SCIENCE
PASSION
TECHNOLOGY

Data Management
05 Query Languages (SQL)

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Announcements/Org

- **#1 Video Recording**
  - Link in **TeachCenter** & **TUbe** (lectures will be public)
  - https://tugraz.webex.com/meet/m.boehm
  - Corona traffic light **RED** until end of April

- **#2 Reminder Communication**
  - **Newsgroup:** news://news.tugraz.at/tu-graz.lv.dbase
  - **Office hours:** Mo 12.30-1.30pm (https://tugraz.webex.com/meet/m.boehm)

- **#3 Exercise Submissions**
  - **Exercise 1:** Mar 30 + 7 late days, grading in progress
  - **Exercise 2:** Apr 27, published Apr 07
  - https://mboehm7.github.io/teaching/ss21_dbs/02_ExerciseQueriesAPIs.pdf

Agenda

- **Structured Query Language (SQL)**
- **Other Query Languages (XML, JSON)**
- Exercise 2: **Query Languages and APIs**

Structured Query Language (SQL)

What is a(n) SQL Query?

```
SELECT Firstname, Lastname, Affiliation, Location
FROM Participant AS R, Locale AS S
WHERE R.LID = S.LID
  AND Location LIKE '%, GER'
```

#1 **Declarative:**
what not how

Firstname	Lastname	Affiliation	Location
Volker	Markl	TU Berlin	Berlin, GER
Thomas	Neumann	TU Munich	Munich, GER

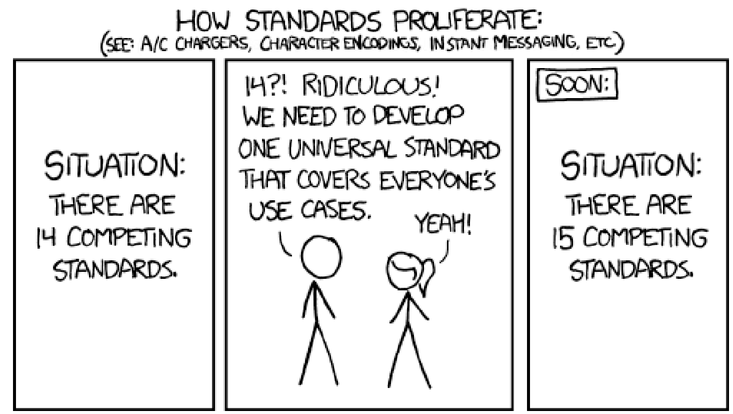
#2 **Flexibility:**
closed → composability

#3 **Automatic Optimization**

#4 **Physical Data Independence**

Why should I care?

- **SQL as a Standard**
  - Standards ensure **interoperability**, avoid **vendor lock-in**, and protect **application investments**
  - **Mature standard** with heavy industry support for decades
  - **Rich eco system** (existing apps, BI tools, services, frameworks, drivers, design tools, systems)



[https://xkcd.com/927/]

- **SQL is here to stay**
  - Foundation of mobile/server **application data management**
  - **Adoption of existing standard** by new systems (e.g., SQL on Hadoop, cloud DBaaS)
  - Complemented by NoSQL abstractions, see lecture **10 NoSQL (key-value, document, graph)**

Microsoft

Overview SQL

- **Structured Query Language (SQL)**
  - Current Standard: ISO/IEC 9075:2016 (SQL:2016)
  - **Data Definition Language (DDL)** → Manipulate the database schema
  - **Data Manipulation Language (DML)** → Update and query database
  - **Data Control Language (DCL)** → Modify permissions

- **Dialects**
  - Spectrum of system-specific dialects for **non-core features**
  - Data types and size constraints
  - Catalog, builtin functions, and tools
  - Support for new/optional features
  - Case-sensitive identifiers

Name	Examples
T-SQL	Microsoft, Sybase
PL/SQL	Oracle, (IBM)
PL/pgSQL	PostgreSQL, derived
Unnamed	**Most systems**

