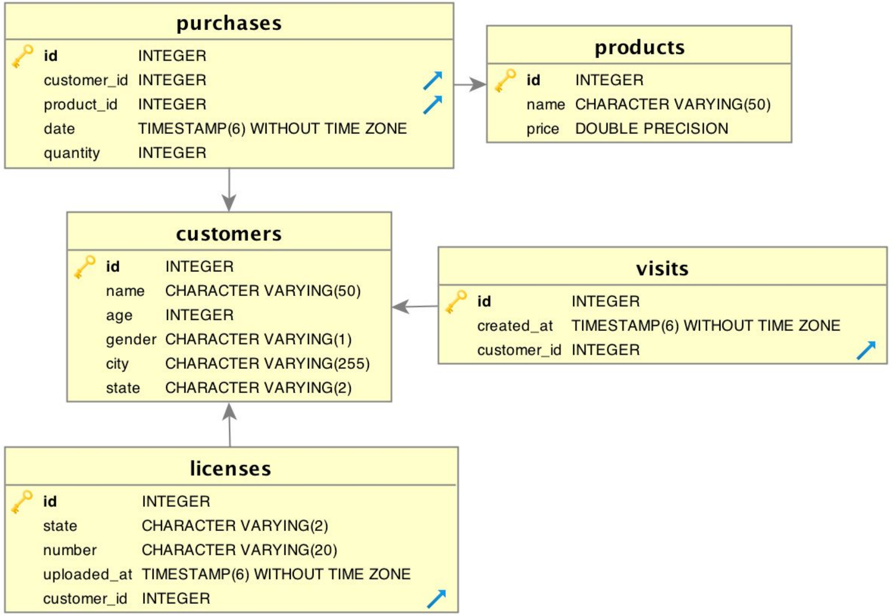
SQL

DSI, Galvanize, Seattle

Jack Bennetto
Jean-François Omhover
Miles Erickson



purchases

id	INTEGER
customer_id	INTEGER
product_id	INTEGER
date	TIMESTAMP(6) WITHOUT TIME ZONE
quantity	INTEGER

products

id	INTEGER
name	CHARACTER VARYING(50)
price	DOUBLE PRECISION

customers

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state	CHARACTER VARYING(2)

visits

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licenses

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OBJECTIVES

- **Explain** the advantages and disadvantages of an RDMBS (i.e., Postgres)
- **Connect** to a Postgres database
- **Design** and **write** queries to answer questions using SQL

Standards

- Connect to a SQL database via command line (i.e. Postgres).
- Connect to a database from within a python program.
- State function of basic SQL commands.
- Write simple queries on a single table including SELECT, FROM, WHERE, CASE... clauses and aggregates.
- Write complex queries including JOINS and subqueries.
- Explain how indexing works in Postgres.
- Create and dump tables.
- Format a query to follow a standard style.
- Move data from SQL database to text file.

Relational Database Management System (RDBMS)

It is a **persistent data storage system**

- survives after the process in which it was created has ended
- is written to non-volatile storage

RDBMS is the de facto standard for storing data

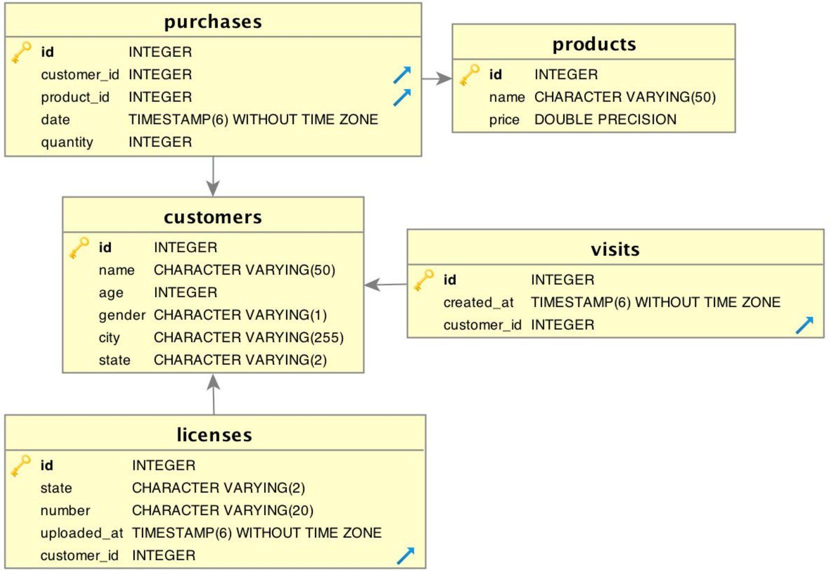
- Examples: Oracle, MySQL, SQLServer, Postgres
- Non-relational models are used for some applications (including data science)

Why RDBMS ?

