

Relational databases & SQL

Introduction with PostgreSQL

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2020-11-16 (updated: 2020-11-19)

Installation

Windows

<https://www.postgresql.org/download/windows>

Mac OS X

<https://www.postgresql.org/download/macosx>

Linux (Debian-based)

```
sudo sh -c 'echo "deb http://apt.postgresql.org/pub/repos/apt $(lsb.  
wget --quiet -O - https://www.postgresql.org/media/keys/ACCC4CF8.as  
sudo apt-get update  
sudo apt-get -y install postgresql'
```

What is SQL?

- SQL - Structured Query Language
- Database software
- Standard: ISO/IEC 9075 (since 1987)

The typical query

```
SELECT
  city_name,
  country,
  population
FROM cities
WHERE country = 'Austria'
```

R

```
require(data.table)
require(dplyr)
```

Why SQL?

SQL Software

FOSS



PostgreSQL



Proprietary

ORACLE®



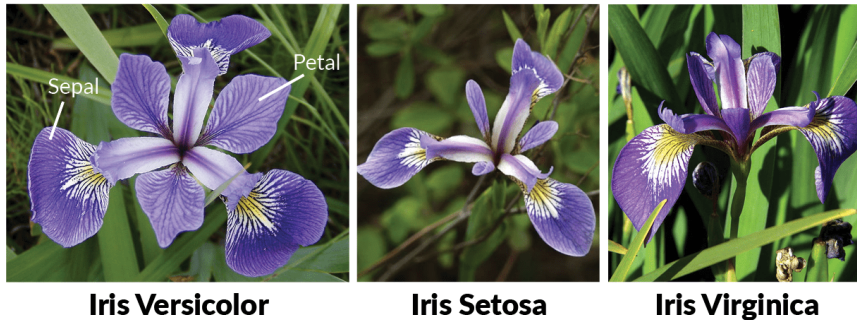
Queries

Queries - The typical query

```
SELECT  
    city_name,  
    country,  
    population  
FROM cities  
WHERE country = 'Austria'
```

Queries - Example data set

- R - iris dat set
- Dimensions: 150, 5



Sepal.Length	Sepal.Width	Petal.Length	Petal.Width	Species
5.1	3.5	1.4	0.2	setosa
4.9	3.0	1.4	0.2	setosa
4.7	3.2	1.3	0.2	setosa
4.6	3.1	1.5	0.2	setosa
5.0	3.6	1.4	0.2	setosa
5.4	3.9	1.7	0.4	setosa

Queries - SELECT

```
SELECT
    sepal_length,
    species AS new_name
FROM iris
```

```
SELECT * -- wildcard
FROM iris
LIMIT 10
```

Schema

```
SELECT *
FROM my_schema.iris
LIMIT 10
```

PostgreSQL addressing

```
database.schema.table.column
```

Queries - WHERE

```
SELECT
  sepal_length,
  species AS fancy_name
FROM iris
WHERE species = 'setosa'
AND sepal_length < 5
```

R-equivalent

```
# data.table
data.table::setDT(iris)
iris[ Species == 'setosa' & Sepal.Length < 5 ]
# dplyr
iris %>%
  dplyr::filter(Species == 'setosa' & Sepal.Length < 5)
```

Different syntax, same logic!

Queries - GROUP BY

```
SELECT
  species,
  count(species) AS n,
  max(sepal_length) AS max_sl,
  avg(sepal_length) AS mean_sl
FROM iris
GROUP BY species
```

R-equivalent

```
# data.table
dt = data.table::as.data.table(iris)
dt[,
  .(N,
    max_sl = max(Sepal.Length)),
  Species ]

# dplyr
iris %>%
  group_by(Species) %>%
  summarise(n = n(),
            max_sl = max(Sepal.Length))
```

Queries - ORDER BY

```
SELECT
  species,
  count(species) AS n,
  max(sepal_length) AS max_sl,
  avg(sepal_length) AS mean_sl
FROM iris
GROUP BY species
ORDER BY max_sl DESC -- ASC
```

Queries - HAVING

Same as WHERE, but only after GROUP BY.

```
SELECT
  species,
  count(species) AS n,
  max(sepal_length) AS max_sl,
  avg(sepal_length) AS mean_sl
FROM iris
GROUP BY species
HAVING species = 'versicolor'
ORDER BY max_sl DESC -- ASC
```

SQL queries run in this order

FROM + JOIN



WHERE



GROUP BY



HAVING



SELECT

(window functions)
happen here !

