Principles of Database Systems (CS307)

Lecture 2: Introduction to SQL

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- Most contents are from slides made by Stéphane Faroult and the authors of Database System Concepts (7th Edition), revised by Dr. Yuxin Ma.
- Their original slides have been modified to adapt to the schedule of CS307 at SUSTech.

How Do We Manage Data in a Database?

- Usually, a special language is needed
  - Be able to use a language to query a database
    - Either interactively or from within a program

- Query language
  - Query data
  - Modify data

If you modify something, you change it slightly, usually in order to improve it.

Some History

- ALPHA
  - Codd's querying language

- Find the supplier names and locations of those suppliers who supply part 15.

$$(r_1[2],\ r_1[3]):\ P_1 r_1 \wedge \exists P_2 r_2 (r_2[2] = 15 \wedge r_2[1] = r_1[1]).$$

- Find the locations of suppliers and the parts being supplied by them (omitting those suppliers who are supplying no parts at this time).

$$(r_1[3],\ r_2[2]):\ P_1 r_1 \wedge P_2 r_2 \wedge (r_1[1] = r_2[1]).$$

Codd, E.F., "Data Base Sublanguage Founded on the Relational Calculus", Proc. 1971 ACM-SIGFIDET Workshop on Data Description, Access, and Control, San Diego.

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However, it didn't excite enthusiasm at IBM

Some History

- "SEQUEL: A Structured English Query Language"
  - IBM Sequel language developed as part of System R project at the IBM San Jose Research Laboratory
  - An "easy" language, with an English-like syntax

Don Chamberlin with Ray Boyce (1974)

SEQUEL: A STRUCTURED ENGLISH QUERY LANGUAGE

by

Donald D. Chamberlin
Raymond F. Boyce

IBM Research Laboratory
San Jose, California

ABSTRACT: In this paper we present the data manipulation facility for a structured English query language (SEQUEL) which can be used for accessing data in an integrated relational data base. Without resorting to the concepts of bound variables and quantifiers SEQUEL identifies a set of simple operations on tabular structures, which can be shown to be of equivalent power to the first order predicate calculus. A SEQUEL user is presented with a consistent set of keyword English templates which reflect how people use tables to obtain information. Moreover, the SEQUEL user is able to compose these basic templates in a structured manner in order to form more complex queries. SEQUEL is intended as a data base sublanguage for both the professional programmer and the more infrequent data base user.

Computing Reviews Categories: 3.5, 3.7, 4.2

Key Words and Phrases: Query Languages
Data Base Management Systems
Information Retrieval
Data Manipulation Languages

Donald D. Chamberlin and Raymond F. Boyce. 1974. SEQUEL: A structured English query language. In Proceedings of the 1974 ACM SIGFIDET (now SIGMOD) workshop on Data description, access and control (SIGFIDET '74). Association for Computing Machinery, New York, NY, USA, 249–264. DOI:https://doi.org/10.1145/800296.811515

Some History

- SEQUEL was then renamed as **Structured Query Language (SQL)**
- ANSI and ISO standard SQL:
  - SQL-86
  - SQL-89
  - SQL-92
  - SQL:1999 (language name became Y2K compliant!)
  - SQL:2003
- Commercial systems offer most, if not all, SQL-92 features, plus varying feature sets from later standards and special proprietary features
  - Not all examples here may work on your particular system.

If you say that someone is compliant, you mean they willingly do what they are asked to do.

The Year 2000 Problem

A huge problem that appears everywhere and many times

relating to an owner or ownership: the company has a proprietary right to the property.
• (of a product) marketed under and protected by a registered trade name: proprietary brands of insecticide.
• behaving as if one were the owner of someone or something: he looked about him with a proprietary air.

Year	Name	Alias	Comments
1986	SQL-86	SQL-87	First formalized by ANSI
1989	SQL-89	FIPS 127-1	Minor revision that added integrity constraints, adopted as FIPS 127-1
1992	SQL-92	SQL2, FIPS 127-2	Major revision (ISO 9075), *Entry Level* SQL-92 adopted as FIPS 127-2
1999	SQL:1999	SQL3	Added regular expression matching, recursive queries (e.g. transitive closure), triggers, support for procedural and control-of-flow statements, nonscalar types (arrays), and some object-oriented features (e.g. structured types), support for embedding SQL in Java (SQL/OLB) and vice versa (SQL/JRT)
2003	SQL:2003		Introduced XML-related features (SQL/XML), window functions, standardized sequences, and columns with autogenerated values (including identity columns)
2006	SQL:2006		ISO/IEC 9075-14:2006 defines ways that SQL can be used with XML. It defines ways of importing and storing XML data in an SQL database, manipulating it within the database, and publishing both XML and conventional SQL-data in XML form. In addition, it lets applications integrate queries into their SQL code with XQuery, the XML Query Language published by the World Wide Web Consortium (W3C), to concurrently access ordinary SQL-data and XML documents.[33]
2008	SQL:2008		Legalizes ORDER BY outside cursor definitions. Adds INSTEAD OF triggers, TRUNCATE statement,[34] FETCH clause
2011	SQL:2011		Adds temporal data (PERIOD FOR)[35] (more information at: Temporal database#History). Enhancements for window functions and FETCH clause.[36]
2016	SQL:2016		Adds row pattern matching, polymorphic table functions, JSON
2019	SQL:2019		Adds Part 15, multidimensional arrays (MDarray type and operators)

https://en.wikipedia.org/wiki/SQL

Standardization of SQL

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https://en.wikipedia.org/wiki/SQL

Standardization of SQL (any other examples of standardization?)

