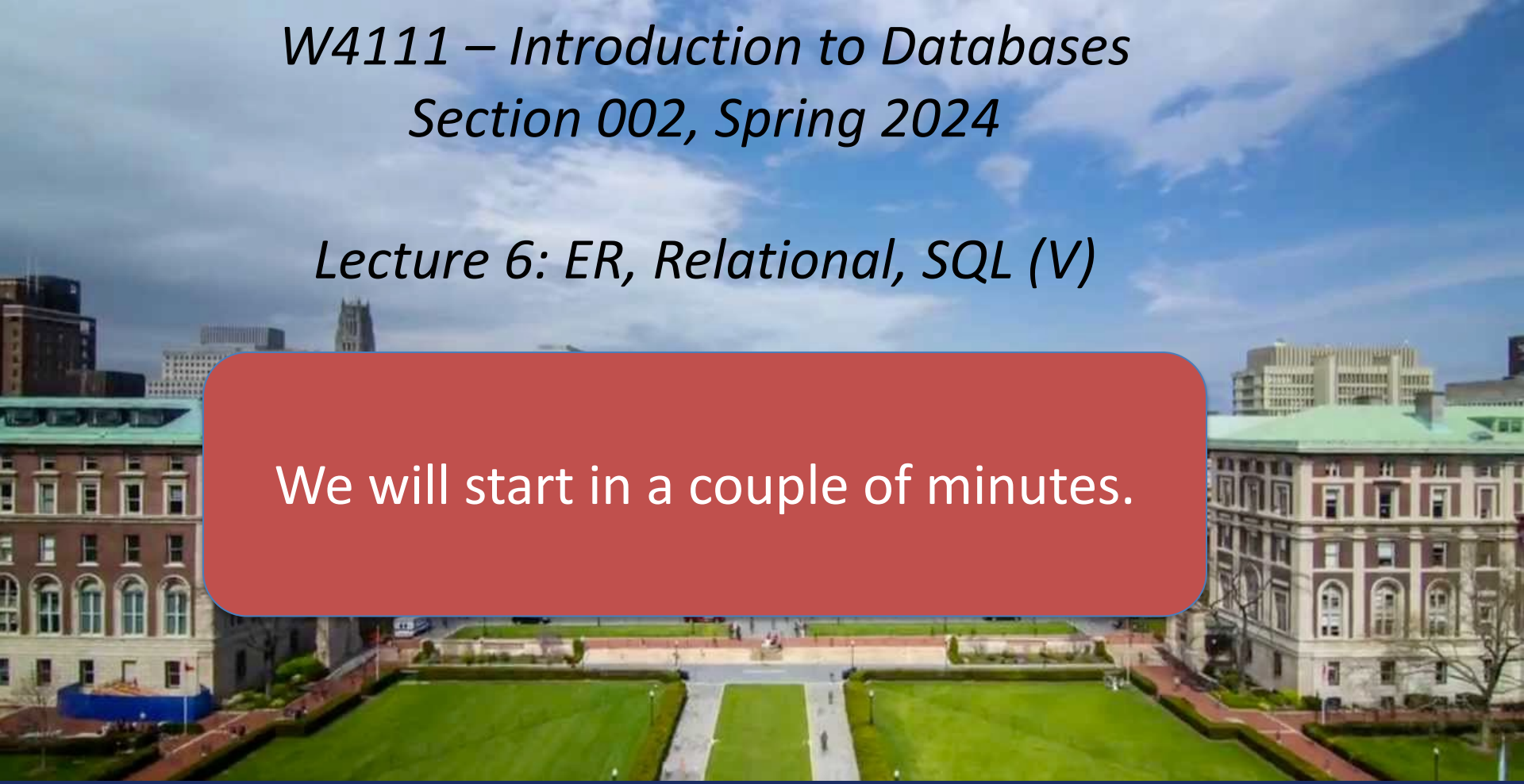
W4111 – Introduction to Databases
Section 002, Spring 2024

Lecture 6: ER, Relational, SQL (V)

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

W4111 – Introduction to Databases
Section 002, Spring 2024

Lecture 6: ER, Relational, SQL (V)



We will start in a couple of minutes.

Contents

Contents

- Some Observations
- ER (Diagram) Modeling – Aggregation, other notations
- SQL Continued (Chapter 3, 4, 5)
- Applications and Databases
- Project Examples:
  - Web Applications and REST
  - Data Engineering and Visualization

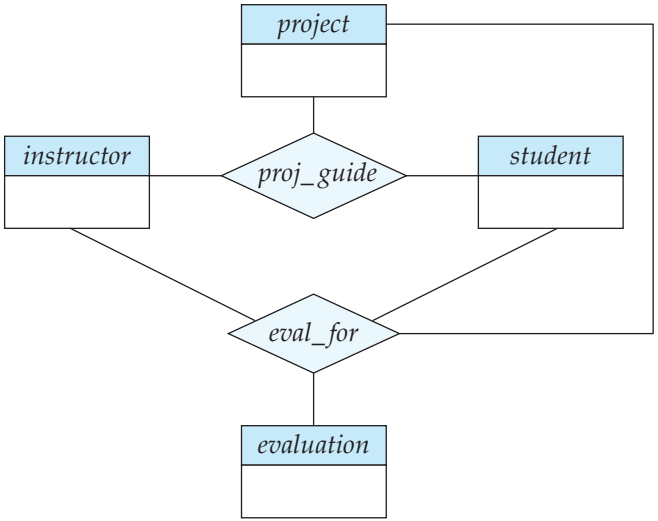
Some Observations

Database design, Entity-Relationship Model
Some Complex Examples

Aggregation

Aggregation

- Consider the ternary relationship *proj_guide*, which we saw earlier
- Suppose we want to record evaluations of a student by a guide on a project

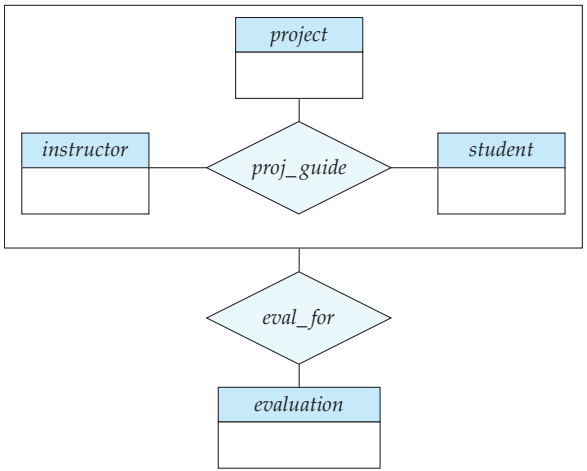


Aggregation (Cont.)

- Relationship sets *eval_for* and *proj_guide* represent overlapping information
  - Every *eval_for* relationship corresponds to a *proj_guide* relationship
  - However, some *proj_guide* relationships may not correspond to any *eval_for* relationships
    - So we can't discard the *proj_guide* relationship
- Eliminate this redundancy via *aggregation*
  - Treat relationship as an abstract entity
  - Allows relationships between relationships
  - Abstraction of relationship into new entity

Aggregation (Cont.)

- Eliminate this redundancy via *aggregation* without introducing redundancy, the following diagram represents:
  - A student is guided by a particular instructor on a particular project
  - A student, instructor, project combination may have an associated evaluation



The simplest way to handle in relational is an associative entity.

Some thoughts here:
https://www.geeksforgeeks.org/aggregate-data-model-in-nosql/

Reduction to Relational Schemas

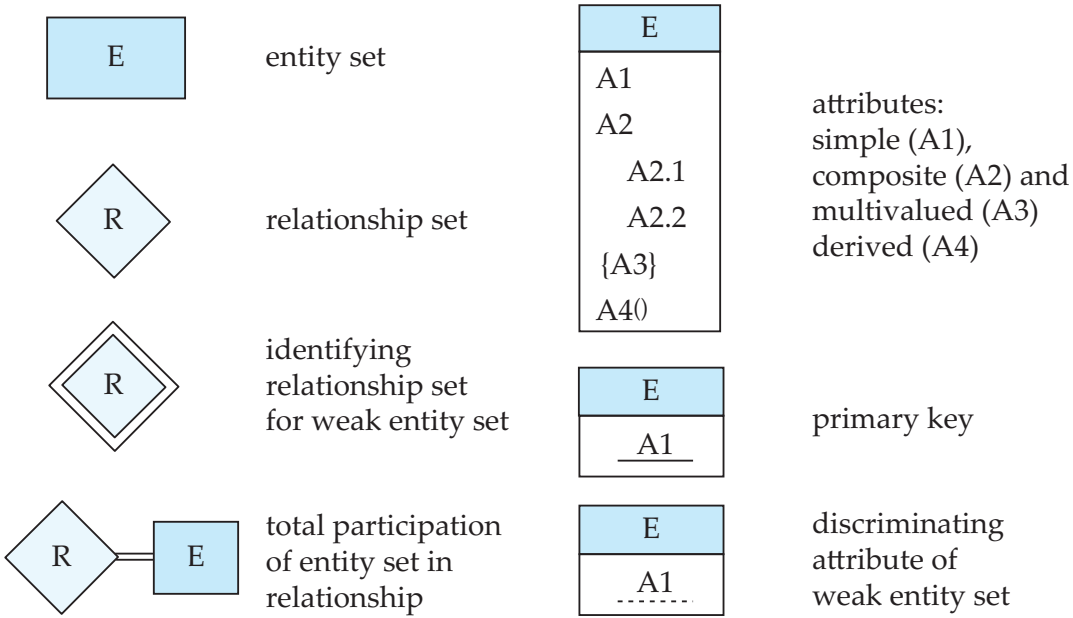
- To represent aggregation, create a schema containing
  - Primary key of the aggregated relationship,
  - The primary key of the associated entity set
  - Any descriptive attributes
- In our example:
  - The schema *eval_for* is:

    eval_for (*s_ID, project_id, i_ID, evaluation_id*)
  - The schema *proj_guide* is redundant.

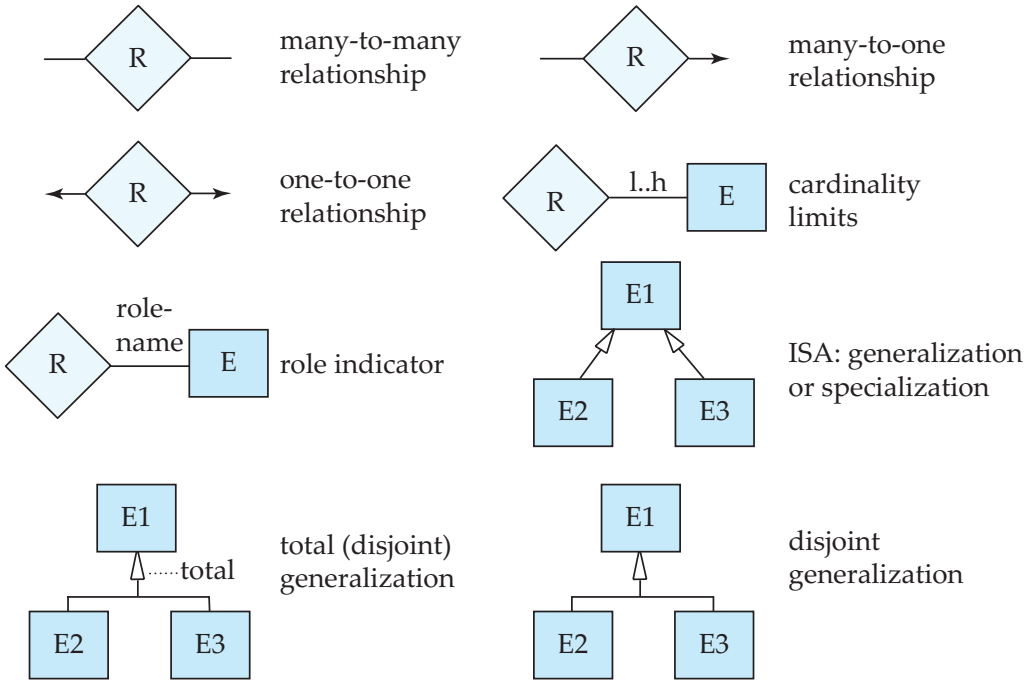
Other Notations

Note: Make sure you show **ER vs. UML Class Diagrams**

Summary of Symbols Used in E-R Notation



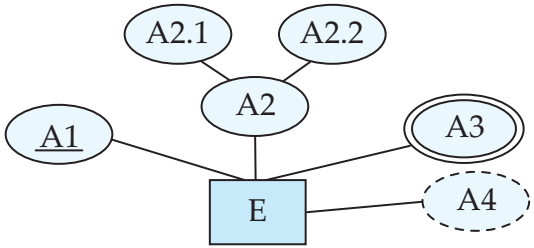
Symbols Used in E-R Notation (Cont.)