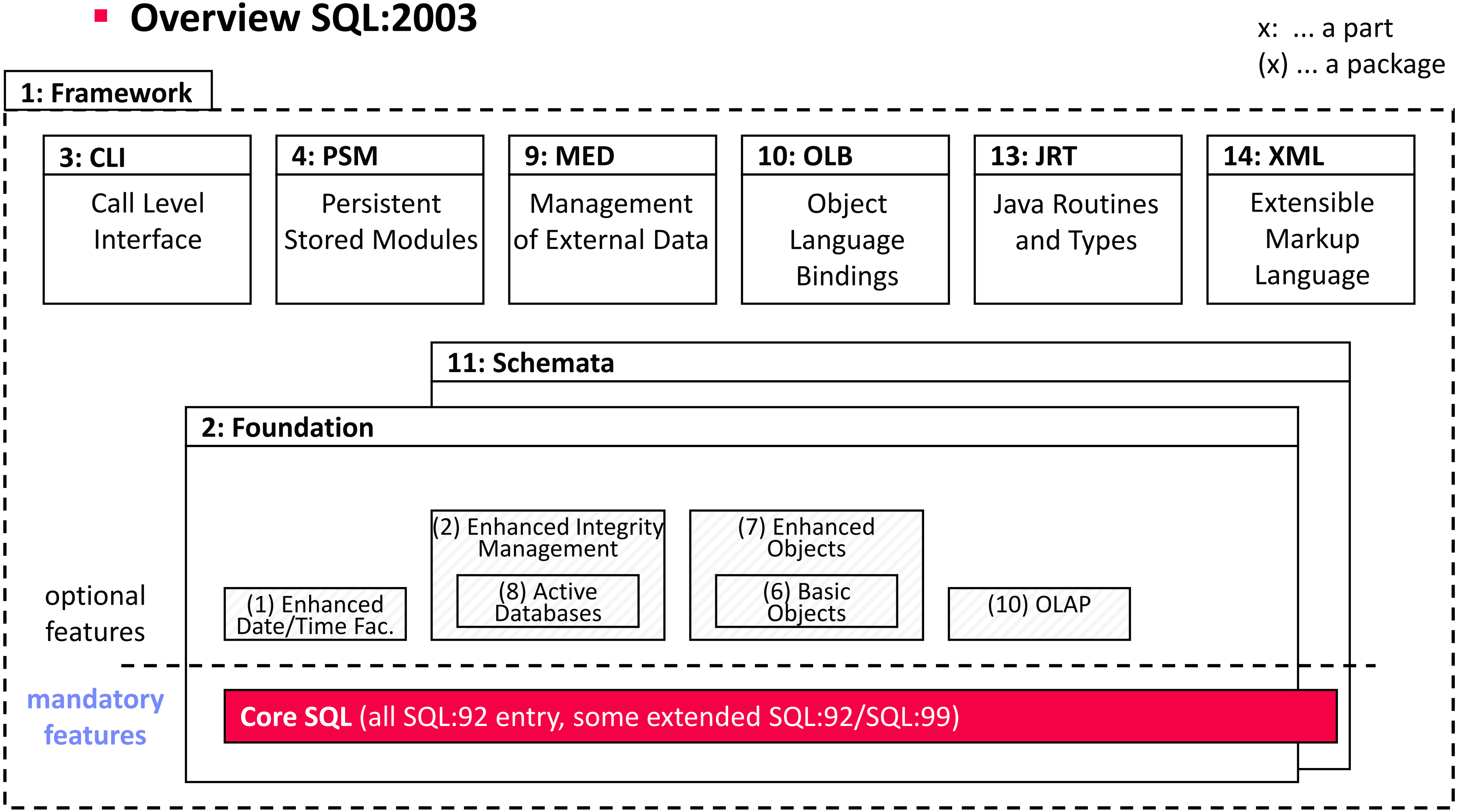
The History of the SQL Standard

[C. J. Date: A Critique of the SQL Database Language. **SIGMOD Record 1984**]

- **SQL:1986**
  - Database Language SQL, ANSI X3.135-1986, ISO-9075-1987(E)
  - ‘87 international edition
- **SQL:1989** (120 pages)
  - **Database Language SQL with Integrity Enhancements**, ANSI X3.135-1989, ISO-9075-1989(E)
- **SQL:1992** (580 pages)
  - Database Language SQL, ANSI X3-1992, ISO/IEC-9075 1992, DIN 66315
  - ‘95 SQL/CLI (part 3), ‘96 SQL/PSM (part 4)
- **SQL:1999** (2000 pages)
  - Information Technology – Database Language – SQL, ANSI/ISO/IEC-9075 1999
  - Complete reorg, ’00 OLAP, ’01 SQL/MED, ’01 SQL/OLB, ‘02 SQL/JRT
- **SQL:2003** (3764 pages)
  - Information Technology – Database Language – SQL, ANSI/ISO/IEC-9075 2003

The History of the SQL Standard, cont.

- **Overview SQL:2003**



The History of the SQL Standard, cont.

Since SQL:2003 overall structure remained unchanged ...