Basic Syntax of SQL

```
select * from lab where time = '3-34';
```

`select …`

- followed by the names of the columns you want to return

`from …`

- followed by the name of the tables that you want to query

`where …`

- followed by filtering conditions

INGRES

原作者 加利福尼亚大学柏克莱分校

開發者 Actian公司
(以前的Relational Technology公司)

穩定版本 11.0（2017年4月21日，5年前[1]）

Competing Languages of SQL

- QUEL, born at **Berkeley**, and associated with INGRES, was highly regarded
  - Ingres Database

QUEL ---------- Ingres → SEQUEL (SQL) ---------- Postgres

QUEL	SQL

`create student(name = c10, age = i4, sex = c1, state = c2)`
 	
`range of s is student`
`append to s (name = "philip", age = 17, sex = "m", state = "FL")`
 	
`retrieve (s.all) where s.state = "FL"`
 	
`replace s (age=s.age+1)`
 	
`retrieve (s.all)`
 	
`delete s where s.name="philip"`
	`create table student(name char(10), age int, sex char(1), state char(2));`
	
	`insert into student (name, age, sex, state) values ('philip', 17, 'm', 'FL');`
	
	`select * from student where state = 'FL';`
	
	`update student set age=age+1;`
	
	`select * from student;`
	
	`delete from student where name='philip';`

无论从任何意义上来说，Ingres 都是历史上最有影响的计算机研究项目之一。

Michael Stonebraker (1943-)
Turing Award 2014

Competing Languages of SQL

- QBE (Query by Example)
  - A visual querying tool (visual but with characters)
  - Created by IBM as well

```
id:
address:
time: 3-34
capacity:
teacher:
```

```
select * from lab where time = '3-34';
```

Moshé M. Zloof

Query languages, data query languages or database query languages (DQLs) are computer languages used to make queries in databases and information systems. A well known example is the Structured Query Language (SQL).

Two Main Components for a Query Language

- From Codd's seminal paper:
  - A good database language should allow to deal as easily with contents (data) as containers (tables)
  - … Something that SQL does reasonably well

Two Main Components for a Query Language

- Data Definition Language (DDL)
  - The SQL data-definition language (DDL) allows the specification of information about relations, including:
    - The **schema** for each relation.
    - The type of value associated with each **attribute**.
    - The Integrity **constraints**.
    - The set of **indices** to be maintained for each relation.
    - **Security** and **authorization** information for each relation.
    - The physical **storage** structure of each relation on disk.

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    - **Security** and **authorization** information for each relation.
    - The physical **storage** structure of each relation on disk.

A schema is an outline of a plan or theory.

A constraint is something that limits or controls what you can do.

a plural of index

```
create
alter
drop
```

Two Main Components for a Query Language

- Data Manipulation Language (DML)
  - Provides the ability to:
    - **Query** information from the database
    - **Insert** tuples into, **delete** tuples from, and **modify** tuples in the database.

If you modify something, you change it slightly, usually in order to improve it.

a row of values in a relational database

```
select
insert
delete
update
```

Something about SQL

- Simple?
  - As you can see, it seems to be simple
  - But it becomes difficult when you combine operations
    - We will talk about it later
- Standard?
  - We have mentioned standardization of SQL before
  - However, no product fully implements it
    - Different product implements SQL differently
    - … and introduces **dialects**

SQL is one of a few languages where you spend more time thinking about how you are going to do things than actually coding them.

Upl

“Problems” in SQL

- SQL ≠ Relational Database
  - SQL wasn't designed as a "relationally correct" language
    - In some respects, it is very lax
    - But easy to use, however
    - And also, easy to misuse
      - So, **using it well is difficult**
- Sometimes, you will get results even if the SQL is wrong
  - SQL is not as strict as C or Java, it will **NOT** give you error messages if your table cannot fit the requirement of the theory
    - “Wrong results” without warnings

“Problems” in SQL

- SQL ≠ Relational Database
  - SQL wasn't designed as a "relationally correct" language
    - In some respects, it is very lax
    - But easy to use, however not sufficiently strict, severe, or careful:
    - And also, easy to misuse
      - So, **using it well is difficult**
- Sometimes, you will get results even if the SQL is wrong
  - SQL is not as strict as C or Java, it will **NOT** give you error messages if your table cannot fit the requirement of the theory
    - “Wrong results” without warnings

Be careful when designing your SQL queries

“Problems” in SQL

- Key propriety of relations (in Codd's original paper)

ALL ROWS ARE DISTINCT

recognizably different in nature from something else of a similar type:

- This can be enforced for tables in SQL
  - (But you have to create your tables well)