Alternative ER Notations

- Chen, IDE1FX, …

entity set E with
simple attribute A1,
composite attribute A2,
multivalued attribute A3,
derived attribute A4,
and primary key A1

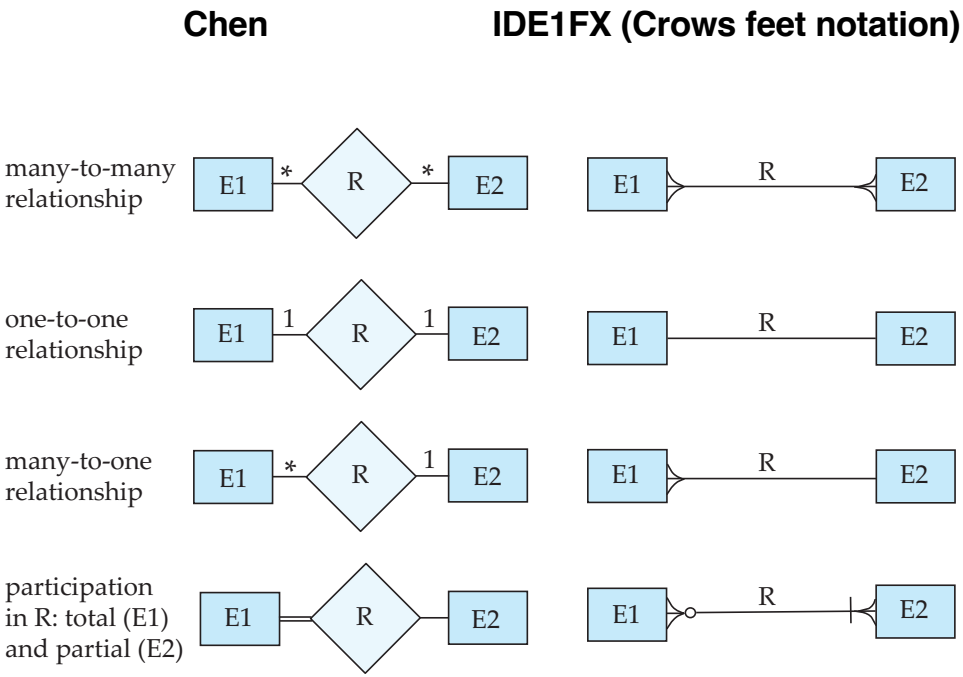


weak entity set 

generalization 

total generalization 

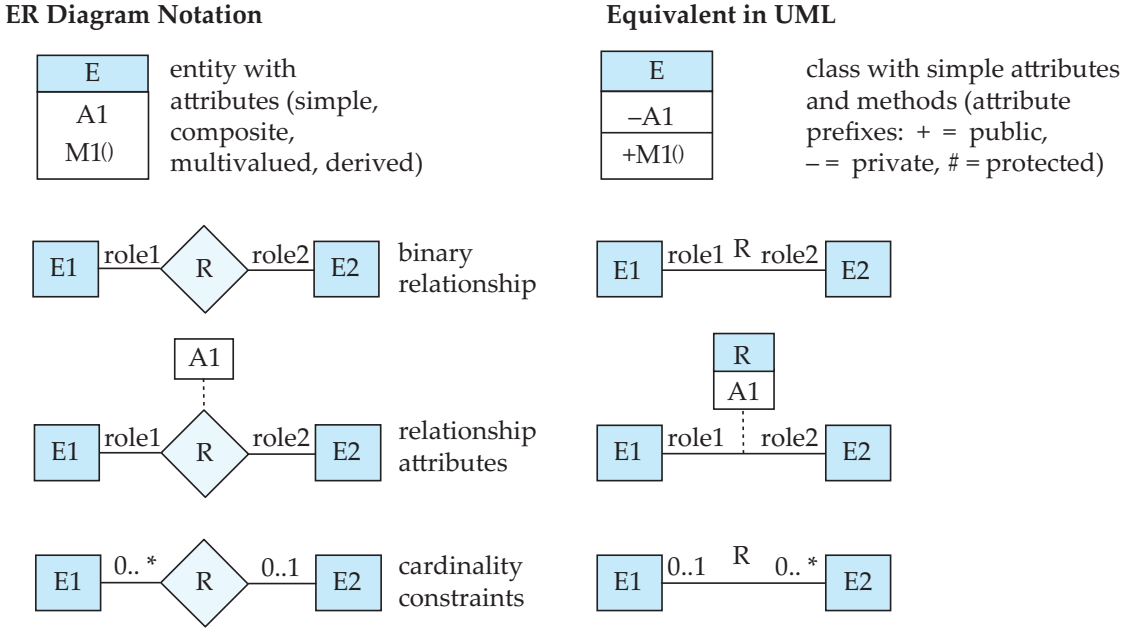
Alternative ER Notations



UML

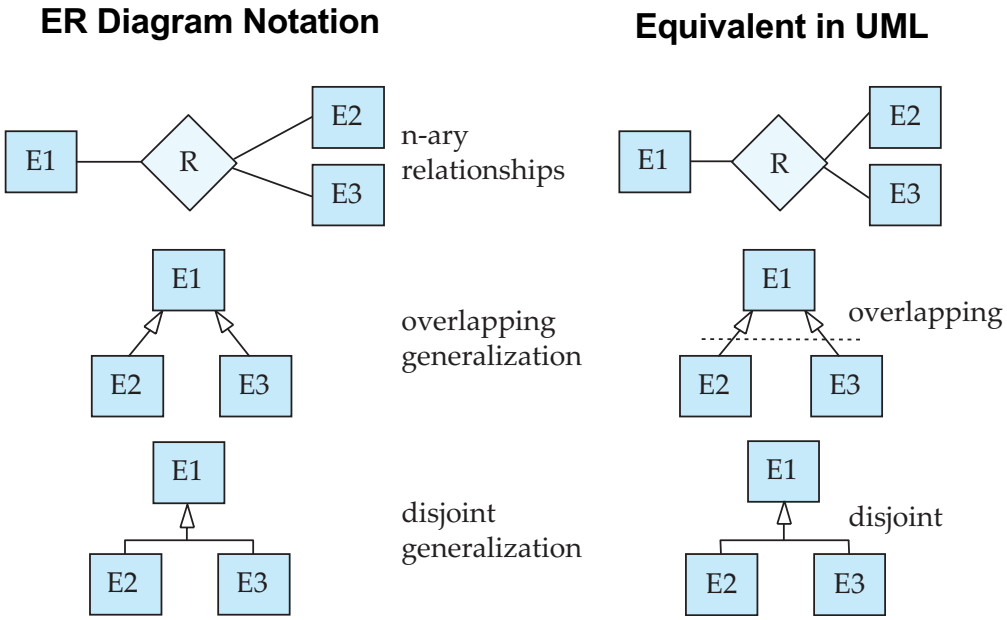
- **UML**: Unified Modeling Language
- UML has many components to graphically model different aspects of an entire software system
- UML Class Diagrams correspond to E-R Diagram, but several differences.

ER vs. UML Class Diagrams



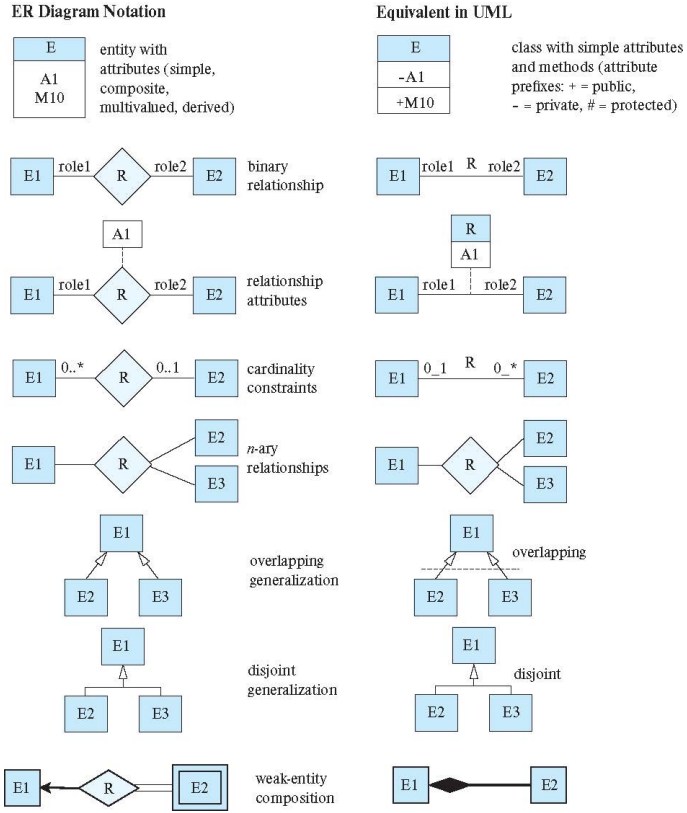
* Note reversal of position in cardinality constraint depiction