An RDBMS provides the ability to

- **Model** relations in data
- **Query** data and their relations efficiently
- **Maintain** data consistency and integrity

It will require a Data Model



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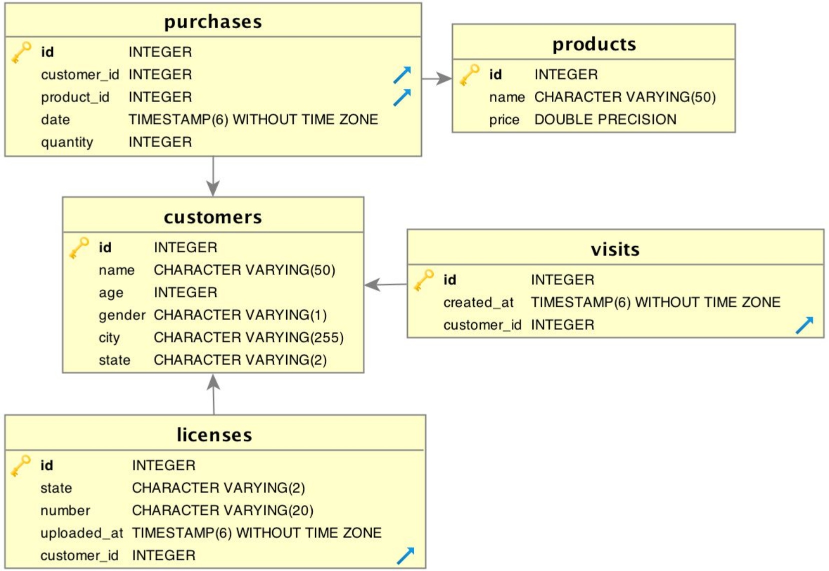
RDBMS Data Model

- **Schema** defines the structure of the data
- The **database** is composed of a number of user-defined **tables**
- Each **table** will have **columns** (aka fields) and **rows** (aka records)
- A column is of a given **data type**
- A row is an entry in a table with data for each column of that table



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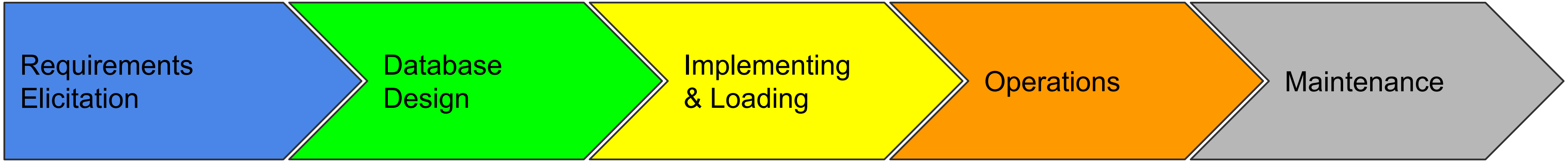
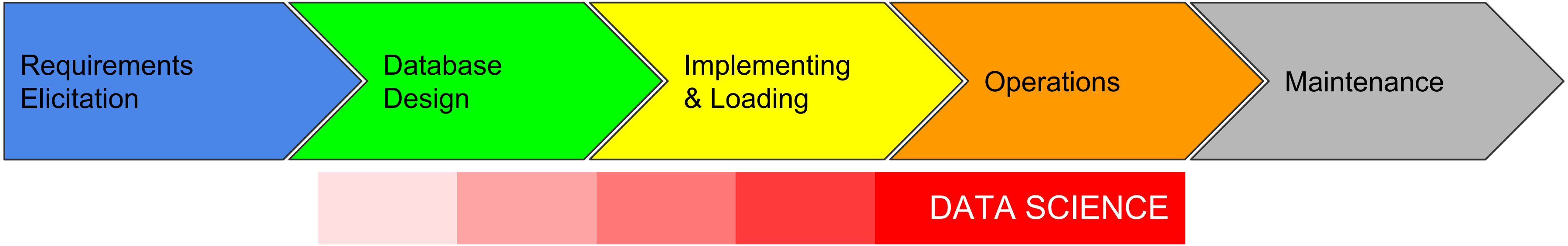
RDBMS and SQL

- SQL is the language used to query relational databases
- **All RDBMS use SQL** and the syntax and keywords are the same for the most part, across systems
- **SQL is used to interact** with RDBMS, allowing you to create tables, alter tables, insert records, update records, delete records, and query records within and across tables.
- Even non-relational databases like **Hadoop** usually have a SQL-like interface available.

