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Modern Packaging in R

Best practices (CI, testing, linting and more)

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Motivation

- Why
- How? → This is what we are now doing
- But: in a nice and easy way
 - using CI
 - producing nicely formatted code
 - automated tested code
- Good ideas:
 - find a good, short name (Package **available**)
 - think about
 - ▶ why the package exist and
 - ▶ what functionality should it contain?
 - define a namespace

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Create a Package

- Traditionally
 - `utils::package.skeleton()`
 - manually writing `man`-files and managing `NAMESPACE`, ...
- Idea:
 - some functions and exports were defined
 - a `README` file with instructions was created
- Problem:
 - quite inconvenient

- Assumptions for this tutorial:
 - Rstudio is installed and also git is available
 - packages devtools, usethis, roxygen2, testthat, covr and lintr are installed
- Using package usethis to create a package skeleton (and a corresponding Rstudio project)
 - `?usethis::create_package()`
- Note: take care to use an absolute path here if you're already in an rstudio project
- Then we can add additional parts for a good package "selectively"

An improved and simpler way (2)

- These codes create a new package urosconf and a Rstudio project

```
usethis::create_package(path = "~/urosconf")
```

- if Rstudio is available, it switches to the new project
- Note: one may change defaults of the DESCRIPTION file

```
usethis::create_package(path = "~/urosconf", fields = list(  
  `Authors@R` = 'person(  
    given = "Bernhard", family = "Meindl",  
    email = "bernhard.meindl@statistik.at", role = c("aut", "cre"))',  
  License = "GPL-3",  
  Version = "0.1"  
)
```

➤ content of the DESCRIPTION file

```
Package: urosconf
Title: What the Package Does (One Line, Title Case)
Version: 0.1
Authors@R:
  person(given = "Bernhard",
         family = "Meindl",
         role = c("aut", "cre"),
         email = "bernhard.meindl@statistik.at")
Description: What the package does (one paragraph).
License: GPL-3
Encoding: UTF-8
LazyData: true
RoxygenNote: 6.1.1
```


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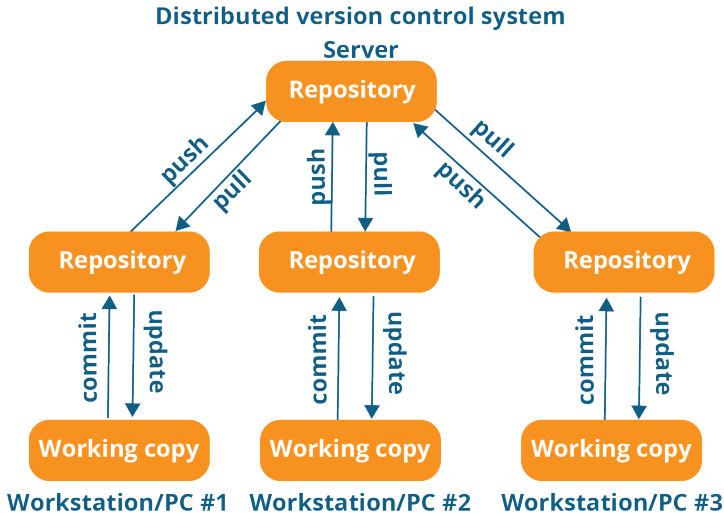
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Using Git

Git is an open source, distributed version control system.

- **control system:** can be used to store content (mostly code)
- **versioned:** keeps track of multiple versions and the entire history
- **distributed:** git has a central repository and a number of local repos



- code should always be versioned → we want to use git
 - 1: `usethis::use_git()` initiates a local git repo
 - 2: `usethis::use_github()` links the local repo to github
- it is required to have **github.com** account
- we need to set up authentication, either
 - `usethis::browse_github_pat()` using an access tokens or
 - using public/private key authorization, see `?usethis::use_github`
- Good documentation can be found **here**

Creating a local git repository

```
usethis::use_git()
```

- this function initiates the local repo
- it asks to also commits all existing files (you should say yes here)
- also say yes, if you are asked whether Rstudio should be restarted

➤ Authorization to github (via token)

```
usethis::browse_github_pat() # create a access token/pattern  
usethis::edit_r_environ() # add it to the .Renviron file
```

- The token is like a password (and should be kept as such)
- The .Renviron file should have a line in the following format:

```
GITHUB_PAT=xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

➤ Next step: create remote repo on github and push our code

```
usethis::use_github()
```

- modifies DESCRIPTION adding URL and BugReports fields
- Note: this linkage may also be done manually, usethis is not required

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Adding Features

- Add a NEWS.md file in markdown format document track changes in the package

```
usethis::use_news_md()
```

```
# urosconf 0.1
```

```
* Added a `NEWS.md` file to track changes to the package.
```


- Add a README.(r)md in (R)markdown format
- already filled with a nice template that can be easily adjusted
- The README.md generates the content at the bottom of a GitHub repository, such as how to install or use the package.
- You can also put your badges for number of downloads, version on CRAN (if applicable), continuous integration status, and code coverage.

