svUnit - A framework for unit testing in R

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1 Introduction

Unit testing (see http://en.wikipedia.org/wiki/Unit_test) is an approach successfully used to develop software, and to ease code refactoring for keeping bugs to the minimum. It is also the insurance that the software is doing the right calculation (quality insurance). Basically, a test just checks if the code is running and is producing the correct answer/behavior in a given situation. As such, unit tests are build in R package production because all examples in documentation files, and perhaps, test code in '/tests' subdirectory are run during the checking of a package (R CMD check <pkg>). However, the R approach lacks a certain number of features to allow optimal use of unit tests as in extreme programming (test first – code second):

- Tests are related to package compilation and cannot easily be run independently (for instance, for functions developed separately).
- Once a test fails, the checking process is interrupted. Thus one has to correct the bug and launch package checking again... and perhaps get caught by the next bug. It is a long and painful process.
- There is no way to choose one or several tests selectively: all are run or not (depending on command line options) during package checking.
- It is very hard, or near to impossible to program in R in a test driven development (write tests first) with the standard tools (http://en.wikipedia.org/wiki/Test-driven_development).
- Consequently, the ‘test-code-simplify’ cycle is not easily accessible yet to R programmer, because of the lack of an interactive and flexible testing mechanism providing immediate, or quasi immediate feedback about changes made.
- We would like also to emphasize that test suites are not only useful to check code, they can also be used to check data, or the pertinence of analyses.

1.1 Unit testing in R without svUnit

Besides the "regular" testing mechanism of R packages, one can find the RUnit package on CRAN (http://cran.r-project.org). Another package used to provide an alternate implementation of test unit: butler, but it is not maintained any more and has given up in favor of RUnit. RUnit implements the following features:

- Assertions, checkEquals(), checkEqualsNumeric(), checkIdentical() and checkTrue() and negative tests (tests that check error conditions, checkException()).

- Assertions are grouped into R functions to form one test function that runs a series of related individual tests. It is easy to temporarily inactivate one or more tests by commenting lines in the function. To avoid forgetting tests that are commented out later on, there is special function, named DEACTIVATED() that tags the test with a reminder for your deactivated items (i.e., the reminder is written in the test log).
1.2 Unit testing framework for R with svUnit

- A series of test functions (whose name typically start with `test...`) are collected together in a sourceable R code file (name starting with `runit...` on disk. This file is called a **test unit**.

- A **test suite** (object `RUnitTestSuite`) is a special object defining a battery of tests. It points to one or several directories containing test units. A test suite is defined by `defineTestSuite()`.

- One or more test suites can be run by calling `runTestSuite()`. There is a shortcut to define and run a test suite constituted by only one test unit by using the function `runTestFile()`. Once the test is run, a `RUnitTestData` object is created that contains all the information collected from the various tests run.

- One can print a synthetic report (how many test units, test functions, number of errors, fails and deactivated item), or get a more extensive `summary()` of the tests with indication about which ones failed or produced errors. The function `printTextProtocol()` does the same, while `printHTMLProtocol()` produces a report in HTML format.

- `RUnit` contains also functions to determine which code is run in the original function when tested, in order to detect the parts of the code not covered by the test suite (code coverage function `inspect()` and function `tracker()`).

As complete and nice as `RUnit` is, there is no tools to integrate the test suite in a given development environment (IDE) or graphical user interface (GUI), as far as we know. In particular, there is no real-time reporting mechanism used to easy the test-code-simplify cycle. The way tests are implemented and run is left to the user, but the implementation suggests that the authors of `RUnit` mainly target batch execution of the tests (for instance, nightly check of code in a server), rather that real-time interaction with the tests.

There is also no integration with the "regular" R CMD check mechanism of R in `RUnit`. There is an embryo of organization of these tests units to make them compatible with R CMD check on the R Wiki ([http://wiki.r-project.org/rwiki/doku.php?id=developers:runit](http://wiki.r-project.org/rwiki/doku.php?id=developers:runit)). This approach works well only on Linux/Unix systems, but needs to be adapted for Windows.

1.2 Unit testing framework for R with svUnit

Our initial goal was to implement a GUI layer on top of `RUnit`, and to integrate test units as smoothly as possible in a code editor, as well as, making tests easily accessible and fully compatible with R CMD check on all platforms supported by R. Ultimately, the test suite should be easy to create, to use interactively, and should be able to test functions in a complex set of R packages.

However, we encountered several difficulties while trying to enhance `RUnit` mechanism. When we started to work on this project, `RUnit` (version 0.4-17) did not allow to subclass its objects. Moreover, its `RUnitTestData` object is optimized for quick testing, but not at all for easy reviewing of its content: it is a list of lists of lists,... requiring embedded for loop and `lapply()` / `sapply()` procedures to extract some content. Finally, the concept of test units as sourceable files on disk is a nice idea, but it is too rigid for quick writing test cases for objects not associated (yet) with an R packages.

