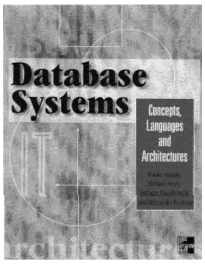
Introduction to Relational Databases

- Licence 3 Informatique, Université Lille 1
- Cours 3 /12
- Topic: Introduction to SQL
  - Data Definition Language
  - Data types
  - Table creation
  - Constraints



Atzeni, Ceri et Paraboschi

Paraboschi est l'auteur des transparents de ce cours avec fond bleu, comme celui-ci. Traductions de l'italien et anglais, par C. Kuttler.

Introduction to SQL: Data Definition Language

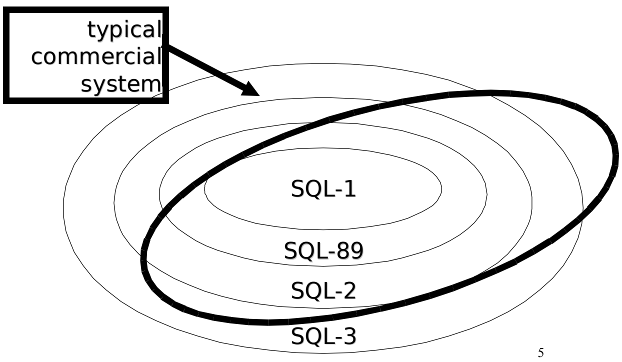
SQL

- Structured Query Language
- Consists of:
  - DDL (Data Description Language): definition of domains, relations, indexes, authorizations, views, constraints, procedures, triggers
  - DML (Data Manipulation Language): query language, update language, transactional commands
- History:
  - First proposal: SEQUEL (IBM Research, 1974)
  - First commercial implementation in SQL/DS (IBM, 1981)
  - Standardization (1986-2003)

Standardization of SQL

- The standardization has been of utmost importance for the success of SQL (mainly within ANSI and ISO)
  - From 1983, it is a standard de facto
  - SQL-1: SQL-86 (basic constructs), SQL-89 (referential integrity constraints)
  - SQL-2: SQL-92 – most adopted version so far
  - SQL-3: SQL:1999 and SQL:2003 – most complete version, with triggers, recursive queries, objects, external functions, extensions for Java and XML
  - 2006,2008,2011,2016: check Wikipedia
- In SQL-2 there are three levels:
  - Entry SQL (more or less equivalent to SQL-89)
  - Intermediate SQL
  - Full SQL
- Most systems are compliant to the Intermediate level and offer proprietary extensions for advanced functions

Expressiveness of commercial systems versus SQL standard



Conventions

- `terms use this font`
- *variables use this font*
- [square brackets]: optional term, at most once
- {curly brackets }: optional term, may be repeated
- vertical bars | | one of several terms separated by the bars must appear
- (parenthesis) : SQL keywords

Data types

- Data types specify the possible values, for each attribute
  - Similar to type definitions in programming languages
- Two categories
  - Built-in (predefined by the SQL standard)
    - SQL-2 distinguishes 6 families
  - user-defined

Built-in data types, 1

- Characters:
  - Single characters or strings
  - Strings can have variable lengths
  - Can use character sets that differ from the defaults (e.g., Latin, Greek, Cyrillic, etc.)
  - `character` [`varying`] [(Length)] [`character set` CharacterFamily]
  - Can use more compact alternatives as `char` and `varchar`, respectively for `character` and `character varying`
  - Examples:
    - `char(6)`
    - `varchar(50)`

Built-in data types, 2

- Bit
  - Boolean values (true/false), single or in a sequence, (the sequence may be of variable length)
  - Syntax:

    `bit` [`varying`] [(Length)]

    Examples: bit(100), varbit(680)
- Precise numeric types
  - Numeric values: integers or reals
  - 4 alternatives:

    `numeric` [(Precision [, Scale])]

    `decimal` [(Precision [, Scale])]

    `integer`

    `smallint`

Built-in data types, 3

- Approximate numeric types
  - Approximate real values
  - Based on a floating point representation: integer part + exponent

    `float` [(Precision)]

    `real`

    `double precision`

Built-in data types, 4

- Time points
  - Allow for fields:

    `date` (fields `month, day, year`)

    `time` [(Precision)] [`with time zone`] : (fields `hour, minute, second`)

    `timestamp` [(Precision)] [`with time zone`]

    with timezone, one has two additional fields `timezone_hour` and `timezone_minute`
    - Example: timestamp(4) with time zone 2-30-2004 3-13-42.0564 5-30
- Time intervals

  `interval` FirstTimeUnit [`to` LastTimeUnit]
  - We distinguish 2 groups of time units groups:
    - year, month
    - day, hour, minute, second
  - Examples:
    - `interval year to month`
    - `interval second`

Built-in data types, 5

- New built-in types in SQL-3
  - `Boolean`
  - `Bigint`
  - `BLOB` Binary Large OBject
  - `CLOB` Character Large Object
- SQL:1999 also introduces constructors (`REF`, `ARRAY`, `ROW`; they go beyond the relational model and we won't talk about them)

User defined data types

- Similar to type definitions in programming languages: for an object, define the values it may take
- A data type is specified by
  - name
  - elementary type
  - default value
  - constraints
- Syntax:
  `create domain` DomainName `as` ElementaryDomain
  [DefaultValue] [Constraints]
- Example:
  `create domain Grade as smallint default null`
- Comparison to programming languages
- \+ constraints, default values, richer basic types
  \- approved constructors (only renaming of types)