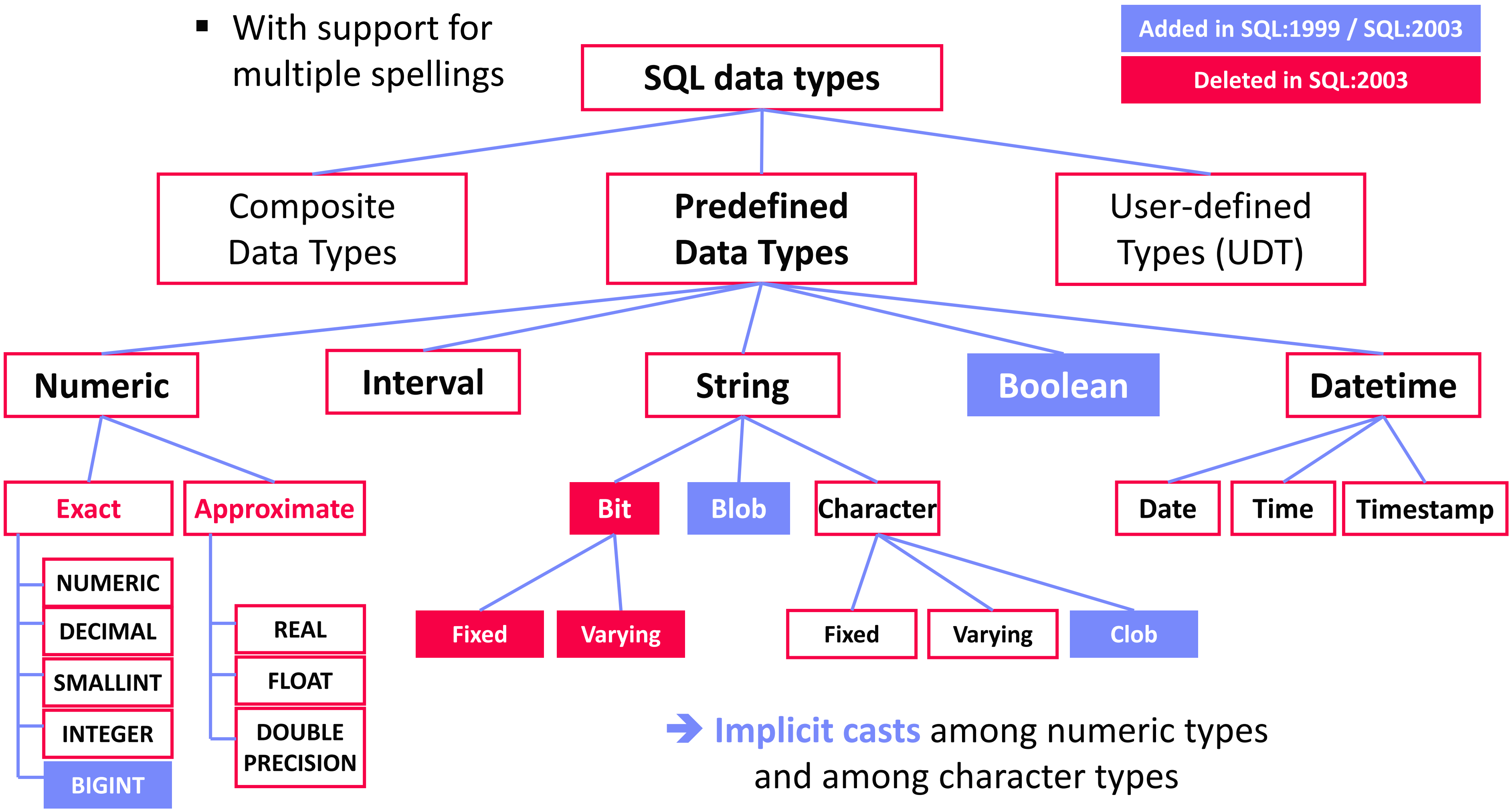
- **SQL:2008** (???? pages)
  - **Information Technology – Database Language – SQL**, ANSI/ISO/IEC-9075 2003
  - E.g., **XML** XQuery extensions, case/trigger extension
- **SQL:2011** (4079 pages)
  - **Information Technology – Database Language – SQL**, ANSI/ISO/IEC-9075 2011
  - E.g., time periods, temporal constraints, time travel queries
- **SQL:2016** (???? pages)
  - **Information Technology – Database Language – SQL**, ANSI/ISO/IEC-9075 2016
  - E.g., **JSON** documents and functions (optional)

→ **Note: We can only discuss common primitives**

[Working Draft SQL:2011: https://www.wiscorp.com/SQLStandards.html]

Data Types in SQL:2003

- **Large Variety of Types**
  - With support for multiple spellings



➔ Implicit casts among numeric types and among character types

Data Types in PostgreSQL

Appropriate, Brief, Complete

- **Strings**
  - **CHAR(n)** → fixed-length character sequence (padded to n)
  - **VARCHAR(n)** → variable-length character sequence (n max)
  - TEXT → variable-length character sequence
- **Numeric**
  - SMALLINT → 2 byte integer (signed short)
  - **INT/INTEGER** → 4 byte integer (signed int)
  - SERIAL → INTEGER w/ auto increment
  - **NUMERIC(p, s)** → exact real with p digits and s after decimal point
- **Time**
  - **DATE** → date
  - TIMESTAMP/TIMESTAMPTZ → date and time, timezone-aware if needed
- **JSON**
  - JSON → text JSON representation (requires reparsing)
  - JSONB → binary JSON representation

Create, Alter, and Delete Tables

Templates in SQL
Examples in PostgreSQL

- **Create Table**
  - Typed attributes
  - Primary and foreign keys
  - NOT NULL, UNIQUE constraints
  - DEFAULT values
  - CHECK constraints

```
CREATE TABLE Students (
   SID INTEGER PRIMARY KEY,
   Fname VARCHAR(128) NOT NULL,
   Lname VARCHAR(128) NOT NULL,
   Mtime DATE DEFAULT CURRENT_DATE
);
CREATE TABLE Students AS SELECT …;
```

- **Alter Table**
  - ADD/DROP columns
  - ALTER data type, defaults, constraints, etc

```
ALTER TABLE Students ADD DoB DATE;
ALTER TABLE Students ADD CONSTRAINT
   PKStudent PRIMARY KEY(SID);
```

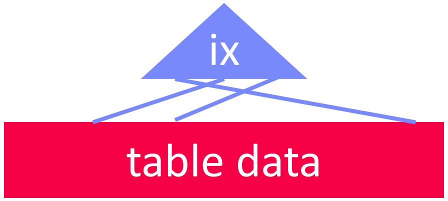
- **Delete Table**
  - Delete table
  - **Note:** order of tables matters due to referential integrity

```
DROP TABLE Students; -- sorry
DROP TABLE Students CASCADE;
DROP TABLE IF EXISTS Countries,
   Cities, Airports, Airlines,
   Routes, Planes, Routes_Planes;
```

Create and Delete Indexes

- **Create Index**
  - Create a secondary (nonclustered) index on a set of attributes
  - **Clustered:** tuples sorted by index
  - **Non-clustered:** sorted attribute with tuple references
  - Can specify uniqueness, order, and indexing method
  - **PostgreSQL methods:** btree, hash, gist, and gin
    - ➔ see lecture **07 Physical Design and Tuning**

```
CREATE INDEX ixStudLname
   ON Students USING btree
   (Lname ASC NULLS FIRST);
```



- **Delete Index**
  - Drop indexes by name

```
DROP INDEX ixStudLname;
```

- **Tradeoffs**
  - Indexes often automatically created for **primary keys** / **unique** attributes
  - **Lookup/scan performance** vs **insert performance**

