5.– 8. September 2011
in Nürnberg

Herbstcampus

Wissenstransfer
par excellence

Ran an die Spec

Ausführbare Software-Spezifikationen mit specs²

Andreas Flierl
imbus AG

„Any sufficiently primitive magic is indistinguishable from technology.“

variation of Arthur C. Clarke‘s third law

… wth?

- Java-Entwickler (J2EE + Swing)
- agil
- clean code
- Scala-Enthusiast
- specs2-Fan

„specs2 is a library for writing executable software specifications.“

Eric Torreborre (author of specs2)

behaviour-driven

fly-by

setup & running

structure

matchers

roundup

behaviour-driven

fly-by

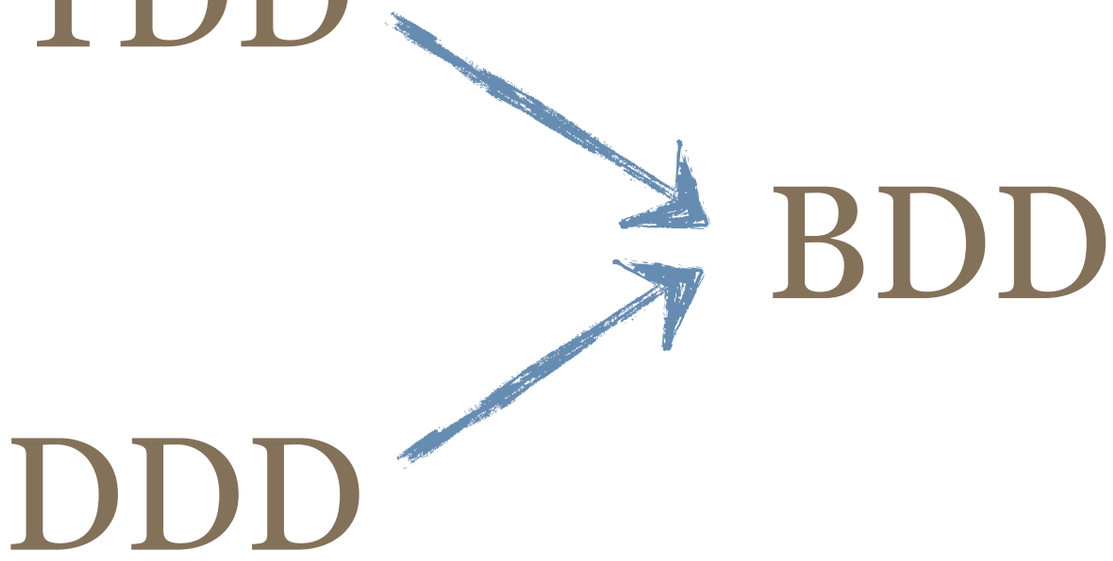
setup & running

structure

matchers

roundup

Behaviour-Driven Development



Behaviour-Driven Development

TDD

DDD

→ BDD

- die richtigen Worte finden
- agile

Ausführbare Software-Spezifikation

- informell
- verhaltensorientiert
- Code wie Literatur
- „literate“

Ausführbare Software-Spezifikation

- informell
- verhaltensorientiert
- Code wie Literatur
- „literate“

- D. E. Knuth (1984)
- R. C. Martin (2008)

… im Sinne von specs²

- selbstbeschreibende Tests
- gewünschtes Verhalten
- Zweck
- *verständliche* Ausgabe

… im Sinne von specs²

- selbstbeschreibende Tests
- gewünschtes Verhalten
- Zweck
- *verständliche* Ausgabe

für alle Beteiligten

behaviour-driven

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roundup

Zwei verschiedene Bauweisen

- unit spec
- acceptance spec

unit spec

```
import org.specs2.mutable._

object FluxCapacitorSpec extends Specification {
  "The flux capacitor" should {
    "be carried by a DeLorean" in {
      FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
    }

    "require approx. 1.21 gigawatts of electrical power" in {
      FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
    }

    "not yet be able to use the MrFusion power converter" in {
      FluxCapacitor.use(MrFusion) must throwA[SciFiException]
    }
  }
}
```

unit spec

- Beschreibung und Code verwoben
- „should“ und „in“
- leichte Einschränkungen
- Veränderbarkeit (mutability)
- Seiteneffekte

acceptance spec

```
import org.specs2._

object FluxCapacitorSpec extends Specification { def is =
  "The flux capacitor should"                                          ^
    "be carried by a DeLorean"                                       ! e1^
    "require approx. 1.21 gigawatts of electrical power"             ! e2^
    "not yet be able to use the MrFusion power converter"            ! e3

  def e1 = FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
  def e2 = FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
  def e3 = FluxCapacitor.use(MrFusion) must throwA[SciFiException]
}
```

acceptance spec

- Beschreibung verweist auf Code
- ^ und !
- voller Funktionsumfang
- referenzielle Transparenz
- Unveränderbarkeit (immutability)

Inline-Beispiele

```
import org.specs2._

object FluxCapacitorSpecInline extends Specification { def is =
  "The flux capacitor should" ^
    "be carried by a DeLorean" ! {
      FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
    } ^
    "require approx. 1.21 gigawatts of electrical power" ! {
      FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
    } ^
    "not yet be able to use the MrFusion power converter" ! {
      FluxCapacitor.use(MrFusion) must throwA[SciFiException]
    }
}
```

