

R, Databases and Docker

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Chapter 1

Introduction

1.1 Using R to query a DBMS in your organization

- Large data stores in organizations are stored in databases that have specific access constraints and structural characteristics. Data documentation may be incomplete, often emphasizes operational issues rather than analytic ones, and often needs to be confirmed on the fly. Data volumes and query performance are important design constraints.
- R users frequently need to make sense of complex data structures and coding schemes to address incompletely formed questions so that exploratory data analysis has to be fast. Exploratory techniques for the purpose should not be reinvented (and so would benefit from more public instruction or discussion).
- Learning to navigate the interfaces (passwords, packages, etc.) between R and a database is difficult to simulate outside corporate walls. Resources for interface problem diagnosis behind corporate walls may or may not address all the issues that R users face, so a simulated environment is needed.

1.2 Docker’s role

Noam Ross’s “Docker for the UseR” suggests that there are four distinct Docker use-cases for useRs.

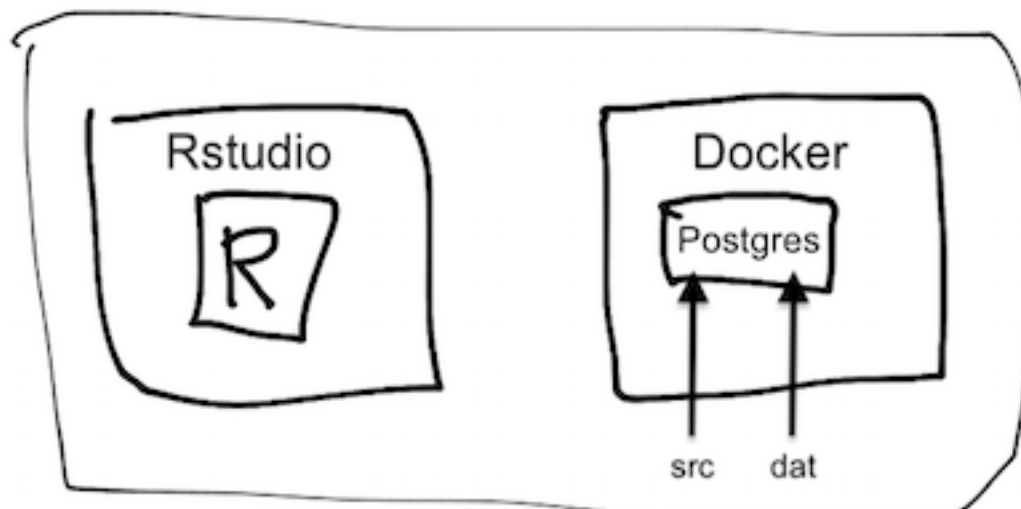
1. Make a fixed working environment for reproducible analysis
2. Access a service outside of R (**e.g., Postgres**)
3. Create an R based service (e.g., with **plumber**)
4. Send our compute jobs to the cloud with minimal reconfiguration or revision

This book explores #2 because it allows us to work on the database access issues described above and to practice on an industrial-scale DBMS.

- Docker is a relatively easy way to simulate the relationship between an R/RStudio session and a database – all on on a single machine, provided you have Docker installed and running.
- You may want to run PostgreSQL on a Docker container, avoiding any OS or system dependencies that might come up.

1.3 Docker and R on your machine

Here is how R and Docker fit on your operating system in this tutorial:



needs to be updated as our directory structure evolves.)

(This diagram

1.4 Who are we?

- M. Edward (Ed) Borasky - @znmeb
- John David Smith - @smithjd
- Scott Came - @scottcame
- Ian Franz - @ianfrantz
- Sophie Yang - @SophieMYang
- Jim Tyhurst - @jimtyhurst
- Paul Refalo - @paulrefalo

1.5 Prerequisites

You will need

- A computer running Windows, MacOS, or Linux (Any Linux distro that will run Docker Community Edition, R and RStudio will work),
- R, and RStudio and
- Docker hosting.

The database we use is PostgreSQL 10, but you do not need to install that - it's installed via a Docker image. RStudio 1.2 is highly recommended but not required.

In addition to the current version of R and RStudio, you will need the following packages:

- tidyverse
- DBI
- RPostgres
- glue
- dbplyr

1.6 Install Docker

Install Docker. Installation depends on your operating system:

- On a Mac
- On UNIX flavors
- For Windows, consider these issues and follow these instructions.

1.7 Download the repo

First step: download this repo. It contains source code to build a Docker container that has the dvdrental database in PostgreSQL and shows how to interact with the database from R.

Chapter 2

Docker Hosting for Windows (02)

Skip these instructions if your computer has either OSX or a Unix variant.

2.1 Hardware requirements

You will need an Intel or AMD processor with 64-bit hardware and the hardware virtualization feature. Most machines you buy today will have that, but older ones may not. You will need to go into the BIOS / firmware and enable the virtualization feature. You will need at least 4 gigabytes of RAM!

2.2 Software requirements

You will need Windows 7 64-bit or later. If you can afford it, I highly recommend upgrading to Windows 10 Pro.

2.2.1 Windows 7, 8, 8.1 and Windows 10 Home (64 bit)

Install Docker Toolbox. The instructions are here: https://docs.docker.com/toolbox/toolbox_install_windows/. Make sure you try the test cases and they work!

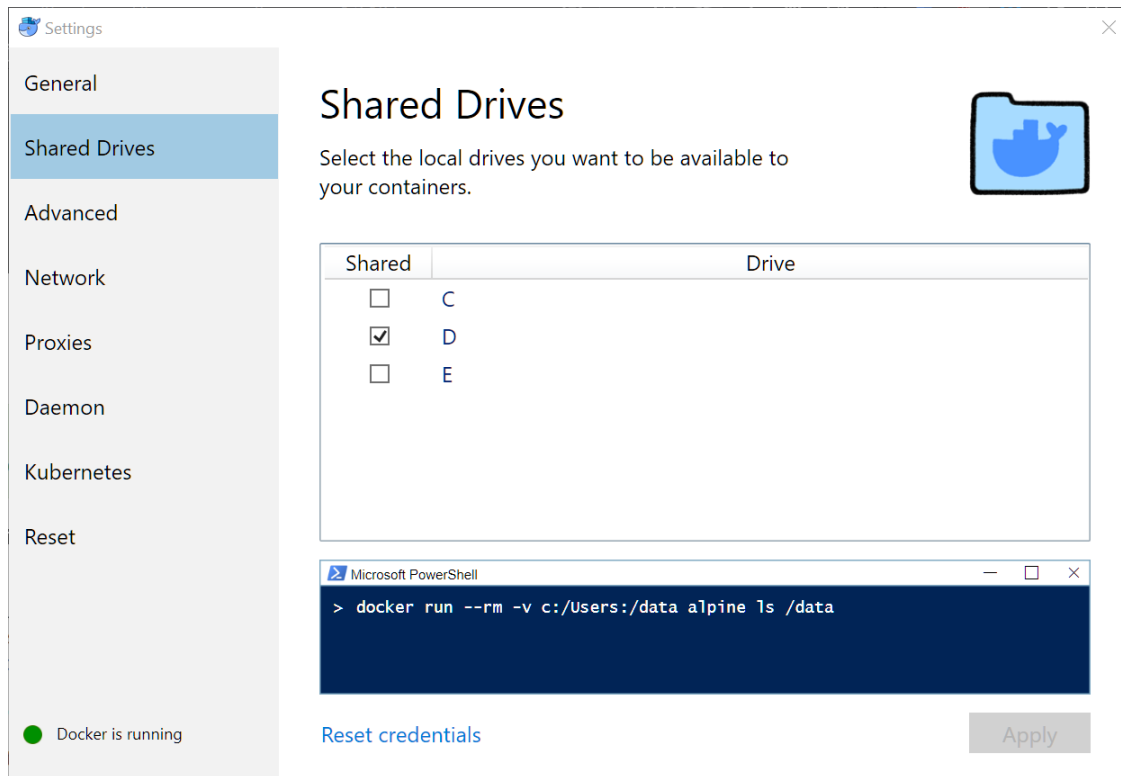
2.2.2 Windows 10 Pro

Install Docker for Windows *stable*. The instructions are here: <https://docs.docker.com/docker-for-windows/install/#start-docker-for-windows>. Again, make sure you try the test cases and they work.

2.3 Docker for Windows settings

2.3.1 Shared drives

If you're going to mount host files into container file systems (as we do in the following chapters), you need to set up shared drives. Open the Docker settings dialog and select **Shared Drives**. Check the drives you want to share. In this screenshot, the D: drive is my 1 terabyte hard drive.



2.3.2 Kubernetes

Kubernetes is a container orchestration / cloud management package that's a major DevOps tool. It's heavily supported by Red Hat and Google, and as a result is becoming a required skill for DevOps.

However, it's overkill for this project at the moment. So you should make sure it's not enabled.

Go to the **Kubernetes** dialog and make sure the **Enable Kubernetes** checkbox is cleared.



2.4 Git, GitHub and line endings

Git was originally developed for Linux - in fact, it was created by Linus Torvalds to manage hundreds of different versions of the Linux kernel on different machines all around the world. As usage has grown, it's achieved a huge following and is the version control system used by most large open source projects, including this one.

If you're on Windows, there are some things about Git and GitHub you need to watch. First of all, there are quite a few tools for running Git on Windows, but the RStudio default and recommended one is Git for Windows (<https://git-scm.com/download/win>).

By default, text files on Linux end with a single linefeed (`\n`) character. But on Windows, text files end with a carriage return and a line feed (`\r\n`). See <https://en.wikipedia.org/wiki/Newline> for the gory details.

Git defaults to checking files out in the native mode. So if you're on Linux, a text file will show up with the Linux convention, and if you're on Windows, it will show up with the Windows convention.

Most of the time this doesn't cause any problems. But Docker containers usually run Linux, and if you have files from a repository on Windows that you've sent to the container, the container may malfunction or give weird results. *This kind of situation has caused a lot of grief for contributors to this project, so beware.*

In particular, executable `sh` or `bash` scripts will fail in a Docker container if they have Windows line endings. You may see an error message with `\r` in it, which means the shell saw the carriage return (`\r`) and gave up. But often you'll see no hint at all what the problem was.

So you need a way to tell Git that some files need to be checked out with Linux line endings. See <https://help.github.com/articles/dealing-with-line-endings/> for the details. Summary:

1. You'll need a `.gitattributes` file in the root of the repository.
2. In that file, all text files (scripts, program source, data, etc.) that are destined for a Docker container will need to have the designator `<spec> text eol=lf`, where `<spec>` is the file name specifier, for

example, `*.sh`.

This repo includes a sample: `.gitattributes`

Chapter 3

Learning Goals and Use Cases

3.1 Context: Why integrate R with databases using Docker? (03)

- Large data stores in organizations are stored in databases that have specific access constraints and structural characteristics.
- Learning to navigate the gap between R and the database is difficult to simulate outside corporate walls.
- R users frequently need to make sense of complex data structures using diagnostic techniques that should not be reinvented (and so would benefit from more public instruction and commentary).
- Docker is a relatively easy way to simulate the relationship between an R/Rstudio session and database – all on on a single machine.

3.2 Learning Goals

After working through this tutorial, you can expect to be able to:

- Run queries against PostgreSQL in an environment that simulates what you will find in a corporate setting.
- Understand some of the trade offs between queries aimed at exploration or informal investigation using dplyr and those where performance is important because of the size of the database or the frequency with which a query is run. You will be able to rewrite dplyr queries as SQL and submit them directly. You will have some understanding of techniques for assessing query structure and performance.
- Set up a PostgreSQL database in a Docker environment and understand enough about Docker to swap databases, swap DBMS' (e.g., MySQL for PostgreSQL, etc.)