Database Catalog

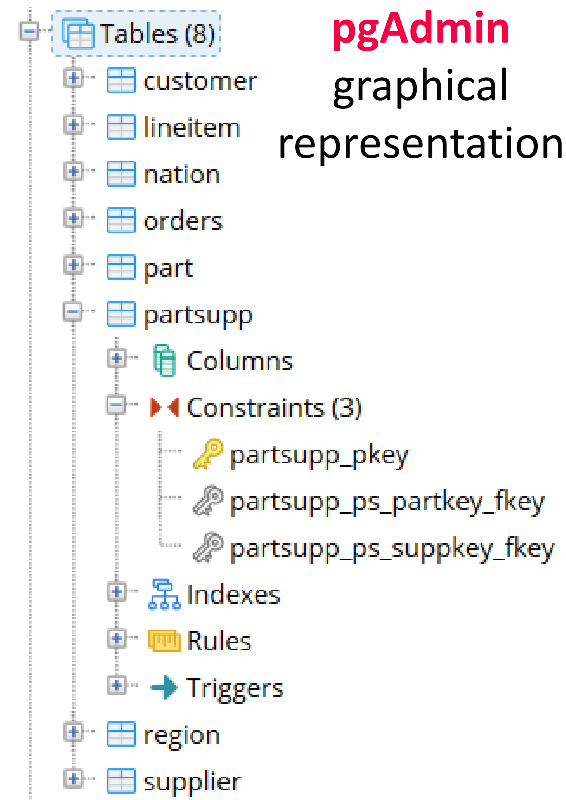
[Meikel Poess: **TPC-H**. **Encyclopedia of Big Data Technologies 2019**]

- **Catalog Overview**
  - **Meta data** of all database objects (tables, constraints, indexes) → **mostly read-only**
  - **Accessible through SQL**
  - Organized by schemas (**CREATE SCHEMA** tpch;)

- **SQL Information_Schema**
  - Schema with tables for all tables, views, constraints, etc
  - **Example:** check for existence of accessible table

```
SELECT 1 FROM information_schema.tables
WHERE table_schema = 'tpch'
   AND table_name = 'customer'
```

(defined as views over PostgreSQL catalog tables)



pgAdmin graphical representation

Insert

- **Insert Tuple**
  - Insert a single tuple with implicit or explicit attribute assignment

```
INSERT INTO Students (SID, Lname, Fname, MTime, DoB)
   VALUES (7,'Boehm','Matthias','2002-10-01','1982-06-25');
```

  - Insert attribute key-value pairs to use auto increment, defaults, NULLs, etc

```
INSERT INTO Students (Lname, Fname, DoB)
   VALUES ('Boehm','Matthias','1982-06-25'),
          (...), (...);
```

SERIAL SID,
DEFAULT MTime

- **Insert Table**
  - Redirect query result into INSERT (append semantics)

```
INSERT INTO Students
   SELECT * FROM NewStudents;
```

Analogy Linux redirect (append):

```
cat NewStudents.txt >> Students.txt
```

Update and Delete

- **Update Tuple/Table**
  - **Set-oriented update** of attributes
  - Update single tuple via predicate on **primary key**

```
UPDATE Students
   SET MTime = '2002-10-02'
   WHERE LName = 'Boehm';
```

- **Delete Tuple/Table**
  - **Set-oriented delete** of tuples
  - Delete single tuple via predicate on **primary key**

```
DELETE FROM Students
   WHERE extract(year
      FROM mtime) < 2010;
```

- **Note: Time travel and multi-version concurrency control**
  - Deleted tuples might be just **marked as inactive**
  - See lecture **09 Transaction Processing and Concurrency**

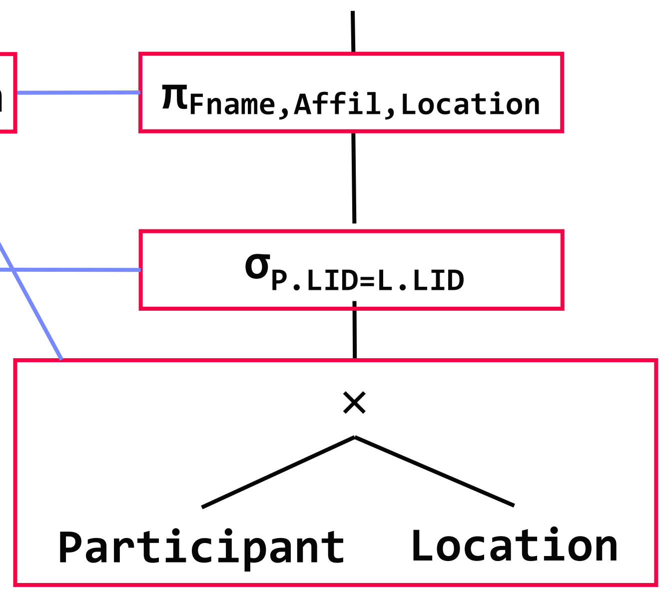
Basic Queries

- **Basic Query Template**
  - Select-From-Where
  - Grouping and Aggregation
  - Having and ordering
  - Duplicate elimination

```
SELECT [DISTINCT] <column_list>
   FROM [<table_list> |
     <table1> [RIGHT | LEFT | FULL] JOIN
     <table2> ON <condition>]
   [WHERE <predicate>]
   [GROUP BY <column_list>]
     [HAVING <grouping predicate>]
   [ORDER BY <column_list> [ASC | DESC]]
```

- **Example**

```
SELECT Fname, Affil, Location
FROM  Participant AS P,
      Locale AS L
WHERE P.LID = L.LID;
```



Basic Queries, cont.