Database Life Cycle (DBLC)



Concepts of the day in the DBLC



Requirements Elicitation

Database Design

Implementing & Loading

Operations

Maintenance

DATA SCIENCE

Normalization

Primary Keys
Foreign Keys
CREATE
DROP
INSERT

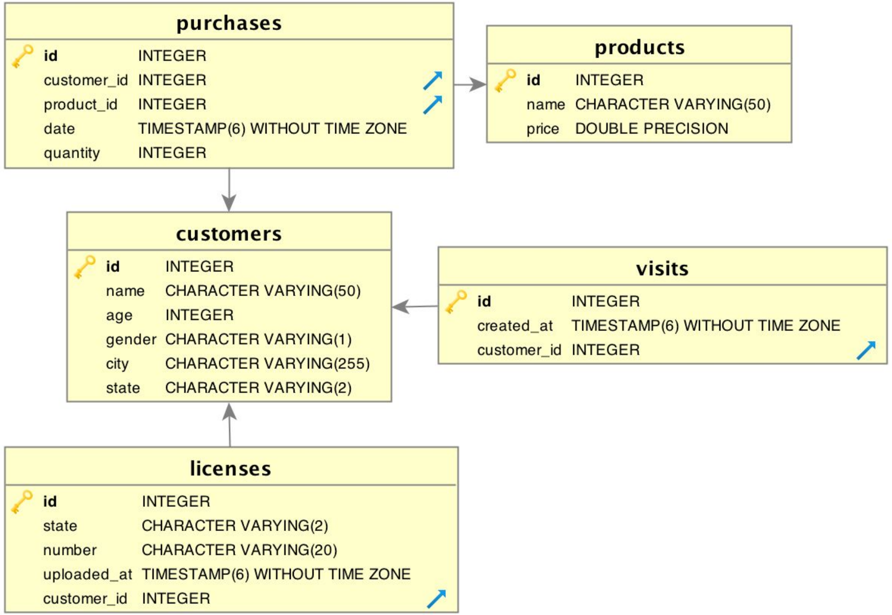
SELECT
FROM
WHERE
JOIN
HAVING
DISTINCT
GROUP BY
ORDER BY

Database Normalization

Store each piece of information in exactly one place

- Details about a user (address, age) are only stored once (in a users table)
- Any other table (eg. purchases) where this data might be relevant, only references the user_id

Why is this a good thing?



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Normal Forms

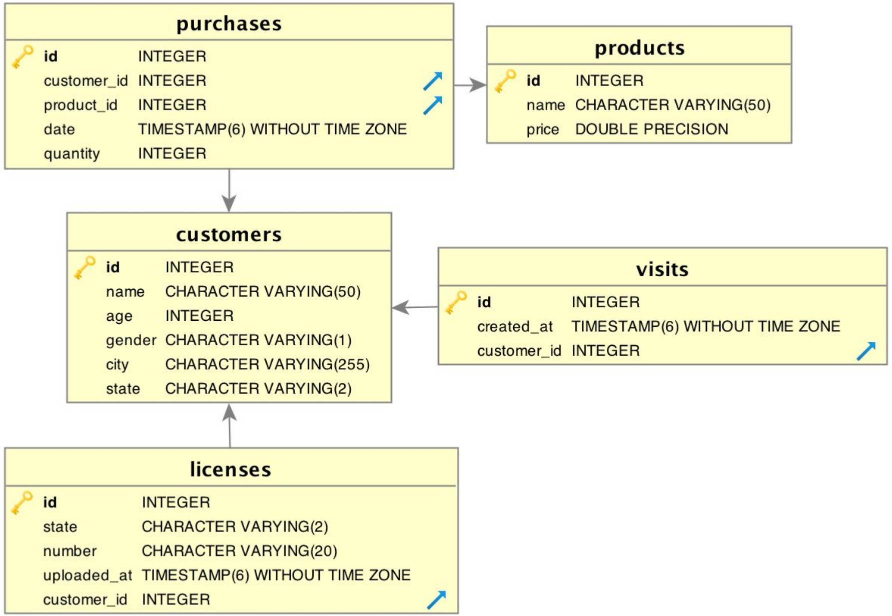
Normalization is explained through “normal forms”

1st Normal Form: each attribute has a single value

2nd Normal Form: no dependencies on part of a key

3rd Normal Form: no transitive dependencies

...



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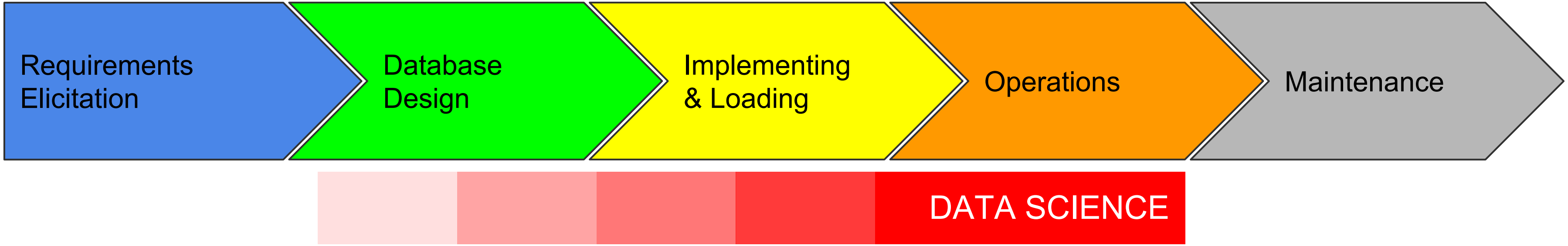
Why Not Normalize?