```
# plain markdown
usethis::use_readme_md()

# rmarkdown style (you can use code-chunks)
usethis::use_readme_rmd()
```

- if using Rmarkdown, one has to regularly regenerate the md file!

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Add functionality

- the R folder is by default empty
- we write a simple function in R/greets.R
- note, we're using a function from another package here!

```
greets <- function(name = "bernhard") {  
  s <- "hi {name}, the uros 2019 in bukaresht is great!"  
  message(glue::glue(s, name = shQuote(name)))  
}
```

- it is required to add the glue package to the Imports section of DESCRIPTION
 - easy: `usethis::use_package("glue")`
- if we use `glue::fun()`, this is all we need to do

➤ the DESCRIPTION file now is

```
Package: urosconf
Title: What the Package Does (One Line, Title Case)
Version: 0.1
Authors@R:
  person(given = "Bernhard",
    family = "Meindl",
    role = c("aut", "cre"),
    email = "bernhard.meindl@statistik.at")
Description: What the package does (one paragraph).
License: GPL-3
Encoding: UTF-8
LazyData: true
Imports:
  glue
RoxygenNote: 6.1.1
```

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Adding data

- Two possible ways:
 - 1: directly use an existing data set with `usethis::use_data()`
 - 2: use a script to generate data for improved reproducibility
- We give an example for the second approach

```
usethis::use_data_raw()
```

- This create a folder `data-raw` in which we can put scripts that generate data

- `data-raw/urodata.R` is a script to generate data (note the `set.seed` call)

```
set.seed(1)
N <- 50
urodata <- data.frame(
  x = sample(letters, N, replace = TRUE),
  v = rnorm(N)
)
usethis::use_data(urodata, overwrite = TRUE)
```

- we just need to source this file
- `usethis::use_data()` copies the dataset to the data folder and makes it available

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Documentation

- do not repeat yourself and document consistently
- make use of markdown to even further simplify the documentation
- More information [here](#)
- `usethis::use_roxygen_md()` sets up everything
- **Note:** If you try to document before setting this up, you probably need to install `roxygen2md` to convert existing documentation to markdown format in advance

```
remotes::install_github("r-lib/roxygen2md")  
usethis::use_roxygen_md()
```

- we need to document `greet()` and the dataset
- in Rstudio: Code → Insert Roxygen Skeleton
- modify `R/greet.R` (note the Markdown tags)

```
#' A nice hello from Bukrarest
#'  
#'[greet()] gives a warm greeting from the Uros19.  
#'  
# '@param name specify who we want to greet.  
# '@return `NULL`  
# '@export  
# '@examples  
# greet("alex")  
greet <- function(name = "bernhard") {  
  s <- "hi {name}, the uros 2019 in bukarest is great!"  
  message(glue::glue(s, name = shQuote(name)))  
}
```

- documenting data is done via `R/data.R`

```
#' urosdata
#'
#' Some testdata for the urosconf pkg with this two variables:
#' - `v`: a factor of lower case letter
#' - `x` random values from a standard normal distribution
#' @usage data(urosdata)
#' @name urosdata
NULL
```

- update the documentation and the NAMESPACE

```
devtools::document() # or in the Rstudio "Build"-tab
```

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Vignette

- Package vignettes are a great way to demonstrate the functionality of your package
- Setting everything up can be done with:

```
usethis::use_vignette("intro")
```

- updates NAMESPACE with required Imports and Suggests
- updates DESCRIPTION to specify the vignette builder (markdown)
- adding files that should be ignored in git (see later)
- creates vignettes/intro.Rmd with a default template

- we modify `vignettes/intro.Rmd`

```
---  
title: "A short introduction"  
author: "Bernhard Meindl"  
date: "`r Sys.Date()`"  
output: rmarkdown::html_vignette  
vignette: >  
  %\VignetteIndexEntry{Vignette Title}  
  %\VignetteEngine{knitr::rmarkdown}  
  %\VignetteEncoding{UTF-8}  
---  
  
## Motivation  
We write this to facilitate the useage of this package.
```

- build with `devtools::build_vignettes()`
- will be updated whenever we build the package.

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Use Rcpp

- Setup the package to use Rcpp is easy

```
usethis::use_rcpp()
```

- modifies the DESCRIPTION file
 - adds Imports and LinkingTo fields
- creates a src folder
- updates .gitignore and .Rbuildignore to exclude compiled files

- We get instructions how to update our NAMESPACE via roxygen2
- we update a R/urosconf-pkg.R adding at the top

```
#' @useDynLib urosconf, .registration = TRUE  
#'  
@importFrom Rcpp sourceCpp  
NULL
```

- The updated DESCRIPTION file now is

```
Package: urosconf
Title: What the Package Does (One Line, Title Case)
Version: 0.1
Authors@R:
  person(given = "Bernhard",
         family = "Meindl",
         role = c("aut", "cre"),
         email = "bernhard.meindl@statistik.at")
Description: What the package does (one paragraph).
License: GPL-3
Encoding: UTF-8
LazyData: true
LinkingTo:
  Rcpp
Imports:
  Rcpp,
  glue
RoxygenNote: 6.1.1
```

- finishing Rcpp requires to add a simple C++ function
- content of `src/info.cpp`