- But it is **NOT** enforced for query results in SQL
  - You must be extra-careful if the result of a query is the starting point for another query, which happens often. (i.e., combined queries)

Comments

```
/* Multi-line
comments */

-- Single line comments, similar to double back-slashes in Java and C++

// *Some DBMS also support double back-slashes, like SQL Server
```

Comments

```
create table people (
    peopleid int not null,
    first_name varchar(30),
    surname varchar(30) not null,  -- the actual surname or the stage name
    born numeric(4) not null,  -- the birth date is mandatorybefore entering the data
    died numeric(4)
)
```

- Add comments to the definition of tables

Create Tables

- A comma-separated list of a column-name followed by spaces and a datatype specifies the columns in the table

Syntax

```
CREATE TABLE table_name (
    column1 datatype,
    column2 datatype,
    column3 datatype,
   ....
);
```

Example

```
CREATE TABLE Persons (
    PersonID int,
    LastName varchar(255),
    FirstName varchar(255),
    Address varchar(255),
    City varchar(255)
);
```

no comma at last line

Create Tables

- Table names
  - Case-insensitive (Usually, by default)
    - But, in some database systems, the case sensitivity is quite different
    - Try, or find the reference for the specific database system

```
CREATE TABLE tablename
CREATE TABLE TABLENAME
CREATE TABLE tABleNamE

/* Same table names */
```

For example, MariaDB is system-dependent with respect to case sensitivity

`https://mariadb.com/kb/en/identifier-case-sensitivity/`

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Actually, keywords are case-insensitive as well

```
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/* Same keywords */
```

Create Tables

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  - Case-insensitive (不区分大小写, by default)
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    - Try, or find the reference for the specific database system
- Naming Convention
  - Underscores (下划线) as word separators (instead of CamelCase in Java)

a way which things usually done

```
CREATE TABLE tablename
CREATE TABLE TABLENAME
CREATE TABLE tABleNamE

/* Same table names */
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Actually, keywords are case-insensitive as well

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Create Tables

- Table names
  - Case-insensitive (不区分大小写, by default)
    - But, in some database systems, the case sensitivity is quite different
    - Try, or find the reference for the specific database system
- Naming Convention
  - Underscores (下划线) as word separators (instead of CamelCase in Java)
- Be careful with double quotes
  - … which represents a “case-sensitive” name

```
CREATE TABLE tablename
CREATE TABLE TABLENAME
CREATE TABLE tABleNamE

/* Same table names */
```

Actually, keywords are case-insensitive as well

```
create table tablename
CREATE table TABLENAME
CReaTE tABle tABleNamE

/* Same keywords */
```

Create Tables

- An SQL relation is defined using the create table command:

```
create table r (
    A1 D1, A2 D2, ..., An Dn,
    (integrity-constraint1),
    ...,
    (integrity-constraintk)
)
```

  - `r` is the name of the relation
  - each `Ai` is an attribute name in the schema of relation `r`
  - `Di` is the data type of values in the domain of attribute `Ai`

Data Types

- Text data types
  - `char(length)` -- fixed-length strings
  - `varchar(max length)` -- non-fixed-length text
  - `varchar2(max length)` ORACLE -- Oracle's transformation of `varchar`
  - `clob` -- very long text (like GB-level text)
    - Or, `text` MySQL

Data Types

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  - `varchar(max lengt`
  - `varchar2(max leng`
  - `clob` -- very long te
    - Or, `text`

SR.NO.	CHAR	VARCHAR
1.	CHAR datatype is used to store character strings of fixed length	VARCHAR datatype is used to store character strings of variable length
2.	In CHAR, If the length of the string is less than set or fixed-length then it is padded with extra memory space.	In VARCHAR, If the length of the string is less than the set or fixed-length then it will store as it is without padded with extra memory spaces.
3.	CHAR stands for "Character"	VARCHAR stands for "Variable Character"
4.	Storage size of CHAR datatypes is equal to n bytes i.e. set length	The storage size of the VARCHAR datatype is equal to the actual length of the entered string in bytes.
5.	We should use the CHAR datatype when we expect the data values in a column are of the same length.	We should use the VARCHAR datatype when we expect the data values in a column are of variable length.
6.	CHAR takes 1 byte for each character	VARCHAR takes 1 byte for each character and some extra bytes for holding length information
9.	Better performance than VARCHAR	Performance is not good as compared to CHAR

Data Types

- Numerical types
  - `int` -- Integer (a finite subset of the integers that is machine-dependent)
  - `float(n)` -- Floating point number, with user-specified precision of at least *n* digits
  - `real` -- Floating point and double-precision floating point numbers, with machine-dependent precision
  - `numeric(p, d)`
    - Fixed point number, with user-specified precision of p digits, with d digits to the right of decimal point (总共p位数字、含小数点后d位)
    - E.g., `numeric(3,1)`, allows 44.5 to be stores exactly, but not 444.5 or 0.32
    - In SQL Server, it is also called `decimal`

- `float(n)` is a floating-point number whose precision, at least, n, up to a maximum of 8 bytes.
- `real` or `float8` is a 4-byte floating-point number.
- `numeric` or `numeric(p,s)` is a real number with p digits with s number after the decimal point. The `numeric(p,s)` is the exact number.

8.1.4. Serial Types

> **Note**
>
> This section describes a PostgreSQL-specific way to create an autoincrementing column. Another way is to use the SQL-standard identity column feature, described at CREATE TABLE.

The data types `smallserial`, `serial` and `bigserial` are not true types, but merely a notational convenience for creating unique identifier columns (similar to the `AUTO_INCREMENT` property supported by some other databases). In the current implementation, specifying:

```
CREATE TABLE tablename (
    colname SERIAL
);
```

is equivalent to specifying:

```
CREATE SEQUENCE tablename_colname_seq AS integer;
CREATE TABLE tablename (
    colname integer NOT NULL DEFAULT nextval('tablename_colname_seq')
);
ALTER SEQUENCE tablename_colname_seq OWNED BY tablename.colname;
```

Thus, we have created an integer column and arranged for its default values to be assigned from a sequence generator. A `NOT NULL` constraint is applied to ensure that a null value cannot be inserted. (In most cases you would also want to attach a `UNIQUE` or `PRIMARY KEY` constraint to prevent duplicate values from being inserted by accident, but this is not automatic.) Lastly, the sequence is marked as "owned by" the column, so that it will be dropped if the column or table is dropped.

Data Types

- Date types
  - `date` -- YYYY-MM-DD
  - `datetime` -- YYYY-MM-DD HH:mm:SS
  - `timestamp` -- YYYY-MM-DD HH:mm:SS
    - But it is in the UNIX timestamp
    - Value range: 1970-01-01 00:00:01 UTC - 2038-01-19 03:14:07 UTC
    - More reading about the “Year 2038 Problem” of the `timestamp` data type: `https://en.wikipedia.org/wiki/Year_2038_problem`

在计算机应用上，**2038年问题**可能会导致某些软件在2038年1月19日3时14分07秒之后无法正常工作。

Data Types

- Binary data types
  - `raw(max length) -- used in Oracle`
  - `varbinary(max length) -- used in SQL Server`
  - `bytea  -- used in PostgreSQL`

Constraints

a limitation or restriction

- Can you find any problem in this statement?

```
create table people (
    peopleid int,
    first_name varchar(30),
    surname varchar(30),
    born numeric(4),
    died numeric(4)
)
```

max length

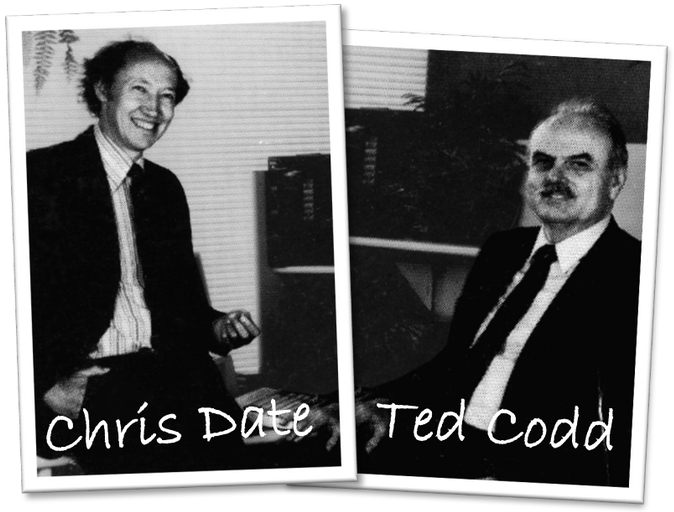
Constraints

- Can you find any problem in this statement?
  - It is valid and can be accepted by most DBMS
  - But it does nothing to enforce that we have a valid “relation” in Codd’s sense

database management system

```
create table people (
    peopleid int,
    first_name varchar(30),
    surname varchar(30),
    born numeric(4),
    died numeric(4)
)
```

Constraints



- Ted Codd and Chris Date
  - Worked on improving the relational theory
- Chris Date's work
  - Ensuring that only correct data that fits the theory can enter the database
  - Data inside the database remains correct
    - No need to double check for application programs

Constraints **are declarative rules that the DBMS will check every time new data will be added, when data is changed, or even when data is deleted, in order to prevent any inconsistency.**

* Any operation that violates a constraint fails and returns an error.

Constraints: Not NULL

- NULL values

```
create table people (
    peopleid int,
    first_name varchar(30),
    surname varchar(30),
    born numeric(4),
    died numeric(4)
)
```

```
create table people (
    peopleid int not null,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4),
    died numeric(4)
)
```

- We don't want someone with no ID and name
- Use `not null` to indicate that these columns are mandatory

required by law or rules; compulsory:

Constraints: Not NULL

- NULL values

```
create table people (
    peopleid int,
    first_name varchar(30),
    surname varchar(30),
    born numeric(4),
    died numeric(4)
)
```

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create table people (
    peopleid int not null,
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    surname varchar(30) not null,
    born numeric(4),
    died numeric(4)
)
```

- We don't want someone with no ID and name
- Use `not null` to indicate that these columns are mandatory

We can still have rows that with `NULL` values in the columns of `born`, `died`, and `first_name`

Constraints: Not NULL

- NULL values

```
create table people (
    peopleid int,
    first_name varchar(30),
    surname varchar(30),
    born numeric(4),
    died numeric(4)
)
```

```
create table people (
    peopleid int not null,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4),
    died numeric(4)
)
```

Why is only surname mandatory?

