i116: Basic of Programming

11. Programming language processor:

syntax & parse trees

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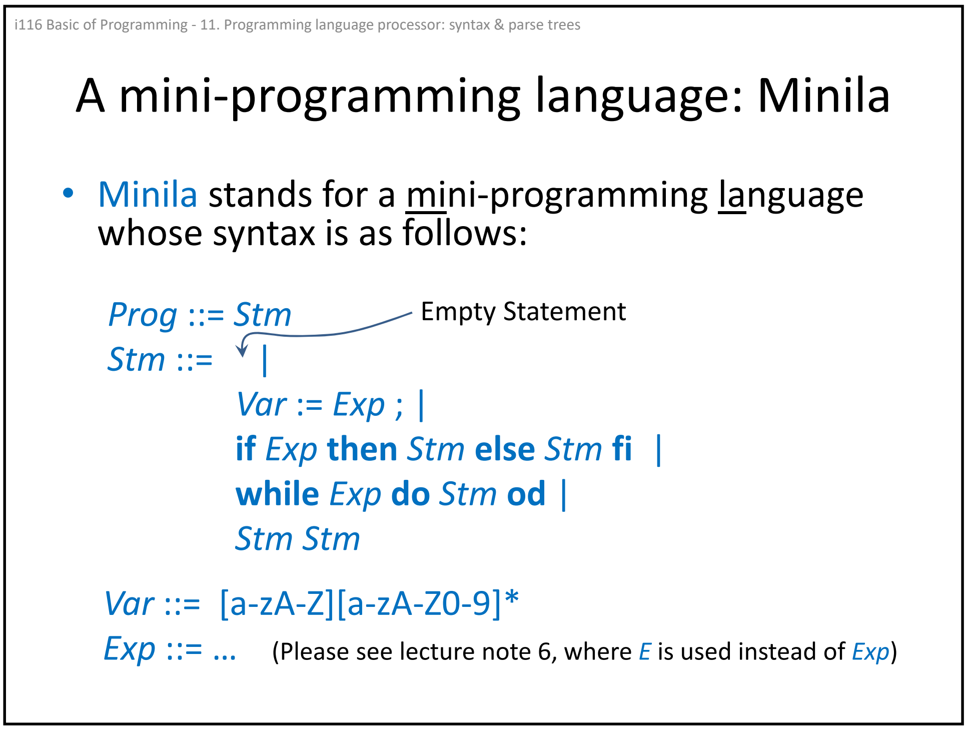
Roadmap

- A mini-programming language: Minila
- Parse trees for Minila
- Scanner and parser for Minila



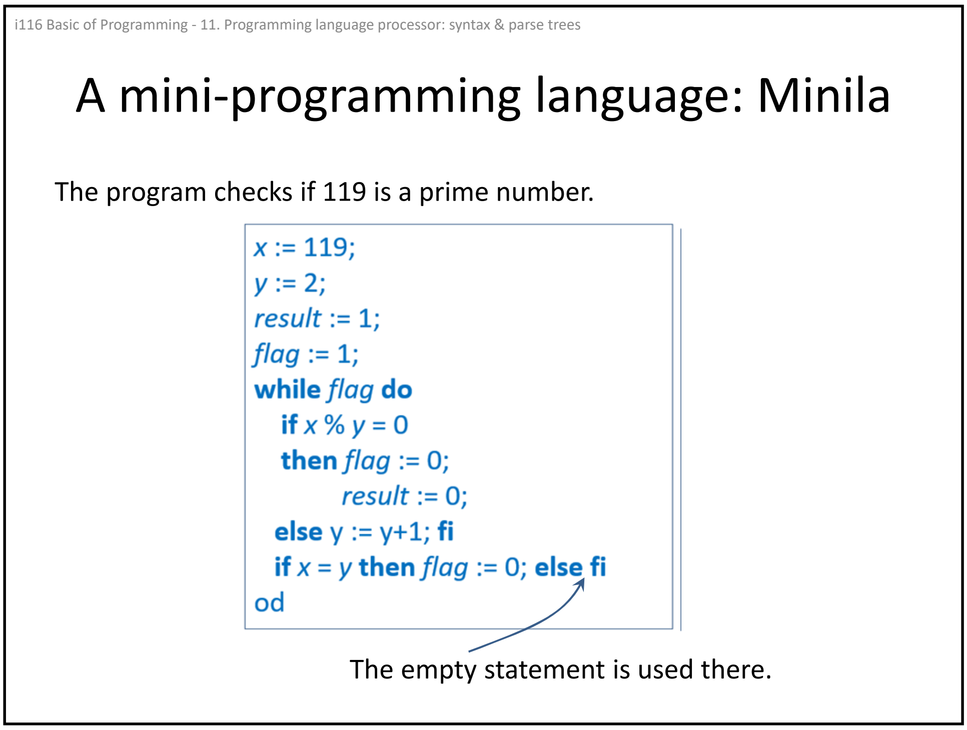
A mini-programming language: Minila

- Minila stands for a mini-programming language whose syntax is as follows:

Prog ::= *Stm*
Stm ::= |
Var := *Exp* ; |
if *Exp* **then** *Stm* **else** *Stm* **fi** |
while *Exp* **do** *Stm* **od** |
Stm Stm

Empty Statement

Var ::= [a-zA-Z][a-zA-Z0-9]*
Exp ::= … (Please see lecture note 6, where *E* is used instead of *Exp*)



A mini-programming language: Minila

The program checks if 119 is a prime number.

```
x := 119;
y := 2;
result := 1;
flag := 1;
while flag do
   if x % y = 0
   then flag := 0;
           result := 0;
  else y := y+1; fi
  if x = y then flag := 0; else fi
od
```

The empty statement is used there.

A mini-programming language: Minila

The program computes 10!.

```
x := 1;
y := 1;
while y < 10 || y = 10
do
   x := x * y;
   y := y + 1;
od
```

A mini-programming language: Minila

The program computes the greatest common divisor of the following integers: 19110 and 17850.

```
x := 19110;
y := 17850;
while y != 0 do
  tmp := x%y;
  x := y;
  y := tmp;
od
```

A mini-programming language: Minila

The program computes the positive integral part of the following integer:

20000000000000000

```
v0 := 20000000000000000;
v1 := 0;
v2 := v0;
while v1 != v2 do
  if (v2-v1)%2 = 0
    then v3 := v1+(v2-v1)/2;
    else v3 := v1+(v2-v1)/2+1;
  fi
  if v3*v3 > v0
    then v2 := v3-1;
    else v1 := v3;
  fi
od
```

Parse trees for Minila

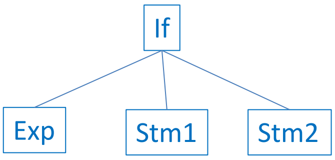
- The three new statements have been introduced:
  - – Empty statement
  - – Conditional (**if**) statement
  - – Loop (**while**) statement
- Then, we need to have a new class for parse trees of each statement.

Parse trees for Minila

```
class EmptyParseTree(StmParseTree):
  def __str__(self):
    return '(Empty Statement)'
```

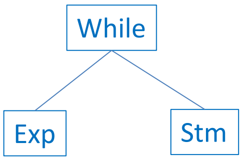
Parse trees for Minila

```
class IfParseTree(StmParseTree):
  def __init__(self, e, s1, s2):
    self.exp = e
    self.stm1 = s1
    self.stm2 = s2
  def __str__(self):
    return '(if  ' + str(self.exp) + ' then ' + str(self.stm1) + ' else '  + str(self.stm2) + ' fi)'
```



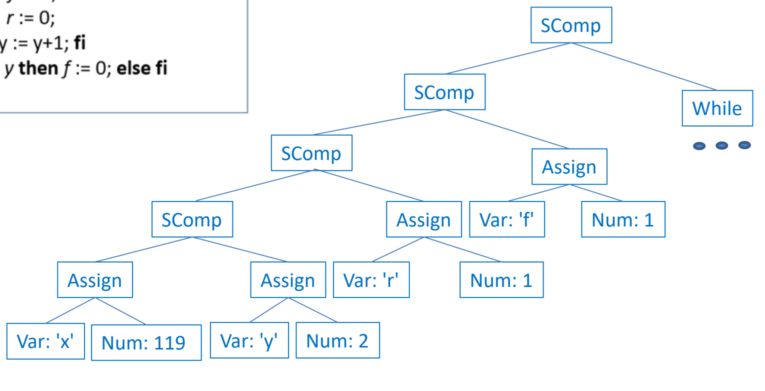
Parse trees for Minila

```
class WhileParseTree(StmParseTree):
  def __init__(self, e, s):
    self.exp = e
    self.stm = s
  def __str__(self):
    return '(while ' + str(self.exp) + ' do ' + str(self.stm) + ' od)'
```