Inline-Beispiele

```
import org.specs2._

object FluxCapacitorSpecInline extends Specification { def is =
  "The flux capacitor should" ^
    "be carried by a DeLorean" ! {
      FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
    } ^
    "require approx. 1.21 gigawatts of electrical power" ! {
      FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
    } ^
    "not yet be able to use the MrFusion power converter" ! {
      FluxCapacitor.use(MrFusion) must throwA[SciFiException]
    }
}
```

Inline-Beispiele

```
import org.specs2._

object FluxCapacitorSpecInline extends Specification { def is =
  "The flux capacitor should" ^
    "be carried by a DeLorean" ! {
      FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
    } ^
    //
    "require approx. 1.21 gigawatts of electrical power" ! {
      FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
    } ^
    //
    "not yet be able to use the MrFusion power converter" ! {
      FluxCapacitor.use(MrFusion) must throwA[SciFiException]
    }
}
```

Ergebnis (Konsole)

```
scala> specs2.run(FluxCapacitorSpec)
FluxCapacitorSpec
The flux capacitor should
+ be carried by a DeLorean
x require approx. 1.21 gigawatts of electrical power
    '1.22E9' is not close to 1.21E9 +/- 1000000.0 (FluxCapacitorSpec.scala:13)
+ not yet be able to use the MrFusion power converter


Total for specification FluxCapacitorSpec
Finished in 185 ms
3 examples, 1 failure (+1), 0 error
```

Ergebnis (HTML)

FluxCapacitorSpec *(issues only)*

The flux capacitor should
- be carried by a DeLorean
- require approx. 1.21 gigawatts of electrical power
  '1.22E9' is not close to 1.21E9 +/- 1000000.0 (FluxCapacitorSpec.scala:9)
- not yet be able to use the MrFusion power converter

Total for specification FluxCapacitorSpec	
Finished in	168 ms
Results	3 examples, 1 failure, 0 error

```
spec.content |> select |> sequence |> execute |> store |> export(spec)
```

behaviour-driven

fly-by

setup & running

structure

matchers

roundup

Tool-Support

- sbt (0.7.x oder > 0.9)
- JUnit
- REPL / Kommandozeile
- IntelliJ IDEA
- NotifierRunner

sbt (> 0.9)

```
libraryDependencies +=
  "org.specs2" %% "specs2" % "1.6" % "test"
```

sbt (> 0.9)

```
libraryDependencies ++= Seq(
  "org.specs2" %% "specs2" % "1.6" % "test",
  //... optional dependencies
)

testOptions := Seq(
  Tests.Filter(_ == "FluxCapacitorSpec"),
  Tests.Argument("html", "console", "junitxml"))

testOptions <+= crossTarget map { ct =>
  Tests.Setup { () =>
    System.setProperty("specs2.outDir",
                       new File(ct, "specs2").getAbsolutePath)
  }
}
```

sbt (> 0.9)

```
> test
...

> test-only FluxCapacitorSpec -- html console xonly
...
```

JUnit

```
import org.specs2._

class FluxCapacitorSpec extends SpecificationWithJUnit { def is =
  //...
}
```

oder

```
import org.specs2._
import org.specs2.runner.JUnitRunner
import org.junit.runner.RunWith

@RunWith(classOf[JUnitRunner])
class FluxCapacitorSpec extends Specification { def is =
  //...
}
```

JUnit

```
import org.specs2._

class FluxCapacitorSpec extends SpecificationWithJUnit { def is =
  //...
}
```

oder

```
import org.specs2._
import org.specs2.runner.JUnitRunner
import org.junit.runner.RunWith

@RunWith(classOf[JUnitRunner])
class FluxCapacitorSpec extends Specification { def is =
  //...
}
```

Scala – specs2tour/src/test/scala/eu/flierl/specs2tour/acceptance/FluxCapacitorSpec.scala – Eclipse – /Users/i0n/Documents/workspace

FluxCapacitorSpec.scala

```
1  package eu.flierl.specs2tour
2  package acceptance
3
4  import org.specs2._
5
6  class FluxCapacitorSpec extends SpecificationWithJUnit { def is =
7    "The flux capacitor should"                                  ^
8      "be carried by a DeLorean"                              ! e1^
9      "require approx. 1.21 gigawatts of electrical power"    ! e2^
10     "not yet be able to use the MrFusion power converter"   ! e3
11
12   def e1 = FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
13   def e2 = FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
14   def e3 = FluxCapacitor.use(MrFusion) must throwA[SciFiException]
15 }
16
```

Outline

- eu.flierl.specs2tour.acceptance
- import declarations
- FluxCapacitorSpec
  - is: org.specs2.specification.Fragments
  - e1: org.specs2.matcher.MatchResult[java.lang.String]
  - e2: org.specs2.matcher.MatchResult[Double]
  - e3: org.specs2.matcher.MatchResult[java.lang.String]

Problems | Tasks | Console | JUnit

Finished after 0,117 seconds

Runs: 3/3 Errors: 0 Failures: 1

- FluxCapacitorSpec [Runner: JUnit 4] (0,049 s)
  - The flux capacitor should (0,049 s)
    - be carried by a DeLorean (0,002 s)
    - require approx. 1.21 gigawatts of electrical power (0,039 s)
    - not yet be able to use the MrFusion power converter (0,000 s)

Failure Trace

```
java.lang.Exception: '1.22E9' is not close to 1.21E9 +/- 1000000.0
at eu.flierl.specs2tour.acceptance.FluxCapacitorSpec.e2(FluxCapacitorSpec.scala:1
at eu.flierl.specs2tour.acceptance.FluxCapacitorSpec$$anonfun$is$1$$anonfun$a
at eu.flierl.specs2tour.acceptance.FluxCapacitorSpec$$anonfun$is$1$$anonfun$a
```

