Blocks and Lexical Scope

August 31, 2012
Nested functions

It’s good functional programming style to split up a task into many small functions.

But the names of functions like $\text{sqrtIter}$, $\text{improve}$, and $\text{isGoodEnough}$ matter only for the *implementation* of $\text{sqrt}$, not for its *usage*.

Normally we would not like users to access these functions directly.

We can achieve this and at the same time avoid “name-space pollution” by putting the auxiliary functions inside $\text{sqrt}$. 
The sqrt Function, Take 2

def sqrt(x: Double) = {
    def sqrtIter(guess: Double, x: Double): Double =
        if (isGoodEnough(guess, x)) guess
        else sqrtIter(improve(guess, x), x)

    def improve(guess: Double, x: Double) =
        (guess + x / guess) / 2

    def isGoodEnough(guess: Double, x: Double) =
        abs(square(guess) - x) < 0.001

    sqrtIter(1.0, x)
}
Blocks in Scala

- A block is delimited by braces `{ ... }`.

```scala
{ val x = f(3)
  x * x
}
```

- It contains a sequence of definitions or expressions.
- The last element of a block is an expression that defines its value.
- This return expression can be preceded by auxiliary definitions.
- Blocks are themselves expressions; a block may appear everywhere an expression can.
val x = 0
def f(y: Int) = y + 1
val result = {
  val x = f(3)
  x * x
}

- The definitions inside a block are only visible from within the block.
- The definitions inside a block shadow definitions of the same names outside the block.
Exercise: Scope Rules

Question: What is the value of \( \text{result} \) in the following program?

```scala
val x = 0
def f(y: Int) = y + 1
val result = {
  val x = f(3)            \( x = 4 \)
  x * x                    \( 16 \)
} + x
```

Possible answers:

- 0 0
- 0 16
- 0 32
- 0 reduction does not terminate
Lexical Scoping

Definitions of outer blocks are visible inside a block unless they are shadowed.

Therefore, we can simplify $\sqrt{\text{t}}$ by eliminating redundant occurrences of the $x$ parameter, which means everywhere the same thing:
The sqrt Function, Take 3

```python
def sqrt(x: Double) = {
    def sqrtIter(guess: Double): Double =
        if (isGoodEnough(guess)) guess
        else sqrtIter(improve(guess))

    def improve(guess: Double) =
        (guess + x / guess) / 2

    def isGoodEnough(guess: Double) =
        abs(square(guess) - x) < 0.001

    sqrtIter(1.0)
}
```
Semicolons

In Scala, semicolons at the end of lines are in most cases optional.
You could write

```scala
val x = 1;
```

but most people would omit the semicolon.

On the other hand, if there are more than one statements on a line, they need to be separated by semicolons:

```scala
val y = x + 1; y * y
```
One issue with Scala’s semicolon convention is how to write expressions that span several lines. For instance

```scala
someLongExpression
+ someOtherExpression
```

would be interpreted as two expressions:

```scala
someLongExpression;
+ someOtherExpression
```
There are two ways to overcome this problem.

You could write the multi-line expression in parentheses, because semicolons are never inserted inside (…):

```
(someLongExpression
 + someOtherExpression)
```

Or you could write the operator on the first line, because this tells the Scala compiler that the expression is not yet finished:

```
someLongExpression +
someOtherExpression
```
You have seen simple elements of functional programming in Scala.

- arithmetic and boolean expressions
- conditional expressions if-else
- functions with recursion
- nesting and lexical scope

You have learned the difference between the call-by-name and call-by-value evaluation strategies.

You have learned a way to reason about program execution: reduce expressions using the substitution model.

This model will be an important tool for the coming sessions.