We did a first implementation of the `RUnit` GUI based on these objects, before realizing that it is really not designed for such an use. So, we decide to write a completely different unit testing framework in R: `svUnit`, but we make it test code compatible with `RUnit` (i.e., the engine and objects used are totally different, but the test code run in `RUnit` or `svUnit` is interchangeable).

Finally, `svUnit` is also designed to be integrated in the SciViews GUI ([http://www.sciviews.org/SciViews-K](http://www.sciviews.org/SciViews-K)), on top of Komodo Edit or IDE ([http://www.activestate.com/komodo_edit](http://www.activestate.com/komodo_edit)), and to approach extreme programming practices with automatic code testing while you write it. A rather simple interface is provided to link and pilot `svUnit` from any GUI/IDE, and the Komodo Edit/IDE implementation could be used as an example to program similar integration panels for other R GUIs. `svUnit` also formats its report with creole wiki syntax. It is directly readable, but it can also be displayed in a much nicer way using any wiki engine compatible with the creole wiki language. It is
thus rather easy to write test reports in wiki servers, possibly through nightly automatic process for your code, if you like.

This vignette is a guided tour of svUnit, showing its features and the various ways you can use it to test your R code.

# Installation

The svUnit package is available on CRAN (http://cran.r-project.org), and its latest development version is also available on R-Forge (http://sciviews.r-forge.r-project.org/). You can install it with¹:

```r
> install.packages("svUnit")
```

This package has no dependence other than R ≥ 1.9.0. However, if you would like to use its interactive mode in a GUI editor, you must also install Komodo Edit or Komodo IDE and SciViews-K. The procedure is explained here: http://www.sciviews.org/SciViews-K.

Once the svUnit package is installed, you can check it is working correctly on your machine with the following example code:

```r
> library(svUnit)
> Square <- function (x) return(x^2)
> test(Square) <- function () {
+   checkEqualsNumeric(9, Square(3))
+   checkEqualsNumeric(10, Square(3)) # This intentionally fails
+   checkEqualsNumeric(9, SSSquare(3)) # This raises error
+   checkEqualsNumeric(c(1, 4, 9), Square(1:3))
+   checkException(Square("xx"))
+ }
> clearLog()
> (runTest(Square))
```

```
* : checkEqualsNumeric(10, Square(3)) run in less than 0.001 sec ... **FAILS**
  Mean relative difference: 0.1
  num 9
* : checkEqualsNumeric(9, SSSquare(3)) run in less than 0.001 sec ... **ERROR**
  Error in as.vector(current) : 
    impossible de trouver la fonction "SSSquare"
== test(Square) run in less than 0.1 sec: **ERROR**
//Pass: 3 Fail: 1 Errors: 1//

* : checkEqualsNumeric(10, Square(3)) run in less than 0.001 sec ... **FAILS**
  Mean relative difference: 0.1
  num 9
* : checkEqualsNumeric(9, SSSquare(3)) run in less than 0.001 sec ... **ERROR**
  Error in as.vector(current) : 
    impossible de trouver la fonction "SSSquare"
```

¹Install the development version with install.packages("svUnit", repos = "http://r-forge.r-project.org").
Although test unit code is compatible with both svUnit and RUnit, do not load both packages in R memory at the same time, or you will badly mix incompatible code!

3 Overview of svUnit

You ensure that code you write in your R functions does the expected work by defining a battery of tests that will compare the output of your code with reference values. In svUnit, the simplest way to define such a battery of tests is by attaching it to functions loaded in R memory. Of course, you can also define batteries of tests that are independent of any R object, or that check several of them together (so called, integration tests). Here is a couple of examples:

```r
> library(svUnit)
> ## Create two R functions that include their own test cases
> Square <- function (x) return(x^2)
> test(Square) <- function () {
+ checkEqualsNumeric(9, Square(3))
+ checkEqualsNumeric(c(4, 9), Square(2:3))
+ checkException(Square("xx"))
+ }
> Cube <- function (x) return(x^3)
> test(Cube) <- function () {
+ checkEqualsNumeric(27, Cube(3))
+ checkEqualsNumeric(c(8, 28), Cube(2:3))
+ checkException(Cube("xx"))
+ }
> ## Add a separate test case
> test_Integrate <- svTest(function () {
+ checkTrue(1 < 2, "check1")
+ v <- c(1, 2, 3) # The reference
+ w <- 1:3 # The value to compare to the reference
+ checkEquals(v, w)
+ })
```

When you run a test in svUnit, it logs its results in a centralized logger. The idea is to get a central repository for tests that you can manipulate as you like (print, summarize, convert, search, display in a GUI, etc.). If you want to start new tests, you should first clean this logger by `clearLog()`. At any time, the logger is accessible by `Log()`, and a summary of its content is displayed using `summary(Log())`. So, to run test for your `Square()` function as well as your `test_Integrate` integration test, you simply do the following:

```r
> clearLog()
> runTest(Square)
> runTest(test_Integrate)
> Log()
```

= A svUnit test suite run in less than 0.1 sec with:

* test(Square) ... OK
* test_Integrate ... OK

---

In fact, you can attach svUnit tests to any kind of R object, not only function. This could be useful to test S3/S4 objects, or even, datasets.
== test(Square) run in less than 0.1 sec: OK
//Pass: 3 Fail: 0 Errors: 0//

== test_Integrate run in less than 0.1 sec: OK
//Pass: 2 Fail: 0 Errors: 0//

In this report, you see that all your tests succeed. Note that svUnit is making the distinction between a test that fails (the code is run correctly, but the result is different from what was expected) and code that raises error (it was not possible to run the test because its code is incorrect, or for some other reasons). Note also that the function checkException() is designed to explicitly test code that should stop() in R^3. So, if that test does not raises an exception, it is considered to have failed. This is useful to check that your functions correctly trap wrong arguments, for instance, like in checkException(Square("xx")) here above (a character string is provided where a numerical value is expected).

Now, let’s look what happens if we test the Cube() function without clearing the logger:

> runTest(Cube)

* : checkEqualsNumeric(c(8, 28), Cube(2:3)) run in less than 0.001 sec ... **FAILS**
Mean relative difference: 0.03571429
num [1:2] 8 27

* : checkEqualsNumeric(c(8, 28), Cube(2:3)) run in less than 0.001 sec ... **FAILS**

> Log()

== test(Square) run in less than 0.1 sec: OK
//Pass: 3 Fail: 0 Errors: 0//

== test_Integrate run in less than 0.1 sec: OK
//Pass: 2 Fail: 0 Errors: 0//

== test(Cube) run in less than 0.1 sec: **FAILS**
//Pass: 2 Fail: 1 Errors: 0//

* : checkEqualsNumeric(c(8, 28), Cube(2:3)) run in less than 0.001 sec ... **FAILS**

\(^3\)checkException() can also track warning() messages with this little trick: first convert all warnings into errors with owarn <- options(warn = 2)$warn, run the code that should generate a warning inside checkException(), and then restore default warning behavior with options(warn = owarn).
3.1 Assertions in svUnit

The most basic item in a test suite is an assertion represented by a checkXXX() function in svUnit/RUnit. Five such functions are currently defined:

- **checkEquals(current, target)** determines if data in target is the same as data in current.
- **checkEqualsNumeric(current, target)** does the same but allows for a better comparison for numbers (variation allowed within a tolerance window).
- **checkIdentical(current, target)** checks whether two R objects are strictly identical.
- **checkTrue(expr)** only succeed if expr is TRUE. Note a difference in svUnit and RUnit (at least, in its version 0.4-17): the RUnit function is not vectorized and expr must return a single atomic logical value. The corresponding svUnit function also accepts a vector of logical values. In this case, all elements of the vector must be TRUE for the test to succeed. When you make sure that expr always returns a single logical value (for instance by using all(expr)), both functions should be compatible.
- **checkException(expr)** verifies that a given code raises an exception (in R, it means that a line of code with stop() is executed).

DEACTIVATED() makes sure that all tests following this instruction (in a test function, see next paragraph) are deactivated, and inserts a reminder in the logger about the fact that some tests are deactivated in this suite.

For all these functions, you have an additional optional argument msg where you can provide a (short) message to print in front of each text in the report. These functions return invisibly: TRUE if the test succeeds, or FALSE if it fails (code is executed correctly, but does not pass the test), and NA if there was an error (the R code of the test was not executed correctly). Moreover, these functions record the results, the context of the test and the timing in a logger (object svSuiteData inheriting from environment) called .Log and located in the user’s workspace. So, executing a series of assertions and getting a report is simply done as (in its simplest form, you can use the various checkXXX() functions directly at the command line):

```r
> clearLog()
> checkEqualsNumeric(1, log(exp(1)))
> checkException(log("a"))
> checkTrue(1 == 2)
```
### 3.2 Manipulating the logger data

The `svUnit` package provides a series of functions to manipulate the logger from the command line, in particular, `stats()`, `summary()`, `metadata()` and `ls()`:

```r
> ## Clear test exclusion list for running all test suites
> options(svUnit.excludeList = NULL)
> ## Clear the logger
> clearLog()
> ## Run all currently defined tests
> runTest(svSuiteList(), name = "AllTests")
```

* : `checkEqualsNumeric(c(8, 28), Cube(2:3))` run in less than 0.001 sec ... **FAILS**
  Mean relative difference: 0.03571429
  num [1:2] 8 27

* runTest(bar) does not work inside test functions: ... DEACTIVATED
3.2 Manipulating the logger data

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Figure 1: a svUnit test report as it appears when inserted in a wiki page (DokuWiki engine with the creole plugin installed). Note the summary of results at the top left of the page, and the clickable table of contents with detailed entries to easily navigate to the test log you are consulting. Timing of the test is also clearly indicated, since it is a complementary but important information (if a test succeeds, but calculation is way too long, it is good to know it)!
## Get some statistics

```r
> stats(Log())[, 1:3]
```