3.3 Use cases

Imagine that you have one of several roles at **DVDs R Us** and that you need to:

- As a data scientist, I want to know the distribution of number of rentals per month per customer, so that the Marketing department can create incentives for customers in 3 segments: Frequent Renters, Average Renters, Infrequent Renters.
- As the Director of Sales, I want to see the total number of rentals per month for the past 6 months and I want to know how fast our customer base is growing/shrinking per month for the past 6 months.
- As the Director of Marketing, I want to know which categories of DVDs are the least popular, so that I can create a campaign to draw attention to rarely used inventory.
- As a shipping clerk, I want to add rental information when I fulfill a shipment order.



Figure 3.1: Entity Relationship diagram for the dvdrental database

- As the Director of Analytics, you want to test as much of the production R code in my shop against a new release of the DBMS that the IT department is implementing next month.
- etc.

3.4 Environment

This tutorial uses the Postgres version of “dvd rental” database, which can be downloaded here. Here’s a glimpse of it’s structure:

Chapter 4

Docker, Postgres, and R (04)

We always load the tidyverse and some other packages, but don't show it unless we are using packages other than tidyverse, DBI, RPostgres, and glue.

4.1 Verify that Docker running

Docker commands can be run from a terminal (e.g., the Rstudio Terminal pane) or with a `system()` command. In this tutorial, we use `system2()` so that all the output that is created externally is shown. Note that `system2` calls are divided into several parts:

1. The program that you are sending a command to.
2. The parameters or commands that are being sent
3. `stdout = TRUE`, `stderr = TRUE` are two parameters that are standard in this book, so that the command's full output is shown in the book.

The `docker version` command returns the details about the docker daemon that is running on your computer.

```
system2("docker", "version", stdout = TRUE, stderr = TRUE)
```

```
## [1] "Client:"
## [2] " Version:      18.06.1-ce"
## [3] " API version:   1.38"
## [4] " Go version:    go1.10.3"
## [5] " Git commit:    e68fc7a"
## [6] " Built:        Tue Aug 21 17:21:31 2018"
## [7] " OS/Arch:       darwin/amd64"
## [8] " Experimental:  false"
## [9] ""
## [10] "Server:"
## [11] " Engine:"
## [12] " Version:      18.06.1-ce"
## [13] " API version:   1.38 (minimum version 1.12)"
## [14] " Go version:    go1.10.3"
## [15] " Git commit:    e68fc7a"
## [16] " Built:        Tue Aug 21 17:29:02 2018"
## [17] " OS/Arch:       linux/amd64"
## [18] " Experimental:  true"
```

4.2 Clean up if appropriate

Remove the `cattle` and `sql-pet` containers if they exists (e.g., from a prior experiments).

```
if (system2("docker", "ps -a", stdout = TRUE) %>%
  grepl(x = ., pattern = 'cattle') %>%
  any()) {
  system2("docker", "rm -f cattle")
}
if (system2("docker", "ps -a", stdout = TRUE) %>%
  grepl(x = ., pattern = 'sql-pet') %>%
  any()) {
  system2("docker", "rm -f sql-pet")
}
```

The convention we use in this book is to assemble a command with `glue` so that the you can see all of its separate parts. The following chunk just constructs the command, but does not execute it. If you have problems executing a command, you can always copy the command and execute in your terminal session.

```
docker_cmd <- glue(
  "run ",          # Run is the Docker command. Everything that follows are `docker run` parameters.
  "--detach ",    # (or `-d`) tells Docker to disconnect from the terminal / program issuing the command
  "--name cattle ",      # tells Docker to give the container a name: `cattle`
  "--publish 5432:5432 ", # tells Docker to expose the Postgres port 5432 to the local network with 5432
  " postgres:10 "      # tells Docker the image that is to be run (after downloading if necessary)
)

# We name containers `cattle` for "throw-aways" and `pet` for ones we treasure and keep around. :-)
```

Submit the command constructed above:

```
# this is what you would submit from a terminal:
cat(glue(" docker ", docker_cmd))
```

```
## docker run --detach --name cattle --publish 5432:5432 postgres:10
```

```
# this is how R submits it to Docker:
```

```
system2("docker", docker_cmd, stdout = TRUE, stderr = TRUE)
```

```
## [1] "80b07e0f5fae72166d374a457e4b22e9a3ca3ecad1baa5a81f984db99841e78b"
```

Docker returns a long string of numbers. If you are running this command for the first time, Docker downloads the PostgreSQL image, which takes a bit of time.

The following command shows that a container named `cattle` is running `postgres:10`. `postgres` is waiting for a connection:

```
system2("docker", "ps", stdout = TRUE, stderr = TRUE)
```

```
## [1] "CONTAINER ID      IMAGE      COMMAND      CREATED      STATUS      PORTS
## [2] "80b07e0f5fae      postgres:10  \"docker-entrypoint.s...\"  1 second ago      Up Less than a second
```

4.3 Connect, read and write to Postgres from R

4.3.1 Pause for some security considerations

We use the following `wait_for_postgres` function, which will repeatedly try to connect to PostgreSQL. PostgreSQL can take different amounts of time to come up and be ready to accept connections from R,

depending on various factors that will be discussed later on.

```
## Connect to Postgres, waiting if it is not ready
##
## @export
##
## @param user Username that will be found
## @param password Password that corresponds to the username
## @param dbname the name of the database in the database
## @param seconds_to_test the number of iterations to try while waiting for Postgres to be ready
##
wait_for_postgres <- function(user, password, dbname, seconds_to_test = 10) {
  for (i in 1:seconds_to_test) {
    db_ready <- DBI::dbCanConnect(RPostgres::Postgres(),
                                  host = "localhost",
                                  port = "5432",
                                  user = user,
                                  password = password,
                                  dbname = dbname)

    if ( !db_ready ) {Sys.sleep(1)}
    else {con <- DBI::dbConnect(RPostgres::Postgres(),
                                host = "localhost",
                                port = "5432",
                                user = user,
                                password = password,
                                dbname = dbname)

    }
    if (i == seconds_to_test & !db_ready) {con <- "There is no connection"}
  }
  con
}
```

When we call `wait_for_postgres` we'll use environment variables that R obtains from reading a file named `.Rprofile`. That file is not uploaded to Github and R looks for it in your default directory. To see whether you have already created that file, execute:

```
dir(path = "~", pattern = ".Rprofile", all.files = TRUE)
```

```
## [1] ".Rprofile"
```

It should contain lines such as:

```
DEFAULT_POSTGRES_PASSWORD=postgres
DEFAULT_POSTGRES_USER_NAME=postgres
```

Those are the default values for the username and password, but this approach demonstrates how they would be kept secret and not uploaded to Github or some other public location.

This is how the `wait_for_postgres` function is used:

```
con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),
                        password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
                        dbname = "postgres",
                        seconds_to_test = 10)
```

Show that you can connect but that PostgreSQL database doesn't contain any tables:

```
dbListTables(con)
```

```
## character(0)
```

4.3.2 Alternative: put the database password in an environment file

The goal is to put the password in an untracked file that will **not** be committed in your source code repository. Your code can reference the name of the variable, but the value of that variable will not appear in open text in your source code.

We have chosen to call the file `dev_environment.csv` in the current working directory where you are executing this script. That file name appears in the `.gitignore` file, so that you will not accidentally commit it. We are going to create that file now.

You will be prompted for the database password. By default, a PostgreSQL database defines a database user named `postgres`, whose password is `postgres`. If you have changed the password or created a new user with a different password, then enter those new values when prompted. Otherwise, enter `postgres` and `postgres` at the two prompts.

In an interactive environment, you could execute a snippet of code that prompts the user for their username and password with the following snippet (which isn't run in the book):

```
prompt_for_postgres <- function(seconds_to_test){
  for (i in 1:seconds_to_test) {
    db_ready <- DBI::dbCanConnect(RPostgres::Postgres(),
                                  host = "localhost",
                                  port = "5432",
                                  user = dplyr::filter(environment_variables, variable == "username")[, "password"],
                                  password = dplyr::filter(environment_variables, variable == "password"),
                                  dbname = "postgres")

    if ( !db_ready ) {Sys.sleep(1)}
    else {con <- DBI::dbConnect(RPostgres::Postgres(),
                                host = "localhost",
                                port = "5432",
                                user = dplyr::filter(environment_variables, variable == "username")[, "password"],
                                password = dplyr::filter(environment_variables, variable == "password"),
                                dbname = "postgres")

    }
    if (i == seconds_to_test & !db_ready) {con <- "there is no connection "}
  }
  con
}
```

```
DB_USERNAME <- trimws(readline(prompt = "username: "), which = "both")
DB_PASSWORD <- getPass::getPass(msg = "password: ")
environment_variables = data.frame(
  variable = c("username", "password"),
  value = c(DB_USERNAME, DB_PASSWORD),
  stringsAsFactors = FALSE)
write.csv(environment_variables, "./dev_environment.csv", row.names = FALSE)
```

Your password is still in plain text in the file, `dev_environment.csv`, so you should protect that file from exposure. However, you do not need to worry about committing that file accidentally to your git repository, because the name of the file appears in the `.gitignore` file.

For security, we use values from the `environment_variables` data.frame, rather than keeping the `username` and `password` in plain text in a source file.

4.3.3 Interact with Postgres

Write `mtcars` to PostgreSQL

```
dbWriteTable(con, "mtcars", mtcars, overwrite = TRUE)
```

List the tables in the PostgreSQL database to show that `mtcars` is now there:

```
dbListTables(con)
```

```
## [1] "mtcars"
```

```
# list the fields in mtcars:
```

```
dbListFields(con, "mtcars")
```

```
## [1] "mpg" "cyl" "disp" "hp" "drat" "wt" "qsec" "vs" "am" "gear"
```

```
## [11] "carb"
```

Download the table from the DBMS to a local data frame:

```
mtcars_df <- tbl(con, "mtcars")
```

```
# Show a few rows:
```

```
knitr::kable(head(mtcars_df))
```

mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
21.0	6	160	110	3.90	2.620	16.46	0	1	4	4
21.0	6	160	110	3.90	2.875	17.02	0	1	4	4
22.8	4	108	93	3.85	2.320	18.61	1	1	4	1
21.4	6	258	110	3.08	3.215	19.44	1	0	3	1
18.7	8	360	175	3.15	3.440	17.02	0	0	3	2
18.1	6	225	105	2.76	3.460	20.22	1	0	3	1

4.4 Clean up

Afterwards, always disconnect from the DBMS, stop the docker container and (optionally) remove it.

```
dbDisconnect(con)
```

```
# tell Docker to stop the container:
```

```
system2("docker", "stop cattle", stdout = TRUE, stderr = TRUE)
```

```
## [1] "cattle"
```

```
# tell Docker to remove the container from it's library of active containers:
```

```
system2("docker", "rm cattle", stdout = TRUE, stderr = TRUE)
```

```
## [1] "cattle"
```

If we `stop` the docker container but don't remove it (with the `rm cattle` command), the container will persist and we can start it up again later with `start cattle`. In that case, `mtcars` would still be there and we could retrieve it from R again. Since we have now removed the `cattle` container, the whole database has been deleted. (There are enough copies of `mtcars` in the world, so no great loss.)

Chapter 5

A persistent database in Postgres in Docker - all at once (05)

5.1 Overview

You've already connected to PostgreSQL with R, now you need a “realistic” (`dvdrental`) database. We're going to demonstrate how to set one up, with two different approaches. This chapter and the next do the same job, illustrating the different approaches that you can take and helping you see the different points where you could swap what's provided here with a different DBMS or a different backup file or something else.

The code in this first version is recommended because it is an “all in one” approach. Details about how it works and how you might modify it are included below. There is another version in the the next chapter that you can use to investigate Docker commands and components.

Note that this approach relies on two files that have quote that's not shown here: `dvdrental.Dockerfile` and `init-dvdrental.sh`. They are discussed below.

Note that `tidyverse`, `DBI`, `RPostgres`, and `glue` are loaded.

