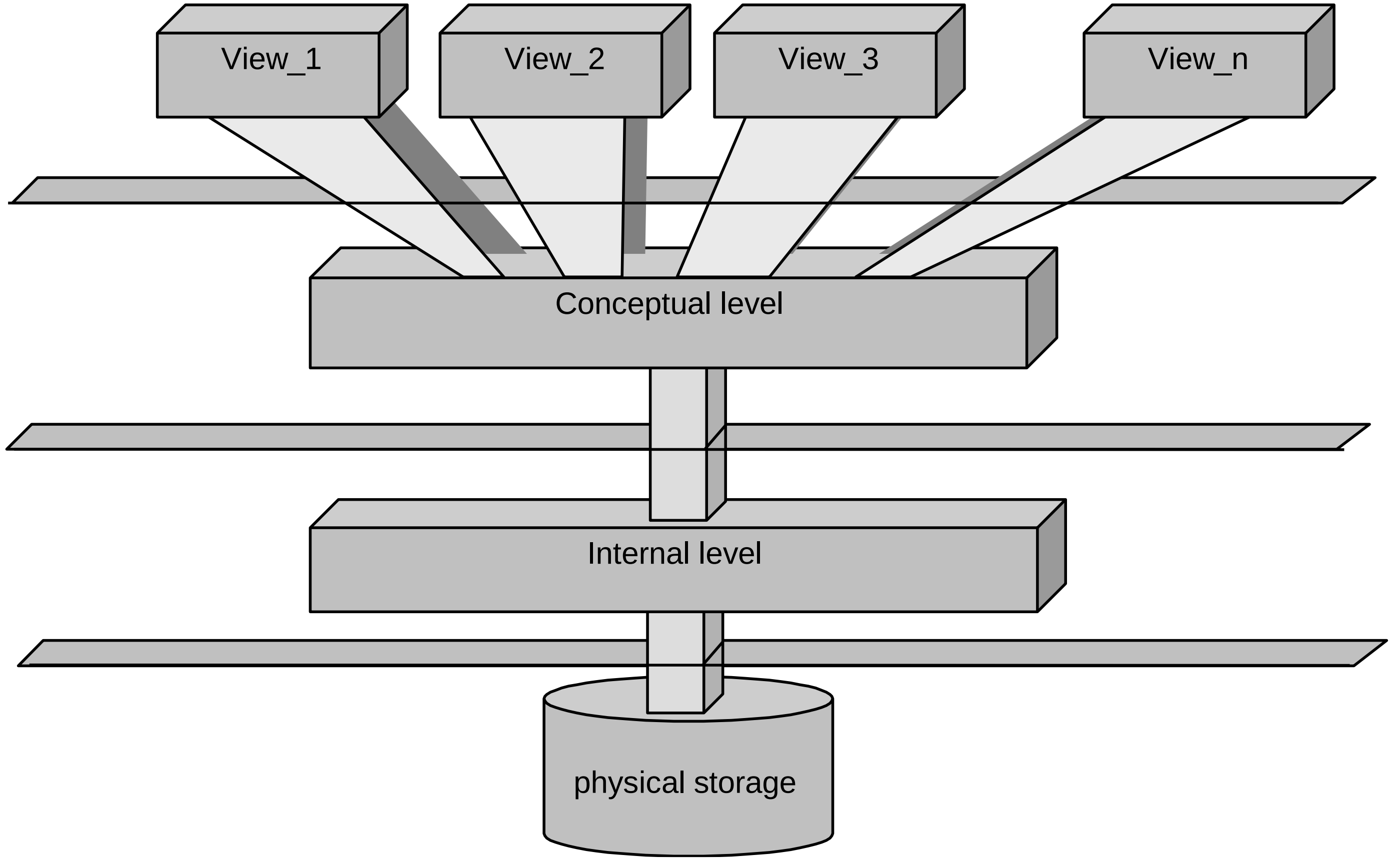
Triggers Implementation

- Postgres
  - The closest to the standard
  - implements row+statement -> {old,new}x{row,table} variables
  - The syntax suffers some changes
- SQLite
  - Only row (no old/new table)
  - Are executed for each row modification
- MySQL
  - Only row (no old/new table)
  - Are executed for each row modification
  - In earlier versions it allowed only one trigger per event per table
- Oracle
  - Implements the standard: row+statement, some syntax changes
  - Instead-of triggers are allowed only for views
  - Allows the use of procedural blocks
  - Introduced the "FOLLOWS" clause in 11g
  - Introduced restrictions to avoid cycling
  - Studied more at the lab in the second semester

…DEMO…

(file *triggers.sql*)