Sometimes databases are not fully normalized.

- Data structure not known/may change
- Writing a schema/converting data is hard
- Simple queries are important
- Data will not be changed/integrity not important
- Storage is cheap

Data Science in the DBLC

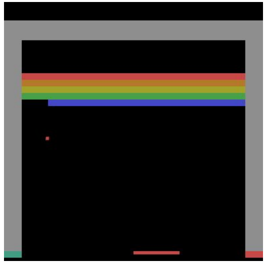


DS / Operations: querying, aggregating

DS / Implementing: identifying, cleaning, pushing external data sources inside a RDBMS

DS / Design: recommendations on the model, specs on operations

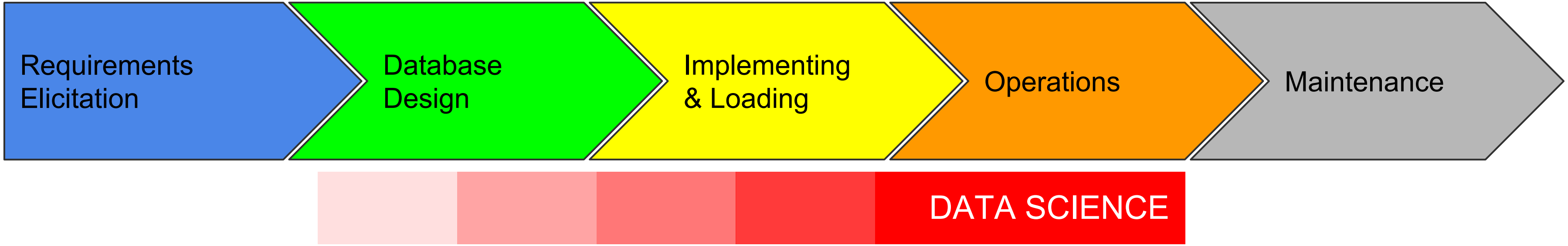
Question !



As a data scientist, what are the advantages of storing, querying, and maintaining data in a SQL database over curating your own flat files (e.g. csv files) ?

...

Concepts of the day in the DBLC



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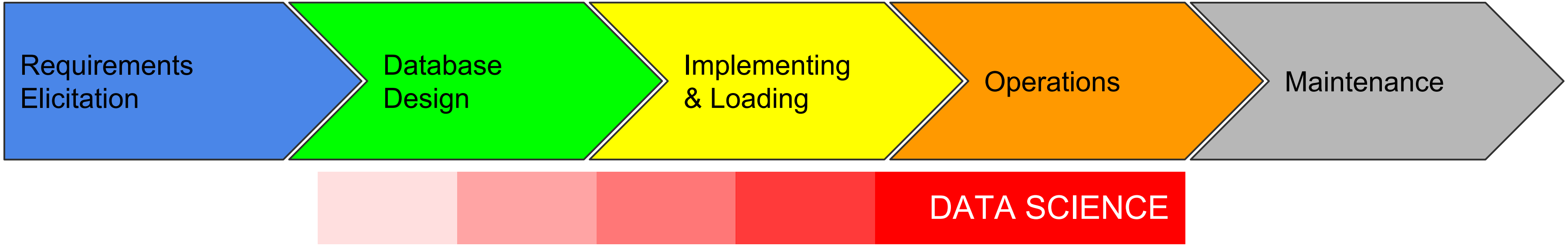

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PostGres Basics

Ways to use psql in the shell/term:

`$ psql`	connects to postgres server
`$ psql -U [USERNAME]`	connects with given username
`$ psql [DBNAME]`	connects to a given database
`$ psql < script.sql`	reads file script.sql and send commands to psql

Try it live:

- *Open file sql/lecture_create.sql in atom*
- *Use it to create a “dsilecture” database on your psql server*

PostGres Basics

Useful psql commands at the prompt [link]:

`# \h`	SQL help
`# \?`	psql commands help
`# \l`	List all the tables in the database
`# \d`	Describe the table schema
`# \d db_name`	Describe tables for a specific db
`# \connect db_name`	Connects to a database

Try it live: Connect to “dsilecture” and describe schema of table “customer”