5.2 First, verify that Docker is up and running:

```
system2("docker", "version", stdout = TRUE, stderr = TRUE)
```

```
## [1] "Client:"
## [2] "  Version:          18.06.1-ce"
## [3] "  API version:      1.38"
## [4] "  Go version:       go1.10.3"
## [5] "  Git commit:       e68fc7a"
## [6] "  Built:            Tue Aug 21 17:21:31 2018"
## [7] "  OS/Arch:          darwin/amd64"
## [8] "  Experimental:     false"
## [9] ""
## [10] "Server:"
## [11] "  Engine:"
## [12] "    Version:        18.06.1-ce"
## [13] "    API version:    1.38 (minimum version 1.12)"
## [14] "    Go version:     go1.10.3"
```

```
## [15] "   Git commit:      e68fc7a"
## [16] "   Built:          Tue Aug 21 17:29:02 2018"
## [17] "   OS/Arch:        linux/amd64"
## [18] "   Experimental:    true"
```

5.3 Clean up if appropriate

Remove the `sql-pet` container if it exists (e.g., from a prior run)

```
if (system2("docker", "ps -a", stdout = TRUE) %>%
  grepl(x = ., pattern = 'sql-pet') %>%
  any()) {
  system2("docker", "rm -f sql-pet")
}
```

5.4 Build the Docker Image

Build an image that derives from `postgres:10`, defined in `dvdrental.Dockerfile`, that is set up to restore and load the `dvdrental` db on startup. The `dvdrental.Dockerfile` is discussed below.

```
system2("docker",
  glue("build ", # tells Docker to build an image that can be loaded as a container
    "--tag postgres-dvdrental ", # (or -t) tells Docker to name the image
    "--file dvdrental.Dockerfile ", # (or -f) tells Docker to read `build` instructions from the d
    " . "), # tells Docker to look for dvdrental.Dockerfile in the current directory
  stdout = TRUE, stderr = TRUE)

## [1] "Sending build context to Docker daemon  3.081MB\r\r"
## [2] "Step 1/4 : FROM postgres:10"
## [3] " ---> ac25c2bac3c4"
## [4] "Step 2/4 : WORKDIR /tmp"
## [5] " ---> Using cache"
## [6] " ---> 3f00a18e0bdf"
## [7] "Step 3/4 : COPY init-dvdrental.sh /docker-entrypoint-initdb.d/"
## [8] " ---> Using cache"
## [9] " ---> 3453d61d8e3e"
## [10] "Step 4/4 : RUN apt-get -qq update && apt-get install -y -qq curl zip > /dev/null 2>&1 && curl -Os I
## [11] " ---> Using cache"
## [12] " ---> f5e93aa64875"
## [13] "Successfully built f5e93aa64875"
## [14] "Successfully tagged postgres-dvdrental:latest"
```

5.5 Run the Docker Image

Run `docker` to bring up `postgres`. The first time it runs it will take a minute to create the PostgreSQL environment. There are two important parts to this that may not be obvious:

- The `source=` parameter points to `dvdrental.Dockerfile`, which does most of the heavy lifting. It has detailed, line-by-line comments to explain what it is doing.

- Inside `dvndrental.Dockerfile` the command `COPY init-dvndrental.sh /docker-entrypoint-initdb.d/` copies `init-dvndrental.sh` from the local file system into the specified location in the Docker container. When the PostgreSQL Docker container initializes, it looks for that file and executes it.

Doing all of that work behind the scenes involves two layers of complexity. Depending on how you look at it, that may be more or less difficult to understand than the method shown in the next Chapter.

```
wd <- getwd()

docker_cmd <- glue(
  "run ",          # Run is the Docker command. Everything that follows are `run` parameters.
  "--detach ",     # (or `-d`) tells Docker to disconnect from the terminal / program issuing the command
  " --name sql-pet ", # tells Docker to give the container a name: `sql-pet`
  "--publish 5432:5432 ", # tells Docker to expose the Postgres port 5432 to the local network with 5432
  "--mount ",       # tells Docker to mount a volume -- mapping Docker's internal file structure to the host
  "type=bind,",      # tells Docker that the mount command points to an actual file on the host system
  "source=",         # tells Docker where the local file will be found
  wd, '/', ',',      # the current working directory, as retrieved above
  "target=/petdir",  # tells Docker to refer to the current directory as "/petdir" in its file system
  " postgres-dvndrental" # tells Docker to run the image was built in the previous step
)

# if you are curious you can paste this string into a terminal window after the command 'docker':
docker_cmd

## run --detach --name sql-pet --publish 5432:5432 --mount type=bind,source="/Users/jds/Documents/Library
system2("docker", docker_cmd, stdout = TRUE, stderr = TRUE)

## [1] "ea9d5d05077dcad92e47aa595728d688174d077684001d149334fd94b6e91e0f"
```

5.6 Connect to Postgres with R

Use the DBI package to connect to PostgreSQL. But first, wait for Docker & PostgreSQL to come up before connecting.

We have loaded the `wait_for_postgres` function behind the scenes.

```
con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),
  password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
  dbname = "dvndrental",
  seconds_to_test = 10)

# if (con == "it's not there") {stop()}

dbListTables(con)

## [1] "actor_info"          "customer_list"
## [3] "film_list"           "nicer_but_slower_film_list"
## [5] "sales_by_film_category" "staff"
## [7] "sales_by_store"      "staff_list"
## [9] "category"            "film_category"
## [11] "country"              "actor"
## [13] "language"             "inventory"
## [15] "payment"              "rental"
```

```
## [17] "city"           "store"
## [19] "film"           "address"
## [21] "film_actor"     "customer"

dbListFields(con, "rental")

## [1] "rental_id"      "rental_date"    "inventory_id"   "customer_id"
## [5] "return_date"    "staff_id"       "last_update"

dbDisconnect(con)

Sys.sleep(2) # Can take a moment to disconnect.
```

5.7 Stop and start to demonstrate persistence

Stop the container

```
system2('docker', 'stop sql-pet',
        stdout = TRUE, stderr = TRUE)

## [1] "sql-pet"

Sys.sleep(3) # can take a moment for Docker to stop the container.
```

Restart the container and verify that the dvdrental tables are still there

```
system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)

## [1] "sql-pet"

con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),
                          password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
                          dbname = "dvdrental",
                          seconds_to_test = 10)

glimpse(dbReadTable(con, "film"))

## Observations: 1,000
## Variables: 13
## $ film_id      <int> 133, 384, 8, 98, 1, 2, 3, 4, 5, 6, 7, 9, 10, ...
## $ title        <chr> "Chamber Italian", "Grosse Wonderful", "Airpo...
## $ description  <chr> "A Fateful Reflection of a Moose And a Husban...
## $ release_year <int> 2006, 2006, 2006, 2006, 2006, 2006, 2006, 200...
## $ language_id <int> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ...
## $ rental_duration <int> 7, 5, 6, 4, 6, 3, 7, 5, 6, 3, 6, 3, 6, 6, ...
## $ rental_rate  <dbl> 4.99, 4.99, 4.99, 4.99, 0.99, 4.99, 2.99, 2.9...
## $ length       <int> 117, 49, 54, 73, 86, 48, 50, 117, 130, 169, 6...
## $ replacement_cost <dbl> 14.99, 19.99, 15.99, 12.99, 20.99, 12.99, 18...
## $ rating       <chr> "NC-17", "R", "R", "PG-13", "PG", "G", "NC-17...
## $ last_update  <dtm> 2013-05-26 14:50:58, 2013-05-26 14:50:58, 20...
## $ special_features <chr> "{Trailers}", "{\\\"Behind the Scenes\\\"}", "{Tr...
## $ fulltext     <chr> "'chamber':1 'fate':4 'husband':11 'italian':...
```

It's always good to have R disconnect from the database

```
dbDisconnect(con)
```

Stop the container & show that the container is still there, so can be started again.


```
system2('docker', 'stop sql-pet',  
        stdout = TRUE, stderr = TRUE)
```

```
## [1] "sql-pet"
```

```
# show that the container still exists even though it's not running
```

```
psout <- system2("docker", "ps -a", stdout = TRUE)  
psout[grepl(x = psout, pattern = 'sql-pet')]
```

```
## [1] "ea9d5d05077d      postgres-dvdrental  \"docker-entrypoint.s...\"  22 seconds ago      Exited (137) Les
```

5.8 Cleaning up

Next time, you can just use this command to start the container:

```
system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)
```

And once stopped, the container can be removed with:

```
system2("docker", "rm sql-pet", stdout = TRUE, stderr = TRUE)
```

5.9 Using the sql-pet container in the rest of the book

After this point in the book, we assume that Docker is up and that we can always start up our *sql-pet database* with:

```
system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)
```


Chapter 6

A persistent database in Postgres in Docker - piecemeal (06)

6.1 Overview

This chapter essentially repeats what was presented in the previous one, but does it in a step-by-step way that might be useful to understand how each of the steps involved in setting up a persistent PostgreSQL database works. If you are satisfied with the method shown in that chapter, skip this one for now.

Note that `tidyverse`, `DBI`, `RPostgres`, and `glue` are loaded.

6.2 Retrieve the backup file

The first step is to get a local copy of the `dvdrental` PostgreSQL restore file. It comes in a zip format and needs to be un-zipped. Use the `downloader` and `here` packages to keep track of things.

```
if (!require(downloader)) install.packages("downloader")

## Loading required package: downloader
if (!require(here)) install.packages("here")

## Loading required package: here

## here() starts at /Users/jds/Documents/Library/R/r-system/sql-pet/r-database-docker
library(downloader, here)

download("http://www.postgresqltutorial.com/wp-content/uploads/2017/10/dvdrental.zip", destfile = here(
unzip(here("dvdrental.zip"), exdir = here()) # creates a tar archive named "dvdrental.tar"
file.remove(here("dvdrental.zip")) # the Zip file is no longer needed.

## [1] TRUE
```

6.3 Now, verify that Docker is up and running:

```
system2("docker", "version", stdout = TRUE, stderr = TRUE)
```

```
## [1] "Client:"
## [2] " Version:      18.06.1-ce"
## [3] " API version:   1.38"
## [4] " Go version:    go1.10.3"
## [5] " Git commit:    e68fc7a"
## [6] " Built:         Tue Aug 21 17:21:31 2018"
## [7] " OS/Arch:       darwin/amd64"
## [8] " Experimental:  false"
## [9] ""
## [10] "Server:"
## [11] " Engine:"
## [12] " Version:      18.06.1-ce"
## [13] " API version:   1.38 (minimum version 1.12)"
## [14] " Go version:    go1.10.3"
## [15] " Git commit:    e68fc7a"
## [16] " Built:         Tue Aug 21 17:29:02 2018"
## [17] " OS/Arch:       linux/amd64"
## [18] " Experimental:  true"
```

Remove the `sql-pet` container if it exists (e.g., from a prior run)

```
if (system2("docker", "ps -a", stdout = TRUE) %>%
  grepl(x = ., pattern = 'sql-pet') %>%
  any()) {
  system2("docker", "rm -f sql-pet")
}
```

6.4 Build the Docker Image

Build an image that derives from `postgres:10`. Connect the local and Docker directories that need to be shared. Expose the standard PostgreSQL port 5432.