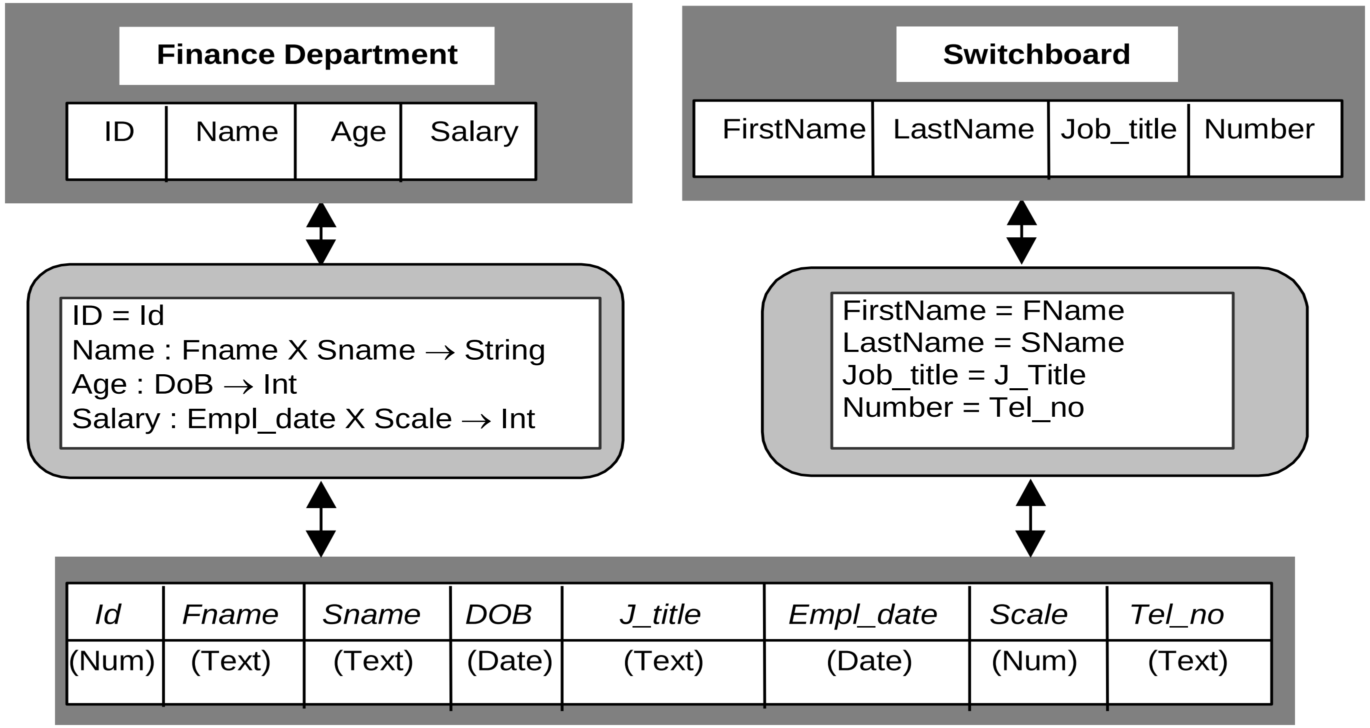
Views



Codd's 12 rules

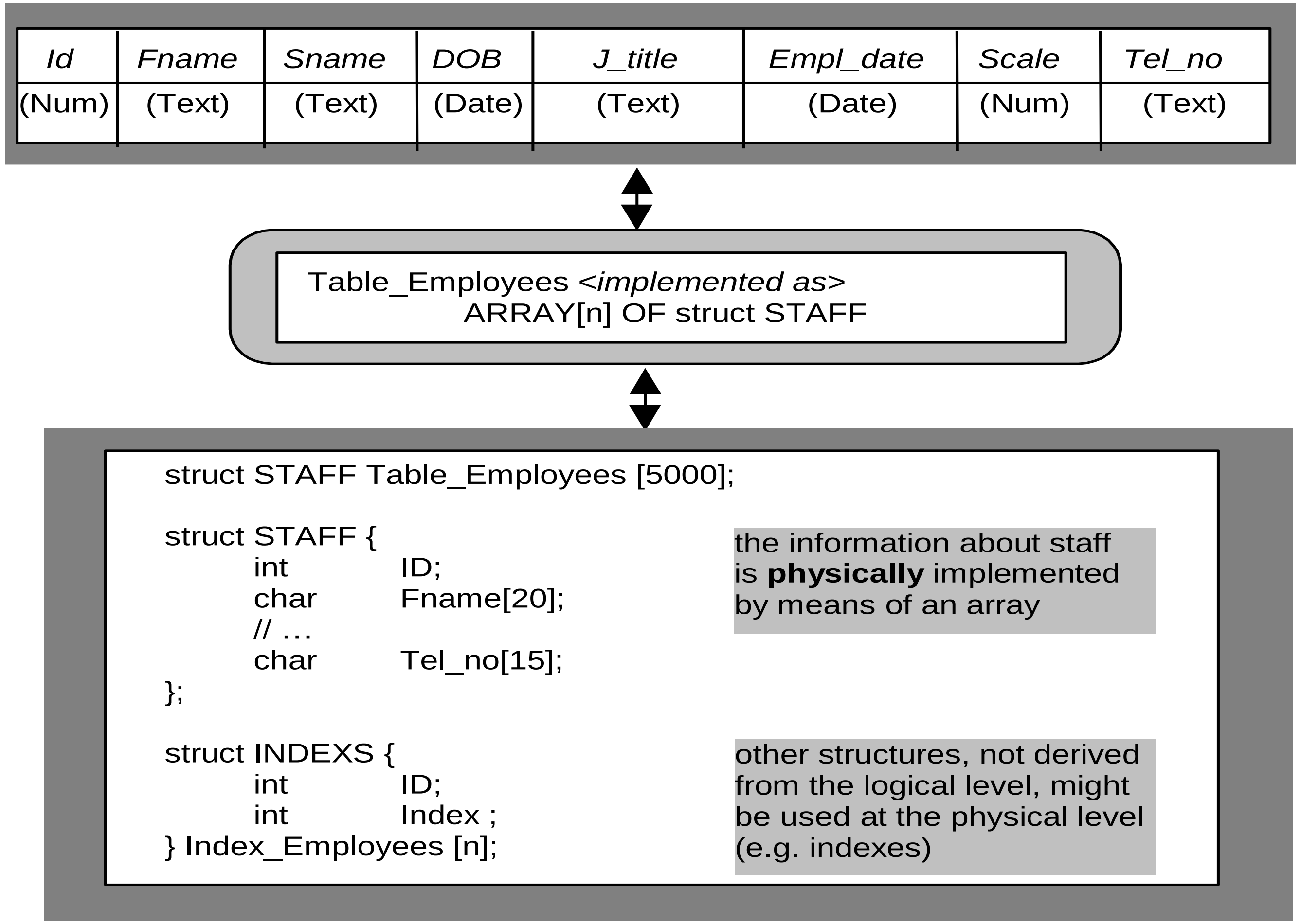
1. Information Rule
2. Guaranteed Access Rule
3. Comprehensive Data Sub-language Rule
4. View Update Rule
5. High Level Insert, Update and Delete
6. Physical Data Independence
7. Logical Data Independence
8. Integrity Independence
9. Non Subversion Rule
10. Systematic Treatment of Null Values
11. Database Description Rule
12. Distribution Independence