ER vs. UML Class Diagrams

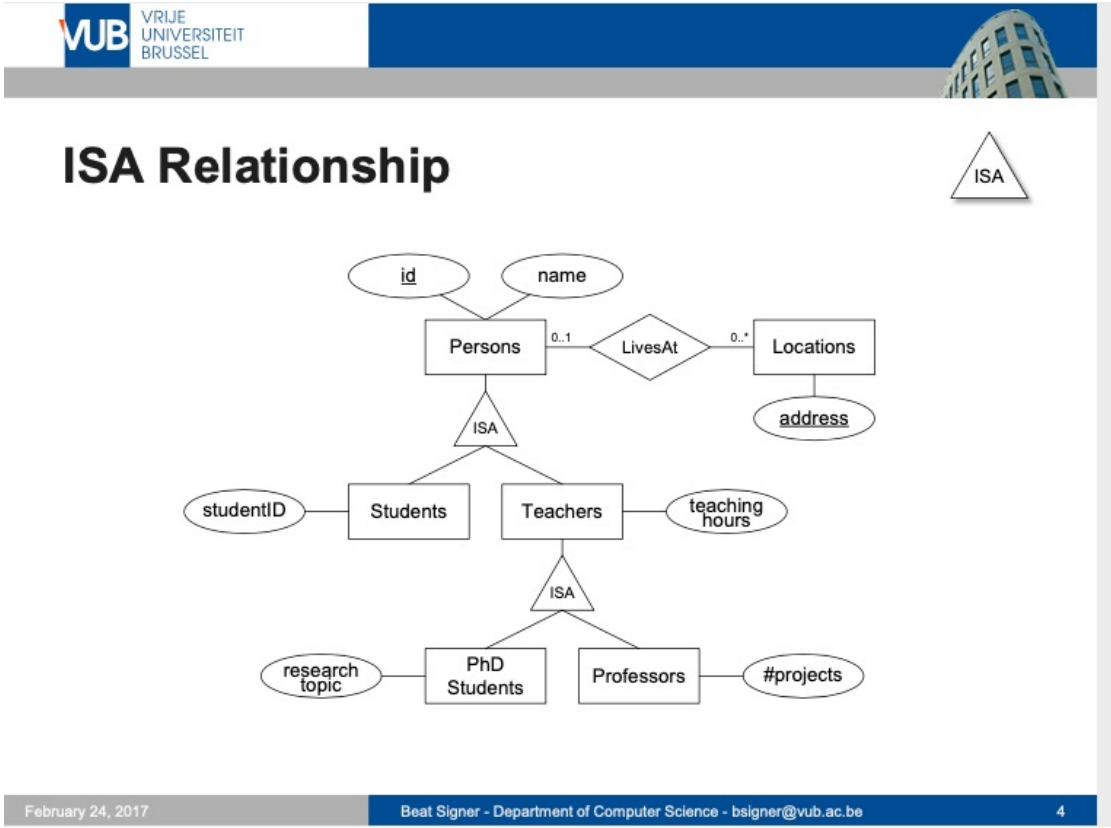


* Generalization can use merged or separate arrows independent of disjoint/overlapping

ER vs. UML Class Diagrams

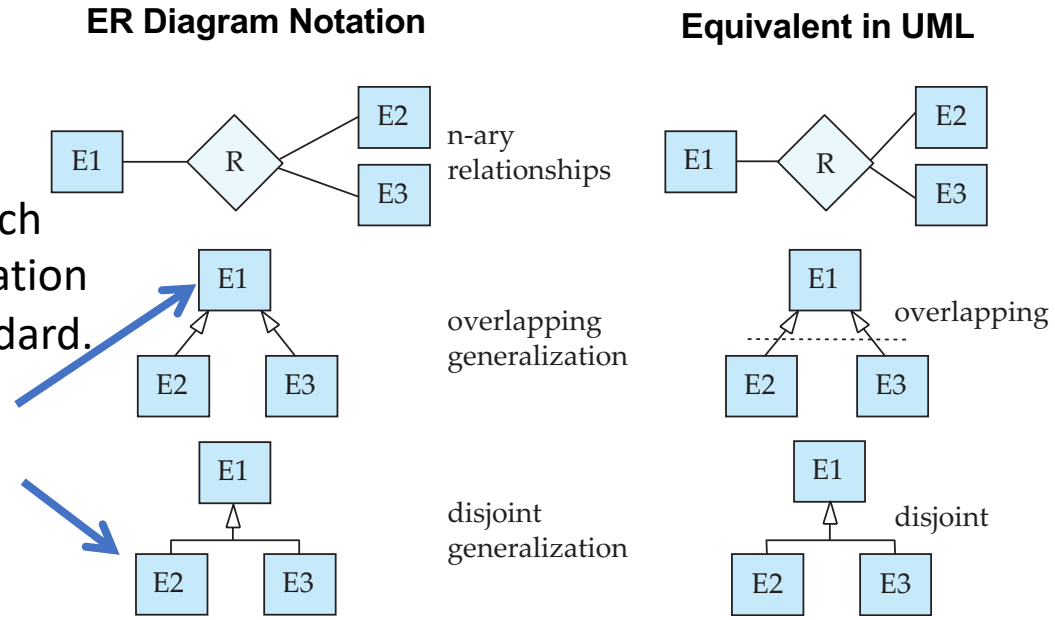


ISA Relationship



ER vs. UML Class Diagrams

I use this approach in Crow's Foot Notation but that is not standard.



* Generalization can use merged or separate arrows independent of disjoint/overlapping

SQL

More on Codd's Rules

Codd's 12 Rules

Rule 1: Information Rule

The data stored in a database, may it be user data or metadata, must be a value of some table cell. Everything in a database must be stored in a table format.

Rule 2: Guaranteed Access Rule

Every single data element (value) is guaranteed to be accessible logically with a combination of table-name, primary-key (row value), and attribute-name (column value). No other means, such as pointers, can be used to access data.

Rule 3: Systematic Treatment of NULL Values

The NULL values in a database must be given a systematic and uniform treatment. This is a very important rule because a NULL can be interpreted as one the following − data is missing, data is not known, or data is not applicable.

Rule 4: Active Online Catalog

The structure description of the entire database must be stored in an online catalog, known as data dictionary, which can be accessed by authorized users. Users can use the same query language to access the catalog which they use to access the database itself.

Rule 5: Comprehensive Data Sub-Language Rule

A database can only be accessed using a language having linear syntax that supports data definition, data manipulation, and transaction management operations. This language can be used directly or by means of some application. If the database allows access to data without any help of this language, then it is considered as a violation.

Rule 6: View Updating Rule

All the views of a database, which can theoretically be updated, must also be updatable by the system.

Codd's 12 Rules

Rule 7: High-Level Insert, Update, and Delete Rule

A database must support high-level insertion, updation, and deletion. This must not be limited to a single row, that is, it must also support union, intersection and minus operations to yield sets of data records.

Rule 8: Physical Data Independence

The data stored in a database must be independent of the applications that access the database. Any change in the physical structure of a database must not have any impact on how the data is being accessed by external applications.

Rule 9: Logical Data Independence

The logical data in a database must be independent of its user's view (application). Any change in logical data must not affect the applications using it. For example, if two tables are merged or one is split into two different tables, there should be no impact or change on the user application. This is one of the most difficult rule to apply.

Rule 10: Integrity Independence

A database must be independent of the application that uses it. All its integrity constraints can be independently modified without the need of any change in the application. This rule makes a database independent of the front-end application and its interface.

Rule 11: Distribution Independence

The end-user must not be able to see that the data is distributed over various locations. Users should always get the impression that the data is located at one site only. This rule has been regarded as the foundation of distributed database systems.

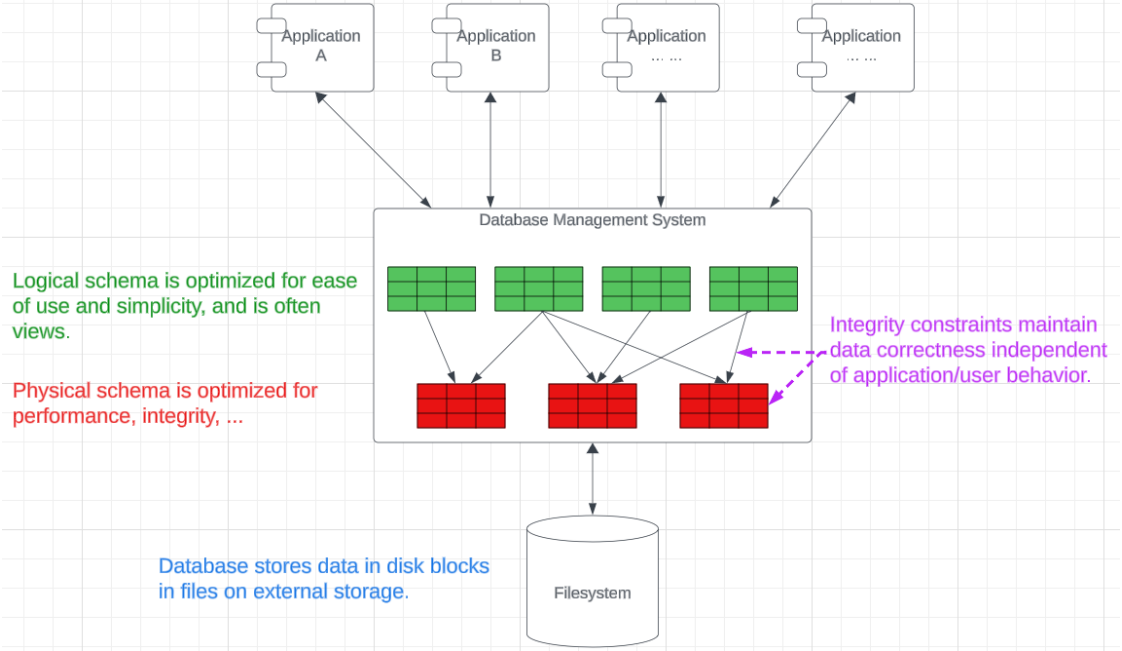
Rule 12: Non-Subversion Rule

If a system has an interface that provides access to low-level records, then the interface must not be able to subvert the system and bypass security and integrity constraints.

Physical Data, Logical Data, Integrity Independence

Overly simplistic explanation:

- Logical Independence:
  - "Uses views"
  - Adapts a potentially complex model to how a user "thinks" about the data.
  - Enables changing the optimized physical model without affecting users – reimplement views.
- Physical Independence:
  - The physical schema is optimized for performance, complex integrity, …
  - Changes as the application evolves, performance requirements change, etc.
  - The representation in the database is independent of the physical storage model.
- Integrity Independence:
  - Integrity constraints associated with the database tables/entities partially allows modification without requiring application changes.
  - Integrity does not rely on correctness of multiple applications and users.



Some Types and Functions

Functions

MySQL CHEAT SHEET: STRING FUNCTIONS

by sqlbackupandftp.com with ♥

MEASUREMENT

Return a string containing binary representation of a number

```
BIN (12) = '1100'
```

Return length of argument in bits

```
BIT_LENGTH ('MySql') = 40
```

Return number of characters in argument

```
CHAR_LENGTH ('MySql') = 5
CHARACTER_LENGTH ('MySql') = 5
```

Return the length of a string in bytes

```
LENGTH ('Ö') = 2
LENGTH ('A') = 1
OCTET_LENGTH ('Ö') = 2
OCTET_LENGTH ('X') = 1
```

Return a soundex string

```
SOUNDEX ('MySql') = 'M240'
SOUNDEX ('MySqlDatabase') = 'M24312'
```

Compare two strings

```
STRCMP ('A', 'A') = 0
STRCMP ('A', 'B') = -1
STRCMP ('B', 'A') = 1
```

SEARCH

Return the index of the first occurrence of substring

```
INSTR ('MySql', 'Sql') = 3
INSTR ('Sql', 'MySql') = 0
```

Return the position of the first occurrence of substring

```
LOCATE ('Sql', 'MySqlSql') = 3
LOCATE ('xSql', 'MySql') = 0
LOCATE ('Sql', 'MySqlSql', 5) = 6
POSITION('Sql' IN 'MySqlSql') = 3
```

Pattern matching using regular expressions

```
'abc' RLIKE '[a-z]+' = 1
'123' RLIKE '[a-z]+' = 0
```

Return a substring from a string before the specified number of occurrences of the delimiter

```
SUBSTRING_INDEX ('A:B:C', ':', 1) = 'A'
SUBSTRING_INDEX ('A:B:C', ':', 2) = 'A:B'
SUBSTRING_INDEX ('A:B:C', ':', -2) = 'B:C'
```

CONVERSION

Return numeric value of left-most character

```
ASCII ('2') = 50
ASCII (2) = 50
ASCII ('dx') = 100
```

Return the character for each number passed

```
CHAR (77.3,121,83,81, '76, 81.6') = 'MySQL'
CHAR (45*256+45) = CHAR (45,45) = '--'
CHARSET(CHAR (X'65' USING utf8)) = 'utf8'
```