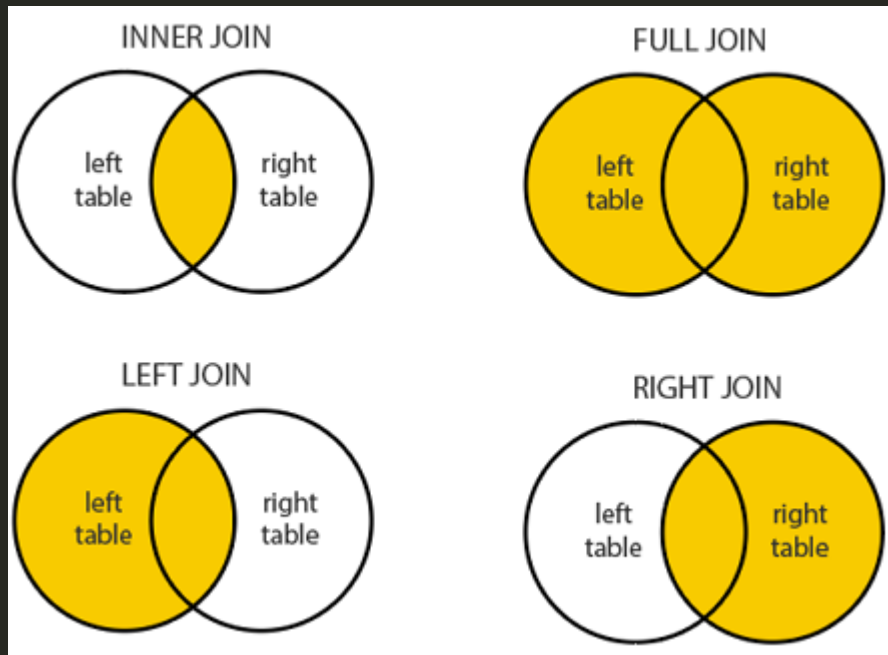


ORDER BY

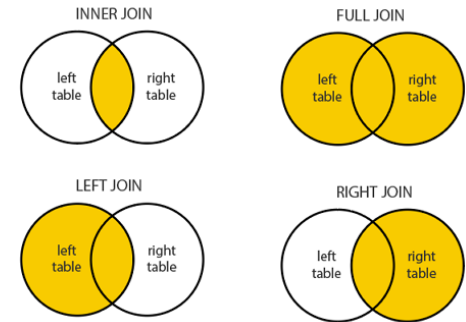


LIMIT

Queries - JOINS



Queries - JOINS



LEFT JOIN

```
SELECT *  
FROM my_table1 tab1  
LEFT JOIN my_table2 tab2 ON tab1.id = tab2.id
```

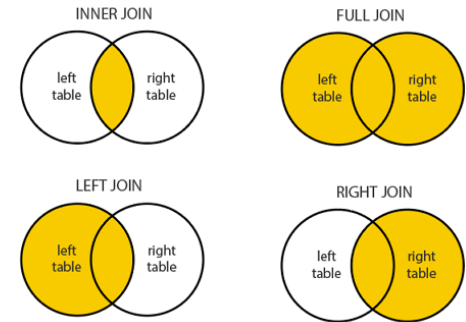
RIGHT JOIN

```
SELECT *  
FROM my_table1 tab1  
RIGHT JOIN my_table2 tab2 ON tab1.id = tab2.id
```