Writable | Smart Insert | 13 : 3 | 289M of 518M

REPL / Kommandozeile

```
> scala -cp ... specs2.run FluxCapacitorSpec [arg1 arg2 ...]
...

> scala -cp ... specs2.html FluxCapacitorSpec [arg1 arg2 ...]
...

> scala -cp ... specs2.junitxml FluxCapacitorSpec [arg1 arg2 ...]
...

> scala -cp ... org.specs2.files [arg1 arg2 ...]
...
```

Weitere

- IntelliJ IDEA
  - Spezifikation oder Beispiel auswählen
  - Ctrl+Shift+F10
  - Test options
- NotifierRunner
  - Trait „Notifier“ für Events

behaviour-driven

fly-by

setup & running

structure

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roundup

Fragmente

- Spezifikation 

Fragment
- Optionen
- Freitext
- Beispiel (example) = Text + Code
- Aktion/Schritt (action/step)
- Etiketten (tags)
- SpecStart/SpecEnd

acceptance spec

```
import org.specs2._

object FluxCapacitorSpec extends Specification { def is =
  "The flux capacitor should"                                          ^
    "be carried by a DeLorean"                                       ! e1^
    "require approx. 1.21 gigawatts of electrical power"             ! e2^
    "not yet be able to use the MrFusion power converter"            ! e3

  def e1 = FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
  def e2 = FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
  def e3 = FluxCapacitor.use(MrFusion) must throwA[SciFiException]
}
```

acceptance spec

```
import org.specs2._

object FluxCapacitorSpec extends Specification { def is =
  "The flux capacitor should"                                          ^
    "be carried by a DeLorean"                                       ! e1^
    "require approx. 1.21 gigawatts of electrical power"             ! e2^
    "not yet be able to use the MrFusion power converter"            ! e3

  def e1 = FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
  def e2 = FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
  def e3 = FluxCapacitor.use(MrFusion) must throwA[SciFiException]
}
```

acceptance spec

```
import org.specs2._

object FluxCapacitorSpec extends Specification { def is =
  "The flux capacitor should"                                          ^
    "be carried by a DeLorean"                                         ! e1^
    "require approx. 1.21 gigawatts of electrical power"               ! e2^
    "not yet be able to use the MrFusion power converter"              ! e3

  def e1 = FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
  def e2 = FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
  def e3 = FluxCapacitor.use(MrFusion) must throwA[SciFiException]
}
```

Ergebnisse

- Matcher-Ergebnis (MatchResult)
- Standard-Ergebnis
  - success / done
  - failure
  - anError
  - skipped
  - pending / todo
- Wahrheitswert (implizit)

Ergebnisse

```
import org.specs2.mutable._

object AnotherFluxCapacitorSpec extends Specification {
  "The flux capacitor" should {
    "be carried by a DeLorean" in {
      FluxCapacitor.carrier must startWith("Trabant")
      FluxCapacitor.carrier must endWith("DMC-12")
    }
  }
}
```

Ergebnisse

```
import org.specs2.mutable._

object AnotherFluxCapacitorSpec extends Specification {
  "The flux capacitor" should {
    "be carried by a DeLorean" in {
      FluxCapacitor.carrier must startWith("Trabant")
      FluxCapacitor.carrier must endWith("DMC-12")
    }
  }
}
```

wirft Exception

Ergebnisse

```
import org.specs2._

object FluxCapacitorSpecFaulty extends Specification { def is =
  "The flux capacitor should be carried by a DeLorean" ! e1

  def e1 = {
    FluxCapacitor.carrier must startWith("Trabant")
    FluxCapacitor.carrier must endWith("DMC-12")
  }
}
```

Ergebnisse

```
import org.specs2._

object FluxCapacitorSpecFaulty extends Specification { def is =
  "The flux capacitor should be carried by a DeLorean" ! e1

  def e1 = {
    FluxCapacitor.carrier must startWith("Trabant")
    FluxCapacitor.carrier must endWith("DMC-12")
  }
}
```

MatchResult[String]
wird verworfen

Ergebnisse

```
import org.specs2._

object FluxCapacitorSpecFaulty extends Specification { def is =
  "The flux capacitor should be carried by a DeLorean" ! e1

  def e1 = {
    FluxCapacitor.carrier must startWith("Trabant")
    FluxCapacitor.carrier must endWith("DMC-12")
  }
}
```

MatchResult[String]
wird verworfen

```
def add(a: Int, b: Int): Int = {
  a * b
  a + b
}
```

Ergebnisse

```
import org.specs2._

object FluxCapacitorSpecRepaired1 extends Specification { def is =
  "The flux capacitor should be carried by a DeLorean" ! e1

  def e1 = FluxCapacitor.carrier must startWith("Trabant") and
                                      endWith("DMC-12")
}
```

Ergebnisse

```
import org.specs2._

object FluxCapacitorSpecRepaired1 extends Specification { def is =
  "The flux capacitor should be carried by a DeLorean" ! e1

  def e1 = FluxCapacitor.carrier must startWith("Trabant") and
                                     endWith("DMC-12")
}
```

Ergebnisse

```
import org.specs2._
import org.specs2.matcher.ThrownExpectations

object FluxCapacitorSpecRepaired2
extends Specification with ThrownExpectations { def is =
  "The flux capacitor should be carried by a DeLorean" ! e1

  def e1 = {
    FluxCapacitor.carrier must startWith("Trabant")
    FluxCapacitor.carrier must endWith("DMC-12")
  }
}
```