Decode to / from a base-64 string

```
TO_BASE64 ('abc') = 'YWJj'
FROM_BASE64 ('YWJj') = 'abc'
```

Convert string or number to its hexadecimal representation

```
X'616263' = 'abc'
HEX ('abc') = 616263
HEX(255) = 'FF'
CONV(HEX(255), 16, 10) = 255
```

Convert each pair of hexadecimal digits to a character

```
UNHEX ('4D7953514C') = 'MySQL'
UNHEX ('GG') = NULL
UNHEX (HEX ('abc')) = 'abc'
```

Return the argument in lowercase

```
LOWER ('MYSQL') = 'mysql'
LCASE ('MYSQL') = 'mysql'
```

Load the named file

```
SET blob_col=LOAD_FILE ('/tmp/picture')
```

Return a string containing octal representation of a number

```
OCT (12) = '14'
```

Return character code for leftmost character of the argument

```
ORD ('2') = 50
```

Escape the argument for use in an SQL statement

```
QUOTE ('Don\'t!') = 'Don\'t!'
QUOTE (NULL) = 'NULL'
```

Convert to uppercase

```
UPPER ('mysql') = 'MYSQL'
UCASE ('mysql') = 'MYSQL'
```

MODIFICATION

Return concatenated string

```
CONCAT ('My', 'S', 'QL') = 'MySQL'
CONCAT ('My', NULL, 'QL') = NULL
CONCAT (14.3) = '14.3'
```

Return concatenate with separator

```
CONCAT_WS (',', 'My', 'Sql') = 'My,Sql'
CONCAT_WS (',','My',NULL,'Sql') = 'My,Sql'
```

Return a number formatted to specified number of decimal places

```
FORMAT (12332.123456, 4) = 12,332.1235
FORMAT (12332.1, 4) = 12,332.1000
FORMAT (12332.2, 0) = 12332.2
FORMAT (12332.2, 2, 'de_DE') = 12.332,20
```

Insert a substring at the specified position up to the specified number of characters

```
INSERT ('12345', 3, 2, 'ABC') = '12ABC5'
INSERT ('12345', 10, 2, 'ABC') = '12345'
INSERT ('12345', 3, 10, 'ABC') = '12ABC'
```

Return the leftmost number of characters as specified

```
LEFT ('MySql', 2) = 'My'
```

Return the string argument, left-padded with the specified string

```
LPAD ('Sql', 2, ':)') = 'Sq'
LPAD ('Sql', 4, ':)') = ':Sql'
LPAD ('Sql', 7, ':)') = ':):)Sql'
```

Remove leading spaces

```
LTRIM ('      MySql') = 'MySql'
```

Repeat a string the specified number of times

```
REPEAT ('MySQL', 3) = 'MySQLMySQLMySQL'
```

Replace occurrences of a specified string

```
REPLACE ('NoSql', 'No', 'My') = 'MySql'
```

Reverse the characters in a string

```
REVERSE ('MySql') = 'lqSyM'
```

Return the specified rightmost number of characters

```
RIGHT ('MySql', 3) = 'Sql'
```

Returns the string argument, right-padded with the specified strin.

```
RPAD ('Sql', 2, ':)') = 'Sq'
RPAD ('Sql', 4, ':)') = 'Sql:'
RPAD ('Sql', 7, ':)') = 'Sql:):)'
```

Remove trailing spaces

```
RTRIM ('MySql      ') = 'MySql'
```

Return a string of the specified number of spaces

```
SPACE ('6') = '      '
```

Return the substring as specified

```
SUBSTRING=SUBSTR=MID('MySql',3) = 'Sql'
SUBSTRING=SUBSTR=MID('MySql' FROM 4) = 'ql'
SUBSTRING=SUBSTR=MID('MySql',3,1) = 'S'
SUBSTRING=SUBSTR=MID('MySql',-3) = 'Sql'
SUBSTRING=SUBSTR=MID('MySql' FROM -4 FOR 2)
= 'yS'
```

Remove leading and trailing spaces

```
TRIM(' MySql ') = 'MySql'
TRIM(LEADING 'x' FROM 'xxxSqlMy') = 'MySql'
TRIM(BOTH 'My' FROM 'MySqlMy') = 'Sql'
TRIM(TRAILING 'Sql' FROM 'MySql') = 'My'
```

SETS

Return string at index number

```
ELT (1, 'ej', 'Heja', 'hej', 'foo') = 'ej'
ELT (4, 'ej', 'Heja', 'hej', 'foo') = 'foo'
```

Return a string such that for every bit set in the value bits, you get an on string and for every unset bit, you get an off string

```
EXPORT_SET (5,'Y','N',',',4) = 'Y,N,Y,N'
EXPORT_SET (6,'1','0',',',6) = '0,1,1,0,0,0'
```

Return the index (position) of the first argument in the subsequent arguments

```
FIELD ('ej','Hj','ej','Heja','hej','oo') = 2
FIELD ('fo','Hj','ej','Heja','hej','oo') = 0
```

Return the index position of the first argument within the second argument

```
FIND_IN_SET ('b', 'a,b,c,d') = 2
FIND_IN_SET ('z', 'a,b,c,d') = 0
FIND_IN_SET ('a,', 'a,b,c,d') = 0
```

Return a set of comma-separated strings that have the corresponding bit in bits set

```
MAKE_SET (1,'a','b','c') = 'a'
MAKE_SET (1|4,'ab','cd','ef') = 'ab,ef'
MAKE_SET (1|4,'ab','cd',NULL,'ef') = 'ab'
MAKE_SET (0,'a','b','c') = ''
```

Standard SQL Functions Cheat Sheet

LearnSQL.com

TEXT FUNCTIONS

CONCATENATION

Use the `||` operator to concatenate two strings:

```
SELECT 'Hi ' || 'there!';
-- result: Hi there!
```

Remember that you can concatenate only character strings using `||`. Use this trick for numbers:

```
SELECT '' || 4 || 2;
-- result: 42
```

Some databases implement non-standard solutions for concatenating strings like `CONCAT()` or `CONCAT_WS()`. Check the documentation for your specific database.

LIKE OPERATOR – PATTERN MATCHING

Use the `_` character to replace any single character. Use the `%` character to replace any number of characters (including 0 characters).

Fetch all names that start with any letter followed by `'atherine'`:

```
SELECT name
FROM names
WHERE name LIKE '_atherine';
```

Fetch all names that end with `'a'`:

```
SELECT name
FROM names
WHERE name LIKE '%a';
```

USEFUL FUNCTIONS

Get the count of characters in a string:

```
SELECT LENGTH('LearnSQL.com');
-- result: 12
```

Convert all letters to lowercase:

```
SELECT LOWER('LEARNSQL.COM');
-- result: learnsql.com
```

Convert all letters to uppercase:

```
SELECT UPPER('LearnSQL.com');
-- result: LEARNSQL.COM
```

Convert all letters to lowercase and all first letters to uppercase (not implemented in MySQL and SQL Server):

```
SELECT INITCAP('edgar frank ted cODD');
-- result: Edgar Frank Ted Codd
```

Get just a part of a string:

```
SELECT SUBSTRING('LearnSQL.com', 9);
-- result: .com
SELECT SUBSTRING('LearnSQL.com', 0, 6);
-- result: Learn
```

Replace part of a string:

```
SELECT REPLACE('LearnSQL.com', 'SQL',
'Python');
-- result: LearnPython.com
```

NUMERIC FUNCTIONS

BASIC OPERATIONS

Use `+`, `-`, `*`, `/` to do some basic math. To get the number of seconds in a week:

```
SELECT 60 * 60 * 24 * 7; -- result: 604800
```

CASTING

From time to time, you need to change the type of a number. The `CAST()` function is there to help you out. It lets you change the type of value to almost anything (`integer`, `numeric`, `double precision`, `varchar`, and many more).

Get the number as an integer (without rounding):

```
SELECT CAST(1234.567 AS integer);
-- result: 1234
```

Change a column type to `double precision`

```
SELECT CAST(column AS double precision);
```

USEFUL FUNCTIONS

Get the remainder of a division:

```
SELECT MOD(13, 2);
-- result: 1
```

Round a number to its nearest integer:

```
SELECT ROUND(1234.56789);
-- result: 1235
```

Round a number to three decimal places:

```
SELECT ROUND(1234.56789, 3);
-- result: 1234.568
```

PostgreSQL requires the first argument to be of the type `numeric` – cast the number when needed.

To round the number **up**:

```
SELECT CEIL(13.1); -- result: 14
SELECT CEIL(-13.9); -- result: -13
```

The `CEIL(x)` function returns the **smallest** integer **not less** than `x`. In SQL Server, the function is called `CEILING()`.

To round the number **down**:

```
SELECT FLOOR(13.8); -- result: 13
SELECT FLOOR(-13.2); -- result: -14
```

The `FLOOR(x)` function returns the **greatest** integer **not greater** than `x`.

To round towards 0 irrespective of the sign of a number:

```
SELECT TRUNC(13.5); -- result: 13
SELECT TRUNC(-13.5); -- result: -13
```

`TRUNC(x)` works the same way as `CAST(x AS integer)`. In MySQL, the function is called `TRUNCATE()`.

To get the absolute value of a number:

```
SELECT ABS(-12); -- result: 12
```

To get the square root of a number:

```
SELECT SQRT(9); -- result: 3
```

NULLs

To retrieve all rows with a missing value in the `price` column:

```
WHERE price IS NULL
```

To retrieve all rows with the `weight` column populated:

```
WHERE weight IS NOT NULL
```

Why shouldn't you use `price = NULL` or `weight != NULL`? Because databases don't know if those expressions are true or false – they are evaluated as `NULL`s.

Moreover, if you use a function or concatenation on a column that is `NULL` in some rows, then it will get propagated. Take a look:

domain	LENGTH(domain)
LearnSQL.com	12
LearnPython.com	15
NULL	*NULL*
vertabelo.com	13

USEFUL FUNCTIONS

COALESCE(x, y, ...)

To replace `NULL` in a query with something meaningful:

```
SELECT
  domain,
  COALESCE(domain, 'domain missing')
FROM contacts;
```

domain	coalesce
LearnSQL.com	LearnSQL.com
NULL	domain missing

The `COALESCE()` function takes any number of arguments and returns the value of the first argument that isn't `NULL`.

NULLIF(x, y)

To save yourself from *division by 0* errors:

```
SELECT
  last_month,
  this_month,
  this_month * 100.0
    / NULLIF(last_month, 0)
    AS better_by_percent
FROM video_views;
```

last_month	this_month	better_by_percent
723786	1085679	150.0
0	178123	*NULL*

The `NULLIF(x, y)` function will return `NULL` if `x` is the same as `y`, else it will return the `x` value.

CASE WHEN

The basic version of `CASE WHEN` checks if the values are equal (e.g., if `fee` is equal to 50, then `'normal'` is returned). If there isn't a matching value in the `CASE WHEN`, then the `ELSE` value will be returned (e.g., if `fee` is equal to 49, then `'not available'` will show up.

```
SELECT
  CASE fee
    WHEN 50 THEN 'normal'
    WHEN 10 THEN 'reduced'
    WHEN  0 THEN 'free'
    ELSE 'not available'
  END AS tariff
FROM ticket_types;
```

The most popular type is the **searched CASE WHEN** – it lets you pass conditions (as you'd write them in the `WHERE` clause), evaluates them in order, then returns the value for the first condition met.

```
SELECT
  CASE
    WHEN score >= 90 THEN 'A'
    WHEN score >  60 THEN 'B'
    ELSE 'F'
  END AS grade
FROM test_results;
```

Here, all students who scored at least 90 will get an A, those with the score above 60 (and below 90) will get a B, and the rest will receive an F.