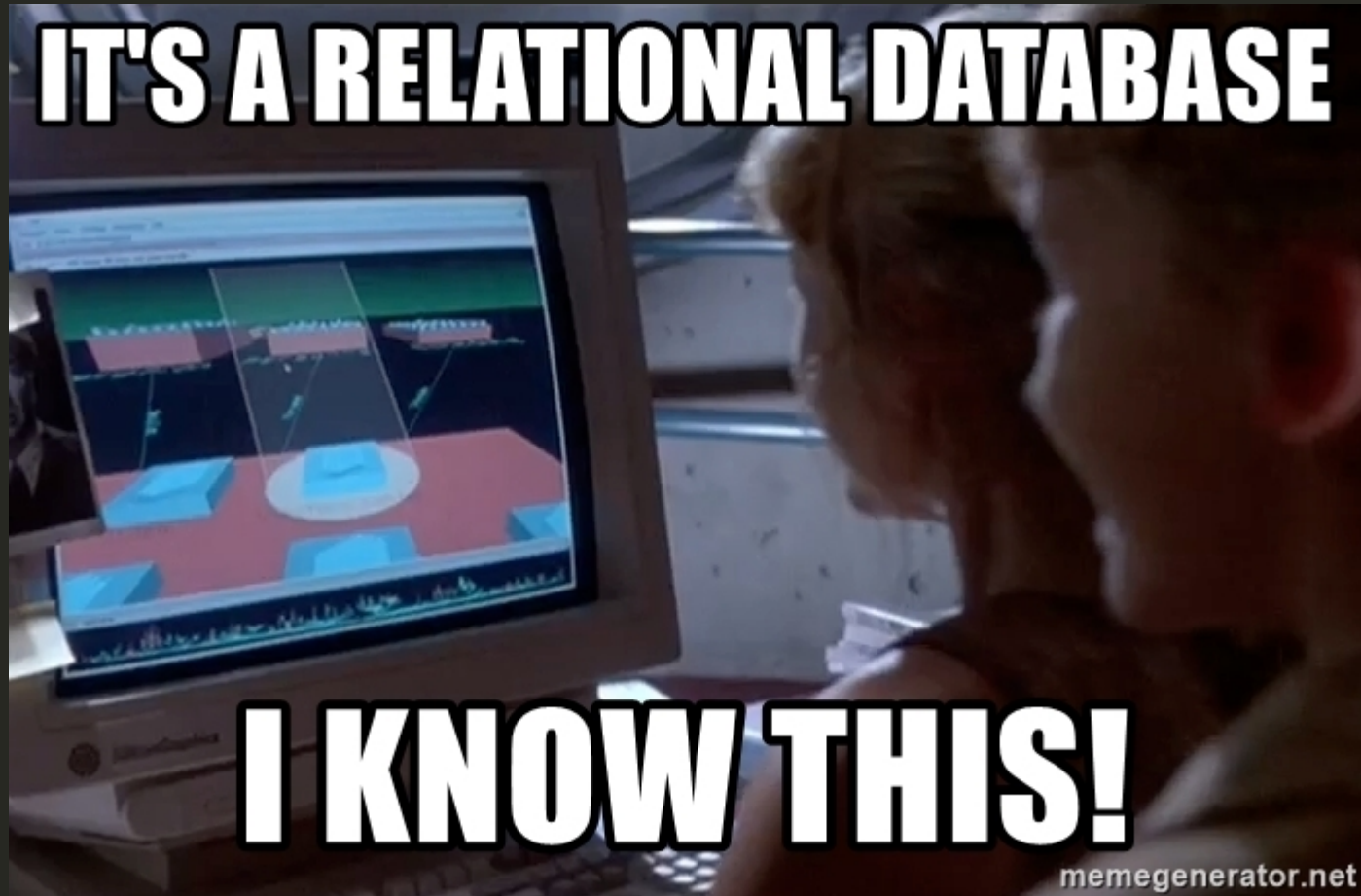

Queries - JOINS

INNER JOIN

```
SELECT *  
FROM my_table1 tab1  
INNER JOIN my_table2 tab2 ON tab1.id = tab2.id
```



Queries - JOINS



Data types

True



False



Data types

- more complex compared to R!

<https://www.postgresql.org/docs/13/datatype.html>

name	size	description	possible values	~R-type
boolean	1 byte	yes, no	true, false	logical
text	variable	string	all	character
<i>integer</i>	4 bytes	typical choice for integer	-2147483648 to +2147483647	integer
bigint	8 bytes	large-range integer	-9223372036854775808 to +9223372036854775807	integer64
numeric	variable	float, exact	up to 131072 digits before the decimal point, 16383 after	numeric
double precision	8 bytes	float	15 decimal digits precision	numeric
date	date	date	4713 BC to 5874897 AD	date
geometry	variable	Geographic information		sfc