Creating a table with a schema

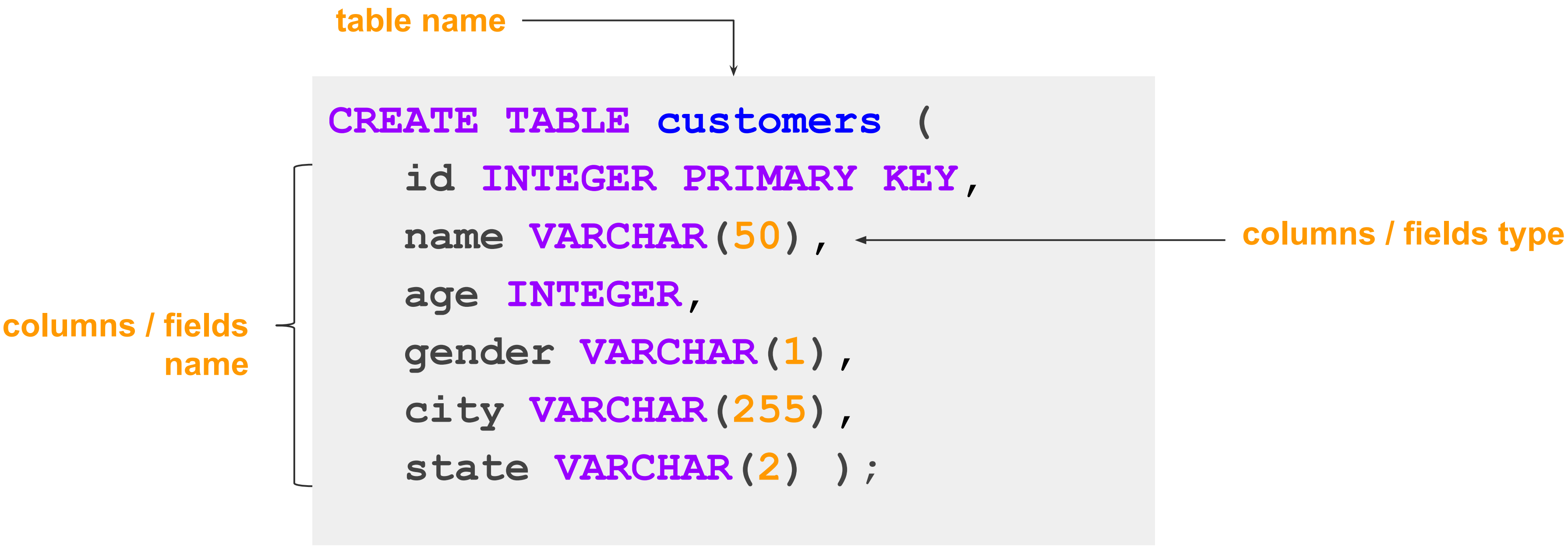


table name

```sql
CREATE TABLE customers (
    id INTEGER PRIMARY KEY,
    name VARCHAR(50),
    age INTEGER,
    gender VARCHAR(1),
    city VARCHAR(255),
    state VARCHAR(2) );
```

columns / fields type

columns / fields name

Inserting values in a table

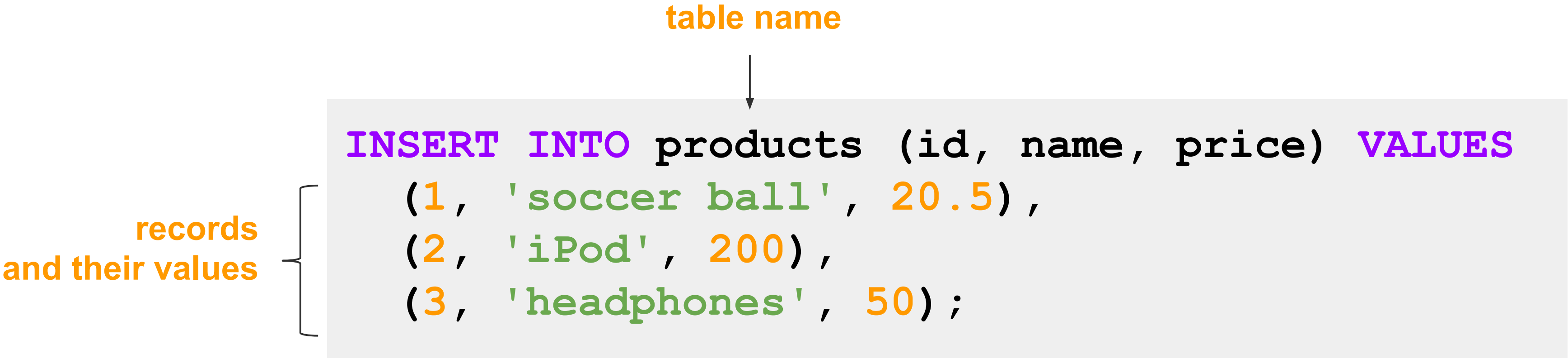


table name

records
and their values

```
INSERT INTO products (id, name, price) VALUES
  (1, 'soccer ball', 20.5),
  (2, 'iPod', 200),
  (3, 'headphones', 50);
```