- **Distinct and All**
  - Distinct and all alternatives
  - Projection w/ **bag semantics** by default

```
SELECT DISTINCT Lname, Fname
   FROM Students;
```

- **Sorting**
  - Convert a bag into a **sorted list** of tuples; order lost if used in other ops
  - Single order: `(Lname, Fname) DESC`
  - Evaluated last in a query tree

```
SELECT * FROM Students
   ORDER BY Lname DESC,
            Fname DESC;
```

- **Set Operations**
  - See 04 Relational Algebra and Calculus → **UNION, INTERSECT, EXCEPT**
  - Set operations **set semantics** by default → **DISTINCT** (set) vs **ALL** (bag)

```
(SELECT Firstname, Lastname
FROM Participant2018)
  UNION DISTINCT
(SELECT Firstname, Lastname
FROM Participant2013)
```

Grouping and Aggregation

- **Grouping and Aggregation**
  - **Grouping:** determines the distinct groups
  - **Aggregation:** compute aggregate f(B) per group
  - Column list can only contain **grouping columns**, **aggregates**, or **literals**
  - **Having:** selection predicate on groups and aggregates

- **Example**
  - Sales (Customer, Location, Product, Quantity, Price)
  - **Q: Compute number of sales** sumQ **and revenue per product** sumQP

```
SELECT Product,
       sum(Quantity) AS SumQ,
       sum(Quantity*Price) AS SumQP
  FROM Sales
  GROUP BY Product
```

Product	Quantity	Price
A	1	10
B	3	20
A	2	10
B	1	20

Product	SumQ	SumQP
A	3	30
B	4	80

BREAK (and Test Yourself)

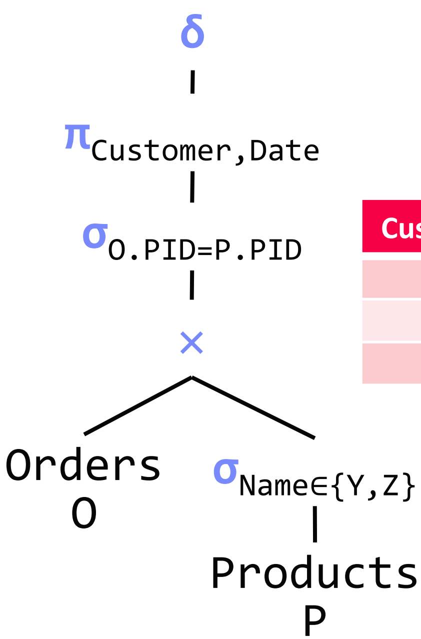
- **Task: SQL queries for the following query trees.**

Orders

OID	Customer	Date	Quantity	PID
1	A	'2019-06-22'	3	2
2	B	'2019-06-22'	1	3
3	A	'2019-06-22'	1	4
4	C	'2019-06-23'	2	2
5	D	'2019-06-23'	1	4
6	C	'2019-06-23'	1	1

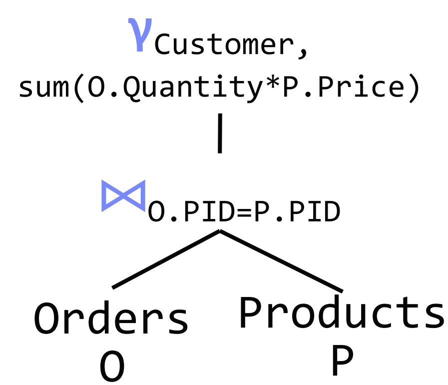
Products

PID	Name	Price
1	X	100
2	Y	15
4	Z	75
3	W	120



Customer	Date
A	'2019-06-22'
C	'2019-06-23'
D	'2019-06-23'

```sql
SELECT DISTINCT Customer, Date
  FROM Orders O, Products P
  WHERE O.PID = P.PID
    AND Name IN('Y','Z')
```



Customer	Sum
A	120
B	120
C	130
D	75

```sql
SELECT Customer,
    sum(O.Quantity * P.Price)
  FROM Orders O, Products P
  WHERE O.PID = P.PID
  GROUP BY Customer
```

Subqueries

- **Subqueries in Table List**
  - Use a subquery result like a base table
  - Modularization with **WITH** C **AS** (**SELECT** …)

```
SELECT S.Fname, S.Lname, C.Name
FROM Students AS S,
  (SELECT CID, Name FROM Country
  WHERE …) AS C
WHERE S.CID=C.CID;
```

- **Subqueries w/ IN**
  - Check containment of values in result set of sub query

```
SELECT Product, Quantity, Price
FROM Sales
WHERE Product NOT IN(
    SELECT Product FROM Sales
    GROUP BY Product
    HAVING sum(Quantity*Price)>1e6)
```

- **Other subqueries**
  - **EXISTS:** existential quantifier **∃x** for correlated subqueries
  - **ALL:** comparison (w/ universal quantifier **∀x**)
  - **SOME/ANY:** comparison (w/ existential quantifier **∃x**)

Correlated and Uncorrelated Subqueries

- **Correlated Subquery**
  - **Evaluated subquery for every tuple** of outer query
  - Use of attribute from table bound in outer query inside subquery

```
SELECT P.Fname, P.Lname
FROM Professors P,
WHERE NOT EXISTS(
    SELECT * FROM Courses C
    WHERE C.PID=P.PID);
```