TROUBLESHOOTING

Integer division

When you don't see the decimal places you expect, it means that you are dividing between two integers. Cast one to `decimal`:

```
CAST(123 AS decimal) / 2
```

Division by 0

To avoid this error, make sure that the denominator is not equal to 0. You can use the `NULLIF()` function to replace 0 with a `NULL`, which will result in a `NULL` for the whole expression:

```
count / NULLIF(count_all, 0)
```

Inexact calculations

If you do calculations using `real` (floating point) numbers, you'll end up with some inaccuracies. This is because this type is meant for scientific calculations such as calculating the velocity. Whenever you need accuracy (such as dealing with monetary values), use the `decimal` / `numeric` type (or `money` if available).

Errors when rounding with a specified precision

Most databases won't complain, but do check the documentation if they do. For example, if you want to specify the rounding precision in PostgreSQL, the value must be of the `numeric` type.

Standard SQL Functions Cheat Sheet

LearnSQL.com

AGGREGATION AND GROUPING

- **COUNT(expr)** – the count of values for the rows within the group
- **SUM(expr)** – the sum of values within the group
- **AVG(expr)** – the average value for the rows within the group
- **MIN(expr)** – the minimum value within the group
- **MAX(expr)** – the maximum value within the group

To get the number of rows in the table:

```
SELECT COUNT(*)
FROM city;
```

To get the number of non-NULL values in a column:

```
SELECT COUNT(rating)
FROM city;
```

To get the count of unique values in a column:

```
SELECT COUNT(DISTINCT country_id)
FROM city;
```

GROUP BY

CITY	
name	**country_id**
Paris	1
Marseille	1
Lyon	1
Berlin	2
Hamburg	2
Munich	2
Warsaw	4
Cracow	4

→

CITY	
country_id	**count**
1	3
2	3
4	2

The example above – the count of cities in each country:

```
SELECT name, COUNT(country_id)
FROM city
GROUP BY name;
```

The average rating for the city:

```
SELECT city_id, AVG(rating)
FROM ratings
GROUP BY city_id;
```

Common mistake: COUNT(*) and LEFT JOIN

When you join the tables like this: `client LEFT JOIN project`, and you want to get the number of projects for every client you know, `COUNT(*)` will return **1** for each client even if you've never worked for them. This is because, they're still present in the list but with the `NULL` in the fields related to the project after the `JOIN`. To get the correct count (**0** for the clients you've never worked for), count the values in a column of the other table, e.g., `COUNT(project_name)`. Check out this exercise to see an example.

DATE AND TIME

There are 3 main time-related types: `date`, `time`, and `timestamp`. Time is expressed using a 24-hour clock, and it can be as vague as just hour and minutes (e.g., `15:30` – 3:30 p.m.) or as precise as microseconds and time zone (as shown below):

```
2021-12-31 14:39:53.662522-05
   date    time
      timestamp
YYYY-mm-dd HH:MM:SS.ssssss±TZ
```

`14:39:53.662522-05` is almost 2:40 p.m. CDT (e.g., in Chicago; in UTC it'd be 7:40 p.m.). The letters in the above example represent:

In the date part:

- YYYY – the 4-digit year.
- mm – the zero-padded month (01—January through 12—December).
- dd – the zero-padded day.

In the time part:

- HH – the zero-padded hour in a 24-hour clock.
- MM – the minutes.
- SS – the seconds. *Omissible.*
- ssssss – the smaller parts of a second – they can be expressed using 1 to 6 digits. *Omissible.*
- ±TZ – the timezone. It must start with either + or −, and use two digits relative to UTC. *Omissible.*

What time is it?

To answer that question in SQL, you can use:

- CURRENT_TIME – to find what time it is.
- CURRENT_DATE – to get today's date. (`GETDATE()` in SQL Server.)
- CURRENT_TIMESTAMP – to get the timestamp with the two above.

Creating values

To create a `date`, `time`, or `timestamp`, simply write the value as a string and cast it to the proper type.

```
SELECT CAST('2021-12-31' AS date);
SELECT CAST('15:31' AS time);
SELECT CAST('2021-12-31 23:59:29+02' AS
timestamp);
SELECT CAST('15:31.124769' AS time);
```

Be careful with the last example – it will be interpreted as 15 minutes 31 seconds and 124769 microseconds! It is always a good idea to write `00` explicitly for hours: `'00:15:31.124769'`.

You might skip casting in simple conditions – the database will know what you mean.

```
SELECT airline, flight_number, departure_time
FROM airport_schedule
WHERE departure_time < '12:00';
```

INTERVALs

Note: In SQL Server, intervals aren't implemented – use the `DATEADD()` and `DATEDIFF()` functions.

To get the simplest interval, subtract one time value from another:

```
SELECT CAST('2021-12-31 23:59:59' AS
timestamp) - CAST('2021-06-01 12:00:00' AS
timestamp);
-- result: 213 days 11:59:59
```

To define an interval: `INTERVAL '1' DAY`

This syntax consists of three elements: the `INTERVAL` keyword, a quoted value, and a time part keyword (in singular form.) You can use the following time parts: `YEAR`, `MONTH`, `WEEK`, `DAY`, `HOUR`, `MINUTE`, and `SECOND`. In MySQL, omit the quotes. You can join many different `INTERVAL`s using the `+` or `-` operator:

```
INTERVAL '1' YEAR + INTERVAL '3' MONTH
```

In some databases, there's an easier way to get the above value. And it accepts plural forms! `INTERVAL '1 year 3 months'`

There are two more syntaxes in the Standard SQL:

Syntax	What it does
`INTERVAL 'x-y' YEAR TO MONTH`	`INTERVAL 'x year y month'`
`INTERVAL 'x-y' DAY TO SECOND`	`INTERVAL 'x day y second'`

In MySQL, write `year_month` instead of `YEAR TO MONTH` and `day_second` instead of `DAY TO SECOND`.

To get the last day of a month, add one month and subtract one day:

```
SELECT CAST('2021-02-01' AS date)
       + INTERVAL '1' MONTH
       - INTERVAL '1' DAY;
```

To get all events for next three months from today:

```
SELECT event_date, event_name
FROM calendar
WHERE event_date BETWEEN CURRENT_DATE AND
CURRENT_DATE + INTERVAL '3' MONTH;
```

To get part of the date:

```
SELECT EXTRACT(YEAR FROM birthday)
FROM artists;
```

One of possible returned values: 1946. In SQL Server, use the `DATEPART(part, date)` function.

TIME ZONES

In the SQL Standard, the `date` type can't have an associated time zone, but the `time` and `timestamp` types can. In the real world, time zones have little meaning without the date, as the offset can vary through the year because of **daylight saving time**. So, it's best to work with the `timestamp` values.

When working with the type `timestamp with time zone` (abbr. `timestamptz`), you can type in the value in your local time zone, and it'll get converted to the UTC time zone as it is inserted into the table. Later when you select from the table it gets converted back to your local time zone. This is immune to time zone changes.

AT TIME ZONE

To operate between different time zones, use the `AT TIME ZONE` keyword.

If you use this format: `{timestamp without time zone} AT TIME ZONE {time zone}`, then the database will read the time stamp in the specified time zone and convert it to the time zone local to the display. It returns the time in the format `timestamp with time zone`.

If you use this format: `{timestamp with time zone} AT TIME ZONE {time zone}`, then the database will convert the time in one time zone to the target time zone specified by `AT TIME ZONE`. It returns the time in the format `timestamp without time zone`, in the target time zone.

You can define the time zone with popular shortcuts like `UTC`, `MST`, or `GMT`, or by `continent/city` such as: `America/New_York`, `Europe/London`, and `Asia/Tokyo`.

Examples

We set the local time zone to `'America/New_York'`.

```
SELECT TIMESTAMP '2021-07-16 21:00:00' AT
TIME ZONE 'America/Los_Angeles';
-- result: 2021-07-17 00:00:00-04
```

Here, the database takes a timestamp without a time zone and it's told it's in Los Angeles time, which is then converted to the local time – New York for displaying. This answers the question **"At what time should I turn on the TV if the show starts at 9 PM in Los Angeles?"**

```
SELECT TIMESTAMP WITH TIME ZONE '2021-06-20
19:30:00' AT TIME ZONE 'Australia/Sydney';
-- result: 2021-06-21 09:30:00
```

Here, the database gets a timestamp specified in the local time zone and converts it to the time in Sydney (note that it didn't return a time zone.) This answers the question **"What time is it in Sydney if it's 7:30 PM here?"**

Functions

- The are dozens if not hundreds of standard functions in SQL.
- All DBMS implementations have product specific functions.
- General rule:
  - If you have to do something, ask yourself
  - Am I the first one who ever had to do this?
  - If the answer is “No,” then ask Dr. Google/ChatGPT.
  - If the answer is Yes,” ask yourself, “Am I sure this is a good idea.”
- The functions are useful and straightforward.
- Some examples ➔ To the notebook we go, yo ho!

Integrity Constraints

Integrity Constraints

- Integrity constraints guard against accidental damage to the database, by ensuring that authorized changes to the database do not result in a loss of data consistency.
  - A checking account must have a balance greater than $10,000.00
  - A salary of a bank employee must be at least $4.00 an hour
  - A customer must have a (non-null) phone number

DFF

- Without integrity constraints in the database, maintaining data correctness requires:
  - Lots of users know what to do and do not make mistakes.
  - Dozens of programs correctly implement constraints in the code and stay up to date on changes.
- Implementing the constraints as part of the schema eliminates many issues.

Constraints on a Single Relation

- **not null**
- **primary key**
- **unique**
- **check** (P), where P is a predicate

Not Null Constraints

- **not null**
  - Declare *name* and *budget* to be **not null**

    name **varchar**(20) **not null**
    budget **numeric**(12,2) **not null**

Unique Constraints

- **unique** (A_1, A_2, …, A_m)
  - The unique specification states that the attributes A_1, A_2, …, A_m form a candidate key.
  - Candidate keys are permitted to be null (in contrast to primary keys).

Simple Example

- Consider a simple example of an entity class *major:*
  - *major(id, name, track)*
  - "id" is a uniquely generated ID
  - "name" is the major name, e.g. "Computer Science," "Economics," … …
  - "track" is a sub-track/specialty within the major, e.g. "Applications," "AI/ML," ...
    - "track" is optional
    - The combination of *(name, track)* is *unique.*
- **Note:** In many DBMS, this automatically creates indices for keys/constraints.
- Switch to Notebook.

```
create table if not exists majors
(
    id          int auto_increment
        primary key,
    major_name  varchar(64) not null,
    major_track varchar(64) null,
    constraint table_name_pk
        unique (major_name, major_track)
);
```

The check clause

- The **check** (P) clause specifies a predicate P that must be satisfied by every tuple in a relation.
- Example: ensure that semester is one of fall, winter, spring or summer

```
create table section
    (course_id varchar (8),
     sec_id varchar (8),
     semester varchar (6),
     year numeric (4,0),
     building varchar (15),
     room_number varchar (7),
     time slot id varchar (4),
     primary key (course_id, sec_id, semester, year),
     check (semester in ('Fall', 'Winter', 'Spring', 'Summer')))
```

DFF:

- We could handle the *semester check* with an *enum.*
- Switch to notebook for a slightly different example.

Referential Integrity

- Ensures that a value that appears in one relation for a given set of attributes also appears for a certain set of attributes in another relation.
  - Example: If “Biology” is a department name appearing in one of the tuples in the *instructor* relation, then there exists a tuple in the *department* relation for “Biology”.
- Let A be a set of attributes. Let R and S be two relations that contain attributes A and where A is the primary key of S. A is said to be a **foreign key** of R if for any values of A appearing in R these values also appear in S.