” `postgres-dvdrental`” # tells Docker the image that is to be run (after downloading if necessary)

```
wd <- getwd()
```

```
docker_cmd <- glue(
  "run ",          # Run is the Docker command. Everything that follows are `run` parameters.
  "--detach ",    # (or `-d`) tells Docker to disconnect from the terminal / program issuing the command
  "--name sql-pet ", # tells Docker to give the container a name: `sql-pet`
  "--publish 5432:5432 ", # tells Docker to expose the Postgres port 5432 to the local network with 5432
  "--mount ",      # tells Docker to mount a volume -- mapping Docker's internal file structure to the host
  'type=bind,source="' , wd, '/', target='/petdir',
  " postgres:10 " # tells Docker the image that is to be run (after downloading if necessary)
)
cat('docker ', docker_cmd)
```

```
## docker run --detach --name sql-pet --publish 5432:5432 --mount type=bind,source="/Users/jds/Documents/
system2("docker", docker_cmd, stdout = TRUE, stderr = TRUE)
```

```
## [1] "df141df324e0f61a771555adae6fa8be6911120e7a50bbd860391d34e66b175b"
```

Peek inside the docker container and list the files in the `petdir` directory. Notice that `dvdrental.tar` is in both.

```
system2('docker', 'exec sql-pet ls petdir | grep "dvdrental.tar" ',
        stdout = TRUE, stderr = TRUE)
```

```
## [1] "dvdrental.tar"
```

```
dir(wd, pattern = "dvdrental.tar")
```

```
## [1] "dvdrental.tar"
```

We can execute programs inside the Docker container with the `exec` command. In this case we tell Docker to execute the `psql` program inside the `sql-pet` container and pass it some commands.

```
Sys.sleep(2) # is this really needed?
# inside Docker, execute the postgres SQL command-line program to create the dvdrental database:
system2('docker', 'exec sql-pet psql -U postgres -c "CREATE DATABASE dvdrental;"',
        stdout = TRUE, stderr = TRUE)
```

```
## [1] "CREATE DATABASE"
```

The `psql` program repeats back to us what it has done, e.g., to create a database named `dvdrental`.

Next we execute a different program in the Docker container, `pg_restore`, and tell it where the restore file is located. If successful, the `pg_restore` just responds with a very laconic `character(0)`.

```
# restore the database from the .tar file
system2("docker", "exec sql-pet pg_restore -U postgres -d dvdrental petdir/dvdrental.tar", stdout = TRUE)
```

```
## character(0)
```

```
file.remove(here("dvdrental.tar")) # the tar file is no longer needed.
```

```
## [1] TRUE
```

Use the DBI package to connect to PostgreSQL. But first, wait for Docker & PostgreSQL to come up before connecting.

We have loaded the `wait_for_postgres` function behind the scenes.

```
con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),
                        password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
                        dbname = "dvdrental",
                        seconds_to_test = 10)

dbListTables(con)
```

```
## [1] "actor_info"           "customer_list"
## [3] "film_list"            "nicer_but_slower_film_list"
## [5] "sales_by_film_category" "staff"
## [7] "sales_by_store"       "staff_list"
## [9] "category"             "film_category"
## [11] "country"              "actor"
## [13] "language"             "inventory"
## [15] "payment"              "rental"
## [17] "city"                 "store"
## [19] "film"                 "address"
## [21] "film_actor"           "customer"
```

```
dbListFields(con, "film")

## [1] "film_id"          "title"            "description"
## [4] "release_year"     "language_id"      "rental_duration"
## [7] "rental_rate"      "length"           "replacement_cost"
## [10] "rating"           "last_update"      "special_features"
## [13] "fulltext"

dbDisconnect(con)
```

6.5 Stop and start to demonstrate persistence

Stop the container

```
system2('docker', 'stop sql-pet',
        stdout = TRUE, stderr = TRUE)
```

```
## [1] "sql-pet"
```

Restart the container and verify that the dvdrental tables are still there

```
system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)
```

```
## [1] "sql-pet"
```

```
con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),
                          password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
                          dbname = "dvdrental",
                          seconds_to_test = 10)
```

```
glimpse(dbReadTable(con, "film"))
```

```
## Observations: 1,000
## Variables: 13
## $ film_id      <int> 133, 384, 8, 98, 1, 2, 3, 4, 5, 6, 7, 9, 10, ...
## $ title        <chr> "Chamber Italian", "Grosse Wonderful", "Airpo...
## $ description  <chr> "A Fateful Reflection of a Moose And a Husban...
## $ release_year <int> 2006, 2006, 2006, 2006, 2006, 2006, 2006, 200...
## $ language_id <int> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ...
## $ rental_duration <int> 7, 5, 6, 4, 6, 3, 7, 5, 6, 3, 6, 3, 6, 6, ...
## $ rental_rate  <dbl> 4.99, 4.99, 4.99, 4.99, 0.99, 4.99, 2.99, 2.9...
## $ length       <int> 117, 49, 54, 73, 86, 48, 50, 117, 130, 169, 6...
## $ replacement_cost <dbl> 14.99, 19.99, 15.99, 12.99, 20.99, 12.99, 18...
## $ rating       <chr> "NC-17", "R", "R", "PG-13", "PG", "G", "NC-17...
## $ last_update  <dtm> 2013-05-26 14:50:58, 2013-05-26 14:50:58, 20...
## $ special_features <chr> "{Trailers}", "{\ Behind the Scenes\ }", "{Tr...
## $ fulltext     <chr> "'chamber':1 'fate':4 'husband':11 'italian':...
```

Stop the container & show that the container is still there, so can be started again.

```
system2('docker', 'stop sql-pet',
        stdout = TRUE, stderr = TRUE)
```

```
## [1] "sql-pet"
```

show that the container still exists even though it's not running

```
psout <- system2("docker", "ps -a", stdout = TRUE)
psout[grepl(x = psout, pattern = 'sql-pet')]
```

```
## [1] "df141df324e0      postgres:10      \"docker-entrypoint.s...\"  18 seconds ago      Exited (137) Less t
```

6.6 Cleaning up

Next time, you can just use this command to start the container:

```
system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)
```

And after disconnecting from it the container can be completely removed with:

```
system2("docker", "rm sql-pet -f", stdout = TRUE, stderr = TRUE)
```

6.7 Using the `sql-pet` container in the rest of the book

After this point in the book, we assume that Docker is up and that we can always start up our *sql-pet database* with:

```
system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)
```


Chapter 7

Introduction to interacting with Postgres from R (10)

Note that `tidyverse`, `DBI`, `RPostgres`, `glue`, and `knitr` are loaded. Also, we've sourced the `[db-login-batch-code.R]` ('r-database-docker/book-src/db-login-batch-code.R') file which is used to log in to PostgreSQL.

7.1 Basics

- keeping passwords secure
- Coverage in this book. There are many SQL tutorials that are available. For example, we are drawing some materials from a tutorial we recommend. In particular, we will not replicate the lessons there, which you might want to complete. Instead, we are showing strategies that are recommended for R users. That will include some translations of queries that are discussed there.

7.2 Ask yourself about what you are aiming for?

- differences between production and data warehouse environments
- learning to keep your DBAs happy
 - You are your own DBA in this simulation, so you can wreak havoc and learn from it, but you can learn to be DBA-friendly here.
 - in the end it's the subject-matter experts that understand your data, but you have to work with your DBAs first

7.3 Get some basic information about your database

Assume that the Docker container with PostgreSQL and the dvdrental database are ready to go.

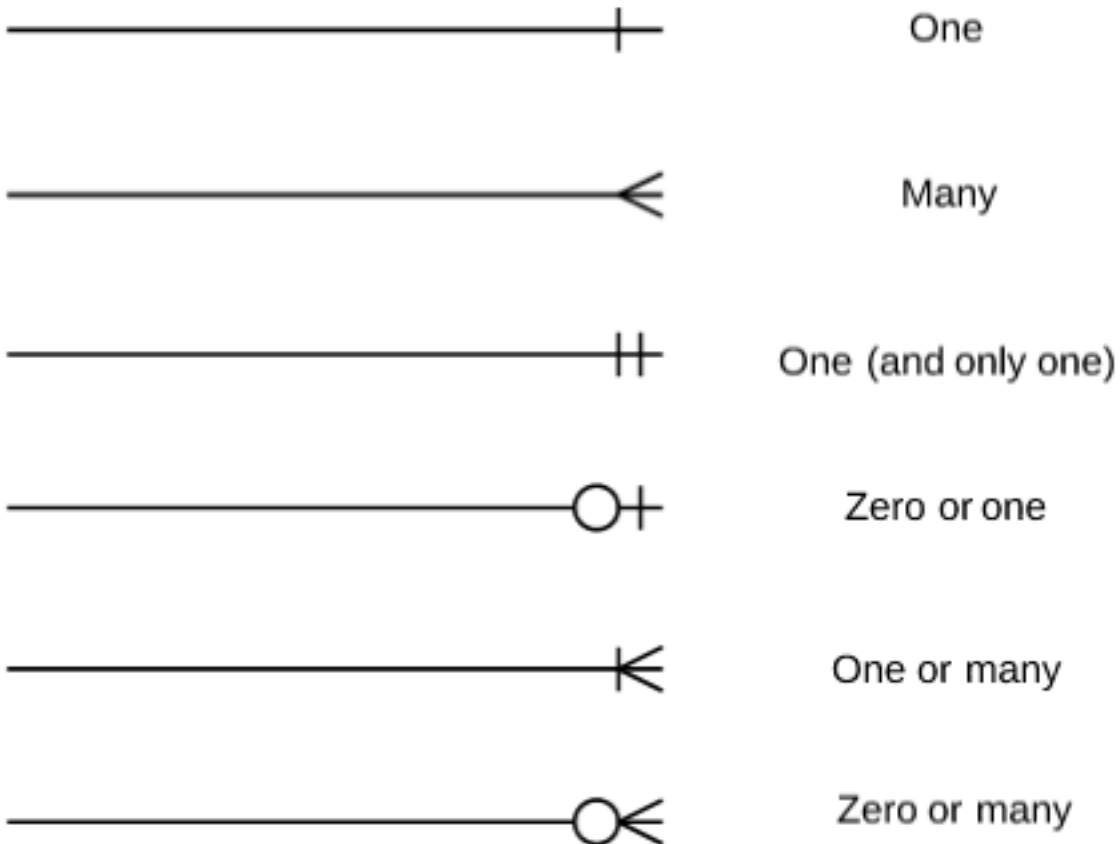
```
system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)
```

```
## [1] "sql-pet"
```

```
con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),  
                        password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
```

```
dbname = "dvdrental",
seconds_to_test = 10)
```

You usually need to use both the available documentation for your database and to be somewhat skeptical (e.g., empirical). It's worth learning to interpret the symbols in an Entity Relationship Diagram:



Depending on how skeptical you are about the documentation, you might want to get an overview of a database by pulling data from the database `information_schema`. Here's a selection of useful information although you may want more (or less). There is a lot to choose from a vast list of metadata. Note that information schemas are somewhat consistent across different DBMS' that you may encounter.

have we hidden “`in_schema()`” as in:

```
con %>% tbl(in_schema("aux", "df"))
table_schema_query <- glue("SELECT ",
  "table_name, column_name, data_type, ordinal_position, column_default, character_maximum_length",
  " FROM information_schema.columns ",
  "WHERE table_schema = 'public'")

rental_meta_data <- dbGetQuery(con, table_schema_query)

glimpse(rental_meta_data)

## Observations: 128
## Variables: 6
## $ table_name      <chr> "actor_info", "actor_info", "actor_in..."
```

```
## $ column_name      <chr> "actor_id", "first_name", "last_name"...
## $ data_type        <chr> "integer", "character varying", "char..."
## $ ordinal_position <int> 1, 2, 3, 4, 1, 2, 3, 4, 5, 6, 7, 8, 9...
## $ column_default   <chr> NA, NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ character_maximum_length <int> NA, 45, 45, NA, NA, NA, 50, 10, 20, 5...
```

Pull out some rough-and-ready but useful statistics about your database. Since we are in SQL-land we talk about variables as columns.