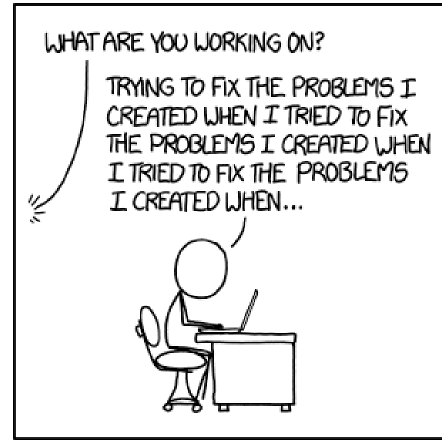
- **Uncorrelated Subquery**
  - Evaluate subquery just once
  - No attribute correlations between subquery and outer query

```
SELECT P.Fname, P.Lname
FROM Professors P,
WHERE P.PID NOT IN(
    SELECT PID FROM Courses);
```

- **Query Unnesting (de-correlation)**
  - Rewrite during query compilation
  - See lecture **08 Query Processing**

[Thomas Neumann, Alfons Kemper: Unnesting Arbitrary Queries. **BTW 2015**]

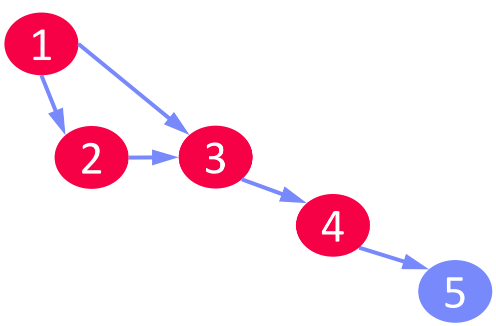
Recursive Queries



[https://xkcd.com/1739/]

- **Approach**
  - `WITH RECURSIVE <name> (<arguments>)`
  - Compose recursive table from **non-recursive term**, **union all/distinct**, and **recursive term**
  - Terminates when recursive term yields empty result

- **Example**
  - Courses(CID, Name), Precond(pre REF CID, suc REF CID)
  - Dependency graph (pre→suc)




```
WITH RECURSIVE rPrereq(p,s) AS(
   (SELECT pre, suc
      FROM Precond WHERE suc=5)
  UNION DISTINCT
   (SELECT B.pre, B.suc                  4
    FROM Precond B, rPrereq R            3
    WHERE B.suc = R.p)                   1
)
SELECT DISTINCT p FROM rPrereq           2
```

Procedures and Functions

- **Overview Procedures and Functions**
  - Stored programs, written in **PL/pgSQL** or other languages
  - **Control flow (loops, branches) and SQL queries**

```
CREATE PROCEDURE prepStud(a INT)
LANGUAGE PLPGSQL AS $$
BEGIN
   DELETE FROM Students;
   INSERT INTO Students
      SELECT * FROM NewStudents;
END; $$;
```

- **(Stored) Procedures**
  - Can be called standalone via `CALL <proc_name>(<args>);`
  - Procedures return no outputs

```
CREATE FUNCTION sampleProp(FLOAT)
   RETURNS FLOAT
   AS 'SELECT $1 * (1 - $1);'
   LANGUAGE SQL;
```

- **Functions**
  - Can be called standalone or inside queries
  - Functions are value mappings
  - Table functions can return sets of records with multiple attributes

Triggers

- **Overview Trigger**
  - Similar to stored procedure but register ON INSERT, DELETE, or UPDATE
  - Allows complex check constraints and active behavior such as replication, auditing, etc (good and bad)

- **Trigger Template**

```
CREATE TRIGGER <triggername>
   BEFORE | AFTER | INSTEAD OF
   INSERT | DELETE | (UPDATE OF <column_list>)
   ON <tablename>
   [REFERENCING <old_new_alias_list>]
   [FOR EACH {ROW | STATEMENT}]
   [WHEN (<search condition>)]
   <SQL procedure statement> |
   BEGIN ATOMIC
     {<SQL Procedure statement>;}...
   END
```

Event: BEFORE | AFTER | INSTEAD OF … ON <tablename>

Condition: [REFERENCING …] [FOR EACH …] [WHEN …]

Action: <SQL procedure statement> | BEGIN ATOMIC … END

Not supported in PostgreSQL (need single UDF) — BEGIN ATOMIC … END

Views and Authorization

- **Creating Views**
  - Create a logical table from a query
  - Inserts can be propagated back to base relations only in special cases
  - **Allows authorization** for subset of tuples

```
CREATE VIEW TeamDM AS
  SELECT * FROM
    Employee E, Employee M
  WHERE E.MgrID = M.EID
    AND M.login = ‘mboehm’;
```

- **Access Permissions Tables/Views**
  - Grant query/modification rights on database objects for specific users, roles
  - Revoke access rights from users, roles (recursively revoke permissions of dependent views via **CASCADE**)

