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uRos 2019 - Bukarest  
May, 2019

# 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 urosconfpkg and a Rstudio project

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

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

```
usethis::create_package(path = "~/urosconfpkg", 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 (after some manual updates)

```
Package: urosconfpkg
Title: A Demo Package for Uros19 in Bukarest
Version: 0.1
Authors@R:
  person(given = "Bernhard",
         family = "Meindl",
         role = c("aut", "cre"),
         email = "bernhard.meindl@statistik.at")
Description: A boilerplate for a CI-capable modern R package
License: GPL-3
Encoding: UTF-8
LazyData: true
RoxygenNote: 6.1.1
```



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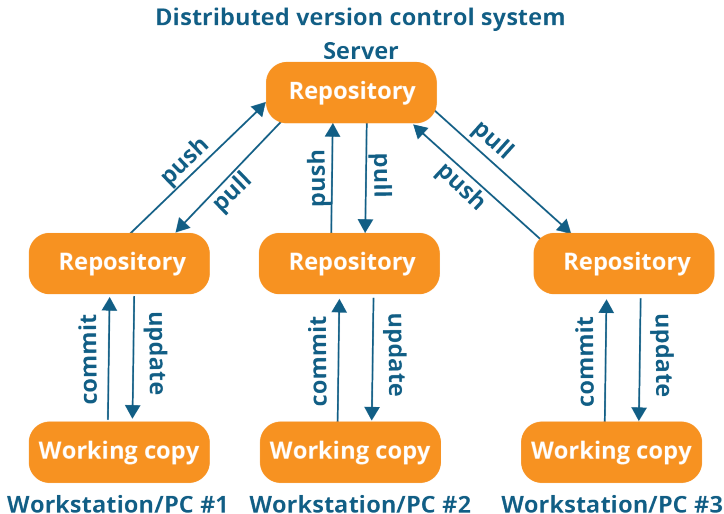
# Modern Packaging in R

## 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

# What is git? (2)



- 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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# Modern Packaging in R

## Adding Features

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

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

```
# urosconfpkg 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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# Modern Packaging in R

## 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 = "everybody") {  
  s <- "hi {name}, the uros 2019 in bukarest 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: urosconfpkg
Title: A Demo Package for Uros19 in Bukarest
Version: 0.1
Authors@R:
  person(given = "Bernhard",
    family = "Meindl",
    role = c("aut", "cre"),
    email = "bernhard.meindl@statistik.at")
Description: A boilerplate for a CI-capable modern R package
License: GPL-3
Encoding: UTF-8
LazyData: true
Imports:
  glue
RoxygenNote: 6.1.1
```

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# Modern Packaging in R

## 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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# Modern Packaging in R

## 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()  
greet <- function(name = "everybody") {  
  s <- "hi {name}, the uros 2019 in bukarest is great!"  
  message(glue::glue(s, name = shQuote(name)))  
}
```

- ```
#' urosdata
#'  
#' Some testdata for `urosconfpkg` 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
```

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

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# Modern Packaging in R

## 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
- 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/urosconfpkg-package.R adding at the top

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

## ➤ The updated DESCRIPTION file now is

```
Package: urosconfpkg
Title: A Demo Package for Uros19 in Bukarest
Version: 0.1
Authors@R:
  person(
    given = "Bernhard",
    family = "Meindl", role = c("aut", "cre"),
    email = "bernhard.meindl@statistik.at")
Description: A boilerplate for a CI-capable modern R package
License: GPL-3
Encoding: UTF-8
LazyData: true
LinkingTo: Rcpp
Imports: Rcpp, glue
Suggests: knitr, rmarkdown, testthat
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;
  v = "the uros 2020 will take place 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()  
greets <- function(name = "everybody") {  
  s <- "hi {name}, the uros 2019 in bukarest is great!"  
  message(glue::glue(s, name = shQuote(name)))  
  message(uros_info())  
}
```

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# Modern Packaging in R

## 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](https://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 urosconfpkg 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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# Modern Packaging in R

## 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](https://coveralls.io)
  - [codecov.io](https://codecov.io)

- we are now using [codecov.io](https://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::codecov()'
```

## Link **codecov** and **travis**

- Login to **codecov.io**
  - Add new repository → Select your package
  - copy Upload Token
- Login to **travis-ci**
  - Go to your package
  - More options → Settings
  - Under Environment variables add:
    - ▶ Name: "CODECOV\_TOKEN"
    - ▶ Value: der Token

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## Code style



- Readability of a package is improves 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
- run `goodpractice::gp()` to get additional hints to improve the package
- 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()` ? :)
- **Downloads**
  - sample package
  - slides