Referential Integrity (Cont.)

- Foreign *keys can be* specified as part of the SQL **create table** statement

  foreign key (*dept_name*) **references** *department*

- By default, a foreign key references the primary-key attributes of the referenced table.
- SQL allows a list of attributes of the referenced relation to be specified explicitly.

  foreign key (*dept_name*) **references** *department* (*dept_name*)

Cascading Actions in Referential Integrity

- When a referential-integrity constraint is violated, the normal procedure is to reject the action that caused the violation.
- An alternative, in case of delete or update is to cascade

```
create table course (
        (…
         dept_name varchar(20),
         foreign key (dept_name) references department
             on delete cascade
             on update cascade,
          . . .)
```

- Instead of cascade we can use :
  - **set null**,
  - **set default**

DFF:

- I do not like using *cascade.* I think making changes should be explicit.
- Other people disagree.
- You will get some simple practice on HW or exams.

Indexes
Review, Concepts, Examples

Index Creation

- Many queries reference only a small proportion of the records in a table.
- It is inefficient for the system to read every record to find a record with particular value
- An **index** on an attribute of a relation is a data structure that allows the database system to find those tuples in the relation that have a specified value for that attribute efficiently, without scanning through all the tuples of the relation.
- We create an index with the **create index** command

  create index <name> **on** <relation-name> (attribute);

Index Creation Example

- **create table** *student*
  (*ID* **varchar** (5),
  name **varchar** (20) **not null**,
  dept_name **varchar** (20),
  tot_cred **numeric** (3,0) **default** 0,
  primary key (*ID*))
- **create index** *studentID_index* **on** *student*(*ID*)
- The query:

  select *
  from *student*
  where *ID* = '12345'

  can be executed by using the index to find the required record, without looking at all records of *student*

DFF:

- An index on (column1, column2, column3)
- Is also an index on (column1) and (column1, column2)
- But not (column2), (column3), (column2, column3).
- We will see “why” later in the semester.

Functions, Procedures, Triggers

Some Concepts

Functions and Procedures

- Functions and procedures allow "business logic" to be stored in the database and executed from SQL statements.
- These can be defined either by the procedural component of SQL or by an external programming language such as Java, C, or C++.
- The syntax we present here is defined by the SQL standard.
  - Most databases implement nonstandard versions of this syntax.

Note:

- The programming language, runtime and tools for functions, procedures and triggers are not easy to use.
- My view is that calling external functions is an anti-pattern (bad idea).
  - External code degrades the reliability, security and performance of the database.
  - Databases are often mission critical and the heart of environments.

Language Constructs for Procedures & Functions

- SQL supports constructs that gives it almost all the power of a general-purpose programming language.
  - Warning: most database systems implement their own variant of the standard syntax below.
- Compound statement: **begin** … **end,**
  - May contain multiple SQL statements between **begin** and **end**.
  - Local variables can be declared within a compound statements
- While and repeat statements:
  - **while** boolean expression **do**
    sequence of statements ;
    end while
  - **repeat**
    sequence of statements ;
    until boolean expression
    end repeat

(Core) Language Constructs (Cont.)

- **For** loop
  - Permits iteration over all results of a query
- Example: Find the budget of all departments

```
declare n integer default 0;
for r as
      select budget from department
          where dept_name = 'Music'
do
                  set n = n + r.budget
end for
```

Note:

- There are various other looping constructs.

(Core) Language Constructs – if-then-else

- Conditional statements (**if-then-else**)

if *boolean expression*
then *statement or compound statement*
elseif *boolean expression*
then *statement or compound statement*
else *statement or compound statement*
end if

Note:

- We will not spend a lot of time writing functions, procedures, or triggers.
- The language and development environment are not easy to use.

Functions

Declaring SQL Functions

- Define a function that, given the name of a department, returns the count of the number of instructors in that department.

```
create function dept_count (dept_name varchar(20))
        returns integer
        begin
        declare d_count  integer;
              select count (* ) into d_count
              from instructor
              where instructor.dept_name = dept_name
        return d_count;
end
```

- The function *dept*_count can be used to find the department names and budget of all departments with more that 12 instructors.

```
select dept_name, budget
from department
where dept_count (dept_name ) > 12
```

Table Functions

- The SQL standard supports functions that can return tables as results; such functions are called **table functions**
- Example: Return all instructors in a given department

```
create function instructor_of (dept_name char(20))
        returns table  (
          ID varchar(5),
              name varchar(20),
           dept_name varchar(20),
              salary numeric(8,2))
      return table
            (select ID, name, dept_name, salary
             from instructor
             where instructor.dept_name = instructor_of.dept_name)
```

- Usage

```
select *
from table (instructor_of ('Music'))
```

Procedures

SQL Procedures

- The *dept_count* function could instead be written as procedure:

```
create procedure dept_count_proc (in dept_name varchar(20),
                                  out d_count integer)
  begin
     select count(*) into d_count
     from instructor
     where instructor.dept_name = dept_count_proc.dept_name
  end
```

- The keywords **in** and **out** are parameters that are expected to have values assigned to them and parameters whose values are set in the procedure in order to return results.
- Procedures can be invoked either from an SQL procedure or from embedded SQL, using the **call** statement.

```
declare d_count integer;
call dept_count_proc( 'Physics', d_count);
```

SQL Procedures (Cont.)

- Procedures and functions can be invoked also from dynamic SQL
- SQL allows more than one procedure of the so long as the number of arguments of the procedures with the same name is different.
- The name, along with the number of arguments, is used to identify the procedure.

Triggers

Triggers

- A **trigger** is a statement that is executed automatically by the system as a side effect of a modification to the database.
- To design a trigger mechanism, we must:
  - Specify the conditions under which the trigger is to be executed.
  - Specify the actions to be taken when the trigger executes.
- Triggers introduced to SQL standard in SQL:1999, but supported even earlier using non-standard syntax by most databases.
  - Syntax illustrated here may not work exactly on your database system; check the system manuals

Triggering Events and Actions in SQL

- Triggering event can be **insert**, **delete** or **update**
- Triggers on update can be restricted to specific attributes
  - For example, **after update of** *takes* **on** *grade*
- Values of attributes before and after an update can be referenced
  - **referencing old row as** : for deletes and updates
  - **referencing new row as** : for inserts and updates
- Triggers can be activated before an event, which can serve as extra constraints. For example, convert blank grades to null.

```
create trigger setnull_trigger before update of takes
referencing new row as nrow
for each row
    when (nrow.grade = ' ')
begin atomic
        set nrow.grade = null;
end;
```

Trigger to Maintain credits_earned value

- **create trigger** *credits_earned* **after update of** *takes* **on** (*grade*)
  referencing new row as *nrow*
  referencing old row as *orow*
  for each row
  when *nrow.grade* <> 'F' **and** *nrow.grade* **is not null**
  and (*orow.grade* = 'F' **or** *orow.grade* **is null**)
  begin atomic
  update *student*
  set *tot_cred*= *tot_cred* +
  (**select** *credits*
  from *course*
  where *course.course_id*= *nrow.course_id*)
  where *student.id* = *nrow.id*;
  end;

Statement Level Triggers

- Instead of executing a separate action for each affected row, a single action can be executed for all rows affected by a transaction
  - Use **for each statement** instead of **for each row**
  - Use **referencing old table** or **referencing new table** to refer to temporary tables (called ***transition tables***) containing the affected rows
  - Can be more efficient when dealing with SQL statements that update a large number of rows

When Not To Use Triggers

- Triggers were used earlier for tasks such as
  - Maintaining summary data (e.g., total salary of each department)
  - Replicating databases by recording changes to special relations (called **change** or **delta** relations) and having a separate process that applies the changes over to a replica
- There are better ways of doing these now:
  - Databases today provide built in materialized view facilities to maintain summary data
  - Databases provide built-in support for replication
- Encapsulation facilities can be used instead of triggers in many cases
  - Define methods to update fields
  - Carry out actions as part of the update methods instead of through a trigger

When Not To Use Triggers (Cont.)

- Risk of unintended execution of triggers, for example, when
  - Loading data from a backup copy
  - Replicating updates at a remote site
  - Trigger execution can be disabled before such actions.
- Other risks with triggers:
  - Error leading to failure of critical transactions that set off the trigger
  - Cascading execution

Summary

Comparison

comparing triggers, functions, and procedures

	triggers	functions	stored procedures
change data	yes	no	yes
return value	never	always	sometimes
how they are called	reaction	in a statement	exec

lynda.com

Comparison – Some Details

A *trigger* has capabilities like a procedure, except ...

- You do not call it. The DB engine calls it before or after an INSERT, UPDATE, DELETE.
- The inputs are the list of incoming new, modified rows.
- The outputs are the modified versions of the new or modified rows.

Sr.No.	User Defined Function	Stored Procedure
1	Function must return a value.	Stored Procedure may or not return values.
2	Will allow only Select statements, it will not allow us to use DML statements.	Can have select statements as well as DML statements such as insert, update, delete and so on
3	It will allow only input parameters, doesn't support output parameters.	It can have both input and output parameters.
4	It will not allow us to use try-catch blocks.	For exception handling we can use try catch blocks.
5	Transactions are not allowed within functions.	Can use transactions within Stored Procedures.
6	We can use only table variables, it will not allow using temporary tables.	Can use both table variables as well as temporary table in it.
7	Stored Procedures can't be called from a function.	Stored Procedures can call functions.
8	Functions can be called from a select statement.	Procedures can't be called from Select/Where/Having and so on statements. Execute/Exec statement can be used to call/execute Stored Procedure.
9	A UDF can be used in join clause as a result set.	Procedures can't be used in Join clause

Worked Example –
Or
Mock Prof. Ferguson While He Codes

Scenario

- The data model is:
  - Students
  - Faculty
  - An abstract base type Person
- We will generate some test data using Mockaroo. We will load the data.
- We will do a three table solution.
- We will implement:
  - A function to compute UNIs.
  - Triggers to automatically assign UNIs.
  - Stored procedures to create student, faculty.
  - Disable SQL operations to prevent people from making mistakes.
- Snicker at Prof. Ferguson

Security

Security Concepts (Terms from Wikipedia)

- Definitions:
  - "A (digital) identity is information on an entity used by computer systems to represent an external agent. That agent may be a person, organization, application, or device."
  - "Authentication is the act of proving an assertion, such as the identity of a computer system user. In contrast with identification, the act of indicating a person or thing's identity, authentication is the process of verifying that identity."
  - "Authorization is the function of specifying access rights/privileges to resources, ... More formally, "to authorize" is to define an access policy. ... During operation, the system uses the access control rules to decide whether access requests from (authenticated) consumers shall be approved (granted) or disapproved.
  - "Within an organization, roles are created for various job functions. The permissions to perform certain operations are assigned to specific roles. Members or staff (or other system users) are assigned particular roles, and through those role assignments acquire the permissions needed to perform particular system functions."
  - "In computing, privilege is defined as the delegation of authority to perform security-relevant functions on a computer system. A privilege allows a user to perform an action with security consequences. Examples of various privileges include the ability to create a new user, install software, or change kernel functions."

- SQL and relational database management systems implementing security by:
  - Creating identities and authentication policies.
  - Creating roles and assigning identities to roles.
  - Granting and revoking privileges to/from roles and identities.