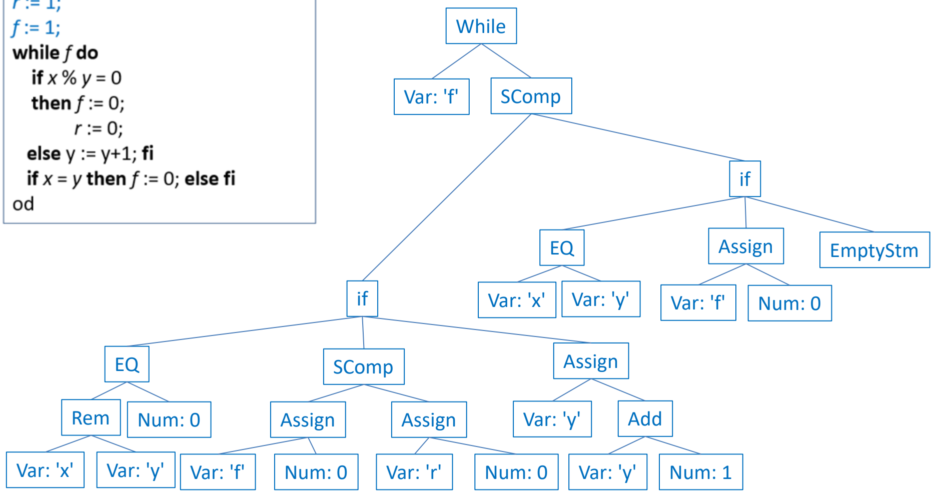
Parse trees for Minila

```
x := 119;
y := 2;
r := 1;
f := 1;
while f do
  if x % y = 0
  then f := 0;
       r := 0;
  else y := y+1; fi
  if x = y then f := 0; else fi
od
```



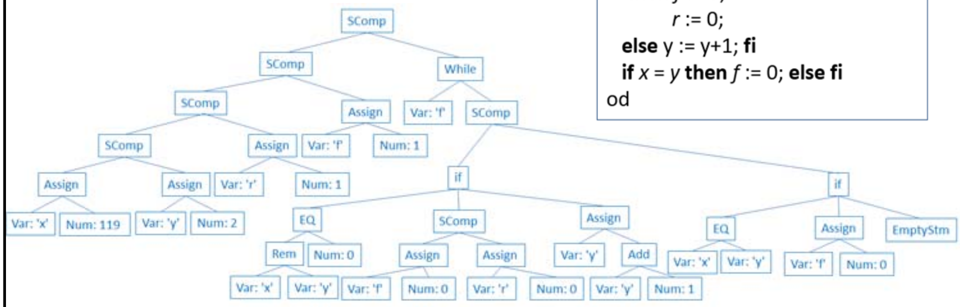
Parse trees for Minila

```
x := 119;
y := 2;
r := 1;
f := 1;
while f do
   if x % y = 0
   then f := 0;
          r := 0;
  else y := y+1; fi
  if x = y then f := 0; else fi
od
```

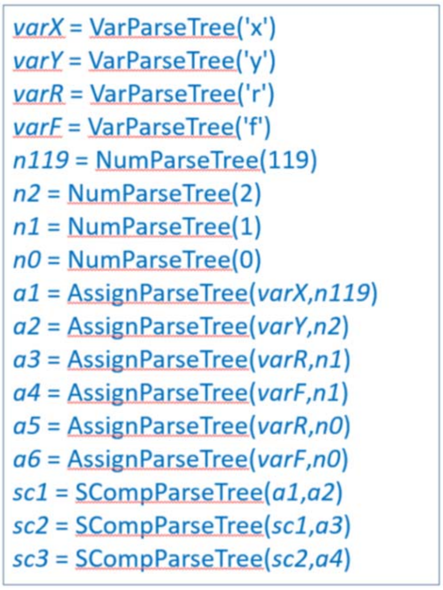


Parse trees for Minila

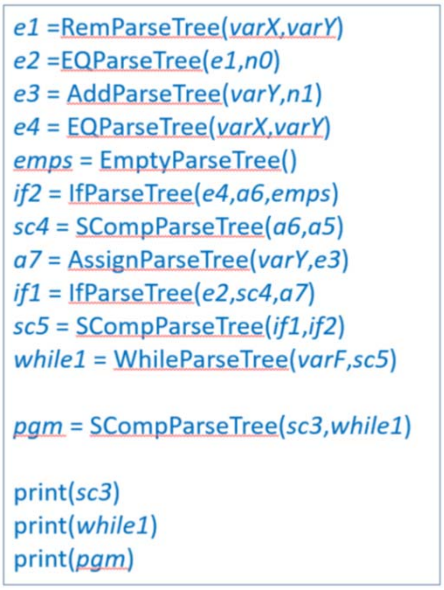
```
x := 119;
y := 2;
r := 1;
f := 1;
while f do
   if x % y = 0
   then f := 0;
          r := 0;
  else y := y+1; fi
  if x = y then f := 0; else fi
od
```