SQL Queries for table creation / maintenance

Creating a table from query:

```
CREATE [TEMPORARY] TABLE table AS <SQL query>;
```

Inserting records in a table:

```
INSERT INTO table [(c1,c2,c3,…)] VALUES (v1,v2,v3,…);
```

Updating records:

```
UPDATE table SET c1=v1,c2=v2,… WHERE cX=vX;
```

Delete records:

```
DELETE FROM table WHERE cX=vX;
```

Change model (add, drop, modify columns):

```
ALTER TABLE table [DROP/ADD/ALTER] column [datatype];
```

Delete a table:

```
DROP TABLE table;
```

Designing a database with keys

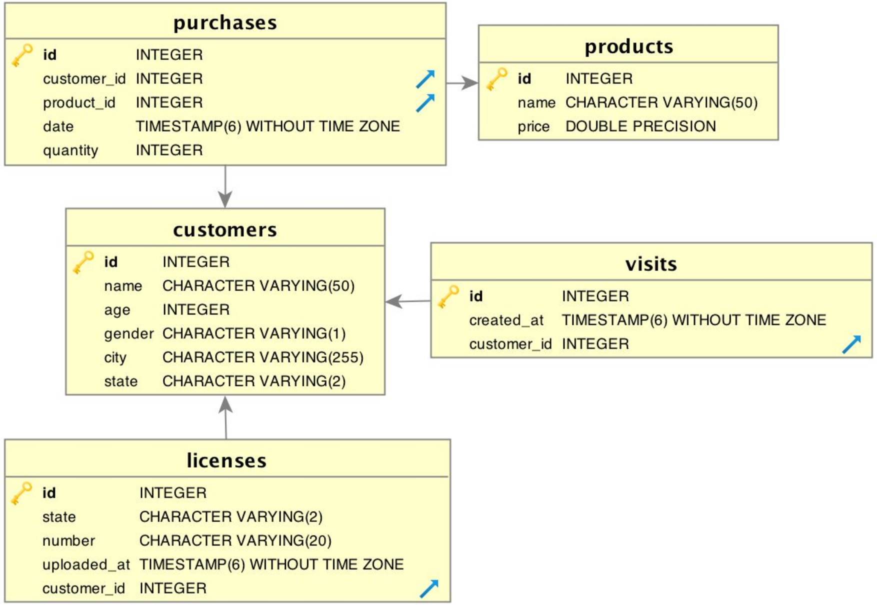
Primary Key

A primary key is a special column of a table that uniquely identifies that entry.

A primary key is not always an integer; it could be a combination of columns, hash, timestamp..etc.,

Foreign Keys

Foreign Keys are columns that reference some other entry in the database.



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visits	
id	INTEGER
created_at	TIMESTAMP(6) WITHOUT TIME ZONE
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licenses	
id	INTEGER
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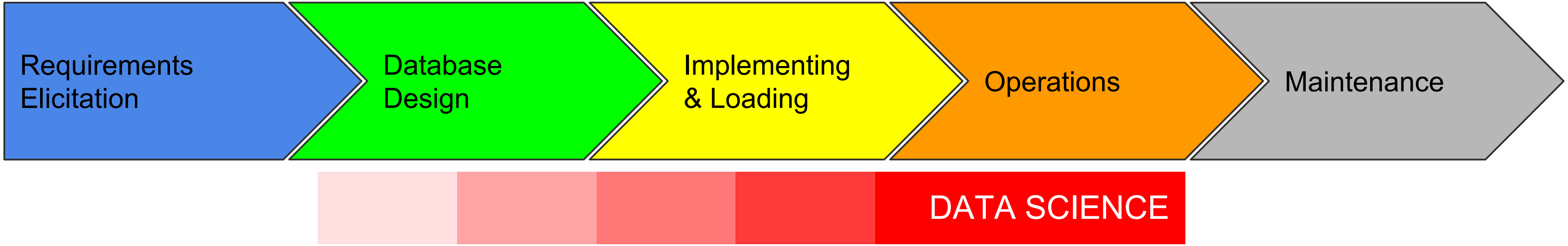

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SQL Syntax

All SQL queries have three main ingredient :

SELECT	*What* data do you want?
FROM	*Where* do you want to get the data from?
WHERE	*Under what* conditions?

SQL is Declarative rather than Imperative. That is, you tell the machine what you want and it (database optimizer) decides how to do it

Advanced: You can use `EXPLAIN` to look at the how

SQL Queries

Select the columns name, age from the table users.

```
SELECT name, age
FROM customers
```

SQL always returns a table, so the output of the query above is a sub-table of users with 2 columns.