Default values for types

- Fix the value of an attribute, when no value is specified as a tuple is inserted
- Syntax:
  `default` < GenericValue | `user` | `null` >
- GenericValue represents a value compatible with the type, given by a constant or expression
- `user` is the login of the user that executes the command

"null" values

`Null`
is a polymorphic value (that is included in all types), and means that a value is unknown

- the value exists in reality, but is unknown to the database (ex.: birthday)
- the value doesn't apply (ex.: driver's license number for children)
- it is unknown if the value is unknown, or used (ex.: driver's license number for adults)

Definition of application domains

```
create domain DailyPrice
as decimal(3)
    default 1,00
    not null
```


Definition of schemas in SQL

Definition of schemas

- A schema is a collection of objects:
  - domain, tables, indexes, assertions, views, privileges
- Each schema has a name and an owner
- Part of the standard SQL-2. Took long to be implemented! In Postgres since version 7.
- Syntax:
  `create schema` [SchemaName]
  [[`authorization`] Authorization]
  { SchemaElementDefinition }

Table creation

- Each SQL table consists of:
  - an ordered set of attributes
  - a set of constraints (may be empty)
- `create table` command
  - Defines the schema of a relation, by creating an empty instance
- Syntax:

```
create table TableName
   (
   AttributeName Domain [ DefaultValue ] [ Constraints ]
   {, AttributeName Domain [ DefaultValue ] [ Constraints ] }
   [ OtherConstraints ]
   )
```


create table example (1)

```
create table Student
  (  Sid        char(6) primary key,
     Name       varchar(30) not null,
     City       varchar(20),
     Major      char(3) )
```


create table examples (2)

```
create table Exam
 (  Sid      char(6),
    Cid      char(6),
    Date     date  not null,
    Grade    smallint not null,
    primary key(Sid,Cid) )

 create table Class
 (  Cid    char(6) primary key,
    Title   varchar(30) not null,
    Teacher  varchar(20) )
```


Integrity constraints

- Integrity constraints: conditions that must be satisfied by all instances of the data base
- Constraints on a single relation
  - `not null` (for one attribute)
  - `primary key` (implies not null);
    - For a single attribute:
      `primary key`, after the type
    - For several attributes:
      `primary key(`Attribute{, Attribute })
  - `unique`: key candidates, syntax as for `unique`
  - `check`: will be explained later (can represent generic predicates in SQL)

Examples of integrity constraints

- Each pair of Name and FirstName uniquely identifies a tuple

```
Name character(20) not null,
FirstName character(20) not null,
unique(Name,FirstName)
```

- Note the difference to the following definition (more restrictive):

```
Name character(20) not null unique,
FirstName character(20) not null unique,
```


Referential integrity

Example: Student - Exam

Student

Sid	
123	
415	
702	

Exam

Sid	
123	
123	
702	

The orphan problems

Student

Sid	
~~123~~	
415	
702	

orphans:
Tuples that are without parent, after deletion of modification in the parent table

Exam

Sid	
~~123~~	
~~123~~	
702	

How to deal with orphans?

- After modification of the parent table, some operations are performed on the child table
- Violation can be introduced by:
  (1) updates of the referred attribute
  (2) deletion of tuples
- Possible reactions:
  - `cascade`: propagates the modification
  - `set null`: cancels the referring attribute
  - `set default`: assigns the default value to the tuple
  - `no action`: makes the modification impossible
- The reaction can depend on the kind of event ; Syntax:

```
on < delete|update >
   < cascade|set null|set default|no action >
```


Dealing with orphans: deletion

If a tuple is deleted within Student, what happens to his/her exams?

- cascade
  the Student's exams are also deleted
- set null
  the Sid within Exam is set to null
- set default
- the Sid within Exam is set to the default value
- no action
  The deletion of tuples within Student is forbidden

Dealing with orphans: update

If an Sid is modified within Student, what happens to his/her exams?

- cascade
  the Sid of the students within Exam is also modified
- set null
  the Sid of the students within Exam is set to null
- set default
  the Sid of the students within Exam is set to the default value
- no action
  the modification of the Sid within Student is forbidden

Syntax for integrity constraints

- Attributes that are foreign keys inside the child relation must have values present as key values inside the father relation
- `references` and `foreign key` for referential integrity constraints;
- Syntax:
  - for one attribute
    `references` after Domain
  - for one or more attributes
    `foreign key` (Attribute {, Attribute })
    `references` …

Definition: inside the child relation

```
create table Exam
  ( ....
    ....
    foreign key Sid
      references Student
        on delete cascade
        on update cascade )
```


Definition: inside the child relation

```
create table Exam
  ( Sid char(6) references Student
       on delete cascade
       on update cascade ,
      ......)
```


It is allowed to have multiple fathers!

```
create table Exam
( ....
    primary key(Sid,Cid)
    foreign key Sid
      references Student
        on delete cascade
        on update cascade
    foreign key Cid
      references Class
        on delete no action
        on update no action )
```


An incorrect instance

Sid	Name	City	Major
123			
415			
702			

Exam

	Sid	Cid	Date	Grade
	123	1	7-9-15	30
	123	2	8-1-16	28
violates the key constraint	~~123~~	~~2~~	~~1-8-15~~	~~28~~
	702	2	7-9-16	20
violates the NULL constraint	~~702~~	~~1~~	~~NULL~~	~~NULL~~
violates the ref. integrity	~~714~~	~~1~~	~~7-9-15~~	~~28~~