External level/conceptual level mapping



Example from Thomas Connolly, Caroline Begg: "*Database Systems. A practical approach to design, implementation and management*". Ed. Addison Wesley

Conceptual level/internal level mapping



Example from Thomas Connolly, Caroline Begg: "*Database Systems. A practical approach to design, implementation and management*". Ed. Addison Wesley

Motivation

- Controlled access to the data:
  - hide data from specific users
  - restrict DML statements
- Reduce the complexity of writing queries

- Real applications tend to use many views

Definition and use

- A view is actually a stored query formulated over tables or other views
- Its schema is generated based on the schema of the query result

- Conceptually, a view is queried just like a table
- In reality, a query over a view is rewritten by replacing the name of the view with the query defining the view; query optimization takes place, as implemented by the DBMS

- Syntax

Create View ***view_name [(a1,a2,…)]*** **As** ***<select_statement>***

Modifying views

- Although the main operation/statement executed on a view is querying it, they may allow DML operations
- Modification commands on views must be rewritten as modification commands over base tables
  - Usually is simple
  - Sometimes several ways exist

- Example 1
  - R(A,B), V(A)=R[A];
  - INSERT INTO V VALUES(3);
- Example 2
  - R(N), V(A)=avg(N),
  - UPDATE V SET A=7;

Modifying views
Approaches

1. The view owner must rewrite all DML statements launched on the view as DML statements on the tables using the INSTEAD OF trigger
   - Covers all the cases
   - Guarantees data consistency

2. The SQL standard defines the existence of (inherently) **updatable views**:
   - The view must be created based on a single table T
   - The attributes in T that are not used in the view may have NULL entries or DEFAULT values
   - There is no aggregation used: no GROUP BY, no DISTINCT keyword

Materialized views

Create Materialized View *V [a1,a2,…]* As *<select_statement>*

- A new table V is created with schema defined by the select statement; the query is also stored
- The tuples result of the query are inserted into V
- Any query on V is executed directly on table V

- Advantages:
  - Specific to regular views + increased query execution speed
- Ddisadvantages:
  - Any DMLs on the base tables require modifications on V
  - Any DMLs on V still must be translated into DMLs on base tables

How decide if materialize?

- Data size
- Query complexity
- The number of queries on the view
- The number of modifications on the base tables and the possibility of incrementally updating the view

- Trade-off the time for query processing over the time for propagating updates on the view when DML commands occur on the base tables

…DEMO…

(file *views.sql*)

Bibliografie

- Hector Garcia-Molina, Jeff Ullman, **Jennifer Widom**: *Database Systems: The Complete Book (2nd edition),* Prentice Hall; (June 15, 2008)
- *Codd's 12 Rules for Relational DBMSs (important to understand the architecture of RDBMSs):* *https://computing.derby.ac.uk/c/codds-twelve-rules/*

- *Oracle:*
  - *http://docs.oracle.com/cd/B28359_01/server.111/b28310/general005.htm*

  - *http://www.oracle-base.com/articles/9i/MutatingTableExceptions.php*
  - *http://www.dba-oracle.com/t_avoiding_mutating_table_error.htm*