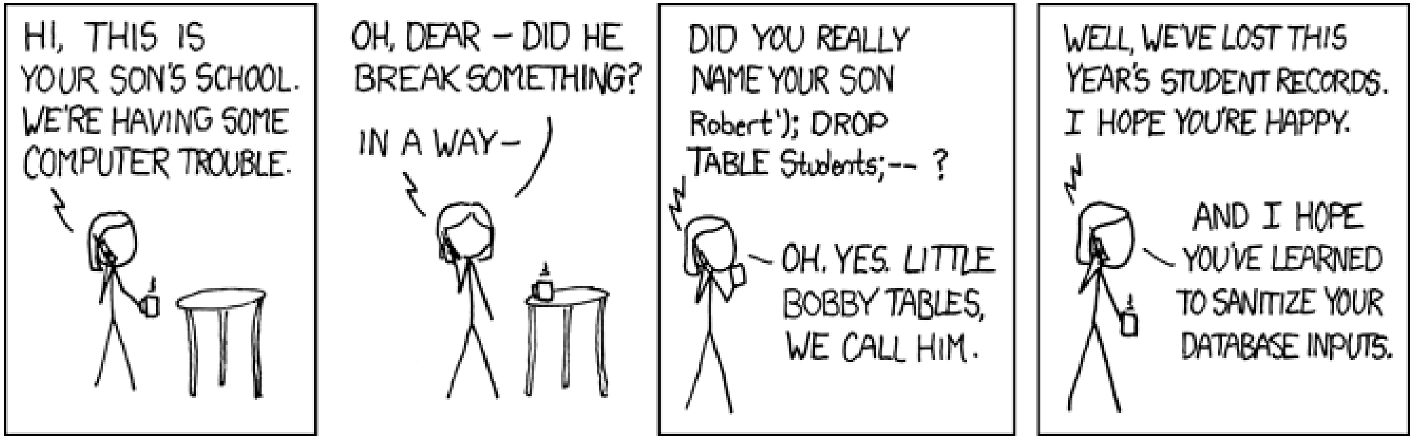
```
GRANT SELECT
   ON TABLE TeamDM
   TO mboehm;

REVOKE SELECT
   ON TABLE TeamDM
   FROM mboehm;
```

Beware of SQL Injection

- **Problematic SQL String Concatenation**

```
INSERT INTO Students (Lname, Fname)
   VALUES ('"+ @lname +"','"+ @fname +"');";
```

- **Possible SQL-Injection Attack**



[https://xkcd.com/327/]

```
INSERT INTO Students (Lname, Fname) VALUES ('Smith','Robert');
DROP TABLE Students; --');
```

Other Query Languages (XML, JSON)

No really, why should I care?

- **Semi-structured XML and JSON**
  - **Self-contained documents** for representing nested data
  - **Common data exchange formats** without redundancy of flat files
  - Human-readable formats → often used for SW configuration

- **Goals**
  - **Awareness of XML and JSON** as data models
  - Query languages and embedded querying in SQL

XML (Extensible Markup Language)

- **XML Data Model**
  - Meta language to define specific **exchange formats**
  - Document format for **semi-structured data**
  - Well formedness
  - XML schema / DTD

```
<?xml version="1.0" encoding="UTF-8"?>
<data>
  <student id="1">
    <course id="INF.01017UF" name="DM"/>
    <course id="706.550" name="AMLS"/>
  </student>
  <student id="5">
    <course id="706.520" name="DIA"/>
  </student>
</data>
```

- **XPath** (XML Path Language)
  - Query language for **accessing collections of nodes** of an XML document
  - Axis specifies for ancestors, descendants, siblings, etc

```
/data/student[@id='1']/course/@name
```

→ "DM" "AMLS"

- **XSLT** (XML Stylesheet Language Transformations)
  - Schema mapping (transformation) language for XML documents
- **XQuery**
  - Query language to extract, transform, and analyze XML documents

XML in PostgreSQL, cont.

- **Overview XML in PostgreSQL**
  - Data types **TEXT** or **XML** (well-formed, type-safe operations)
  - ISO/IEC 9075-14 XML-related specifications (SQL/XML)

- **Creating XML**
  - Various **built-in functions** to parse documents, and create elements/attributes
  - XMLPARSE(<xml_document>) → **XML type**
  - XMLELEMENT / XMLATTRIBUTES

```
INSERT INTO Students
  (Fname,Lname,Doc)
  VALUES('John','Smith',
  xmlparse(<source_doc>));
```

- **Processing XML**
  - Execute **XPath** expressions on XML types
  - XMLEXIST with **XPath instead of XQuery**
  - XPATH with optional namespace handling

```
SELECT Fname, Lname,
  xpath('/student/@id',Doc)
  FROM Students
```

JSON (JavaScript Object Notation)

- **JSON Data Model**
  - Data exchange format for **semi-structured data**
  - **Not as verbose as XML** (especially for arrays)
  - Popular format (e.g., Twitter)

```
{"students:"[
  {"id": 1, "courses":[
    {"id":"INF.01017UF", "name":"DM"},
    {"id":"706.550", "name":"AMLS"}]},
 {"id": 5, "courses":[
    {"id":"706.520", "name":"DIA"}]},
]}
```

- **Query Languages**
  - **Most common: libraries** for tree traversal and data extraction
  - **JSONig:** XQuery-like query language
  - **JSONPath:** XPath-like query language

JSONiq Example:

```
declare option jsoniq-version "…";
for $x in collection("students")
  where $x.id lt 10
  let $c := count($x.courses)
  return {"sid":$x.id, "count":$c}
```

[http://www.jsoniq.org/docs/JSONiq/html-single/index.html]

JSON in PostgreSQL, cont.

- **Overview JSON in PostgreSQL**
  - Alternative data types: **JSON** (text), **JSONB** (binary, with restrictions)
  - Implements RFC 7159, built-ins for conversion and access
- **Creating JSON**
  - Built-in functions for creating JSON from tables and tables from JSON input

```
SELECT row_to_json(t) FROM
   (SELECT Fname, Lname
   FROM Students) t
```

- **Processing JSON**
  - Specialized operators for **tree traversal and data extraction**

```
SELECT Fname, Lname,
   Doc->students->>id
   FROM Students
```

  - **-> operator:** get JSON array element/object
  - **->> operator:** get JSON array element/object as text
  - Built-in functions for extracting json (e.g., json_each)

Exercise 2: Query Languages and APIs

Published: **Apr 07, 2021**
(updated: data Apr 07, task description Apr 08)