Ergebnisse

```
import org.specs2._
import org.specs2.matcher.ThrownExpectations

object FluxCapacitorSpecRepaired2
extends Specification with ThrownExpectations { def is =
  "The flux capacitor should be carried by a DeLorean" ! e1

  def e1 = {
    FluxCapacitor.carrier must startWith("Trabant")
    FluxCapacitor.carrier must endWith("DMC-12")
  }
}
```

Ergebnisse

```
import org.specs2._
import org.specs2.matcher.ThrownExpectations

object FluxCapacitorSpecRepaired2
extends Specification with ThrownExpectations { def is =
  "The flux capacitor should be carried by a DeLorean" ! e1

  def e1 = {
    FluxCapacitor.carrier must startWith("Trabant")
    FluxCapacitor.carrier must endWith("DMC-12")
  }
}
```

wirft Exception

Standard-Ergebnisse

```
import org.specs2.mutable._

object FluxCapacitorSpec extends Specification {
  "The flux capacitor" should {
    "be carried by a DeLorean" >> { todo }

    "require approx. 1.21 gigawatts of electrical power" >> { todo }

    "not yet be able to use the MrFusion power converter" >> { todo }
  }
}
```

Standard-Ergebnisse

```
import org.specs2.mutable._

object FluxCapacitorSpec extends Specification {
  "The flux capacitor" should {
    "be carried by a DeLorean" in {
      FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
    }

    "require approx. 1.21 gigawatts of electrical power" >> { todo }

    "not yet be able to use the MrFusion power converter" >> { todo }
  }
}
```

Standard-Ergebnisse

```
import org.specs2.mutable._

object FluxCapacitorSpec extends Specification {
  "The flux capacitor" should {
    "be carried by a DeLorean" in {
      FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
    }

    "require approx. 1.21 gigawatts of electrical power" in {
      FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
    }

    "not yet be able to use the MrFusion power converter" >> { todo }
  }
}
```

Standard-Ergebnisse

```
import org.specs2.mutable._

object FluxCapacitorSpec extends Specification {
  "The flux capacitor" should {
    "be carried by a DeLorean" in {
      FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
    }

    "require approx. 1.21 gigawatts of electrical power" in {
      FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
    }

    "not yet be able to use the MrFusion power converter" in {
      FluxCapacitor.use(MrFusion) must throwA[SciFiException]
    }
  }
}
```

Standard-Ergebnisse

```
import org.specs2.mutable._

object FluxCapacitorSpec extends Specification {
  "The flux capacitor" should {
    "be carried by a DeLorean" in {
      FluxCapacitor.carrier must be equalTo "DeLorean DMC-12"
    }

    "require approx. 1.21 gigawatts of electrical power" in {
      FluxCapacitor.requiredPower must be closeTo(1.21e9 +/- 1e6)
    }.pendingUntilFixed("ISSUE-42")

    "not yet be able to use the MrFusion power converter" in {
      FluxCapacitor.use(MrFusion) must throwA[SciFiException]
    }
  }
}
```

Automatisches Layout

```
object TimeMachineSpec extends Specification { def is =
  "A time machine should"                                                ^
    "have been invented by Dr. Emmet Brown"                          ! success^
    "break the time barrier at 88 mph"                               ! success^
    "use a flux capacitor that should"                                     ^
      "be carried by a *DeLorean*"                                   ! success^
      "require approx. 1.21 gigawatts of electrical power"           ! success^
      "not yet be able to use the MrFusion power converter"          ! success
}
```

A time machine should
- have been invented by Dr. Emmet Brown
- break the time barrier at 88 mph

use a flux capacitor that should
- be carried by a *DeLorean*
- require approx. 1.21 gigawatts of electrical power
- not yet be able to use the MrFusion power converter

Automatisches Layout

```
object TimeMachineSpec extends Specification { def is =
  "A time machine should"                                                ^
    "have been invented by Dr. Emmet Brown"                          ! success^
    "break the time barrier at 88 mph"                               ! success^
    "use a flux capacitor that should"                                     ^
      "be carried by a *DeLorean*"                                   ! success^
      "require approx. 1.21 gigawatts of electrical power"           ! success^
      "not yet be able to use the MrFusion power converter"          ! success
}
```

markdown

A time machine should
- have been invented by Dr. Emmet Brown
- break the time barrier at 88 mph

use a flux capacitor that should
- be carried by a *DeLorean*
- require approx. 1.21 gigawatts of electrical power
- not yet be able to use the MrFusion power converter

Formatierungs-Fragmente

- nur in Acceptance-Spec

```
object TimeMachineSpecLayout extends Specification { def is =
  "A time machine should"                                                ^
    "have been invented by Dr. Emmet Brown"                    ! success^
    "break the time barrier at 88 mph"                         ! success^
                                                                       br^
    "use a flux capacitor that should"                                  ^
      "be carried by a DeLorean"                               ! success^
      "require approx. 1.21 gigawatts of electrical power"     ! success^
      "not yet be able to use the MrFusion power converter"    ! success^
                                                                    endp^
  "In the end, the time machine is destroyed by an oncoming" +
  "freight train."
}
```