Authorization

- We may assign a user several forms of authorizations on parts of the database.
  - **Read** - allows reading, but not modification of data.
  - **Insert** - allows insertion of new data, but not modification of existing data.
  - **Update** - allows modification, but not deletion of data.
  - **Delete** - allows deletion of data.
- Each of these types of authorizations is called a **privilege**. We may authorize the user all, none, or a combination of these types of privileges on specified parts of a database, such as a relation or a view.

Authorization (Cont.)

- Forms of authorization to modify the database schema
  - **Index** - allows creation and deletion of indices.
  - **Resources** - allows creation of new relations.
  - **Alteration** - allows addition or deletion of attributes in a relation.
  - **Drop** - allows deletion of relations.

Authorization Specification in SQL

- The **grant** statement is used to confer authorization

  grant <privilege list> **on** <relation or view > **to** <user list>
- <user list> is:
  - a user-id
  - **public**, which allows all valid users the privilege granted
  - A role (more on this later)
- Example:
  - **grant select on** *department* **to** Amit, Satoshi
- Granting a privilege on a view does not imply granting any privileges on the underlying relations.
- The grantor of the privilege must already hold the privilege on the specified item (or be the database administrator).

Privileges in SQL

- **select**: allows read access to relation, or the ability to query using the view
  - Example: grant users U_1, U_2, and U_3 **select** authorization on the *instructor* relation:

    grant select on *instructor* **to** U_1, U_2, U_3
- **insert**: the ability to insert tuples
- **update**: the ability to update using the SQL update statement
- **delete**: the ability to delete tuples.
- **all privileges**: used as a short form for all the allowable privileges

Revoking Authorization in SQL

- The **revoke** statement is used to revoke authorization.

  revoke <privilege list> **on** <relation or view> **from** <user list>

- Example:

  revoke select on *student* **from** U_1, U_2, U_3

- <privilege-list> may be **all** to revoke all privileges the revokee may hold.
- If <revokee-list> includes **public,** all users lose the privilege except those granted it explicitly.
- If the same privilege was granted twice to the same user by different grantees, the user may retain the privilege after the revocation.
- All privileges that depend on the privilege being revoked are also revoked.

Roles

- A **role** is a way to distinguish among various users as far as what these users can access/update in the database.
- To create a role we use:

  create a role <name>
- Example:
  - **create role** instructor
- Once a role is created we can assign “users” to the role using:
  - **grant** <role> **to** <users>

Roles Example

- **create role** instructor;
- **grant** *instructor* **to** Amit**;**
- Privileges can be granted to roles:
  - **grant select on** *takes* **to** *instructor*;
- Roles can be granted to users, as well as to other roles
  - **create role** *teaching_assistant*
  - **grant** *teaching_assistant* **to** *instructor*;
    - *Instructor* inherits all privileges of *teaching_assistant*
- Chain of roles
  - **create role** *dean*;
  - **grant** *instructor* **to** *dean*;
  - **grant** *dean* **to** Satoshi;

Authorization on Views

- **create view** *geo_instructor* **as**
  (**select** *
  from *instructor*
  where *dept_name* = 'Geology');
- **grant select on** *geo_instructor* **to** *geo_staff*
- Suppose that a *geo_staff* member issues
  - **select** *
    from *geo_instructor*;
- What if
  - *geo_staff* does not have permissions on *instructor?*
  - Creator of view did not have some permissions on *instructor?*

Other Authorization Features

- **references** privilege to create foreign key
  - **grant reference** (*dept_name*) **on** *department* **to** Mariano;
  - Why is this required?
- transfer of privileges
  - **grant select on** *department* **to** Amit **with grant option**;
  - **revoke select on** *department* **from** Amit, Satoshi **cascade**;
  - **revoke select on** *department* **from** Amit, Satoshi **restrict**;
  - And more!

Note:

- Like in many other cases, SQL DBMS have product specific variations.

Switch to notebook.

REST

Data Modeling Concepts and REST

Almost any data model has the same core concepts:

- Types and instances:
  - Entity Type: A definition of a type of thing with properties and relationships.
  - Entity Instance: A specific instantiation of the Entity Type
  - Entity Set Instance: An Entity Type that:
    - Has properties and relationships like any entity, but ...
    - Has at least one *special relationship* – ***contains.***
- Operations, minimally CRUD, that manipulate entity types and instances:
  - Create
  - Retrieve
  - Update
  - Delete
  - Reference/Identify/... ...

REST (https://www.tutorialspoint.com/restful/restful_introduction.htm)

What is REST architecture?

REST stands for REpresentational State Transfer. REST is web standards based architecture and uses HTTP Protocol. It revolves around resource where every component is a resource and a resource is accessed by a common interface using HTTP standard methods. REST was first introduced by Roy Fielding in 2000.

In REST architecture, a REST Server simply provides access to resources and REST client accesses and modifies the resources. Here each resource is identified by URIs/ global IDs. REST uses various representation to represent a resource like text, JSON, XML. JSON is the most popular one.

HTTP methods

Following four HTTP methods are commonly used in REST based architecture.

- **GET** – Provides a read only access to a resource.
- **POST** – Used to create a new resource.
- **DELETE** – Used to remove a resource.
- **PUT** – Used to update a existing resource or create a new resource.

REST (https://www.tutorialspoint.com/restful/restful_introduction.htm)

Introduction to RESTFul web services

A web service is a collection of open protocols and standards used for exchanging data between applications or systems. Software applications written in various programming languages and running on various platforms can use web services to exchange data over computer networks like the Internet in a manner similar to inter-process communication on a single computer. This interoperability (e.g., between Java and Python, or Windows and Linux applications) is due to the use of open standards.

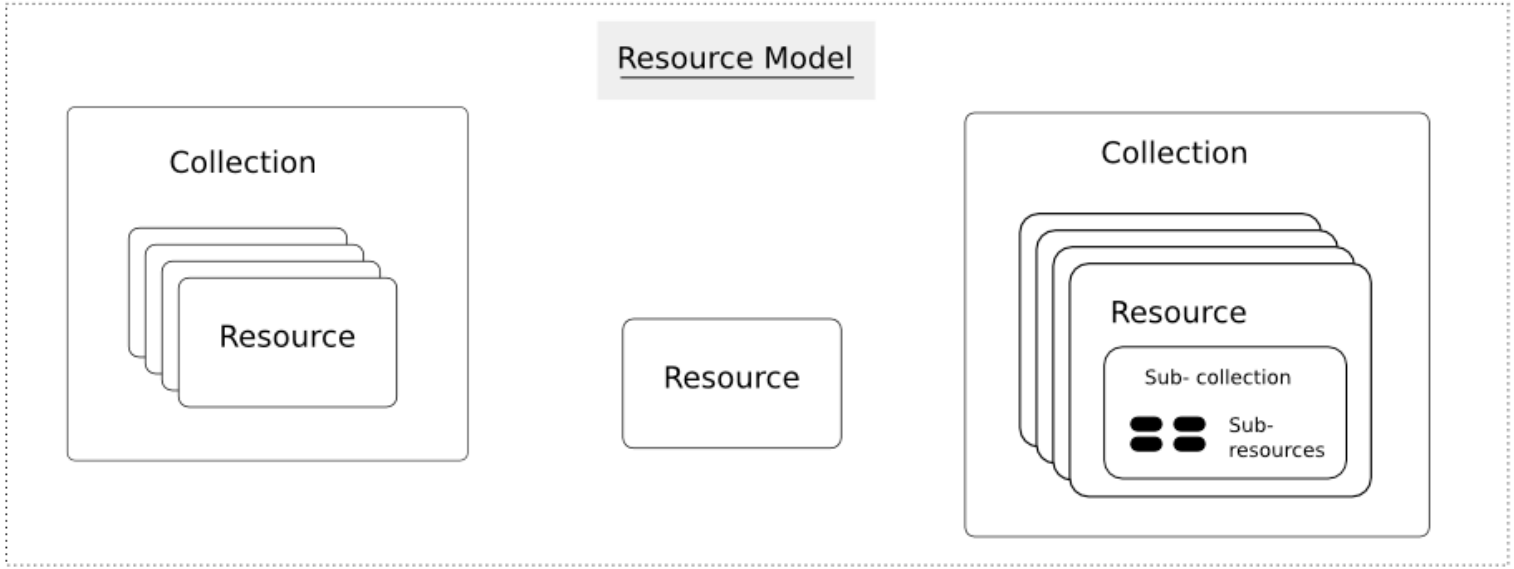
Web services based on REST Architecture are known as RESTful web services. These webservices uses HTTP methods to implement the concept of REST architecture. A RESTful web service usually defines a URI, Uniform Resource Identifier a service, provides resource representation such as JSON and set of HTTP Methods.

Creating RESTFul Webservice

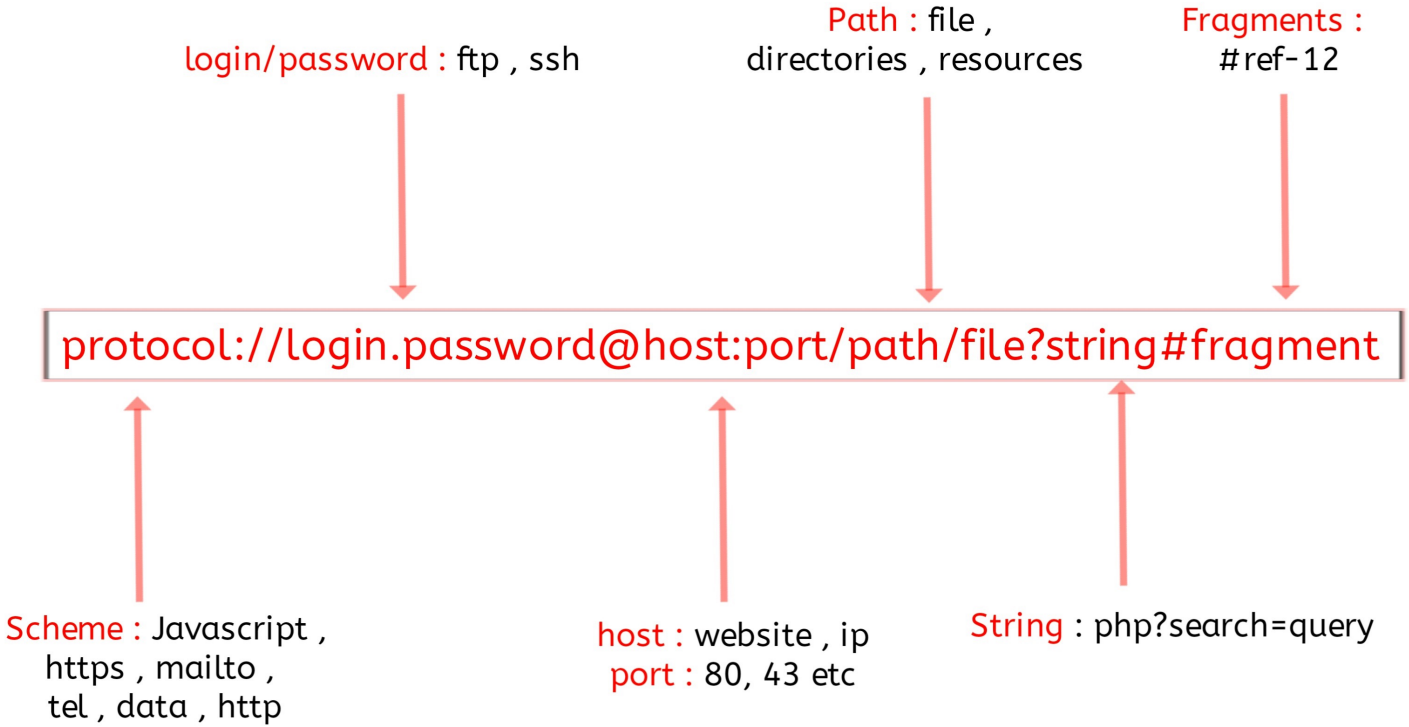
In next chapters, we'll create a webservice say user management with following functionalities –

Sr.No.	URI	HTTP Method	POST body	Result
1	/UserService/users	GET	empty	Show list of all the users.
2	/UserService/addUser	POST	JSON String	Add details of new user.
3	/UserService/getUser/:id	GET	empty	Show details of a user.