Start with a list of tables names and a count of the number of columns that each one contains.

```
rental_meta_data %>% count(table_name) %>% rename(number_of_columns = n) %>% as.data.frame()
```

```
##           table_name number_of_columns
## 1             actor              4
## 2          actor_info              4
## 3             address              8
## 4            category              3
## 5              city              4
## 6             country              3
## 7            customer             10
## 8         customer_list              9
## 9              film             13
## 10          film_actor              3
## 11         film_category              3
## 12          film_list              8
## 13           inventory              4
## 14           language              3
## 15 nicer_but_slower_film_list          8
## 16             payment              6
## 17             rental              7
## 18  sales_by_film_category              2
## 19          sales_by_store              3
## 20              staff             11
## 21          staff_list              8
## 22             store              4
```

How many column names are shared across tables (or duplicated)?

```
rental_meta_data %>% count(column_name, sort = TRUE) %>% filter(n > 1)
```

```
## # A tibble: 34 x 2
##   column_name      n
##   <chr>         <int>
## 1 last_update    14
## 2 address_id      4
## 3 film_id         4
## 4 first_name      4
## 5 last_name       4
## 6 name            4
## 7 store_id        4
## 8 actor_id        3
## 9 address         3
## 10 category       3
## # ... with 24 more rows
```

How many column names are unique?

```
rental_meta_data %>% count(column_name) %>% filter(n > 1)
```

```
## # A tibble: 34 x 2
##   column_name      n
##   <chr>          <int>
## 1 active          2
## 2 actor_id        3
## 3 actors          2
## 4 address         3
## 5 address_id      4
## 6 category        3
## 7 category_id     2
## 8 city            3
## 9 city_id         2
## 10 country         3
## # ... with 24 more rows
```

What data types are found in the database?

```
rental_meta_data %>% count(data_type)
```

```
## # A tibble: 13 x 2
##   data_type      n
##   <chr>          <int>
## 1 ARRAY          1
## 2 boolean        2
## 3 bytea          1
## 4 character      1
## 5 character varying 36
## 6 date           1
## 7 integer        22
## 8 numeric         7
## 9 smallint       25
## 10 text          11
## 11 timestamp without time zone 17
## 12 tsvector        1
## 13 USER-DEFINED    3
```

Chapter 8

Real work with real data (11)

8.1 Some extra handy libraries

Here are some packages that we find handy in the preliminary investigation of a database (or a problem that involves data from a database).

```
library(glue)
library(skimr)
```

8.2 Basic investigation

- R tools for data investigation
 - glimpse
 - str
 - View and kable
- overview investigation: do you understand your data
 - documentation and its limits
 - what's *missing* from the database: (columns, records, cells)
- find out how the data is used by those who enter it and others who've used it before
 - why is there missing data?

8.3 Using Dplyr

We already started, but that's OK.

8.3.1 finding out what's in the database

- DBI / RPostgres packages
- R tools like glimpse, skimr, kable.
- examining dplyr queries (show_query on the R side v EXPLAIN on the PostgreSQL side)
- Tutorials like: <https://suzan.rbind.io/tags/dplyr/>
- Benjamin S. Baumer, A Grammar for Reproducible and Painless Extract-Transform-Load Operations on Medium Data: <https://arxiv.org/pdf/1708.07073>

8.3.2 sample query

- rental
- date subset
- left join staff
- left join customer

8.3.3 Subset: only retrieve what you need

- Columns
- Rows
 - number of row
 - specific rows
- dplyr joins in the R

8.3.4 Make the server do as much work as you can

discuss this simple example? <http://www.postgresqltutorial.com/postgresql-left-join/>

- dplyr joins on the server side
- Where you put (`collect(n = Inf)`) really matters

8.4 What is dplyr sending to the server?

- `show_query` as a first draft

8.5 Writing your on SQL directly to the DBMS

- `dbquery`
- Glue for constructing SQL statements
 - parameterizing SQL queries

8.6 Chosing between dplyr and native SQL

- performance considerations: first get the right data, then worry about performance
- Trade offs between leaving the data in PostgreSQL vs what's kept in R:
 - browsing the data
 - larger samples and complete tables
 - using what you know to write efficient queries that do most of the work on the server

Chapter 9

Real work with real data (12)

9.1 Some extra handy libraries

Here are some packages that we find handy in the preliminary investigation of a database (or a problem that involves data from a database).

```
library(glue)

##
## Attaching package: 'glue'
## The following object is masked from 'package:dplyr':
##
##      collapse
library(skimr)
```

9.2 More topics

- Check this against Aaron Makubuya's workshop at the Cascadia R Conf.

9.3 Standards for production jobs

- writing tests for your queries

Chapter 10

Postgres Examples, part A (13)

Libraries loaded and functions are loaded

10.1 Verify Docker is up and running:

```
result <- system2("docker", "version", stdout = TRUE, stderr = TRUE)
result
```

```
## [1] "Client:"
## [2] " Version:      18.06.1-ce"
## [3] " API version:   1.38"
## [4] " Go version:    go1.10.3"
## [5] " Git commit:    e68fc7a"
## [6] " Built:        Tue Aug 21 17:21:31 2018"
## [7] " OS/Arch:       darwin/amd64"
## [8] " Experimental:  false"
## [9] ""
## [10] "Server:"
## [11] " Engine:"
## [12] " Version:      18.06.1-ce"
## [13] " API version:   1.38 (minimum version 1.12)"
## [14] " Go version:    go1.10.3"
## [15] " Git commit:    e68fc7a"
## [16] " Built:        Tue Aug 21 17:29:02 2018"
## [17] " OS/Arch:       linux/amd64"
## [18] " Experimental:  true"
```

verify pet DB is available, it may be stopped.

```
result <- system2("docker", "ps -a", stdout = TRUE, stderr = TRUE)
result
```

```
## [1] "CONTAINER ID      IMAGE               COMMAND              CREATED            STATUS             PORTS
## [2] "df141df324e0      postgres:10        \"docker-entrypoint.s...\" 26 seconds ago    Up 6 seconds      0.
```

```
any(grepl('Up .+pet$',result))
```

```
## [1] TRUE
```

Start up the docker-pet container

```
result <- system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)
result
```

```
## [1] "sql-pet"
```

now connect to the database with R

need to wait for Docker & Postgres to come up before connecting.

```
con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),
                        password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
                        dbname = "dvdrental",
                        seconds_to_test = 10)
```

```
## Get list of database objects
```

```
rs <- dbGetQuery(con
  , "select table_catalog, table_schema, table_name, table_type
      from information_schema.tables
      where table_schema not in ('pg_catalog', 'information_schema')
      order by table_name
  ;"
)
```

Get list of tables

```
kable(dbListTables(con))
```

x
actor_info
customer_list
film_list
nicer_but_slower_film_list
sales_by_film_category
staff
sales_by_store
staff_list
category
film_category
country
actor
language
inventory
payment
rental
city
store
film
address
film_actor
customer

```
rs <- dbGetQuery(con
  , "select table_catalog || '.' || table_schema || '.' || table_name table_name
      , column_name, ordinal_position seq --, data_type
      , case when data_type = 'character varying'
            then data_type || '(' || character_maximum_length || ')'
            when data_type = 'real'
            then data_type || '(' || numeric_precision || ',' || numeric_precision_radix
```

```

        else data_type
      end data_type
--      ,character_maximum_length,numeric_precision,numeric_precision_radix
      from information_schema.columns
      where table_name in (select table_name
                          from information_schema.tables
                          where table_schema not in ('pg_catalog','information_schema'))
      order by table_name,ordinal_position;

";
)
kable(head(rs, n = 20))

```

table_name	column_name	seq	data_type
dvdrental.public.actor	actor_id	1	integer
dvdrental.public.actor	first_name	2	character varying(45)
dvdrental.public.actor	last_name	3	character varying(45)
dvdrental.public.actor	last_update	4	timestamp without time zone
dvdrental.public.actor_info	actor_id	1	integer
dvdrental.public.actor_info	first_name	2	character varying(45)
dvdrental.public.actor_info	last_name	3	character varying(45)
dvdrental.public.actor_info	film_info	4	text
dvdrental.public.address	address_id	1	integer
dvdrental.public.address	address	2	character varying(50)
dvdrental.public.address	address2	3	character varying(50)
dvdrental.public.address	district	4	character varying(20)
dvdrental.public.address	city_id	5	smallint
dvdrental.public.address	postal_code	6	character varying(10)
dvdrental.public.address	phone	7	character varying(20)
dvdrental.public.address	last_update	8	timestamp without time zone
dvdrental.public.category	category_id	1	integer
dvdrental.public.category	name	2	character varying(25)
dvdrental.public.category	last_update	3	timestamp without time zone
dvdrental.public.city	city_id	1	integer

There are $\{r \dim(rs)[1]\}$ rows in the catalog.

```

rs <- dbGetQuery(con,
"
--SELECT conrelid::regclass as table_from
select table_catalog||'.'||table_schema||'.'||table_name table_name
,conname,pg_catalog.pg_get_constraintdef(r.oid, true) as condef
FROM information_schema.columns c,pg_catalog.pg_constraint r
WHERE 1 = 1 --r.conrelid = '16485'
      AND r.contype in ('f','p') ORDER BY 1
";
)

kable(head(rs))

```

table_name	conname	condef
dvdrental.information_schema.administrable_role_authorizations	actor_pkey	PRIMARY KEY (actor_id)
dvdrental.information_schema.administrable_role_authorizations	actor_pkey	PRIMARY KEY (actor_id)
dvdrental.information_schema.administrable_role_authorizations	actor_pkey	PRIMARY KEY (actor_id)
dvdrental.information_schema.administrable_role_authorizations	country_pkey	PRIMARY KEY (country_id)
dvdrental.information_schema.administrable_role_authorizations	country_pkey	PRIMARY KEY (country_id)
dvdrental.information_schema.administrable_role_authorizations	country_pkey	PRIMARY KEY (country_id)

```
rs <- dbGetQuery(con,
"select conrelid::regclass as table_from
    ,c.conname
    ,pg_get_constraintdef(c.oid)
  from pg_constraint c
  join pg_namespace n on n.oid = c.connamespace
 where c.contype in ('f','p')
    and n.nspname = 'public'
 order by conrelid::regclass::text, contype DESC;
")
kable(head(rs))
```

table_from	conname	pg_get_constraintdef
actor	actor_pkey	PRIMARY KEY (actor_id)
address	address_pkey	PRIMARY KEY (address_id)
address	fk_address_city	FOREIGN KEY (city_id) REFERENCES city(city_id)
category	category_pkey	PRIMARY KEY (category_id)
city	city_pkey	PRIMARY KEY (city_id)
city	fk_city	FOREIGN KEY (country_id) REFERENCES country(country_id)

```
dim(rs)[1]
```

```
## [1] 33
```

```
rs <- dbGetQuery(con,
"SELECT r.*,
    pg_catalog.pg_get_constraintdef(r.oid, true) as condef
FROM pg_catalog.pg_constraint r
WHERE 1=1 --r.conrelid = '16485' AND r.contype = 'f' ORDER BY 1;
")
head(rs)
```

```
##               conname connamespace contype condeferrable
## 1 cardinal_number_domain_check      12703      c      FALSE
## 2          yes_or_no_check      12703      c      FALSE
## 3          year_check      2200      c      FALSE
## 4          actor_pkey      2200      p      FALSE
## 5          address_pkey      2200      p      FALSE
## 6          category_pkey      2200      p      FALSE
##   condeferred convalidated conrelid contypid conindid confrelid
## 1      FALSE          TRUE         0   12716         0         0
## 2      FALSE          TRUE         0   12724         0         0
## 3      FALSE          TRUE         0   16397         0         0
## 4      FALSE          TRUE    16420         0   16555         0
## 5      FALSE          TRUE    16461         0   16557         0
## 6      FALSE          TRUE    16427         0   16559         0
##   confupdtype confdeltype confmatchtype conislocal coninhcount
## 1                                TRUE              0
```

```

## 2          TRUE          0
## 3          TRUE          0
## 4          TRUE          0
## 5          TRUE          0
## 6          TRUE          0
##   connoinherit conkey confkey confpeqop comppeqop confpeqop conexclp
## 1      FALSE <NA>   <NA>   <NA>   <NA>   <NA>   <NA>
## 2      FALSE <NA>   <NA>   <NA>   <NA>   <NA>   <NA>
## 3      FALSE <NA>   <NA>   <NA>   <NA>   <NA>   <NA>
## 4       TRUE  {1}   <NA>   <NA>   <NA>   <NA>   <NA>
## 5       TRUE  {1}   <NA>   <NA>   <NA>   <NA>   <NA>
## 6       TRUE  {1}   <NA>   <NA>   <NA>   <NA>   <NA>
##
## 1
## 2 {SCALARARRAYOPEXPR :opno 98 :opfuncid 67 :useOr true :inputcollid 100 :args ({RELABELTYPE :arg {COERCET
## 3                                     {BOOLEXPR :boolop and :args
## 4
## 5
## 6
##
##                                     consrc
## 1                                     (VALUE >= 0)
## 2 ((VALUE)::text = ANY ((ARRAY['YES']::character varying, 'NO']::character varying))::text[]))
## 3                                     ((VALUE >= 1901) AND (VALUE <= 2155))
## 4                                     <NA>
## 5                                     <NA>
## 6                                     <NA>
##
##                                     condef
## 1                                     CHECK (VALUE >= 0)
## 2 CHECK (VALUE::text = ANY (ARRAY['YES']::character varying, 'NO']::character varying)::text[]))
## 3                                     CHECK (VALUE >= 1901 AND VALUE <= 2155)
## 4                                     PRIMARY KEY (actor_id)
## 5                                     PRIMARY KEY (address_id)
## 6                                     PRIMARY KEY (category_id)
##
## select examples
##   dbGetQuery returns the entire result set as a data frame.
##   For large returned datasets, complex or inefficient SQL statements, this may take a
##   long time.
##
##   dbSendQuery: parses, compiles, creates the optimized execution plan.
##   dbFetch: Execute optimized execution plan and return the dataset.
##   dbClearResult:remove pending query results from the database to your R environment