- It depends on the requirement. In this movie database case, some actors may be known as their stage names instead of real names. (Lady Gaga vs. Stefani Joanne Angelina Germanotta)

Takeaway: design your table according to the requirements

Constraints: Not NULL

- NULL values

```
create table people (
    peopleid int,
    first_name varchar(30),
    surname varchar(30),
    born numeric(4),
    died numeric(4)
)
```

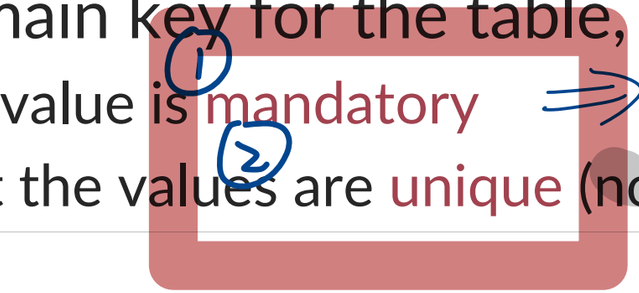
```
create table people (
    peopleid int not null,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4),
    died numeric(4)
)
```

Similar to the column `born`

- We can either accept that
  - A row is created before we have information of that person's birth date
  - Or we require that the information should be found before entering the data

Constraints: Primary Key

- The main key for the table, and indicates two things:
  - the value is mandatory
  - that the values are unique (no duplicates allowed in the column)




```
create table people (
    peopleid int not null
                primary key,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4) not null,
    died numeric(4)
)
```

Primary Key

Primary Key is a field that can be used to identify all the tuples uniquely in the database.

Only one of the columns can be declared as a primary key.

A Primary Key can not have a NULL value.

primary key { only ONE attribute
unique
madatory: not Null

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  - that the values are unique (no duplicates allowed in the column)

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    peopleid int not null
                 primary key,
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    surname varchar(30) not null,
    born numeric(4) not null,
    died numeric(4)
)
```

`primary key` implies `not null`, so `not null` here is redundant (but doesn't hurt)

Constraints: Unique

- So far, nothing would prevent us from entering two same rows with different IDs

peopleid	first_name	surname	born	died
1	Alfred	Hitchcock	1899	1980
2	Alfred	Hitchcock	1899	1980
3	....	...	...	...

```
create table people (
    peopleid int not null
                    primary key,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4) not null,
    died numeric(4)
)
```

Constraints: Unique

- A unique constraint (on a combination of multiple columns)

peopleid	first_name	surname	born	died
1	Alfred	Hitchcock	1899	1980
2	Alfred	Hitchcock	1899	1980
3	....	...	...	...

```
create table people (
    peopleid int not null
                    primary key,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4) not null,
    died numeric(4),
    unique (first_name, surname)
)
```

The combination of `(first_name, surname)` cannot be the same for any two rows

- But you still can have people with the same first name or surname, respectively

Constraints: Unique

- A unique constraint (on a single column)

peopleid	first_name	surname	born	died
1	Alfred	Hitchcock	1899	1980
2	Alfred	Hitchcock	1899	1980
3	....	...	...	...