REST and Resources



URLs



jdbc:mysql://columbia-examples.ckkqqktwkcji.us-east-1.rds.amazonaws.com:3306

Simplistic, Conceptual Mapping (Examples)

REST Method	Resource Path	Relational Operation	DB Resource
DELETE	/people	DROP TABLE	people table
POST	/people	INSERT INTO PEOPLE (...) VALUES(...)	people table people row
GET	/people/21	SHOW KEYS FROM people ...; SELECT * FROM people WHERE playerID= 21	people row
GET	/people/21/batting	SELECT batting.* FROM people JOIN batting USING(playerID) WHERE playerID=21	
GET	/people/21/batting/2004_1	SELECT batting.* FROM people JOIN batting USING(playerID) WHERE playerID=21 AND yearID=2004 AND stint=1	

Application Architecture

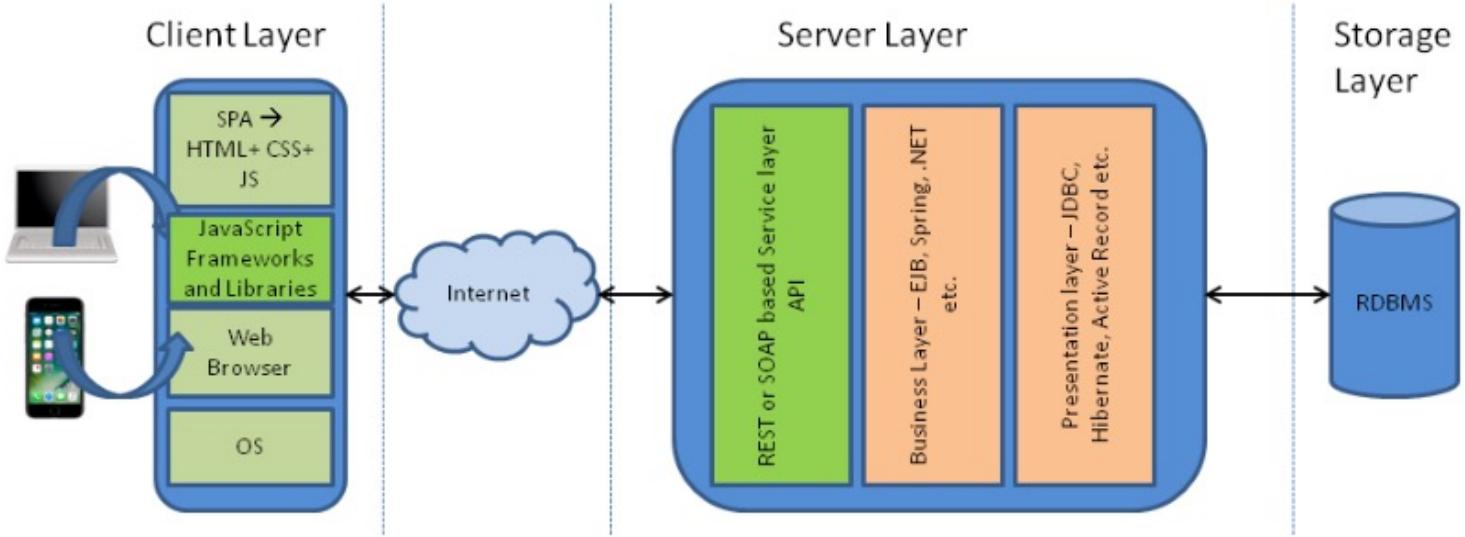


Diagram 2: The moving of the Web Layer from the Server to the Client

Sample Projects

Projects

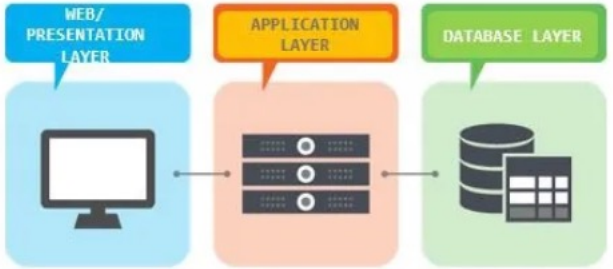
- The programming track will implement a simple, full stack web application.

Full-stack Web Developer

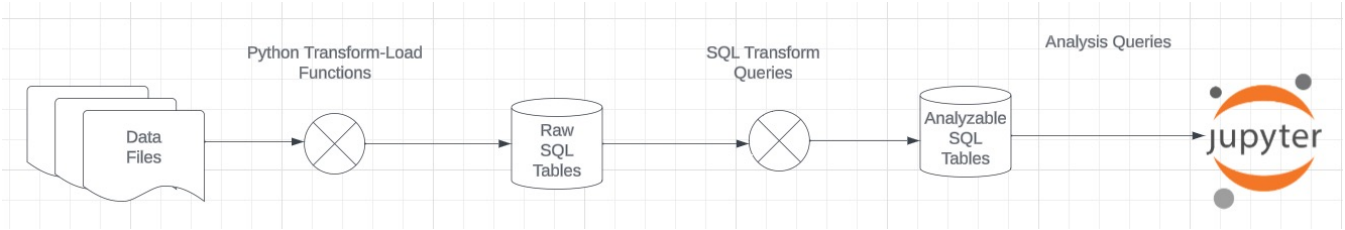
A full-stack web developer is a person who can develop both **client** and **server** software.

In addition to mastering HTML and CSS, he/she also knows how to:

- Program a **browser** (e.g. using JavaScript, jQuery, Angular, or Vue)
- Program a **server** (e.g. using PHP, ASP, Python, or Node)
- Program a **database** (e.g. using SQL, SQLite, or MongoDB)



- The non-programming track will implement a data engineering and visualization process in a Jupyter notebook.



Game of Thrones

- Bottom-Up Data Mapping:
  - "Nouns" usually map to Entity/Entity Set.
  - Nouns inside other nouns often map to:
    - Attribute
    - Relationship
  - Verbs often map to relationships.
  - Adjectives usually map to properties.
- We will start with a subset of the information:
  - Game of Thrones:
    - Episodes
    - Characters
  - IMDB:
    - names_basics
    - title_basics

- Entities Sets
  - Character
  - Season
  - Episode
  - Scene
  - Location, Sublocation
  - … …
- Relationships
  - Character – Scene
  - Character – Character (e.g. KilledBy)
  - Season – IMDB Title
  - Character – IMDB Name
  - … …

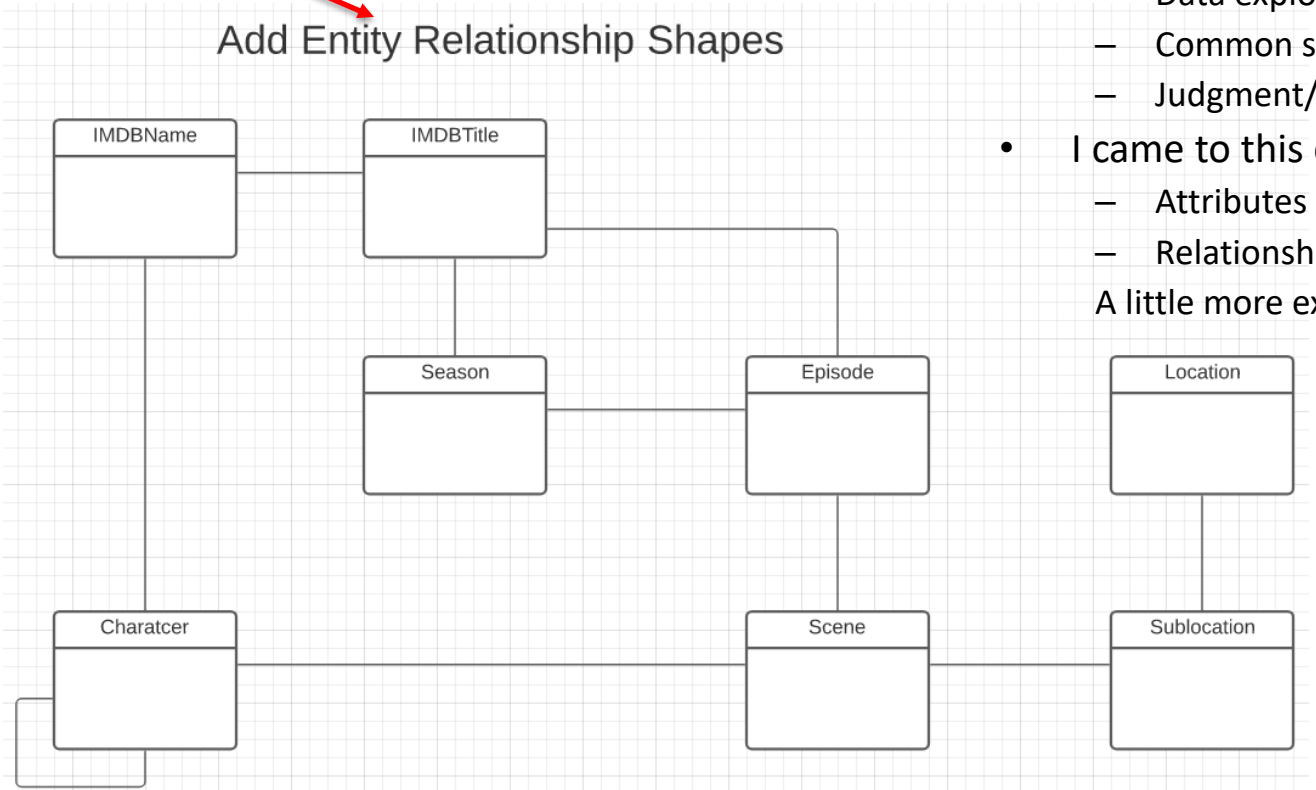
Game of Thrones

- Bottom-Up Data Mapping:
  - –
  - –
  - –
  - –
- We
  info
  - –
  - – IM
    - names_basics
    - title_basics
- Entities Sets
  - – Character – IMDB Name
  - – … …

1. IMDB: https://developer.imdb.com/non-commercial-datasets/
   - Do not download.
   - Despite being “tiny” compared to the reall world.
   - The datasets are too big for most laptops.
2. Game of Thrones: https://github.com/jeffreylancaster/game-of-thrones

Game of Thrones – Conceptual Model

Add shapes in Lucidchart ...



- With a little
  - Data exploration
  - Common sense
  - Judgment/experience
- I came to this conceptual model.
  - Attributes unspecified
  - Relationship required/cardinality unspecified.

  A little more exploration is needed.

Sample Projects

- Walkthrough of Web Apps:
  - /Users/donaldferguson/Dropbox/000/000-A-Current-Examples/W4111-FastAPI-IMDB-Solution
  - /Users/donaldferguson/Dropbox/000/000-A-Current-Examples/current-dashboard

- Data Engineering:
  - /Users/donaldferguson/Dropbox/000/000-Columbia/2024-Spring/W4111-Intro-to-Databases-Spring-2024/Lectures/s-2024-Lecture-3/More-Data-Engineering.ipynb
  - And others.

- Sample Notebook on GoT.