```

How many customers are there in the DVD Rental System

```
rs1 <- dbGetQuery(con,'select * from customer;')
kable(head(rs1))
```

customer_id	store_id	first_name	last_name	email	address_id	activebool	cre
524	1	Jared	Ely	jared.ely@sakilacustomer.org	530	TRUE	200
1	1	Mary	Smith	mary.smith@sakilacustomer.org	5	TRUE	200
2	1	Patricia	Johnson	patricia.johnson@sakilacustomer.org	6	TRUE	200
3	1	Linda	Williams	linda.williams@sakilacustomer.org	7	TRUE	200
4	2	Barbara	Jones	barbara.jones@sakilacustomer.org	8	TRUE	200
5	1	Elizabeth	Brown	elizabeth.brown@sakilacustomer.org	9	TRUE	200

```
pco <- dbSendQuery(con,'select * from customer;')
rs2 <- dbFetch(pco)
dbClearResult(pco)
kable(head(rs2))
```

customer_id	store_id	first_name	last_name	email	address_id	activebool	create_date
524	1	Jared	Ely	jared.ely@sakilacustomer.org	530	TRUE	2008-09-13
1	1	Mary	Smith	mary.smith@sakilacustomer.org	5	TRUE	2005-05-09
2	1	Patricia	Johnson	patricia.johnson@sakilacustomer.org	6	TRUE	2006-02-04
3	1	Linda	Williams	linda.williams@sakilacustomer.org	7	TRUE	2007-12-17
4	2	Barbara	Jones	barbara.jones@sakilacustomer.org	8	TRUE	2006-04-04
5	1	Elizabeth	Brown	elizabeth.brown@sakilacustomer.org	9	TRUE	2007-08-13

```
# insert yourself as a new customer
dbExecute(con
  , "insert into customer
    (store_id,first_name,last_name,email,address_id
    ,activebool,create_date,last_update,active)
    values(2, 'Sophie', 'Yang', 'dodreamdo@yahoo.com',1,TRUE, '2018-09-13', '2018-09-13',1)
  "
)
```

```
## [1] 0
```

```
## anti join -- Find customers who have never rented a movie.
```

```
rs <- dbGetQuery(con,
  "select c.first_name
    ,c.last_name
    ,c.email
  from customer c
  left outer join rental r
    on c.customer_id = r.customer_id
  where r.rental_id is null;
  "
)
head(rs)
```

```
##   first_name last_name          email
## 1    Sophie      Yang dodreamdo@yahoo.com
```

```
## how many films and languages exist in the DVD rental application
```

```
rs <- dbGetQuery(con,
  "      select 'film' table_name,count(*) count from film
  union select 'language' table_name,count(*) count from language
  ;
  "
)
head(rs)
```

```
##   table_name count
## 1      film  1000
## 2  language     6
```

```
## what is the film distribution based on language
```

```
rs <- dbGetQuery(con,
```

```

        "select l.language_id id
              ,l.name
              ,sum(case when f.language_id is not null then 1 else 0 end) total
        from language l
             full outer join film f
              on l.language_id = f.language_id
        group by l.language_id,l.name
        order by l.name;
        ;
    "
)
head(rs)

```

```

##      id          name total
## 1  1 English          1000
## 2  5 French           0
## 3  6 German           0
## 4  2 Italian          0
## 5  3 Japanese         0
## 6  4 Mandarin         0

```

```
## Store analysis
```

```
### which store has had more rentals and income
```

```

rs <- dbGetQuery(con,
    "select *
    from (
        select 'actor' tbl_name,count(*) from actor
        union select 'category' tbl_name,count(*) from category
        union select 'film' tbl_name,count(*) from film
        union select 'film_actor' tbl_name,count(*) from film_actor
        union select 'film_category' tbl_name,count(*) from film_category
        union select 'language' tbl_name,count(*) from language
        union select 'inventory' tbl_name,count(*) from inventory
        union select 'rental' tbl_name,count(*) from rental
        union select 'payment' tbl_name,count(*) from payment
        union select 'staff' tbl_name,count(*) from staff
        union select 'customer' tbl_name,count(*) from customer
        union select 'address' tbl_name,count(*) from address
        union select 'city' tbl_name,count(*) from city
        union select 'country' tbl_name,count(*) from country
        union select 'store' tbl_name,count(*) from store
    ) counts
    order by tbl_name
    ;
    "
)
head(rs)

```

```

##      tbl_name count
## 1      actor    200
## 2    address    603
## 3   category     16
## 4        city    600
## 5    country    109
## 6  customer    600

```

```
## Store analysis
### which store has the largest income stream
rs <- dbGetQuery(con,
  "select store_id,sum(amount) amt,count(*) cnt
    from payment p
      join staff s
        on p.staff_id = s.staff_id
   group by store_id order by 2 desc
  ;
"
)
head(rs)
```

```
##   store_id      amt  cnt
## 1         2 31059.92 7304
## 2         1 30252.12 7292
```

```
## Store analysis
### How many rentals have not been paid
### How many rentals have been paid
### How much has been paid
### What is the average price/movie
### Estimate the outstanding balance
rs <- dbGetQuery(con,
  "select sum(case when payment_id is null then 1 else 0 end) missing
        ,sum(case when payment_id is not null then 1 else 0 end) found
        ,sum(p.amount) amt
        ,count(*) cnt
        ,round(sum(p.amount)/sum(case when payment_id is not null then 1 else 0 end),2) avg_price
        ,round(round(sum(p.amount)/sum(case when payment_id is not null then 1 else 0 end)
                    * sum(case when payment_id is null then 1 else 0 end),2) est_balance
   from rental r
      left outer join payment p
        on r.rental_id = p.rental_id
  ;
"
)
head(rs)
```

```
##   missing found      amt    cnt avg_price est_balance
## 1     1452 14596 61312.04 16048      4.2      6098.4
```

```
### what is the actual outstanding balance
```

```
rs <- dbGetQuery(con,
  "select sum(f.rental_rate) open_amt,count(*) count
   from rental r
      left outer join payment p
        on r.rental_id = p.rental_id
      join inventory i
        on r.inventory_id = i.inventory_id
      join film f
        on i.film_id = f.film_id
   where p.rental_id is null
  ;"
```



```

    )
head(rs)

##    open_amt count
## 1  4297.48  1452

### Rank customers with highest open amounts

rs <- dbGetQuery(con,
  "select c.customer_id,c.first_name,c.last_name,sum(f.rental_rate) open_amt,count(*) cou
    from rental r
    left outer join payment p
      on r.rental_id = p.rental_id
    join inventory i
      on r.inventory_id = i.inventory_id
    join film f
      on i.film_id = f.film_id
    join customer c
      on r.customer_id = c.customer_id
  where p.rental_id is null
  group by c.customer_id,c.first_name,c.last_name
  order by open_amt desc
  limit 25
  ;"
)
head(rs)

```

```

##    customer_id first_name last_name open_amt count
## 1           293      Mae  Fletcher   35.90     10
## 2           307    Joseph      Joy    31.90     10
## 3           316   Steven   Curley    31.90     10
## 4           299    James   Gannon    30.91      9
## 5           274    Naomi  Jennings   29.92      8
## 6           326     Jose   Andrew    28.93      7

```

```
### what film has been rented the most
```

```

rs <- dbGetQuery(con,
  "select i.film_id,f.title,rental_rate,sum(rental_rate) revenue,count(*) count  --16044
    from rental r
    join inventory i
      on r.inventory_id = i.inventory_id
    join film f
      on i.film_id = f.film_id
  group by i.film_id,f.title,rental_rate
  order by count desc
  ;"
)
head(rs)

```

```

##    film_id      title rental_rate revenue count
## 1     103  Bucket Brotherhood      4.99  169.66    34
## 2     738  Rocketeer Mother      0.99   32.67    33
## 3     382   Grit Clockwork      0.99   31.68    32
## 4     767   Scalawag Duck      4.99  159.68    32
## 5     489   Juggler Hardly      0.99   31.68    32
## 6     730  Ridgemont Submarine      0.99   31.68    32

```

```
### what film has been generated the most revenue assuming all amounts are collected
rs <- dbGetQuery(con,
```

```
  "select i.film_id,f.title,rental_rate
    ,sum(rental_rate) revenue,count(*) count --16044
  from rental r
    join inventory i
      on r.inventory_id = i.inventory_id
    join film f
      on i.film_id = f.film_id
  group by i.film_id,f.title,rental_rate
  order by revenue desc
  ;"
)
```

```
head(rs)
```

##	film_id	title	rental_rate	revenue	count
## 1	103	Bucket Brotherhood	4.99	169.66	34
## 2	767	Scalawag Duck	4.99	159.68	32
## 3	973	Wife Turn	4.99	154.69	31
## 4	31	Apache Divine	4.99	154.69	31
## 5	369	Goodfellas Salute	4.99	154.69	31
## 6	1000	Zorro Ark	4.99	154.69	31

```
### which films are in one store but not the other.
```

```
rs <- dbGetQuery(con,
  "select coalesce(i1.film_id,i2.film_id) film_id
    ,f.title,f.rental_rate,i1.store_id,i1.count,i2.store_id,i2.count
  from      (select film_id,store_id,count(*) count
              from inventory where store_id = 1
              group by film_id,store_id) as i1
    full outer join
      (select film_id,store_id,count(*) count
        from inventory where store_id = 2
        group by film_id,store_id
       ) as i2
    on i1.film_id = i2.film_id
  join film f
    on coalesce(i1.film_id,i2.film_id) = f.film_id
  where i1.film_id is null or i2.film_id is null
  order by f.title ;
  "
)
```

```
head(rs)
```

##	film_id	title	rental_rate	store_id	count	store_id..6
## 1	2	Ace Goldfinger	4.99	NA	<NA>	2
## 2	3	Adaptation Holes	2.99	NA	<NA>	2
## 3	5	African Egg	2.99	NA	<NA>	2
## 4	8	Airport Pollock	4.99	NA	<NA>	2
## 5	13	Ali Forever	4.99	NA	<NA>	2
## 6	20	Amelie Hellfighters	4.99	1	3	NA
##	count..7					
## 1	3					
## 2	4					
## 3	3					

```
## 4      4
## 5      4
## 6      <NA>
```

```
# Compute the outstanding balance.
```

```
rs <- dbGetQuery(con,
  "select sum(f.rental_rate) open_amt,count(*) count
    from rental r
      left outer join payment p
        on r.rental_id = p.rental_id
      join inventory i
        on r.inventory_id = i.inventory_id
      join film f
        on i.film_id = f.film_id
    where p.rental_id is null
  ;"
)
head(rs)
```

```
##   open_amt count
## 1  4297.48  1452
```

```
list what's there
```

```
dbListTables(con)
```

```
## [1] "actor_info"          "customer_list"
## [3] "film_list"           "nicer_but_slower_film_list"
## [5] "sales_by_film_category" "staff"
## [7] "sales_by_store"      "staff_list"
## [9] "category"            "film_category"
## [11] "country"             "actor"
## [13] "language"            "inventory"
## [15] "payment"             "rental"
## [17] "city"                "store"
## [19] "film"                "address"
## [21] "film_actor"          "customer"
```

```
Clean up
```

```
# dbRemoveTable(con, "cars")
# dbRemoveTable(con, "mtcars")
# dbRemoveTable(con, "cust_movies")
```

```
# diconnect from the db
```

```
dbDisconnect(con)
```

```
result <- system2("docker", "stop sql-pet", stdout = TRUE, stderr = TRUE)
result
```

```
## [1] "sql-pet"
```