<table>
<thead>
<tr>
<th>kind</th>
<th>timing</th>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td>test_Integrate</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testCube</td>
<td><strong>FAILS</strong></td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testSquare</td>
<td>OK</td>
<td>0.01 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>test_R</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testsvSuite</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testsvSuiteList</td>
<td>OK</td>
<td>0.03 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testis.test</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testmat</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testbar</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testrunTest</td>
<td>DEACTIVATED</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testsvTest</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testCreateClass</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testMyVirtualBaseClass.getX</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
<tr>
<td>testMyVirtualBaseClass.setX</td>
<td>OK</td>
<td>0.00 2011-08-01 19:30:57</td>
</tr>
</tbody>
</table>

## A slightly different presentation than with print

```r
> summary(Log())
```

= A svUnit test suite run in less than 0.1 sec with:

* test_Integrate ... OK
* testCube ... **FAILS**
* testSquare ... OK
* test_R ... OK
* testsvSuite ... OK
* testsvSuiteList ... OK
* testis.test ... OK
* testmat ... OK
* testbar ... OK
* testrunTest ... DEACTIVATED
* testsvTest ... OK
* testCreateClass ... OK
* testMyVirtualBaseClass.getX ... OK
* testMyVirtualBaseClass.setX ... OK

== test_Integrate (in runitAllTests.R) run in less than 0.1 sec: OK

//Pass: 2 Fail: 0 Errors: 0//

== testCube (in runitAllTests.R) run in less than 0.1 sec: **FAILS**

//Pass: 2 Fail: 1 Errors: 0//

=== Failures

[2] : checkEqualsNumeric(c(8, 28), Cube(2:3))
3.2 Manipulating the logger data

== testSquare (in runitAllTests.R) run in less than 0.1 sec: OK
//Pass: 3 Fail: 0 Errors: 0//

== test_R (in runitsvSuite.R) run in less than 0.1 sec: OK
//Pass: 1 Fail: 0 Errors: 0//

== testsvSuite (in runitsvSuite.R) run in less than 0.1 sec: OK
//Pass: 5 Fail: 0 Errors: 0//

== testsvSuiteList (in runitsvSuite.R) run in less than 0.1 sec: OK
//Pass: 6 Fail: 0 Errors: 0//

== testis.test (in runitsvTest.R) run in less than 0.1 sec: OK
//Pass: 15 Fail: 0 Errors: 0//

== testmat (in runitsvTest.R) run in less than 0.1 sec: OK
//Pass: 2 Fail: 0 Errors: 0//

== testbar run in less than 0.1 sec: OK
//Pass: 2 Fail: 0 Errors: 0//

== testrunTest (in runitsvTest.R) run in less than 0.1 sec: DEACTIVATED
//Pass: 1 Fail: 0 Errors: 0//

== testsvTest (in runitsvTest.R) run in less than 0.1 sec: OK
//Pass: 14 Fail: 0 Errors: 0//

== testCreateClass (in runitVirtualClass.R) run in less than 0.1 sec: OK
//Pass: 2 Fail: 0 Errors: 0//

== testMyVirtualBaseClass.getX (in runitVirtualClass.R) run in less than 0.1 sec: OK
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3.2 Manipulating the logger data

//Pass: 3 Fail: 0 Errors: 0//

== testMyVirtualBaseClass.setX (in runitVirtualClass.R) run in less than 0.1 sec: OK

//Pass: 6 Fail: 0 Errors: 0//

> ## Metadata collected on the machine where tests are run
> metadata(Log())

$.R.version

platform i386-pc-mingw32
arch i386
os mingw32
system i386, mingw32
status 
minor 11.1
year 2010
month 05
day 31
svn rev 52157
language R
version.string R version 2.11.1 (2010-05-31)

$.sessionInfo
R version 2.11.1 (2010-05-31)
i386-pc-mingw32
locale:
[1] LC_COLLATE=French_Belgium.1252  LC_CTYPE=French_Belgium.1252
[3] LC_MONETARY=French_Belgium.1252  LC_NUMERIC=C
[5] LC_TIME=French_Belgium.1252

attached base packages:
[1] tools stats graphics grDevices utils datasets methods
[8] base

other attached packages:
[1] svUnit_0.7-6

$.time
[1] "2011-08-01 19:30:57 CEST"

> ## List content of the log
> is(Log())