Formatierungs-Fragmente

- nur in Acceptance-Spec

```
object TimeMachineSpecLayout extends Specification { def is =
  "A time machine should"
    "have been invented by Dr. Emmet Brown"
    "break the time barrier at 88 mph"

    "use a flux capacitor that should"
      "be carried by a DeLorean"
      "require approx. 1.21 gigawatts of electrical power"
      "not yet be able to use the MrFusion power converter"

  "In the end, the time machine is destroyed by an oncoming" +
  "freight train."
}
```

```
                                  ^
! success^
! success^
        br^
          ^
! success^
! success^
! success^
    endp^
```

```
object TimeMachineSpecLayout extends Specification { def is =
                                                              args(noindent = true) ^
  "A time machine should"                                                             ^
  "have been invented by Dr. Emmet Brown"                                  ! success^
  "break the time barrier at 88 mph"                                       ! success^
  "use a flux capacitor that should"                                                  ^
  "be carried by a DeLorean"                                               ! success^
  "require approx. 1.21 gigawatts of electrical power"                     ! success^
  "not yet be able to use the MrFusion power converter"                    ! success^
  "In the end, the time machine is destroyed by an " +
  "oncoming freight train."
}
```

```
object TimeMachineSpecLayout extends Specification { def is =
                                                              args(noindent = true) ^
                                                                                    ^
  "A time machine should"                                                           ^
  "have been invented by Dr. Emmet Brown"                                 ! success^
  "break the time barrier at 88 mph"                                      ! success^
  "use a flux capacitor that should"                                                ^
  "be carried by a DeLorean"                                              ! success^
  "require approx. 1.21 gigawatts of electrical power"                    ! success^
  "not yet be able to use the MrFusion power converter"                   ! success^
  "In the end, the time machine is destroyed by an " +
  "oncoming freight train."
}
```

Optionen

- Auswahl
- Ausführung
- Statistiken
- Ausgabe

Optionen

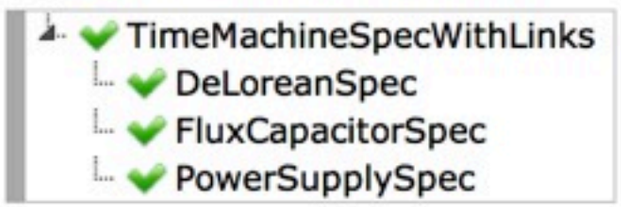
- am Anfang einer Spec
- Kommandozeile
- System-Property
- sbt-Option

Einbinden anderer Specs

```
object TimeMachineSpec extends Specification { def is =
  "A time machine".title                                ^
    DeLoreanSpec                                        ^
    include(FluxCapacitorSpec)                          ^
    include(xonly, PowerSupplySpec)                     ^
    "a regular example"                         ! todo
}
```

Verlinken anderer Specs

```
object TimeMachineSpecWithLinks extends Specification { def is =
  "A time machine consists of"                                    ^
    "a DeLorean" ~ DeLoreanSpec                                   ^
    "the marvellous " ~ ("FluxCapacitor", FluxCapacitorSpec)      ^
    link(PowerSupplySpec)                                         ^
                                                                 p^
    "some history"                                          ! todo
}
```



TimeMachineSpecWithLinks *(issues only)*

A time machine consists of
- a DeLorean
- the marvellous FluxCapacitor
- PowerSupplySpec

- some history
- TODO

Total for specification TimeMachineSpecWithLinks	
Finished in	181 ms
Results	5 examples, 1 failure, 0 error, 1 pending

Copy & Paste

```
object PowerSupplySpecCopies extends Specification { def is =
  "A nuclear reactor power supply should"                                  ^
    "supply at least 1.21 gigawatts of electrical power"          ! e1^
    "fit into a DeLorean DMC-12"                                  ! e2^
    "be named 'Nuclear Reactor'"                                  ! e3^
                                                                  endp^
  "A lightning bolt power supply should"                                   ^
    "supply at least 1.21 gigawatts of electrical power"          ! e4^
    "fit into a DeLorean DMC-12"                                  ! e5^
    "be named 'Lightning Bolt'"                                   ! e6^
                                                                  endp^
  "A Mr Fusion power supply should"                                        ^
    "supply at least 1.21 gigawatts of electrical power"          ! e7^
    "fit into a DeLorean DMC-12"                                  ! e8^
    "be named 'Mr Fusion'"                                        ! e9

  def e1 = NuclearReactor.supply must be greaterThanOrEqualTo 1.21e9
  def e2 = NuclearReactor.volume must be lessThan 150
  def e3 = NuclearReactor.name must be equalTo "Nuclear Reactor"

  def e4 = LightningBolt.supply must be greaterThanOrEqualTo 1.21e9
  def e5 = LightningBolt.volume must be lessThan 150
  def e6 = LightningBolt.name must be equalTo "Lightning Bolt"

  def e7 = MrFusion.supply must be greaterThanOrEqualTo 1.21e9
  def e8 = MrFusion.volume must be lessThan 150
  def e9 = MrFusion.name must be equalTo "Mr Fusion"
}
```

Copy & Paste

```
object PowerSupplySpecCopies extends Specification { def is =
  "A nuclear reactor power supply should"                                  ^
    "supply at least 1.21 gigawatts of electrical power"                  ! e1^
    "fit into a DeLorean DMC-12"                                          ! e2^
    "be named 'Nuclear Reactor'"                                          ! e3^
                                                                          endp^
  "A lightning bolt power supply should"                                   ^
    "supply at least 1.21 gigawatts of electrical power"                  ! e4^
    "fit into a DeLorean DMC-12"                                          ! e5^
    "be named 'Lightning Bolt'"                                           ! e6^
                                                                          endp^
  "A Mr Fusion power supply should"                                        ^
    "supply at least 1.21 gigawatts of electrical power"                  ! e7^
    "fit into a DeLorean DMC-12"                                          ! e8^
    "be named 'Mr Fusion'"                                                ! e9

  def e1 = NuclearReactor.supply must be greaterThanOrEqualTo 1.21e9
  def e2 = NuclearReactor.volume must be lessThan 150
  def e3 = NuclearReactor.name must be equalTo "Nuclear Reactor"

  def e4 = LightningBolt.supply must be greaterThanOrEqualTo 1.21e9
  def e5 = LightningBolt.volume must be lessThan 150
  def e6 = LightningBolt.name must be equalTo "Lightning Bolt"

  def e7 = MrFusion.supply must be greaterThanOrEqualTo 1.21e9
  def e8 = MrFusion.volume must be lessThan 150
  def e9 = MrFusion.name must be equalTo "Mr Fusion"
}
```