```
create table people (
    peopleid int not null
                    primary key,
    first_name varchar(30) unique,
    surname varchar(30) not null,
    born numeric(4) not null,
    died numeric(4)
)
```

No identical first names for any two people here

- But it is not what we want in this table

Constraints: Check

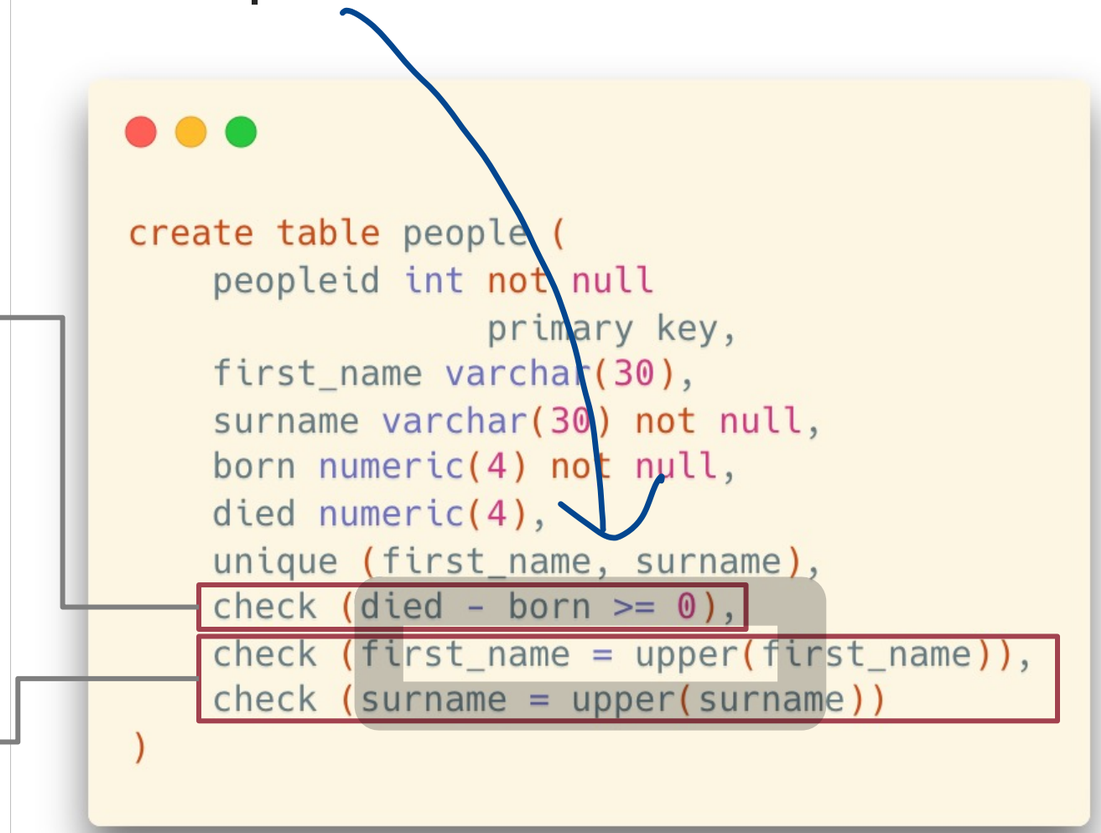
- A column must santisfy a certain boolean expression test
  - The most generic constriant type

characteristic of or relating to a class or group of things; not specific

You must ensure that the person died after birthday

A useful trick to standardize names

- Such that there won't be rows with the same name of "Alfred Hitchcock", "ALFRED HITCHCOCK", and "alfred hitchcock".
- `upper(string)` is a function in PostgreSQL



```
create table people (
    peopleid int not null
                    primary key,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4) not null,
    died numeric(4),
    unique (first_name, surname),
    check (died - born >= 0),
    check (first_name = upper(first_name)),
    check (surname = upper(surname))
)
```

Named Constraints (给约束命名)

```
CREATE TABLE products (
    product_no integer,
    name text,
    price numeric CHECK (price > 0)
);
```

definition of data type

constrain ⇓ can come after the data type

- A name can be assigned to the constraints
  - … in order to refer to them easier in some other operations
    - PostgreSQL will give a name to the constraints if you don't assign a name explicitly

in a clear and detailed manner, leaving no room for confusion or doubt:

⇓ Clarifies error messages

```
create table people (
    peopleid int not null
                primary key,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4) not null,
    died numeric(4),
    unique (first_name, surname),
    check (died - born >= 0),
    check (first_name = upper(first_name)),
    check (surname = upper(surname))
)
```

```
create table people (
    peopleid int not null
                primary key,
    first_name varchar(30),
    surname varchar(30) not null,
    born numeric(4) not null,
    died numeric(4),
    unique (first_name, surname),
    constraint validate_birthdate check (died - born >= 0),
    constraint standardize_first_name check (first_name = upper(first_name)),
    constraint standardize_surname check (surname = upper(surname))
)
```

Syntax: constraint con_name + 内容

Constraint constraint_name check (Boolean expression)

Referential Integrity

- Check constaints are static
  - Once it is written into the table, the criteria cannot be updated automatically

a principle or standard by which
something may be judged or decided

```
create table movies (
    movieid int not null primary key,
    title varchar (60) not null,
    country char (2) not null,
    year_released numeric(4) not null
    check (year_released >= 1895),
    unique (title, country, year_released)
)
```

- It is very difficult to perform static checks
  - Too many countries; country names and codes may change

Referential Integrity

- Check constaints are static
  - Once it is written into the table, the criteria cannot be updated automatically

