Software Engineering: Tutorial 10
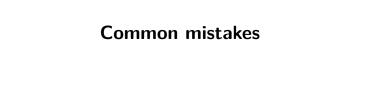
David Voigt

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Agenda

1. Common homework mistakes
2. Recap: Tests
3. Exercises

Common mistakes

Converting a precondition into a postcondition

The general idea is to make a distinction in the postcondition:
   "If A is `null`, then . . . else . . . "

Example: Task 1: `findIndex`

Preconditions:

- `searched` is not null
- `list` is not null
- all elements of `list` are not null

Postconditions:

- result is between -1 and the length of `list` - 1

Before conversion

```scala
def findIndex(searched: String, list: List[String]): Int = {
  require(
    searched != null
    && list != null
    && list.forall(x => { x != null })
  )
  ...
  result
} ensuring { i =>
    i >= -1 && i <= list.length - 1
}
```

Solution

```scala
def findIndex(searched: String, list: List[String]): Int = {
  // notice the precondition regarding searched is gone
  require(
    && list != null
    && list.forall(x => { x != null })
  )
  ...
  result
} ensuring { idx =>
  if searched != null && list.contains(searched) then
    -1 < idx && idx < list.length
  else
    i == -1
}
```

Example: Task 1: `getNth`

Convert preconditions regarding n to a postcondition

- $0 \le n < \text{list.length}$

Solution

```scala
def getNth(n: Int, list: List[String]): String = {
  require(list != null && list.forall(_ != null))
  ...
} ensuring { elem =>
  if n < 0 || n >= list.length then
    elem == ""
  else
    elem != null
}
```

`Nil` is not the same as `null`

- Even though they have similar meanings, `Nil` and `null` are not to be confused
- `Nil` is the same as an empty list: `List() == Nil`
- Whereas `null` is a subtype of every other type, but cannot be accessed without an exception being thrown

Weak postconditions

Given this function

```scala
def reverse[T](list: List[T]): List[T] = {
  require(???)
  var result: List[T] = List(list.head)
  list.tail.foreach { elem =>
    result = elem :: result
  }
  result
} ensuring (???)
```

- What precondition is neccessary?
- Which postconditions can you think of?

Precondition

- The list must be non-empty and not `null`
- We do not need to check that all element are non-null since we are not directly accessing them!

Postconditions

- (obligatory list is not `null`)
- The list contains exactly the same elements as the input list
- Without ensuring the reverse of the resulting list is the input list, we can ensure, that the `head` element is now the `last` element and vice versa.

One possible solution

```
def reverse[T](list: List[T]): List[T] = {
  require(list != null)
  var result: List[T] = List(list.head)
  list.tail.foreach { elem =>
    result = elem :: result
  }
  result
} ensuring { xs =>
  xs != null
  && xs.length == list.length
  && xs.forall(list.contains(_))
  && list.forall(xs.contains(_))
  && xs.head == list.last
  && xs.last == list.head
}
```

Testing

Test coverage

- Test coverage meassures how much code your tests cover
- There is a distinction between **code coverage**, **test coverage** and **control-flow coverage**
    - Test coverage is meassured by (but not limited to) how much the tests cover the code consisting of e.g. expressions, functions, classes
    - Test coverage is also meassured by the control-flow coverage, that is, how many branches in match or if-else expressions/statements have been executed by the tests

Unit tests (example based tests)

Test the behavioural correctness of individual software components (units) with varying granularity, that is, on functions, classes, modules, . . .

Steps

1. Setup a know state
2. Interact with the "unit"
3. Assert that the observed behaviour matches the expected
4. Teardown the state and check if it is in the expected end state

Property tests (property based tests)

Instead of testing with handpicked examples, we formulate general
properties we expect the tested system to uphold for all possible
inputs.

Example[1]

```
// unit tests
assert(List().reverse == List())
assert(List(1,2,3).reverse == List(3,2,1))
...
// property tests
property("reversing a list twice corresponds to the identity") {
    forAll(lists) { xs =>
        assert(xs == xs.reverse.reverse)
    }
}
```

[1]This is not a sufficient test but only a neccessary

Exercises

Link

https://github.com/se-tuebingen-exercises/tut7-exercise10

Usefull resources

- https://github.com/se-tuebingen-exercises/se-lecture-testing/tree/main/src/test/scala
- https://scalameta.org/munit/docs/getting-started.html
- https://scalameta.org/munit/docs/integrations/scalacheck.html
- Guide for property testing on the forum