Gemeinsame Beispiele

```
object PowerSupplySpecShared extends Specification { def is =
  "A nuclear reactor power supply should"                                    ^
    "behave like any good power supply"                                ^a(NuclearReactor)^
    "be named '${Nuclear Reactor}'"                                 ! equalName(NuclearReactor)^
                                                                            endp^
  "A lightning bolt power supply should"                                     ^
    "behave like any good power supply"                                ^a(LightningBolt)^
    "be named '${Lightning Bolt}'"                                  ! equalName(LightningBolt)^
                                                                            endp^
  "A Mr Fusion power supply should"                                          ^
    "behave like any good power supply"                                    ^a(MrFusion)^
    "be named '${Mr Fusion}'"                                        ! equalName(MrFusion)

  def a(p: => PowerSupply) =
    "supply at least 1.21 gigawatts of electrical power"  ! Any(p).e1^
    "fit into a DeLorean DMC-12"                          ! Any(p).e2

  case class Any(p: PowerSupply) {
    def e1 = p.supply must be greaterThanOrEqualTo 1.21e9
    def e2 = p.volume must be lessThan 150
  }

  def equalName(p: PowerSupply) = so { case n: String => p.name must be equalTo n }
}
```

Gemeinsame Beispiele

```
object PowerSupplySpecShared extends Specification { def is =
  "A nuclear reactor power supply should"                                    ^
    "behave like any good power supply"                                  ^a(NuclearReactor)^
    "be named '${Nuclear Reactor}'"                                ! equalName(NuclearReactor)^
                                                                           endp^
  "A lightning bolt power supply should"                                     ^
    "behave like any good power supply"                                  ^a(LightningBolt)^
    "be named '${Lightning Bolt}'"                                 ! equalName(LightningBolt)^
                                                                           endp^
  "A Mr Fusion power supply should"                                          ^
    "behave like any good power supply"                                    ^a(MrFusion)^
    "be named '${Mr Fusion}'"                                      ! equalName(MrFusion)

  def a(p: => PowerSupply) =
    "supply at least 1.21 gigawatts of electrical power"  ! Any(p).e1^
    "fit into a DeLorean DMC-12"                          ! Any(p).e2

  case class Any(p: PowerSupply) {
    def e1 = p.supply must be greaterThanOrEqualTo 1.21e9
    def e2 = p.volume must be lessThan 150
  }

  def equalName(p: PowerSupply) = so { case n: String => p.name must be equalTo n }
}
```

Gemeinsame Beispiele

```
object PowerSupplySpecShared extends Specification { def is =
  "A nuclear reactor power supply should"                                    ^
    "behave like any good power supply"                                ^a(NuclearReactor)^
    "be named '${Nuclear Reactor}'"                                ! equalName(NuclearReactor)^
                                                                           endp^
  "A lightning bolt power supply should"                                     ^
    "behave like any good power supply"                                ^a(LightningBolt)^
    "be named '${Lightning Bolt}'"                                 ! equalName(LightningBolt)^
                                                                           endp^
  "A Mr Fusion power supply should"                                          ^
    "behave like any good power supply"                                    ^a(MrFusion)^
    "be named '${Mr Fusion}'"                                      ! equalName(MrFusion)

  def a(p: => PowerSupply) =
    "supply at least 1.21 gigawatts of electrical power"  ! Any(p).e1^
    "fit into a DeLorean DMC-12"                          ! Any(p).e2

  case class Any(p: PowerSupply) {
    def e1 = p.supply must be greaterThanOrEqualTo 1.21e9
    def e2 = p.volume must be lessThan 150
  }

  def equalName(p: PowerSupply) = so { case n: String => p.name must be equalTo n }
}
```

Automatischer Beispieltext

```
object PowerSupplySpecAutoExample extends Specification { def is =
  "A nuclear reactor power supply should"                                    ^
    "behave like any good power supply"                          ^ a(NuclearReactor)^
    { NuclearReactor.name should be equalTo "Nuclear Reactor" }                ^
                                                                         endp^
  "A lightning bolt power supply should"                                     ^
    "behave like any good power supply"                           ^ a(LightningBolt)^
    { LightningBolt.name should be equalTo "Lightning Bolt" }                  ^
                                                                         endp^
  "A Mr Fusion power supply should"                                          ^
    "behave like any good power supply"                           ^ a(MrFusion)^
    { MrFusion.name should be equalTo "Mr Fusion" }                          ^end

  def a(p: => PowerSupply) =
    "supply at least 1.21 gigawatts of electrical power"           ! Any(p).e1^
    "fit into a DeLorean DMC-12"                                   ! Any(p).e2

  case class Any(p: PowerSupply) {
    def e1 = p.supply must be greaterThanOrEqualTo 1.21e9
    def e2 = p.volume must be lessThan 150
  }
}
```