Select name and age for every user in users who live in CA.

```
SELECT name, age
FROM customers
WHERE state = 'CA'
```

SQL Examples

Open file sql/lecture_examples.sql

Run them in psql

JOIN

JOIN clause used to query across multiple tables using foreign keys

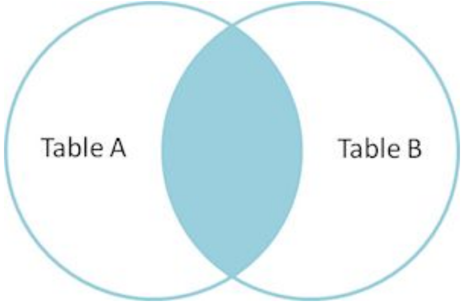
Every JOIN has two segments:

Specifying the tables to JOIN
Specifying the columns to match

JOIN types

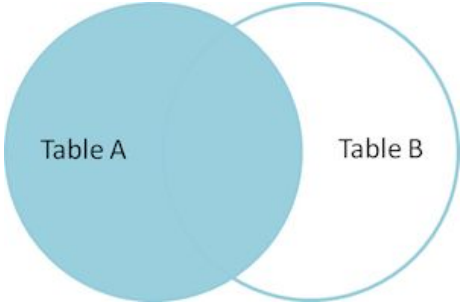
INNER JOIN

discards any entries
that do not have a match
between the tables
based on the given keys.



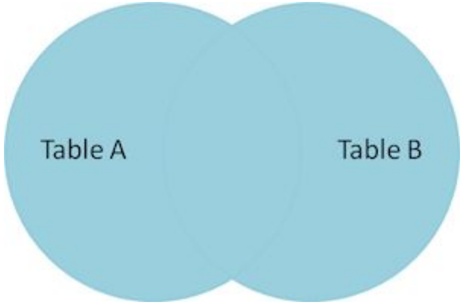
LEFT OUTER JOIN

keeps all entries
in the left table
regardless of
whether a match is found
in the right table



FULL OUTER JOIN

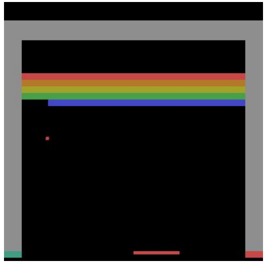
will keep the rows
of both tables
no matter what



copied from http://blog.codinghorror.com/a-visual-explanation-of-sql-joins/

Question

How many rows would result in
(inner join, left join, right join, full outer join) on `department_id` ?



employee_id	department_id	name	salary
2	1	Jon	40000
7	1	Linda	50000
12	2	Ashley	15000
1	0	Mike	80000

department_id	location
1	NY
2	SF
3	Austin

Subqueries

In general, you can replace any table name with a SELECT statement.

```
SELECT ..... FROM (SELECT ....) tempname
```

You can also declare some query as a temporary table

```
WITH tempname AS (SELECT ...)
SELECT * FROM tempname...
```

If a query returns a **single value**, you can treat it as such.

```
WHERE var1 = (SELECT ...)
```

If a query returns a **single column**, you can treat it sort of like a list/vector

```
WHERE var1 IN (SELECT ...)
```

Order of Evaluation of a SQL SELECT Statement

1. FROM + JOIN: first the product of all tables is formed

2. WHERE: the where clause filters rows that do not meet the search condition

3. GROUP BY + (COUNT, SUM, etc): the rows are grouped using the columns in the group by clause and the aggregation functions are applied on the grouping