[1] "test_Integrate"  "test_R"
[3] "testbar"  "testCreateClass"
[5] "testCube"  "testis.test"
[7] "testmat"  "testMyVirtualBaseClass.getX"
[9] "testMyVirtualBaseClass.setX"  "testrunTest"
As you can see, ls() lists all components recorded in the test suite. Each component is a svTestData object inheriting from data.frame, and it can be easily accessed through the $ operator. There are, of course similar methods defined for those svTestData objects, like print(), summary() and stats():

```r
> myTest <- Log()$testCube
> class(myTest)
[1] "svTestData" "data.frame"

> myTest
== testCube (in runitAllTests.R) run in less than 0.1 sec: **FAILS**

//Pass: 2 Fail: 1 Errors: 0//

* : checkEqualsNumeric(c(8, 28), Cube(2:3)) run in less than 0.001 sec ... **FAILS**
  Mean relative difference: 0.03571429
  num [1:2] 8 27

> summary(myTest)
== testCube (in runitAllTests.R) run in less than 0.1 sec: **FAILS**

//Pass: 2 Fail: 1 Errors: 0//

=== Failures
[2] : checkEqualsNumeric(c(8, 28), Cube(2:3))

> stats(myTest)

$kind
  OK **FAILS** **ERROR** DEACTIVATED
  2 1 0 0

$timing
timing
  0

As the logger inherits from environment, you can manage individual test data the same way as objects in any other environment. For instance, if you want to delete a particular test data without touching to the rest, you can use:

```r
> ls(Log())
[1] "test_Integrate"  "test_R"
[3] "testbar"          "testCreateClass"
[5] "testCube"         "testis.test"
[7] "testmat"          "testMyVirtualBaseClass.getX"
[9] "testMyVirtualBaseClass.setX"  "testrunTest"
[11] "testSquare"       "testsvSuite"
[13] "testsuiteList"    "testsvTest"
```
As we will see in the following section, svUnit proposes several means to organize individual assertions in modules: test functions, test units and test suites. This organization is inspired from RUnit, but with additional ways of using tests in interactive sessions (for instance, the ability to attach a test to the objects to be tested).

3.3 Test function

The first organization level for grouping assertions together is the test function. A test function is a function without arguments whose name must start with test. It typically contains a series of assertions applied to one object, method, or function to be checked (this is not obligatory, assertions are not restricted to one object, but good practices strongly suggest such a restriction). Here is an example:

```r
> test_function <- function () {
+   checkTrue(1 < 2, "check1")
+   v <- c(1, 2, 3) # The reference
+   w <- 1:3        # The object to compare to the reference
+   checkEqualsNumeric(v, w)
+ }
> ## Turn this function into a test
> test_function <- as.svTest(test_function)
> is.svTest(test_function)
[1] TRUE
```

A test function should be made a special object called svTest, so that svUnit can recognize it. This svTest object, is allowed to live on its own (for instance, in the user's workspace, or anywhere you like). It can be defined in a R script, be saved in a '.RData' file, etc... Note that this is very different from RUnit where test must always be located in a unit test file on disk. In svUnit (not RUnit), you run such a test simply by using runTest(), which returns the results invisibly and add it to the logger:

```r
> clearLog()
> runTest(test_function)
> Log()

= A svUnit test suite run in less than 0.1 sec with:

* test_function ... OK

== test_function run in less than 0.1 sec: OK

//Pass: 2 Fail: 0 Errors: 0//
```
Now, a test function is most likely designed to test an R object. The svUnit package also provides facilities to attach the test function to the object to be tested. Hence, the test cases and the tested object conveniently form a single entity that one can manipulate, copy, save, reload, etc. with all the usual tools in R. This association is simply made using test(myobj) <-:

```r
> ## A very simple function
> Square <- function (x) return(x^2)
> ## A test case to associate with the Square() function
> test(Square) <- function () {
+   checkEqualsNumeric(9, Square(3))
+   checkEqualsNumeric(c(1, 4, 9), Square(1:3))
+   checkException(Square("xx"))
+ }
> is.test(Square) # Does this object contain tests?
[1] TRUE
```

One can retrieve the test associated with the object by using:

```r
> test(Square)
svUnit test function:
{
   checkEqualsNumeric(9, Square(3))
   checkEqualsNumeric(c(1, 4, 9), Square(1:3))
   checkException(Square("xx"))
}
attr(,"srcfile")
<text>
```

And of course, running the test associated with an object is as easy as:

```r
> runTest(Square)
> Log() # Remember we didn't clear the log!
= A svUnit test suite run in less than 0.1 sec with:
* test_function ... OK
* test(Square) ... OK

== test_function run in less than 0.1 sec: OK
//Pass: 2 Fail: 0 Errors: 0//

== test(Square) run in less than 0.1 sec: OK
//Pass: 3 Fail: 0 Errors: 0//
```

Now that you master test functions, you will discover how you can group them in logical units, and associate them to R packages.
3.4 Test units

A unit is a coherent piece of software that can be tested separately from the rest. Typically, a R package is a structured way to compile and distribute such code units in R. Hence, we need a mean to organize tests related to this “unit” conveniently.

Since a package can contain several functions, data frames, or other objects, our unit should collect together individual test functions related to each of these objects that compose our package. Also, the test unit should accommodate the well-define organization of a package, and should integrate in the already existing testing features of R, in particular, R CMD check. In both RUnit, and svUnit, one can define such test units, and they are made code compatible between the two implementations.

A test unit is a sourceable text file that contains one or more test functions, plus possibly .setUp() and .tearDown() functions (see the online help for further information on these special functions). In RUnit, you must write such test unit files from scratch. With svUnit, you can “promote” one or several test functions (associated to other objects, or “living” alone as separate svTest objects) by using makeUnit(). Here is how you promote the test associated with our Square() function to a simple test unit containing only one test function:

```r
> # Create a test unit on disk and view its content
> unit <- makeUnit(Square)
> file.show(unit, delete.file = TRUE)
```

You got the following file whose name must start with ‘runit’, with an ‘.R’ extension (‘runit*.R’), and located by default in the temporary directory of R. Specify another directory with the dir = argument of makeUnit() for a more permanent record of this test unit file. Note also that .setUp() and .tearDown() functions are constructed automatically for you. They specify the context of these tests. This context is used, for instance, by the GUI in Komodo Edit/IDE to locate the test function and the code being tested.