Chapter 11

Postgres Examples, part B (14)

11.1 Verify Docker is up and running:

```
result <- system2("docker", "version", stdout = TRUE, stderr = TRUE)
result
```

```
## [1] "Client:"
## [2] " Version:          18.06.1-ce"
## [3] " API version:      1.38"
## [4] " Go version:       go1.10.3"
## [5] " Git commit:       e68fc7a"
## [6] " Built:            Tue Aug 21 17:21:31 2018"
## [7] " OS/Arch:          darwin/amd64"
## [8] " Experimental:     false"
## [9] ""
## [10] "Server:"
## [11] " Engine:"
## [12] " Version:          18.06.1-ce"
## [13] " API version:      1.38 (minimum version 1.12)"
## [14] " Go version:       go1.10.3"
## [15] " Git commit:       e68fc7a"
## [16] " Built:            Tue Aug 21 17:29:02 2018"
## [17] " OS/Arch:          linux/amd64"
## [18] " Experimental:     true"
```

verify pet DB is available, it may be stopped.

```
result <- system2("docker", "ps -a", stdout = TRUE, stderr = TRUE)
result
```

```
## [1] "CONTAINER ID      IMAGE               COMMAND             CREATED             STATUS              PORTS
## [2] "df141df324e0      postgres:10        \"docker-entrypoint.s...\" 31 seconds ago      Exited (0) 2 seconds
any(grepl('Up .+pet$',result))
```

```
## [1] FALSE
```

Start up the docker-pet container

```
result <- system2("docker", "start sql-pet", stdout = TRUE, stderr = TRUE)
result
```

```
## [1] "sql-pet"
```

now connect to the database with R

```
con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),
                        password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
                        dbname = "dvdrental",
                        seconds_to_test = 10)
```

```
## meta data: check existence of a table
```

```
rs1 <- dbGetQuery(con
  , "SELECT c.*
    FROM pg_catalog.pg_class c
    JOIN pg_catalog.pg_namespace n ON n.oid = c.relnamespace
    WHERE n.nspname = 'public'
    AND c.relname = 'cust_movies'
    AND c.relkind = 'r'
  ;
  "
)
head(rs1)
```

```
## [1] relname          relnamespace      reltype
## [4] reloftype        relowner          relam
## [7] relfilenode      reltablespace     relpages
## [10] reltuples        relallvisible     reltoastrelid
## [13] relhasindex      relisshared       relpersistence
## [16] relkind          relnatts          relchecks
## [19] relhasoids       relhaspkey        relhasrules
## [22] relhastriggers   relhassubclass    relrowsecurity
## [25] relforcerowsecurity relispopulated    relreplident
## [28] relispartition   relfrozenxid      relminmxid
## [31] relacl          reloptions        relpartbound
## <0 rows> (or 0-length row.names)
```

```
## create table via SQL statement
```

```
rs <- dbGetQuery(con
  , 'CREATE TABLE cust_movies AS
    select c.customer_id
    ,first_name
    ,last_name,title
    ,description
    from customer c join rental r on c.customer_id = r.customer_id
    join inventory i on r.inventory_id = i.inventory_id
    join film f on i.film_id = f.film_id
    order by last_name,first_name;
  ,
)
```

```
## Warning in result_fetch(res@ptr, n = n): Don't need to call dbFetch() for
## statements, only for queries
```

```
head(rs)
```

```
## data frame with 0 columns and 0 rows
```

Moved the following lines from #13

```
## how many customers are there in the DVD Rental System
rs1 <- dbGetQuery(con,'select * from customer;')
kable(head(rs1))
```

customer_id	store_id	first_name	last_name	email	address_id	activebool	crea
524	1	Jared	Ely	jared.ely@sakilacustomer.org	530	TRUE	200
1	1	Mary	Smith	mary.smith@sakilacustomer.org	5	TRUE	200
2	1	Patricia	Johnson	patricia.johnson@sakilacustomer.org	6	TRUE	200
3	1	Linda	Williams	linda.williams@sakilacustomer.org	7	TRUE	200
4	2	Barbara	Jones	barbara.jones@sakilacustomer.org	8	TRUE	200
5	1	Elizabeth	Brown	elizabeth.brown@sakilacustomer.org	9	TRUE	200

```
pco <- dbSendQuery(con,'select * from customer;')
rs2 <- dbFetch(pco)
dbClearResult(pco)
kable(head(rs2))
```

customer_id	store_id	first_name	last_name	email	address_id	activebool	crea
524	1	Jared	Ely	jared.ely@sakilacustomer.org	530	TRUE	200
1	1	Mary	Smith	mary.smith@sakilacustomer.org	5	TRUE	200
2	1	Patricia	Johnson	patricia.johnson@sakilacustomer.org	6	TRUE	200
3	1	Linda	Williams	linda.williams@sakilacustomer.org	7	TRUE	200
4	2	Barbara	Jones	barbara.jones@sakilacustomer.org	8	TRUE	200
5	1	Elizabeth	Brown	elizabeth.brown@sakilacustomer.org	9	TRUE	200

```
pco <- dbSendQuery(con,"select * from customer where customer_id between $1 and $2")
dbBind(pco,list(501,525))
rs2 <- dbFetch(pco)
dbClearResult(pco)
kable(head(rs2))
```

customer_id	store_id	first_name	last_name	email	address_id	activebool	crea
524	1	Jared	Ely	jared.ely@sakilacustomer.org	530	TRUE	200
501	1	Ruben	Geary	ruben.geary@sakilacustomer.org	506	TRUE	200
502	1	Brett	Cornwell	brett.cornwell@sakilacustomer.org	507	TRUE	200
503	1	Angel	Barclay	angel.barclay@sakilacustomer.org	508	TRUE	200
504	1	Nathaniel	Adam	nathaniel.adam@sakilacustomer.org	509	TRUE	200
505	1	Rafael	Abney	rafael.abney@sakilacustomer.org	510	TRUE	200

```
rs1 <- dbGetQuery(con,
  "explain select r.*
    from rental r
  ;"
)
head(rs1)
```

```
## QUERY PLAN
## 1 Seq Scan on rental r (cost=0.00..310.44 rows=16044 width=36)
```

```
rs2 <- dbGetQuery(con,
  "explain select count(*) count
    from rental r
    left outer join payment p
      on r.rental_id = p.rental_id
    where p.rental_id is null
  ;")
head(rs2)
```

```
##
## 1
## 2
## 3
## 4
## 5
```

QUERY PLAN

```
Aggregate (cost=2086.78..2086.80 rows=1 width=8)
-> Merge Anti Join (cost=0.57..2066.73 rows=8022 width=0)
Merge Cond: (r.rental_id = p.rental_id)
-> Index Only Scan using rental_pkey on rental r (cost=0.29..1024.95 rows=16044 width=4)
-> Index Only Scan using idx_fk_rental_id on payment p (cost=0.29..819.23 rows=14596 width=4)
```

```
rs3 <- dbGetQuery(con,
  "explain select sum(f.rental_rate) open_amt,count(*) count
    from rental r
      left outer join payment p
        on r.rental_id = p.rental_id
      join inventory i
        on r.inventory_id = i.inventory_id
      join film f
        on i.film_id = f.film_id
    where p.rental_id is null
  ;")
head(rs3)
```

```
##
## 1
## 2
## 3
## 4
## 5
## 6
```

QUERY PLAN

```
Aggregate (cost=2353.64..2353.65 rows=1 width=40)
-> Hash Join (cost=205.14..2313.53 rows=8022 width=12)
Hash Cond: (i.film_id = f.film_id)
-> Hash Join (cost=128.64..2215.88 rows=8022 width=2)
Hash Cond: (r.inventory_id = i.inventory_id)
-> Merge Anti Join (cost=0.57..2066.73 rows=8022 width=4)
```

```
rs4 <- dbGetQuery(con,
  "explain select c.customer_id,c.first_name,c.last_name,sum(f.rental_rate) open_amt,count(*) count
    from rental r
      left outer join payment p
        on r.rental_id = p.rental_id
      join inventory i
        on r.inventory_id = i.inventory_id
      join film f
        on i.film_id = f.film_id
      join customer c
        on r.customer_id = c.customer_id
    where p.rental_id is null
    group by c.customer_id,c.first_name,c.last_name
    order by open_amt desc
  ;")
head(rs4)
```

```
##
## 1
## 2
## 3
## 4
## 5
## 6
```

QUERY PLAN

```
Sort (cost=2452.49..2453.99 rows=599 width=260)
Sort Key: (sum(f.rental_rate)) DESC
-> HashAggregate (cost=2417.37..2424.86 rows=599 width=260)
Group Key: c.customer_id
-> Hash Join (cost=227.62..2357.21 rows=8022 width=232)
Hash Cond: (r.customer_id = c.customer_id)
```