```
create table movies (
    movieid int not null primary key,
    title varchar (60) not null,
    country char (2) not null,
    year_released numeric(4) not null
    check (year_released >= 1895),
    unique (title, country, year_released)
)
```

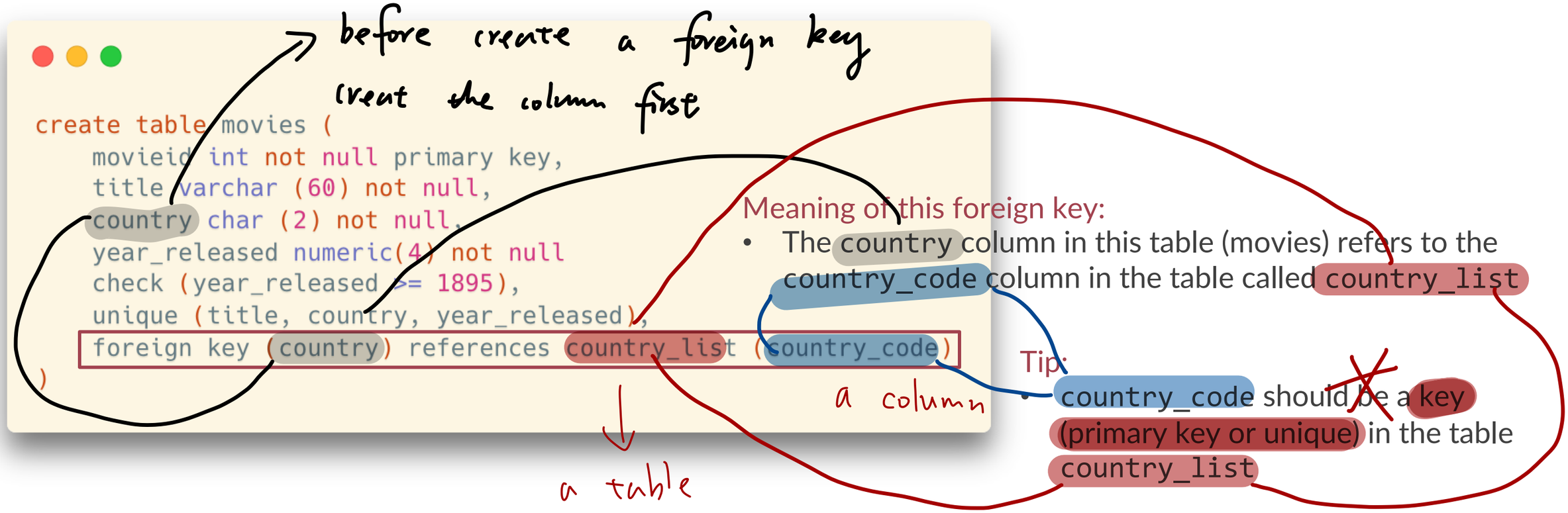
country_code	country_name	continent
US	United States	AMERICA
CN	China	ASIA
RU	Russia	EUROPE

Referential Integrity

- The `country` column in `movies` should be linked with the `country_code` column in another table (called reference table)

Foreign Key

- Format:
  - `foreign key (Am, ..., An ) references r`



Foreign Key

A foreign key is a column which is known as Primary Key in the other table

i.e. A Primary Key in a table can be referred to as a Foreign Key in another table.

Foreign Key may have duplicate & NULL values if it is defined to accept NULL values.

Foreign Key

- Format:
  - `foreign key (Am, ..., An ) references r`

Movie ID	Movie Title	Country	Year
0	Citizen Kane	US	1941
1	La règle du jeu	FR	1939
2	North By Northwest	US	1959
3	Singin' in the Rain	US	1952
4	Rear Window	US	1954

Movie Entities

Directed By

Movie ID	Director ID
0	2
1	5
2	1

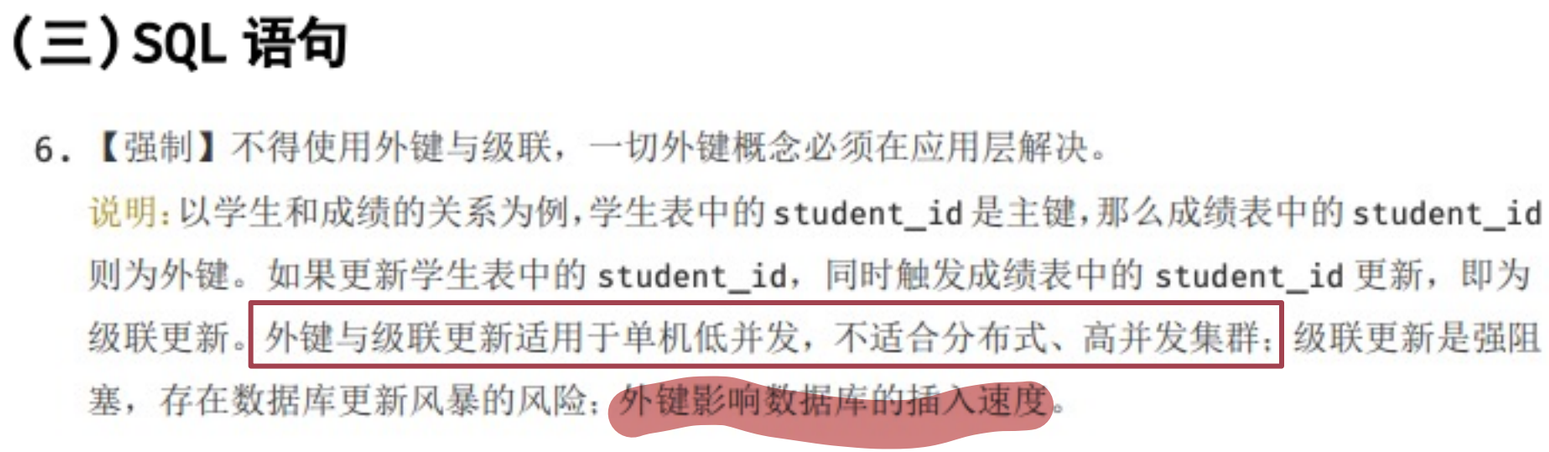
Foreign keys required in this table

Director ID	Director_ Firstname	Director_ Lastname	Born	Died
1	Alfred	Hitchcock	1899	1980
2	Orson	Welles	1915	1985
3	....	...	...	...

Director Entities

Foreign Key

- However, in some cases, foreign key can be a problem
  - Especially in big data processing applications
    - E.g., Alibaba Java Coding Guideline (阿里巴巴Java开发手册)



（三）SQL 语句

6.【强制】不得使用外键与级联，一切外键概念必须在应用层解决。

说明：以学生和成绩的关系为例，学生表中的 student_id 是主键，那么成绩表中的 student_id 则为外键。如果更新学生表中的 student_id，同时触发成绩表中的 student_id 更新，即为级联更新。外键与级联更新适用于单机低并发，不适合分布式、高并发集群；级联更新是强阻塞，存在数据库更新风暴的风险；外键影响数据库的插入速度。

https://ucc.alicdn.com/download/%E9%98%BF%E9%87%8C%E5%B7%B4%E5%B7%B4Java%E5%BC%80%E5%8F%91%E6%89%8B%E5%86%8C1.4.0.pdf

Summary: How to Create Tables

- Creating tables requires:
  - Proper modelling
  - Defining keys
  - Determining correct data types
  - Defining constraints

- Boring, but important
  - No further checks in the application programs; most things are ensured in the database layer

Updates to Tables

- Insert
  - `insert into instructor values ('10211', 'Smith', 'Biology', 66000);`
- Delete
  - Remove all tuples from the student relation
    - `delete from movies`

Updates to Tables

rows { records / tuples
columns : attributes

- Drop Table — remove table from database
  - `drop table r`
- Alter — ɔ:ltəɾ
  - `alter table r add A D`
    - where A is the name of the attribute to be added to relation r and D is the domain of A.
    - All existing tuples in the relation are assigned null as the value for the new attribute.
  - `alter table r drop A`
    - where A is the name of an attribute of relation r
    - Dropping of attributes not supported by many databases.

Updates to Tables

- More about insert