Deadline: **Apr 27, 2021**

Exercises: Summer Olympics

TOKYO 2020 2021

TOKYO 2020 PARALYMPIC GAMES 2021

- **Dataset**
  - Past Summer Olympics (games, teams, athletes, events, medals)
  - Clone or download your copy from https://github.com/tugraz-isds/datasets.git (summer_olympics)
  - **Finished data cleaning by Apr 07**

```
AthletesEvents.csv
HostCities.csv
NOCRegions.csv
```

- **Exercises**
  - **01** Data modeling (relational schema)
  - **02** **Data ingestion and SQL query processing**
  - **03** Physical design tuning, query processing, and transaction processing
  - **04** Large-scale data analysis (distributed query processing and ML model training)

Task 2.1: Schema Creation via SQL (3/25 points)

- **Schema creation via SQL**
  - Relies on lectures **04 Relational Algebra** and **05 Query Languages (SQL)**
  - Setup DBMS PostgreSQL, and start `pgAdmin` (UI), or `psql` (terminal)
  - Create database `db<studentID>` and setup relational schema, including primary keys, foreign keys, `NOT NULL`, `UNIQUE`

- **Recommended Schema**
  - Feel free to use and submit the provided schema
  - https://mboehm7.github.io/teaching/ss21_dbs/CreateSchema.sql

- **Partial Results**
  - `CreateSchema.sql`

Task 2.2 Data Ingestion via CLI (10/25 points)

- **Data Ingestion Program via ODBC/JDBC**
  - Relies on lectures **05 Query Languages (SQL)** and **06 APIs (ODBC, JDBC)**
  - Write a program that performs **deduplication and data ingestion**
  - Programming language of your choosing (Python, Java, C#, C++ recommended)

- **Data Ingestion Process**
  - Data: https://github.com/tugraz-isds/datasets/tree/master/movies
  - Invoke your ingestion program as follows → script to compile and run

```
./runIngestData.sh ./AthleteEvents.csv ./HostCities.csv \
  ./NOCRegions.csv <host> <port> <database> <user> <password>
```

(e.g., `localhost 5432 db1234567 postgres postgres`)

- **Partial Results**
  - Source code `IngestData.*`, and
  - Script `runIngestData.sh`

Task 2.3: SQL Query Processing (10/25 points)

- **SQL Query Processing**
  - Relies on lecture **05 Query Languages (SQL)**
  - Expected results: https://mboehm7.github.io/teaching/ss21_dbs/Results.zip

- **List of Queries**
  - **Q01:** Obtain the detailed information of the athlete `Usain St. Leo Bolt`. (return name, gender, day of birth, height)
  - **Q02:** Compute the distinct cities that hosted the Olympic games. (return distinct {city name, country name} pairs, **sorted** ascending by country name)
  - **Q03:** List the athletes of team Austria 2012.
    (return name, gender, day of birth, **sorted** ascending by gender, day of birth)
  - **Q04:** Compute for each sport type, the number of distinct event types as well as its last (i.e., maximum) year of occurrence.
    (return sport name, count, last occurrence, **sorted** descending by count)
  - **Q05:** Determine the years in which female athletes whose names contain `Ledecky` won (in total) greater or equal than five gold or silver medals.
    (return year)

Task 2.3: SQL Query Processing (10/25 points)

- **List of Queries, cont.**
  - **Q06:** How many medals of each type did `Michael Fred Phelps; II` win? (return medal, count, **sorted** descending by count)
  - **Q07:** Determine the top-10 athletes that participated between 1948 and 2016 in the most event occurrences but never won a single medal. (return name, day of birth, participation count, **sorted** descending by count, name).
  - **Q08:** Compute the athlete-centric Olympic medal table of 2016, which counts every medal awarded (i.e., multiple medals in team events). (return country name, NOC, #gold, #silver, #bronze, #total, **sorted** descending by {#gold, #silver, #bronze, #total}) **// be careful about years**

- **Partial Results**
  - SQL Script for each query: `Q01.sql`, `Q02.sql`, …, `Q08.sql`

Task 2.4: Query Plans (2/25 points)

- **Explain Query Plans**
  - Relies on lecture **04 Relational Algebra** and **05 Query Languages (SQL)**
  - Obtain and **analyze execution plans** of Q05

- **Example**

```
EXPLAIN VERBOSE
SELECT L.location, count(*)
  FROM Participant P,
       Locale L
  WHERE P.lid = L.lid
  GROUP BY L.location
  HAVING count(*)>1
```

```
"HashAggregate  (...)"      // grouping
" Output: l.location, count(*)"
" Group Key: l.location"
" Filter: (count(*) > 1)"  // selection
" -> Hash Join  (...)"      // join
"     Output: l.location"  // projection
"     Hash Cond: (l.lid = p.lid)"
"     -> Seq Scan on Locale l  (...)"
"         Output: l.lid, l.location"
"     -> Hash  (...)"
"         Output: p.lid"    // projection
"         -> Seq Scan on Participant p  (...)"
"             Output: p.lid"
```

- **Partial Results**
  - `ExplainQ05.sql`

Conclusions and Q&A

- **Summary**
  - History and fundamentals of the **Structured Query Language (SQL)**
  - Awareness of **XML and JSON** (data model and querying)

- **Exercise Submissions**
  - **Exercise 1:** Mar 30 + 7 late days, grading in progress
  - **Exercise 2:** Apr 27, published Apr 07

- **Next Lectures**
  - **06 APIs (ODBC, JDBC, OR frameworks)** [Apr 19] → videos available
  - **07 Physical Design and Tuning** [Apr 26]
  - **08 Query Processing** [May 03]
  - **09 Transaction Processing and Concurrency** [May 10]