11.2 SQL Execution Steps

- Parse the incoming SQL query
- Compile the SQL query
- Plan/optimize the data acquisition path
- Execute the optimized query / acquire and return data

```
dbWriteTable(con, "mtcars", mtcars, overwrite = TRUE)
rs <- dbSendQuery(con, "SELECT * FROM mtcars WHERE cyl = 4")
dbFetch(rs)
```

```
##      mpg cyl  disp  hp drat   wt  qsec vs am gear carb
## 1  22.8   4 108.0  93 3.85 2.320 18.61 1  1   4    1
## 2  24.4   4 146.7  62 3.69 3.190 20.00 1  0   4    2
## 3  22.8   4 140.8  95 3.92 3.150 22.90 1  0   4    2
## 4  32.4   4  78.7  66 4.08 2.200 19.47 1  1   4    1
## 5  30.4   4  75.7  52 4.93 1.615 18.52 1  1   4    2
## 6  33.9   4  71.1  65 4.22 1.835 19.90 1  1   4    1
## 7  21.5   4 120.1  97 3.70 2.465 20.01 1  0   3    1
## 8  27.3   4  79.0  66 4.08 1.935 18.90 1  1   4    1
## 9  26.0   4 120.3  91 4.43 2.140 16.70 0  1   5    2
## 10 30.4   4  95.1 113 3.77 1.513 16.90 1  1   5    2
## 11 21.4   4 121.0 109 4.11 2.780 18.60 1  1   4    2
```

```
dbClearResult(rs)
```

```
#Pass one set of values with the param argument:
rs <- dbSendQuery(con, "SELECT * FROM mtcars WHERE cyl = 4")
dbFetch(rs)
```

```
##      mpg cyl  disp  hp drat   wt  qsec vs am gear carb
## 1  22.8   4 108.0  93 3.85 2.320 18.61 1  1   4    1
## 2  24.4   4 146.7  62 3.69 3.190 20.00 1  0   4    2
## 3  22.8   4 140.8  95 3.92 3.150 22.90 1  0   4    2
## 4  32.4   4  78.7  66 4.08 2.200 19.47 1  1   4    1
## 5  30.4   4  75.7  52 4.93 1.615 18.52 1  1   4    2
## 6  33.9   4  71.1  65 4.22 1.835 19.90 1  1   4    1
## 7  21.5   4 120.1  97 3.70 2.465 20.01 1  0   3    1
## 8  27.3   4  79.0  66 4.08 1.935 18.90 1  1   4    1
## 9  26.0   4 120.3  91 4.43 2.140 16.70 0  1   5    2
## 10 30.4   4  95.1 113 3.77 1.513 16.90 1  1   5    2
## 11 21.4   4 121.0 109 4.11 2.780 18.60 1  1   4    2
```

```
dbClearResult(rs)
```

```
# Pass multiple sets of values with dbBind():
rs <- dbSendQuery(con, "SELECT * FROM mtcars WHERE cyl = $1")
dbBind(rs, list(6L)) # cyl = 6
dbFetch(rs)
```

```
##      mpg cyl  disp  hp drat   wt  qsec vs am gear carb
## 1  21.0   6 160.0 110 3.90 2.620 16.46 0  1   4    4
## 2  21.0   6 160.0 110 3.90 2.875 17.02 0  1   4    4
## 3  21.4   6 258.0 110 3.08 3.215 19.44 1  0   3    1
## 4  18.1   6 225.0 105 2.76 3.460 20.22 1  0   3    1
## 5  19.2   6 167.6 123 3.92 3.440 18.30 1  0   4    4
## 6  17.8   6 167.6 123 3.92 3.440 18.90 1  0   4    4
```

```
## 7 19.7 6 145.0 175 3.62 2.770 15.50 0 1 5 6
```

```
dbBind(rs, list(8L)) # cyl = 8
dbFetch(rs)
```

```
##      mpg  cyl  disp  hp drat   wt  qsec vs am gear carb
## 1  18.7    8 360.0 175 3.15 3.440 17.02 0 0   3    2
## 2  14.3    8 360.0 245 3.21 3.570 15.84 0 0   3    4
## 3  16.4    8 275.8 180 3.07 4.070 17.40 0 0   3    3
## 4  17.3    8 275.8 180 3.07 3.730 17.60 0 0   3    3
## 5  15.2    8 275.8 180 3.07 3.780 18.00 0 0   3    3
## 6  10.4    8 472.0 205 2.93 5.250 17.98 0 0   3    4
## 7  10.4    8 460.0 215 3.00 5.424 17.82 0 0   3    4
## 8  14.7    8 440.0 230 3.23 5.345 17.42 0 0   3    4
## 9  15.5    8 318.0 150 2.76 3.520 16.87 0 0   3    2
## 10 15.2    8 304.0 150 3.15 3.435 17.30 0 0   3    2
## 11 13.3    8 350.0 245 3.73 3.840 15.41 0 0   3    4
## 12 19.2    8 400.0 175 3.08 3.845 17.05 0 0   3    2
## 13 15.8    8 351.0 264 4.22 3.170 14.50 0 1   5    4
## 14 15.0    8 301.0 335 3.54 3.570 14.60 0 1   5    8
```

```
dbClearResult(rs)
```

This is an example from the DBI help file

```
dbWriteTable(con, "cars", head(cars, 3)) # not to be confused with mtcars
dbReadTable(con, "cars") # there are 3 rows
```

```
##      speed dist
## 1         4    2
## 2         4   10
## 3         7    4
```

```
dbExecute(
  con,
  "INSERT INTO cars (speed, dist) VALUES (1, 1), (2, 2), (3, 3)"
)
```

```
## [1] 3
```

```
dbReadTable(con, "cars") # there are now 6 rows
```

```
##      speed dist
## 1         4    2
## 2         4   10
## 3         7    4
## 4         1    1
## 5         2    2
## 6         3    3
```

Pass values using the param argument:

```
dbExecute(
  con,
  "INSERT INTO cars (speed, dist) VALUES ($1, $2)",
  param = list(4:7, 5:8)
)
```

```
## [1] 4
```

```
dbReadTable(con, "cars")  # there are now 10 rows
```

```
##      speed dist
## 1         4    2
## 2         4   10
## 3         7    4
## 4         1    1
## 5         2    2
## 6         3    3
## 7         4    5
## 8         5    6
## 9         6    7
## 10        7    8
```

Clean up

```
dbRemoveTable(con, "cars")
dbRemoveTable(con, "mtcars")
dbRemoveTable(con, "cust_movies")
```

```
# diconnect from the db
```

```
dbDisconnect(con)
```

```
result <- system2("docker", "stop sql-pet", stdout = TRUE, stderr = TRUE)
result
```

```
## [1] "sql-pet"
```


Chapter 12

Other resources

12.1 Editing this book

- Here are instructions for editing this tutorial

12.2 Docker alternatives

- Choosing between Docker and Vagrant

12.3 Docker and R

- Noam Ross' talk on Docker for the UseR and his Slides give a lot of context and tips.
- Good Docker tutorials
 - An introductory Docker tutorial
 - A Docker curriculum
- Scott Came's materials about Docker and R on his website and at the 2018 UseR Conference focus on **R inside Docker**.
- It's worth studying the ROpensci Docker tutorial

12.4 Documentation Docker and Postgres

- The Postgres image documentation
- Dockerize PostgreSQL
- Postgres & Docker documentation
- Usage examples of Postgres with Docker

12.5 More Resources

- David Severski describes some key elements of connecting to databases with R for MacOS users
- This tutorial picks up ideas and tips from Ed Borasky's Data Science pet containers, which creates a framework based on that Hack Oregon example and explains why this repo is named pet-sql.

Chapter 13

Mapping your local environment (92)

```
library(tidyverse)

## -- Attaching packages -----
## v ggplot2 3.0.0    v purrr  0.2.5
## v tibble  1.4.2    v dplyr  0.7.6
## v tidyr   0.8.1    v stringr 1.3.1
## v readr   1.1.1    v forcats 0.3.0

## -- Conflicts -----
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()

library(DBI)
library(RPostgres)
library(glue)

##
## Attaching package: 'glue'
## The following object is masked from 'package:dplyr':
##
##      collapse

library(knitr)
```

13.1 Environment Tools Used in this Chapter

Note that `tidyverse`, `DBI`, `RPostgres`, `glue`, and `knitr` are loaded. Also, we've sourced the `[db-login-batch-code.R]` (`'r-database-docker/book-src/db-login-batch-code.R'`) file which is used to log in to PostgreSQL.

```
library(rstudioapi)
```

The following code block defines `Tool` and versions for the graph that follows. The information order corresponds to the order shown in the graph.

```
library(DiagrammeR)

## OS information
os_lbl <- .Platform$OS.type
```

```

os_ver <- 0
if (os_lbl == 'windows') {
  os_ver <- system2('cmd', stdout = TRUE) %>%
    grep(x = ., pattern = 'Microsoft Windows \\[', value = TRUE) %>%
    gsub(x = ., pattern = "^Microsoft.+Version |\\]", replace = '')
}

if (os_lbl == 'unix' || os_lbl == 'Linux' || os_lbl == 'Mac') {
  os_ver <- system2('uname', '-r', stdout = TRUE)
}

## Command line interface into Docker Apps
## CLI/system2
cli <- array(dim = 3)
cli[1] <- "docker [OPTIONS] COMMAND ARGUMENTS\n\nsystem2(docker,[OPTIONS,]\n, COMMAND, ARGUMENTS)"
cli[2] <- 'docker exec -it sql-pet bash\n\nsystem2(docker,exec -it sql-pet bash)'
cli[3] <- 'docker exec -ti sql-pet psql -a \n-p 5432 -d dvdrental -U postgres\n\nsystem2(docker,exec -t'

# R Information
r_lbl      <- names(R.Version())[1:7]
r_ver      <- R.Version()[1:7]

# RStudio Information
rstudio_lbl <- c('RStudio version', 'Current program mode')
rstudio_ver <- c(as.character(rstudioapi::versionInfo()$version), rstudioapi::versionInfo()$mode)

# Docker Information
docker_lbl <- c('client version', 'server version')
docker_ver <- system2("docker", "version", stdout = TRUE) %>%
  grep(x = ., pattern = 'Version', value = TRUE) %>%
  gsub(x = ., pattern = ' +Version: +', replacement = '')

# Linux Information
linux_lbl <- 'Linux Version'
linux_ver <- system2('docker', 'exec -i sql-pet /bin/uname -r', stdout = TRUE)

# Postgres Information
con <- wait_for_postgres(user = Sys.getenv("DEFAULT_POSTGRES_USER_NAME"),
  password = Sys.getenv("DEFAULT_POSTGRES_PASSWORD"),
  dbname = "dvdrental",
  seconds_to_test = 10)

postgres_ver <- dbGetQuery(con, "select version()") %>%
  gsub(x = ., pattern = '\\(.*$', replacement = '')

```

The following code block uses the data generated from the previous code block as input to the subgraphs, the ones outlined in red. The application nodes are the parents of the subgraphs and are not outlined in reds. The `Environment` application node represents the machine you are running the tutorial on and hosts the sub-applications.

Note that the '@@' variables are populated at the end of the `Environment` definition following the `## @@1 - @@5` source data comment.

```

grViz("
digraph Envgraph {

```



```

# graph, node, and edge definitions
graph [compound = true, nodesep = .5, ranksep = .25,
      color = red]

node [fontname = Helvetica, fontcolor = darkslategray,
      shape = rectangle, fixedsize = true, width = 1,
      color = darkslategray]

edge [color = grey, arrowhead = none, arrowtail = none]

# subgraph for Environment information
subgraph cluster1 {
  node [fixedsize = true, width = 3]
  '@@1-1'
}

# subgraph for R information
subgraph cluster2 {
  node [fixedsize = true, width = 3]
  '@@2-1' -> '@@2-2' -> '@@2-3' -> '@@2-4'
  '@@2-4' -> '@@2-5' -> '@@2-6' -> '@@2-7'
}

# subgraph for RStudio information
subgraph cluster3 {
  node [fixedsize = true, width = 3]
  '@@3-1' -> '@@3-2'
}

# subgraph for Docker information
subgraph cluster4 {
  node [fixedsize = true, width = 3]
  '@@4-1' -> '@@4-2'
}

# subgraph for Docker-Linux information
subgraph cluster5 {
  node [fixedsize = true, width = 3]
  '@@5-1'
}

# subgraph for Docker-Postgres information
subgraph cluster6 {
  node [fixedsize = true, width = 3]
  '@@6-1'
}

# subgraph for Docker-Postgres information
subgraph cluster7 {
  node [fixedsize = true, height = 1.25, width = 4.0]
  '@@7-1' -> '@@7-2' -> '@@7-3'
}

```

```

CLI [label='CLI\nRStudio system2',height = .75,width=3.0, color = 'blue' ]
Environment [label = 'Linux,Mac,Windows',width = 2.5]
Environment -> R
Environment -> RStudio
Environment -> Docker

Environment -> '@@1' [lhead = cluster1] # Environment Information
R -> '@@2-1' [lhead = cluster2] # R Information
RStudio -> '@@3' [lhead = cluster3] # RStudio Information
Docker -> '@@4' [lhead = cluster4] # Docker Information
Docker -> '@@5' [lhead = cluster5] # Docker-Linux Information
Docker -> '@@6' [lhead = cluster6] # Docker-Postgres Information

'@@1' -> CLI
CLI -> '@@7' [lhead = cluster7] # CLI
'@@7-2' -> '@@5'
'@@7-3' -> '@@6'
}
[1]: paste0(os_lbl, ':\n', os_ver)
[2]: paste0(r_lbl, ':\n', r_ver)
[3]: paste0(rstudio_lbl, ':\n', rstudio_ver)
[4]: paste0(docker_lbl, ':\n', docker_ver)
[5]: paste0(linux_lbl, ':\n', linux_ver)
[6]: paste0('PostgreSQL:\n', postgres_ver)
[7]: cli
")

```

One sub-application not shown above is your local console/terminal/cli application. In the tutorial, fully constructed docker commands are printed out and then executed. If for some reason the executed docker command fails, one can copy and paste it into your local terminal window to see additional error information. Failures seem more prevalent in the Windows environment.

13.2 Communicating with Docker Applications

In this tutorial, the two main ways to interface with the applications in the Docker container are through the CLI or the RStudio `system2` command. The blue box in the diagram above represents these two interfaces.