```
create table lab (
    id serial primary key,
    address varchar(20) not null,
    time varchar(20) not null,
    capacity int,
    teacher varchar(20),
    unique (address,time)
);

insert into lab (address, time, capacity, teacher) values ('402','2-78',36,'yueming');

insert into lab (address, time, teacher) values ('402','2-78','yueming');

insert into lab (address, time, teacher) values ('408','2-78','o''relly');
```

Values must match column names one by one

Updates to Tables

- More about insert

```
create table lab (
    id serial primary key,
    address varchar(20) not null,
    time varchar(20) not null,
    capacity int,
    teacher varchar(20),
    unique (address,time)
);


insert into lab (address, time, capacity, teacher) values ('402','2-78',36,'yueming');

insert into lab (address, time, teacher) values ('402','2-78','yueming');

insert into lab (address, time, teacher) values ('408','2-78','o''relly');
```

Missing columns and values for "nullable" columns are allowed

- … and a NULL willl be inserted

* But if you miss a mandatory column (such as address), an error will occur.

Updates to Tables

- More about insert

```
create table lab (
    id serial primary key,
    address varchar(20) not null,
    time varchar(20) not null,
    capacity int,
    teacher varchar(20),
    unique (address,time)
);

insert into lab (address, time, capacity, teacher) values ('402','2-78',36,'yueming');

insert into lab (address, time, teacher) values ('402','2-78','yueming');

insert into lab (address, time, teacher) values ('408','2-78','o''relly');
```

table.name

* Use two single quotes to represent a single quote in the content (i.e., escape charactor)

Lab Session (Week 2)

- We will have more examples for manipulating a table and inserting data into tables

Please remember to upload your "*Undergraduate Students Declaration Form*" to the correct place

Identifiers and Key Words

Tokens such as SELECT, UPDATE, or VALUES in the example above are examples of key words, that is, words that have a fixed meaning in the SQL language. The tokens MY_TABLE and A are examples of identifiers.

They identify names of tables, columns, or other database objects, depending on the command they are used in. Therefore they are sometimes simply called “names”.

Key words and identifiers have the same lexical structure, meaning that one cannot know whether a token is an identifier or a key word without knowing the language. A complete list of key words can be found in Appendix C.

```
SELECT * FROM MY_TABLE;
UPDATE MY_TABLE SET A = 5;
INSERT INTO MY_TABLE VALUES (3, 'hi there');
```

SQL distinguishes between reserved and non-reserved key words.

According to the standard, reserved key words are the only real key words; they are never allowed as identifiers.

Non-reserved key words only have a special meaning in particular contexts and can be used as identifiers in other contexts. Most non-reserved key words are actually the names of built-in tables and functions specified by SQL. The concept of non-reserved key words essentially only exists to declare that some predefined meaning is attached to a word in some contexts.

Key Word	PostgreSQL	SQL:2016	SQL:2011	SQL-92
`TIME`	non-reserved (cannot be function or type)	reserved	reserved	reserved