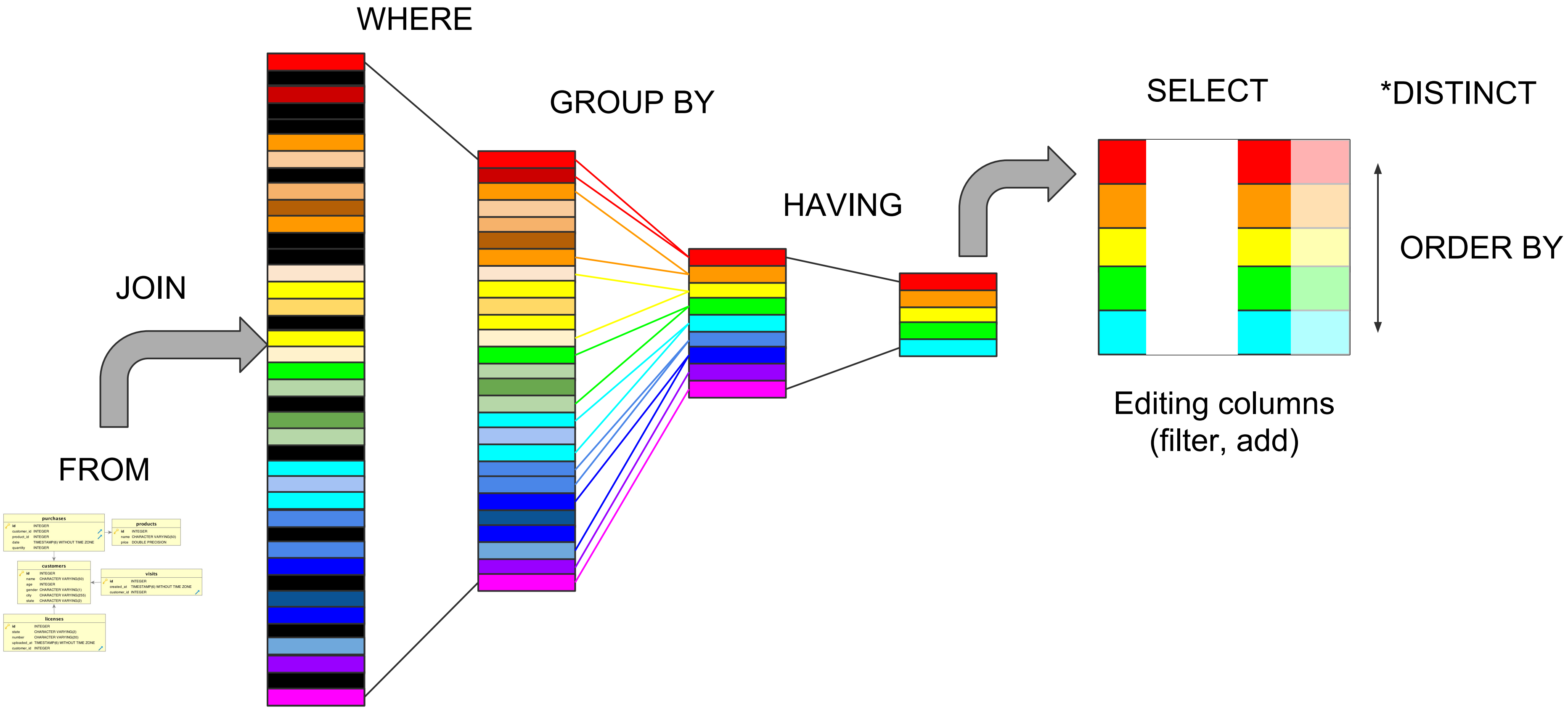
4. HAVING: like the WHERE clause, but can be applied after aggregation

5. SELECT: the targeted list of columns are evaluated and returned

6. DISTINCT: duplicate rows are eliminated

7. ORDER BY: the resulting rows are sorted

Order of Evaluation of a SQL SELECT Statement



FROM

JOIN

WHERE

GROUP BY

HAVING

SELECT

*DISTINCT

ORDER BY

Editing columns
(filter, add)

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Transactions

Suppose you update multiple records in a single statement.

One update fails.

What should happen?

What does happen?

Transactions

Database statements can be groups into a transaction.

End transaction with `commit` or `rollback`.

Default interactive behavior is autocommit.

Transactions are

- Atomic
- Consistent
- Isolated
- Durable

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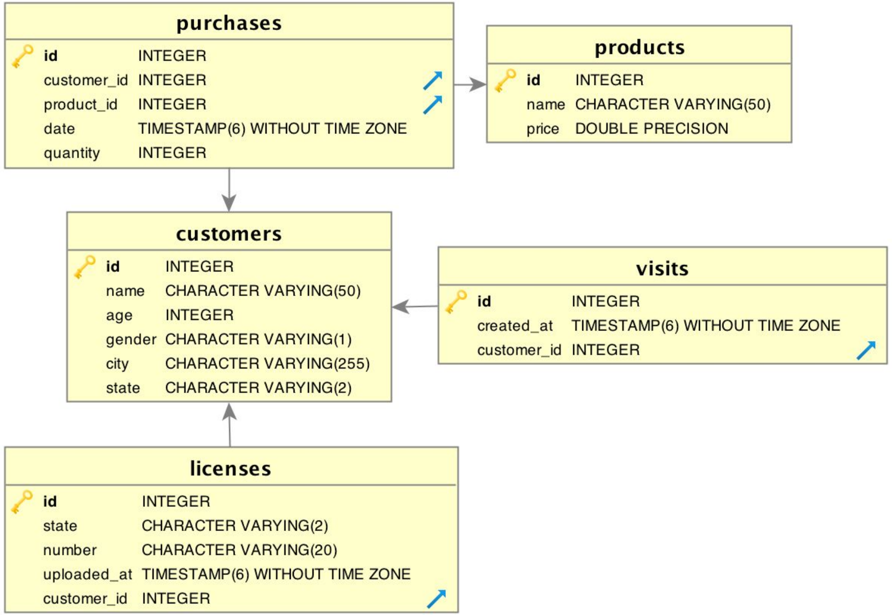

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