i116: Basic of Programming

8. Assignment calculator: assignments & parse trees

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Roadmap

- Assignments
- Parse trees for assignment calculator

Assignments

- The syntax of an assignment (treated as a statement but not an expression) used for the assignment calculator being developed in this course is as follows:

  aVariable := *anExpression* ;
- anExpression may have variables.

  For example, *x* := *x* * *x* + 4 * *x* + 4 ;
- If we know the value of variable x, we can calculate the expression *x* * *x* + 4 * *x* + 4.

  For example, when *x* is 2, the expression is 2 * 2 + 4 * 2 + 4, which can be easily calculated.
- But, how do we know the value of variable *x*?

Assignments

- Even though we happen to know that the value of variable *x* is 2, it does not seem reasonable to replace each occurrence of variable *x* with 2.

  2 := 2 * 2 + 4 * 2 + 4 ;
- The left-hand side occurrence of variable *x* should not be replaced with 2.

  x := 2 * 2 + 4 * 2 + 4 ;
- If we calculate the right-hand side expression, the assignment becomes the following:

  x := 16 ;

Assignments

x := 16 ;

- How should we deal with it?
- So far, we have learned several data structures, such as built-in tuples and lists.
- One data structure makes it possible to keep variable *x* and know (or maintain) the value of *x*.
- It suffices to make an association between variable *x* and the value of *x*.
- We can use dictionaries to do so.

Assignments

Suppose that we are given the following dictionary:

{..., *x*:2, ...}

Let *env* be the dictionary, where *env* stands for environment.

We can ask *env* to know the value of variable *x*.

env[x]

Assignments

Therefore, we can calculate the expression

$$x * x + 4 * x + 4$$

basically as follows:

$$env[x] * env[x] + 4 * env[x] + 4$$

Assignments

Then, the assignment

$$x := x * x + 4 * x + 4 ;$$

becomes

$$x := env[x] * env[x] + 4 * env[x] + 4 ;$$

and then becomes

$$x := 16 ;$$

Assignments

How should we handle it?

$x := 16 ;$

env should be updated as follows:

$env[x] = 16$

Then, *env* becomes as follows:

$\{..., x{:}16, ...\}$

Assignments

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```

{ }

Assignments

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```

{x:2}

Assignments

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```

{x:4}

Assignments

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```

{x:16}

Assignments

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```

{x:256}

Assignments

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```

{*x*:256, *y*:2}

Assignments

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```

{*x*:256, *y*:4}

Assignments

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```

{*x*:1024, *y*:4}

Parse trees for assignment calculator

- Because variables have been introduced, we need to have parse trees for variables.

```
class VarParseTree(ExpParseTree):
    def __init__(self, n):
        self.name = n
    def __str__(self):
        return self.name
```

Var: 'x'

A string is used to represent a variable or a variable name.

Parse trees for assignment calculator

- We keep the other classes for expression parse trees.

```
class NumParseTree(ExpParseTree):
    ...
```

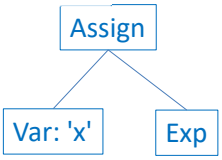
```
class UmiParseTree(ExpParseTree):
    ...
```

```
class AddParseTree(ExpParseTree):
    ...
```


Parse trees for assignment calculator

- Because assignments or assignment statements have been introduced, we need to have parse tree for them.

```
class AssignParseTree(StmParseTree):
    def __init__(self, v, e):
        self.var = v
        self.exp = e
    def __str__(self):
        return '(' + self.var.name + ' := ' + str(self.exp) + ' ;' + ')'
```



Parse trees for assignment calculator

```
class StmParseTree(object):
    def __str__(self):
        pass
```

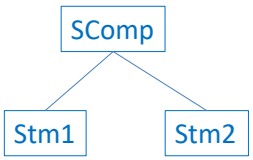
Note that as written already we do not need to have this class, but this class is used like an interface of Java.

Parse trees for assignment calculator

- How should we combine two or more assignments?
- Actually we do not have any means to do so.
- It is necessary to have a language construct that makes it possible to combine two or more statements.
- It is called sequential compositions or sequential composition statements.

Parse trees for assignment calculator

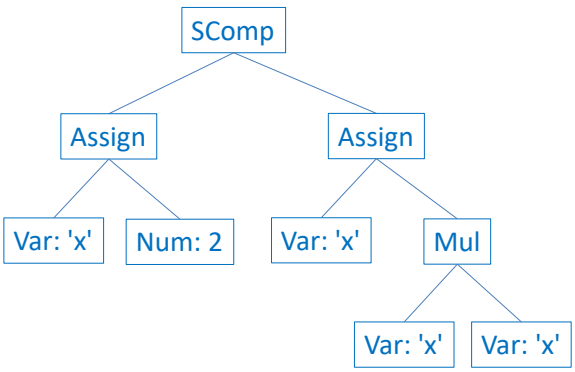
```
class SCompParseTree(StmParseTree):
    def __init__(self, s1, s2):
        self.stm1 = s1
        self.stm2 = s2
    def __str__(self):
        return '(' + str(self.stm1) + " " + str(self.stm2) + ')'
```



x := 2 ;
x := *x* * *x* ;

Parse trees for assignment calculator

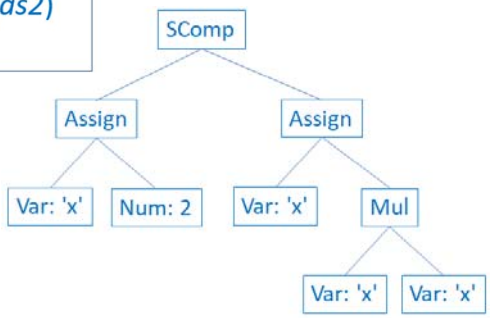
x := 2 ;
x := *x* * *x* ;



Parse trees for assignment calculator

```
varX = VarParseTree('x')
two = NumParseTree(2)
as1 = AssignParseTree(varX,two)
e1 = MulParseTree(varX,varX)
as2 = AssignParseTree(varX,e1)
pgm1 = SCompParseTree(as1,as2)
print(pgm1)
```

$x := 2 ;$
$x := x * x ;$



Parse trees for assignment calculator

```
varX = VarParseTree('x')
varY = VarParseTree('y')
two = NumParseTree(2)
as1 = AssignParseTree(varX,two)
as2 = AssignParseTree(varY,two)
e1 = MulParseTree(varX,varX)
e2 = MulParseTree(varY,varY)
as3 = AssignParseTree(varX,e1)
as4 = AssignParseTree(varY,e2)
e3 = MulParseTree(varX,varY)
as5 = AssignParseTree(varX,e3)
pgm1 = SCompParseTree(as1,as3)
pgm2 = SCompParseTree(pgm1,as3)
pgm3 = SCompParseTree(pgm2,as3)
pgm4 = SCompParseTree(pgm3,as2)
pgm5 = SCompParseTree(pgm4,as4)
pgm6 = SCompParseTree(pgm5,as5)
print(pgm6)
```

$x := 2 ;$
$x := x * x ;$
$x := x * x ;$
$x := x * x ;$
$y := 2 ;$
$y := y * y ;$
$x := x * y ;$

Parse trees for assignment calculator

```
x := 2 ;
x := x * x ;
x := x * x ;
x := x * x ;
y := 2 ;
y := y * y ;
x := x * y ;
```