Special symbols

Smbol	Description
--	One-line comment
/* Comment this */	Multi-line comment
*	Wildcard, meaning <i>all</i>
;	End query

Connect



Connect

Command Line Interface

```
psql -d 'my_db' -c 'SELECT * FROM my_table'
```

R, python, etc. clients

```
require(RPostgreSQL)
```

Graphical User Interfaces

- pgAdmin4
- dbeaver
- QGIS

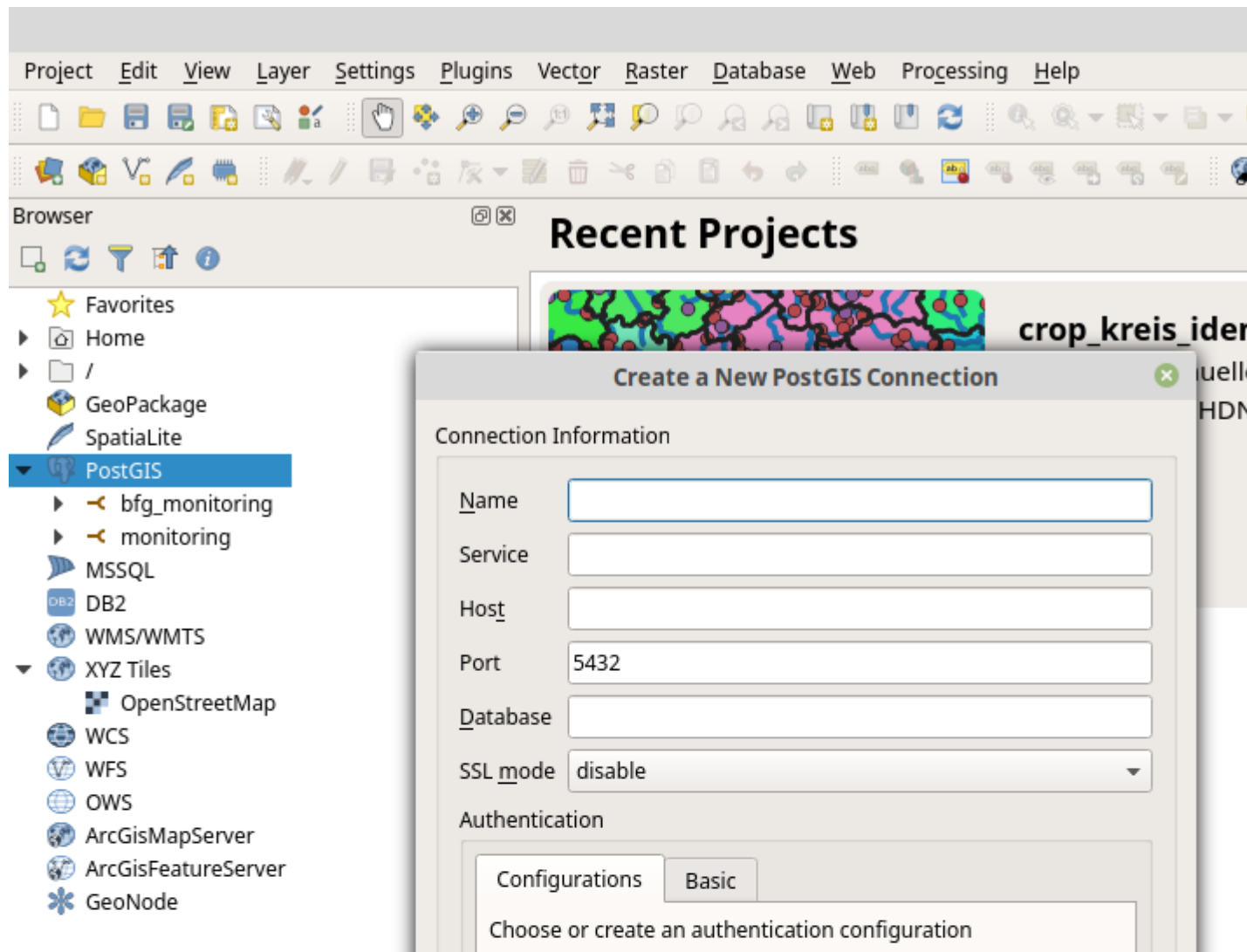
Connect - pgAdmin

The screenshot shows the pgAdmin 4 web interface in a Mozilla Firefox browser. The browser tab is labeled 'pgAdmin 4' and the address bar shows '110%'. The main navigation bar includes links for 'Server', 'Properties', 'SQL', 'Statistics', 'Dependencies', and 'Dependents'. The 'Dependents' tab is currently selected. A modal dialog box titled 'Create - Server' is open, displaying the 'Connection' tab. The dialog contains the following fields and controls:

- Host name/address:** 127.0.0.1
- Port:** 5432
- Maintenance database:** postgres
- Username:** postgres
- Password:** (empty field)
- Save password?:** ☐
- Role:** (empty field)
- Service:** (empty field)

At the bottom of the dialog, there are three buttons: 'Cancel', 'Reset', and 'Save'. There are also information and help icons on the left.

Connect - QGIS



Connect - R

Read

```
require(RPostgreSQL)

drv = dbDriver('PostgreSQL')
con = DBI::dbConnect(drv,
                     host = '127.0.0.1',
                     port = 5432,
                     dbname = 'my_db',
                     user = 'my_user',
                     password = 'my_password')

q_get = "SELECT *
        FROM my_table
        LIMIT 10"

dat = dbGetQuery(con, q) # a data.frame

dbDisconnect(con)
dbUnloadDriver(drv)
```

Careful, credentials!



Connect - R

Separate file for credentials

~/credentials.R

```
host = '127.0.0.1'  
port = 5432  
user = 'my_user'  
password = 'my_password'
```

Connect - R

Read

```
source('credentials.R') # credentials

drv = dbDriver('PostgreSQL')
con = DBI::dbConnect(drv,
                     host = host,
                     port = port,
                     dbname = 'mydb',
                     user = user,
                     password = password)

q_get = "SELECT *
        FROM my_table
        LIMIT 10"

dat = dbGetQuery(con, q) # a data.frame

dbDisconnect(con)
dbUnloadDriver(drv)
```

Connect - R

Write

```
source('credentials.R') # credentials

drv = dbDriver('PostgreSQL')
con = DBI::dbConnect(drv,
                     host = host,
                     port = port,
                     dbname = 'mydb',
                     user = user,
                     password = password)

dbWriteTable(con,
             name = c('schema', 'tbl'),
             value = iris, # data set
             overwrite = TRUE,
             row.names = FALSE)

dbDisconnect(con)
dbUnloadDriver(drv)
```

Connect - R

Send

```
source('credentials.R') # credentials

drv = dbDriver('PostgreSQL')
con = DBI::dbConnect(drv,
                     host = host,
                     port = port,
                     dbname = 'mydb',
                     user = user,
                     password = password)

q_send = "ALTER TABLE my_table ADD COLUMN col_new text;"
dbSendQuery(con, q_send)

dbDisconnect(con)
dbUnloadDriver(drv)
```

Differences SQL & R

Differences

PostgreSQL

- database
- data on disk
 - unlimited rows, 250-1600 columns
 - (partly) slow

R

- programming language
- data in memory
 - limited
 - fast

Advanced Queries

Queries - SELECT

```
SELECT
  CASE
    WHEN column1 < 10
    THEN 'small'
    ELSE 'large'
  END AS column1_categories,
  column2
FROM my_table
LIMIT 1e3
```

R-equivalent

```
data.table::fcase()
dplyr::case_when()
```

Queries - CEATE TABLE

```
CREATE new_table (  
  SELECT  
    tab1.id PRIMARY KEY,  
    tab1.column1  
  FROM my_table1 tab1  
  INNER JOIN my_table2 tab2 ON tab1.id = tab2.id  
)
```

Material

PostgreSQL: <https://www.postgresql.org/docs/13/index.html>

freeCodeCamp: <https://www.freecodecamp.org/news/sql-and-databases-full-course>

Data Camp: <https://www.datacamp.com/courses/introduction-to-sql>

Julia Evans (@b0rk): <https://wizardzines.com/comics/sql-query-order>

YouTube

Slides

- OLAT
- <https://andschar.github.io/teaching>

Made with

- <https://github.com/rstudio/rmarkdown>
- <https://github.com/yihui/knitr>
- <https://github.com/yihui/xaringan>

Thank you for your attention!