Given-When-Then

```
object InventorSpec extends Specification { def is =
  "Given the inventor ${Dr. Emmet Brown}"    ^ inventor  ^
  "when in the year ${2015}"                 ^ year      ^
  "then he should invent ${Mr Fusion}"       ^ invention

  def inventor = new Given[Inventor] {
    def extract(text: String): Inventor = new Inventor(extract1(text))
  }

  def year = new When[Inventor, PowerSupply] {
    def extract(doc: Inventor, text: String) =
      doc.inventPowerSupplyInTheYear(extract1(text).toInt)
  }

  def invention = new Then[PowerSupply] {
    def extract(invention: PowerSupply, text: String) =
      invention.name must be equalTo extract1(text)
  }
}
```

Kontext

```
import org.specs2.mutable._

object TimeMachineSpecContext extends Specification {
  "A time machine" should {
    "change the current year" in new movie {
      travel.currentYear must be equalTo 1955
    }
  }

  trait movie extends After {
    lazy val travel = new TimeMachine

    def after = travel.backToTheFuture()
  }
}
```

Context

- Before
- After
- Around
- Outside
- Step
- Action

Weiteres

- Titel
- Etiketten (tags)
- Abschnitte (sections)
- Index-Seite

behaviour-driven

fly-by

setup & running

structure

matchers

roundup

Standard-Typen

```
42 must be equalTo 42

"ABBA" must beMatching("[AB]{4}")

1 / 0 must throwAn[ArithmeticException]

List(1, 2, 3) must have size 3

1.5 must be closeTo(1.0 +/- 0.5)

<a><b><c attr="value"/></b></a> must \\("c", "attr" -> "value")

"/dev/null" must beAWritablePath
```

Varianten

```
42 must beEqualTo(42)
42 must be_==(42)
42 must_== 42
42 mustEqual 42
42 should_== 42
42 === 42
42 must be equalTo 42

23 must not be equalTo(2)
23 must_!= 42
23 mustNotEqual 42
23 must be_!=(42)
23 !== 42
```

Beschreibung

```
FluxCapacitor.inventor aka
  "the inventor of the flux capacitor" must
  be equalTo "Dr. Emmet Brown"
```

```
"TwoWords" as camel must be equalTo "TwoWords"

def camel(s: String) = s.replaceAll("([A-Z])", " $1").toLowerCase.trim
```

Auflistungen

```
{ (_:Int) must be lessThan 23 } foreach List(1, 2, 3, 4, 5)

{ (_:Int) must be lessThan 23 } forall List(1, 2, 3, 4, 5)

{ (_:Int) must be lessThan 23 } atLeastOnce List(1, 2, 3, 4, 5)
```

Eigene Matcher

```
object MatchersSpec extends Specification { def is =
  "matchers should match" ! {

    val iter = List(1, 2, 3) iterator

    iter.next must eventuallyBe(3)
  }

  val eventuallyBe = beEqualTo(_:Int).eventually
}
```

Eigene Matcher

```
object MatchersSpec extends Specification { def is =
  "matchers should match" ! {

    3 must beBetween(1, 5)

  }

  def beBetween(a: Int, b: Int) = be_>=(a) and be_<=(b)
}
```

Eigene Matcher

```
object MatchersSpec extends Specification { def is =
  "matchers should match" ! {

    List(1, 2, 3) must haveAShortStringRepresentation

  }

  def haveAShortStringRepresentation =
    beLessThanOrEqualTo(10) ^^ { (a: Any) => a.toString.size }
}
```

Eigene Matcher

```
object MatchersSpec extends Specification { def is =
  "matchers should match" ! {

    "fear" must beAnFWord

  }

  val beAnFWord: Matcher[String] =
    ((_: String).toLowerCase.startsWith("f"), "doesn't start with f")
}
```

Mocks

```
object MockingSpec extends Specification {
  "The road runner" should {
    "run the road after meeping" in new canyon {
      roadRunner meepAt "Wile E. Coyote"
      there was atLeastOne(road).run
    }
  }

  trait canyon extends Scope with Mockito {
    lazy val road = mock[Runnable]
    lazy val roadRunner = new RoadRunner(road)
  }
}

class RoadRunner(road: Runnable) {
  def meepAt(target: String) = {
    println("Meep meep, %s!" format target)
    road.run
  }
}
```

Testfall-Tabellen

```
import org.specs2._
import org.specs2.matcher.DataTables

object DataTableSpec extends Specification with DataTables { def is =
  "A string should be found inside a phrase" ! example

  def example =
    "phrase"                      || "string" || "expected position" |
    "Hello world!"                !! "Hell"   !! 0                   |
    "The quick brown fox..."      !! "own"    !! 12                  |
    "Somewhere over the rainbow" !! "misery" !! -1                  |> {

    (phrase, string, position) => phrase indexOf string must be equalTo position

  }
}
```

Testfall-Tabellen

```
import org.specs2._
import org.specs2.matcher.DataTables

object DataTableSpec extends Specification with DataTables { def is =
  "A string should be found inside a phrase" ! example

  def example =
    "phrase"                          || "string" || "expected position" |
    "Hello world!"                    !! "Hell"   !! 0                   |
    "The quick brown fox..."          !! "own"    !! 12                  |
    "Somewhere over the rainbow"      !! "misery" !! -1                  |> {

    (phrase, string, position) => phrase indexOf string must be equalTo position

  }
}
```

Testfall-Tabellen

```
import org.specs2._
import org.specs2.matcher.DataTables

object DataTableSpec extends Specification with DataTables { def is =
  "A string should be found inside a phrase" ! example

  def example =
    "phrase"                          || "string" || "expected position" |
    "Hello world!"                    !! "Hell"   !! 0                   |
    "The quick brown fox..."          !! "own"    !! 12                  |
    "Somewhere over the rainbow"      !! "misery" !! -1                  |> {

    (phrase, string, position) => phrase indexOf string must be equalTo position

  }
}
```