```
#include <Rcpp.h>
using namespace Rcpp;

// [[Rcpp::export]]
CharacterVector uros_info() {
    CharacterVector v = "the uros20 will be in vienna :)";
    return(v);
}
```

- run `devtools::load_all()` and `devtools::document()`

- We can then either
 - write a wrapper function and export those for the cpp function
 - call it within an existing R function like greets()

```
#' A nice hello from Bukrarest
#'
#' [greets()] gives a **warm** greeting from the Uros19.
#'
#' @param name specify who we want to greet.
#' @return `NULL`
#' @export
#' @examples
#' greets("alex")
greets <- function(name = "bernhard") {
  s <- "hi {name}, the uros 2019 in bukarest is great!"
  message(glue::glue(s, name = shQuote(name)))
  message(uros_info())
}
```

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Using CI

- Continuous integration: allows to automatically build, check, test and deploy our code
- runs whenever the underlying code base (typically a connected git repo) changes
- we are using Travis CI: (travis-ci.org)
 - allows to build, test and check R packages
 - account is required, but you can use your github.com account
 - required to authorize travis to be able to access your github repos
 - after successful authorizing and syncing the accounts, the new urosconf repo is shown

- telling R that we want to use travis

```
usethis::use_travis()
```

- it adds a basic .travis.yml file
- adds this file to .Rbuildignore
- useful settings in .travis.yml
 - warnings_are_errors: true
 - r_check_args: "--as-cran"

➤ additional options

```
language: r
sudo: required

cache:
  - packages: true

r_packages:
  - devtools

r_github_packages:
  - r-lib/usethis

notifications:
  email:
    on_success: always
    on_failure: always
```


- further documentation: [travis for R](#)
- additional options:
 - `after_success`: additional steps that should be done after the package was successfully built, checked and tested can be listed
 - `deploy`: it is possible to copy results, e.g a [pkgdown site](#)

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Testing the Package

- Testing the package is important
- package `testthat` can be used for this
- setting up the testing infrastructure is as easy as

```
usethis::use_testthat()
```

- adds `testthat` to field `Suggests` in `DESCRIPTION`
- creates a folder `tests` in which the unit-tests should be placed

- add as many files and tests folder tests/testthat as you like
- we add files/tests/test_hello.R (must start with test*)

```
## files/tests  
## +-- testthat  
## |   \-- test_greets.R  
## \-- testthat.R
```

- content of tests/testthat/test_hello.R

```
# testing greets()  
expect_null(greets())  
expect_message(greets())  
NULL
```

- finally, all tests can be run using devtools::test()

- Code Coverage: measures the percentage of code that is tested through unit tests
- we want the percentage as high as possible
- we are using package **covr**
- interactive: `covr::report()` returns an clickable html-widget
- provides backends to two online code coverage tools
 - coveralls.io
 - codecov.io

- we are now using codecov.io
- adding the coverage step to the package can be done with:

```
usethis::use_coverage("codecov")
```

- this function
 - creates `codecov.yml`
 - updates `.Rbuildignore`
 - updates `.travis.yml` adding
- after the package is successfully built, the code coverage is computed and uploaded

```
after_success:  
- Rscript -e 'covr::coveralls()'
```

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Code style

- Readability of a package is improved a lot, when
 - coding style is consistent within the package
 - e.g. snake_case vs. camelCase or indenting
- one (of many) styleguides: **tidyverse styleguide**
- Package **styler** allows automated code formatting
- Package **lintr** allows to automate checks

- Linting rules can be defined either
 - directly within `lintr::lintr_package()` or
 - in a file `.lintr` in the root of the package
- Adding code-style checks to CI is easy by adding a line `.travis.yml` to the `after_success` step

```
after_success:  
- # ...  
- Rscript -e 'lintr::lint_package()'
```

- Alternative: create `tests/testthat/test_style.R` with

```
test_that("style is nice", {  
  lintr::expect_lint_free()  
})
```

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Even more

➤ Add badges to your README.md

```
# travis
! [Build] (https://travis-ci.org/{user/repo}.svg?branch=master)]
(https://travis-ci.org/{user/repo})

# codecov.io
[! [Coverage] (https://codecov.io/gh/{user/repo}/branch/master/graph/badge.s
(https://codecov.io/gh/{user/repo}/branch/master)
```

- many other badges available
- don't forget the badge with the cool sunglasses from the **awesome official statistics software**



- `pkgdown` is a nice way to build a static webpage for a package
 - github has github pages (free hosting for static project pages)
 - `usethis::use_pkgdown()`
 - automatic deployment via travis → [documentation](#)
- `devtools::spell_check()` allows to detect typos
- use package analytics, e.g. using the [cranlogs](#) package
- think of good examples to help users

- commit all changes to the local git repo
- push the changes to github and let the magic happen
 - the package is now built
 - checked
 - tested
 - vignettes are built
- if successful:
 - code coverage is computed and synced
 - code style is checked

- Once everything works, it is easy to reproduce for other packages
- `devtools::release() ? :`