```r
## Test unit 'Square'
.setUp <-
 function () {
  ## Specific actions for svUnit: prepare context
  if ("package:svUnit" %in% search()) {
    .Log <- Log() ## Make sure .Log is created
    .Log$..Unit <- "/tmp/RtmpBoZnId/runitSquare.R"
    .Log$..File <- ""
    .Log$..Obj <- ""
    .Log$..Tag <- ""
    .Log$..Msg <- ""
    rm(.Test, envir = .Log)
  }
}
.tearDown <-
 function () {
  ## Specific actions for svUnit: clean up context
  if ("package:svUnit" %in% search()) {
    .Log$..Unit <- ""
    .Log$..File <- ""
    .Log$..Obj <- ""
    .Log$..Tag <- ""
    .Log$..Msg <- ""
    rm(.Test, envir = .Log)
  }
}
```
"testSquare" <-
  function()
  {
    checkEqualsNumeric(9, Square(3))
    checkEqualsNumeric(c(1, 4, 9), Square(1:3))
    checkException(Square("xx"))
  }

Compatibility of these test unit files between RUnit and svUnit was a major concern in the design of svUnit. Consequently, code specific to svUnit (for managing the context of the tests) is embedded in a if (!"package:svUnit" %in% search()) construct. That way, if svUnit is not loaded in memory, this code is not executed. Note that you should avoid loading in memory both svUnit and RUnit at the same time! If you do so, you will most likely crash your tests.

You will see further that it is possible to write much more complex test units with the same makeUnit() function. But for the moment, let’s discuss a little bit how such test units should be organized in R package.

If you intend to associate test units to your R package, you should respect the following conventions:

- Name your test units ‘runit*.R’.
- Place them in the ‘/inst/unitTests’ subdirectory of the package sources, or in one of its subdirectories. If you place them in a subdirectory of ‘/inst/unitTests’, then you define secondary unit tests for (optional) detailed testing of specific item in your package. Always keep in mind that all ‘runit*.R’ files in a directory will be run one after the other. So, if you want to make subgroups you would like to dissociate them, and locate them in separate subdirectories.
- When the package will be compiled, all these test units will be located in ‘/unitTests’ in the compiled/installed version of your R package.

If you respect these conventions, svUnit knows where package unit tests are located and will be able to find and run them quite easily. See, for instance, the examples in the svUnit package.

So, with test units associated to packages, you have a very convenient way to run these tests, including from the Komodo GUI. With just a little bit more coding you can also include these test units in the R CMD check process of your packages. You do this by means of examples in a help page (we prefer to use examples, instead of ‘/tests’ in the R CMD check process, because examples offer a more flexible way to run tests and you can also run them in interactive sessions through the example() R function, which is not the case for code located in the ‘/tests’ subdirectory of your package). Here is what you do to associate some or all of your unit tests to the R CMD check process (illustrated with the case of the svUnit package itself):

- Define a ‘.Rd’ help file in the ‘/man’ subdirectory called ‘unitTests.<mypackage>.Rd’ where <mypackage> is the name of your package (or whatever name you prefer).
- Fill the ‘.Rd’ file, making sure that you define an alias as ‘unitTests.<mypackage>’. Also place a little bit of information telling how users can run your test in an interactive session.
- The important part of this file is, of course, the \examples{} section. You must first clear the log, then run each test, and then, call the errorLog() function. That function looks if one or more tests failed or raised an error. In this case, it stops execution of the example and causes a dump of the test log in the R CMD check process. That way, providing that you have the svUnit package installed in the machine where you run R CMD check, your test units will be included nicely in the checking process of your packages, that is, they will run silently each time you check your package if no error occurs, but will produce a detailed report in case of problems.
- Here is how your ‘.Rd’ file should looks like (exemple of the svUnit package):
\name{unitTests.svUnit}
\alias{unitTests.svUnit}
\title{Unit tests for the package svUnit}
\description{Performs unit tests defined in this package by running \code{example(unitTests.svUnit)}. Tests are in \code{runit*.R} files located in the '/unitTests' subdirectory or one of its subdirectories ('/inst/unitTests' and subdirectories in package sources).}
\author{Philippe Grosjean (\email{phgrosjean@sciviews.org})}
\examples{
if (require(svUnit)) {
  clearLog()
  runTest(svSuite("package:svUnit"), "svUnit")
  ## Possibly run other tests here...
  errorLog()
}
}
\keyword{utilities}

Note, however, that if the package \pkg{svUnit} is not available on the computer where you run \proglang{R CMD check}, your tests are silently ignored (\code{require()} issues a warning, but that does not prevent the checking process to continue). This is an intended feature in order to allow compilation of your package without requiring \pkg{svUnit}. Hence, dependence to \pkg{svUnit} is less strict and also allows you to check your tests using \pkg{RUnit} (but you have to write a dedicated function for that). Still to keep such a less strict dependence on \pkg{svUnit}, you should add \pkg{svUnit} in the \code{Suggests:} field in the \code{'DESCRIPTION'} file of your package, not in \code{Depends:} or \code{Imports:} fields (except if you use \pkg{svUnit} for other purposes that testing your package using the mechanism discussed here, of course.

Also, this approach, associated with examples, provides a very convenient and easy way to test a package from the command line in an interactive session by running:

```r
> example(unitTests.svUnit)
```

\begin{Verbatim}
untT.U> if (require(svUnit)) {
untT.U+  clearLog()
untT.U+  runTest(svSuite("package:svUnit"), "svUnit")
untT.U+  ## No test:
untT.U+  ## Tests to run with example() but not with R CMD check
untT.U+  runTest(svSuite("package:svUnit (VirtualClass)"), "VirtualClass")
untT.U+
untT.U+  ## End(No test)
untT.U+  ## Not run:
untT.U+  ##D  ## Tests to present in \code{?unitTests.svUnit} but not run automatically
untT.U+  ##D  ## Run all currently loaded packages test cases and test suites
untT.U+  ##D  runTest(svSuiteList(), "AllTests")
untT.U+  ##D  ## End(Not run)
untT.U+  ##D  ## Don't show:
untT.U+  ##D  ## Put here test units you want to run during R CMD check but
untT.U+  ##D  ## don't want to show or run with example(unitTests.svUnit)
untT.U+
\end{Verbatim}
runTest(bar) does not work inside test functions: ... DEACTIVATED

In the present case, the `errorLog()` instruction in the examples returns nothing, because all tests succeed. If there is an error somewhere, you will see it printed at the end of this example.

### 3.5 Test suites: collections of test functions and units

The highest level of organization of your tests is the **test suite**. A test suite is an unordered collection of test functions and test units. You can select test units associated with R package in a very convenient way: just specify `package:myPkg` and all test units in the `/unitTests` subdirectory of the package `myPkg` will be included (svUnit does all the required work to map these to actual directories where the test unit files are located). Also, if you specify `package:myPkg (subgroup)`, you will include the test units defined in `/unitTests/subgroup` in the package `myPkg`. Of course, you will be able to also add test units defined in custom directories, outside of R packages (for instance for integration of harness tests that check cross-packages, or multi-packages features of your application).

Test functions associated to your test suite receive a special treatment. Unlike `runTest()` applied to a single test function, or to an object that has an associated test function, these tests are not run from the version loaded in memory. Instead, they are first collected together in a test unit file on disk (located in the R temporary directory, by default), and run from there. Hence, building a more complex test unit file by collecting together several test functions is just a question of constructing a test suite, and then, applying the `makeUnit()` function to this `svSuite` object.

Before we apply all this, you should also know the existence of one more function: `svSuiteList()`. This function lists all test units and test functions available in your system at a given time. So, you don’t need to manually create lists of components. You are better to list them automatically. Of course, this function has a lot of arguments for listing only test units in packages, only test functions, specifying where (in which environment) the test functions are located, adding custom directories where to look for test units, etc, etc. See the online help of this function for the description of all these arguments. One argument is particularly important: `excludeList`. This argument defines one or several regular expressions that are used as filters to hide items from the list. This is required, since you will certainly not want to run again and again, let’s say, the example tests associated with the `svUnit` package (svUnit must be loaded in memory to run the tests, so its tests examples will always be listed by `svSuiteList()`), unless you define an adequate filter expression that will exclude them from your list)! As the default argument suggests it, the regular expression for list exclusion could also be recorded in `options(svUnit.excludeList = ...)`. Here is how it works:

```r
> # Reset default exclusion list
> options(svUnit.excludeList = c("package:sv", "package:RUnit"))
> # List all currently available tests
> svSuiteList()
```

A svUnit test suite definition with:

- Test functions:
  
  ```
  [1] "test(Cube)"  "test(Square)"  "test_function"  "test_Integrate"
  ```

Thus, every entry matching the regular expressions `package:sv` and `package:RUnit` are excluded from the list. The entries `package:svUnit` and `package:svUnit (VirtualClass)` match first pattern and are thus excluded. Now, let’s clear the exclusion list to see what happens:

```r
> # Reset default exclusion list
> options(svUnit.excludeList = c("package:sv", "package:RUnit"))
> # List all currently available tests
> svSuiteList()
```
A svUnit test suite definition with:

- Test suites:
  
  1. "package:svUnit"
     "package:svUnit (VirtualClass)"

- Test functions:
  
  1. "test(Cube)"
     "test(Square)"
     "test_function"
     "test_Integrate"

The test units associated with the package svUnit are now listed. You have noticed that svSuiteList() can also find automatically svTest objects, as well as tests attached to objects in the user's workspace. You can create a suite by collecting all these items together very easily:

```
> (mySuite <- svSuiteList())
```

A svUnit test suite definition with:

- Test suites:
  
  1. "package:svUnit"
     "package:svUnit (VirtualClass)"

- Test functions:
  
  1. "test(Cube)"
     "test(Square)"
     "test_function"
     "test_Integrate"

Now let's make a test unit using tests collected in this suite:

```
> myUnit <- makeUnit(mySuite, name = "ExampleTests")
> file.show(myUnit, delete.file = TRUE)
```

This produces a file named 'runExampleTests.R' located (by default) in the R temporary directory, and which collects together all tests in the user's workspace (either as svTest objects, or as tests attached to other objects), plus tests suites in packages that are not in the exclusion list. Running all tests in your suite is very simple. You still use runTest() as usual, but this time, you apply it to your svSuite object:

```
> clearLog()
> runTest(mySuite)
```

```
* : checkEqualsNumeric(c(8, 28), Cube(2:3)) run in less than 0.001 sec ... **FAILS**
  Mean relative difference: 0.03571429
  num [1:2] 8 27
*
 runTest(bar) does not work inside test functions: ... DEACTIVATED
```

```
> summary(Log())
```

= A svUnit test suite run in less than 0.1 sec with:

```
  * test_function ... OK
  * test_Integrate ... OK
  * testCube ... **FAILS**
  * testSquare ... OK
  * test_R ... OK
```
3.5 Test suites: collections of test functions and units

* testsvSuite ... OK
* testsvSuiteList ... OK
* testis.test ... OK
* testmat ... OK
* testbar ... OK
* testrunTest ... DEACTIVATED
* testsvTest ... OK
* testCreateClass ... OK
* testMyVirtualBaseClass.getX ... OK
* testMyVirtualBaseClass.setX ... OK

== test_function (in runitmySuite.R) run in less than 0.1 sec: OK
//Pass: 2 Fail: 0 Errors: 0//

== test_Integrate (in runitmySuite.R) run in less than 0.1 sec: OK
//Pass: 2 Fail: 0 Errors: 0//

== testCube (in runitmySuite.R) run in less than 0.1 sec: **FAILS**
//Pass: 2 Fail: 1 Errors: 0//

=== Failures
[2] : checkEqualsNumeric(c(8, 28), Cube(2:3))

== testSquare (in runitmySuite.R) run in less than 0.1 sec: OK
//Pass: 3 Fail: 0 Errors: 0//

== test_R (in runitsvSuite.R) run in less than 0.1 sec: OK
//Pass: 1 Fail: 0 Errors: 0//

== testsvSuite (in runitsvSuite.R) run in less than 0.1 sec: OK
//Pass: 5 Fail: 0 Errors: 0//

== testsvSuiteList (in runitsvSuite.R) run in less than 0.1 sec: OK
//Pass: 6 Fail: 0 Errors: 0//

== testis.test (in runitsvTest.R) run in less than 0.1 sec: OK
There are many other tools to manipulate svSuite objects in the svUnit package, including functions to define the content of the suite manually (see online help).

4 Using svUnit with SciViews Komodo

If you use the SciViews Komodo GUI (see http://www.sciviews.org/SciViews-K), you can integrate svUnit tests in this IDE and display reports in a convenient hierarchical tree presentation (Fig. 2). If R is started from within Komodo Edit or IDE (with the SciViews-K and SciViews-K Unit plugins installed), then, loading the svUnit package in R automatically installs the R Unit side panel in Komodo at right. Its use should be straightforward:

- Select the tests you want to run in the top part,
- Click the Run button each time you want to refresh the test tree,
- Browse the tree for failures or errors (the color at the top of the panel immediately indicates if there is a problem somewhere: green -> everything is fine, red -> there is a problem).
Figure 2: Komodo Edit with SciViews-K and SciViews-K Unit after running tests. At right: the R Unit panel that display (at the top) the list of available tests, and test units where you can select the ones to run, and at the bottom, a tree with the results from last tests run. The stripe at the very top is green if all tests succeed, and red (as here), if at least one tests failed or raised an error.
If you have failures or errors, move the mouse on top of the corresponding item in the tree, and you get more information displayed in a tooltip,

- Click on an item to open the test unit at that place in a buffer in Komodo.

The Auto mode, when activated, sources R files currently edited in Komodo whenever you save them, and then, refreshes the test report tree. This mode allows you to run automatically your tests in the background while you edit your R code!

If you want to implement such a side panel in another GUI, make sure to look at the koUnit_XXX() functions in the svUnit package. These functions allow to control the GUI in Komodo remotely from within R, and similar functions should not be too difficult to implement for other GUIs.

References