Testfall-Tabellen (Erfolg)

A string should be found inside a phrase

phrase	string	expected position
Hello world!	Hell	0
The quick brown fox...	own	12
Somewhere over the rainbow	misery	-1

Testfall-Tabellen (Fehlschlag)

⚠ A string should be found inside a phrase

phrase	string	expected position	message
Hello world!	Hell	1	'0' is not equal to '1'
The quick brown fox...	own	42	'12' is not equal to '42'
Somewhere over the rainbow	misery	-1	

Formulare (forms)

- Datenstrukturen
- Geschäftsabläufe
- tabellarische Form

Entscheidungstabelle

a	b	a + b	a – b
2	1	3	1
2	2	4	0
23	42	65	-19

Entscheidungstabelle

```
object Calculator {
  def add(a: Int, b: Int) = a + b
  def subtract(a: Int, b: Int) = math.abs(a - b)
}
```

Entscheidungstabelle

```
object CalculatorSpec extends Specification { def is =
  "A calculator should add and subtract correctly" ^
    CalculatorForm(Form.th("a", "b", "a + b", "a - b")).
                       tr(  2,   1,    3,        1    ).
                       tr(  2,   2,    4,        0    ).
                       tr( 23,  42,   65,      -19    )
}

case class CalculatorForm(form: Form) {
  def tr(a: Int, b: Int, a_plus_b: Int, a_minus_b: Int) =
    CalculatorForm(form.tr(
      a,
      b,
      prop( Calculator.add(a, b)      )(a_plus_b),
      prop( Calculator.subtract(a, b) )(a_minus_b)))
}
```

Entscheidungstabelle

CalculatorSpec *(issues only)*

A calculator should add and subtract correctly

a	b	a + b	a - b	
2	1	3	1	
2	2	4	0	
23	42	65	-19	'19' is not equal to '-19'

[click on failed cells to see the stacktraces]

ScalaCheck

- Property-Based Testing
- Invarianten
- viele zufällige Testfälle

ScalaCheck

```
object SquareRootSpec extends Specification with ScalaCheck {
  "The integer square root of n" should {
    "never be negative" in check {
      (n: Int) => SquareRoot of n should be greaterThanOrEqualTo 0
    }
  }
}
```

ScalaCheck

The integer square root of n should
never be negative
A counter-example is '-1': java.lang.ArithmeticException: n must be >= 0 (after 1 try)
(SquareRootSpec.scala:12)

ScalaCheck

```
object SquareRootSpec extends Specification with ScalaCheck {
  "never be negative" in check {
    (n: Int) => (n >= 0) ==> {
      SquareRoot of n should be greaterThanOrEqualTo 0
    }
  }
}
```

ScalaCheck

```
object SquareRootSpec extends Specification with ScalaCheck {
  "never be negative" in check {
    (n: Int) => (n >= 0) ==> {
      SquareRoot of n should be greaterThanOrEqualTo 0
    }
  }
}
```

ScalaCheck

```
object SquareRootSpec extends Specification with ScalaCheck {
  "The integer square root of n" should {
    "never be negative" in check { positiveInteger {
      (n: Int) => SquareRoot of n should be greaterThanOrEqualTo 0
    }}
  }

  def positiveInteger = Arbitrary {
    for (n <- arbitrary[Int]) yield
     if (n == Int.MinValue) Int.MaxValue
     else math.abs(n)
  }
}
```

ScalaCheck

```
object SquareRootSpec extends Specification with ScalaCheck {
  "The integer square root of n" should {
    "never be negative" in check { positiveInteger {
      (n: Int) => SquareRoot of n should be greaterThanOrEqualTo 0
    }}
  }

  def positiveInteger = Arbitrary {
    for (n <- arbitrary[Int]) yield
     if (n == Int.MinValue) Int.MaxValue
     else math.abs(n)
  }
}
```

ScalaCheck

```
object SquareRootSpec extends Specification with ScalaCheck {
  "The integer square root of n" should {
    "never be negative" in check { positiveInteger {
      (n: Int) => SquareRoot of n should be greaterThanOrEqualTo 0
    }.set(minTestsOk -> 500)}
  }

  def positiveInteger = Arbitrary {
    for (n <- arbitrary[Int]) yield
     if (n == Int.MinValue) Int.MaxValue
     else math.abs(n)
  }
}
```

ScalaCheck

```
object SquareRootSpec extends Specification with ScalaCheck {
  "The integer square root of n" should {
    "never be negative" in check { positiveInteger {
      (n: Int) => SquareRoot of n should be greaterThanOrEqualTo 0
    }.set(minTestsOk -> 500)}
  }

  def positiveInteger = Arbitrary {
    for (n <- arbitrary[Int]) yield
     if (n == Int.MinValue) Int.MaxValue
     else math.abs(n)
  }
}
```

behaviour-driven

fly-by

setup & running

structure

matchers

roundup

specs2

- ausdrucksstarke DSL
- gute Tool-Anbindung
- Open Source (specs2.org)

Andere Bibliotheken

- ScalaTest (morgen 11:20)
- JUnit / TestNG + FEST + Mockito
- ausprobieren!

„The first step is just to try to write readable and maintainable specs. The rest follows.“

Eric Torreborre

5.– 8. September 2011
in Nürnberg

Herbstcampus

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Vielen Dank

Andreas Flierl
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