Parse trees for Minila



```
varX = VarParseTree('x')
varY = VarParseTree('y')
varR = VarParseTree('r')
varF = VarParseTree('f')
n119 = NumParseTree(119)
n2 = NumParseTree(2)
n1 = NumParseTree(1)
n0 = NumParseTree(0)
a1 = AssignParseTree(varX,n119)
a2 = AssignParseTree(varY,n2)
a3 = AssignParseTree(varR,n1)
a4 = AssignParseTree(varF,n1)
a5 = AssignParseTree(varR,n0)
a6 = AssignParseTree(varF,n0)
sc1 = SCompParseTree(a1,a2)
sc2 = SCompParseTree(sc1,a3)
sc3 = SCompParseTree(sc2,a4)
```



```
e1 =RemParseTree(varX,varY)
e2 =EQParseTree(e1,n0)
e3 = AddParseTree(varY,n1)
e4 = EQParseTree(varX,varY)
emps = EmptyParseTree()
if2 = IfParseTree(e4,a6,emps)
sc4 = SCompParseTree(a6,a5)
a7 = AssignParseTree(varY,e3)
if1 = IfParseTree(e2,sc4,a7)
sc5 = SCompParseTree(if1,if2)
while1 = WhileParseTree(varF,sc5)

pgm = SCompParseTree(sc3,while1)

print(sc3)
print(while1)
print(pgm)
```

Scanner and parser for Minila

- A scanner takes a program as a string, converting the string into a list of tokens.
- A parser takes a list of tokens, checking whether the list of tokens conforms to the Minila syntax and constructing the parse tree if it does so.

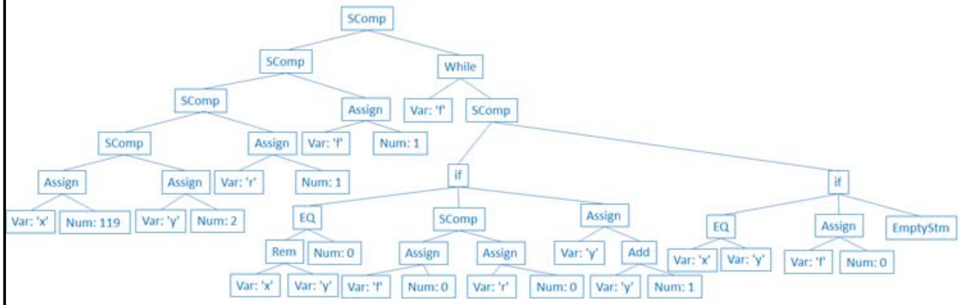
Scanner and parser for Minila

' x := 119; y := 2; r := 1; f := 1; while f do if x % y = 0 then f := 0; …'

scan

[var: x, :=, num: 119, ;, var: y, :=, num: 2, ;, var: r, :=, num: 1, ;, var: f, :=, num: 1, ;, while, var: f, do, if, var: x, %, var: y, =, num: 0, then, var: f, :=, num: 0, ;, …]

parse



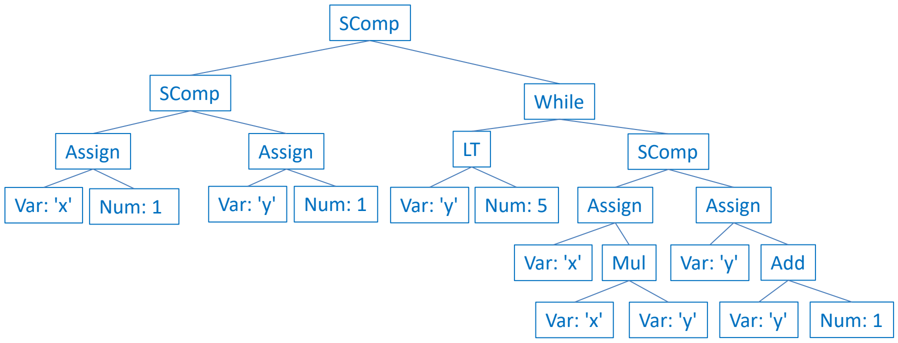
Scanner and parser for Minila

' x := 1; y := 1; while y < 5 do x := x * y; y := y + 1; od'

scan

[var: x, :=, num: 1, ;, var: y, :=, num: 1, ;, while, var: y, <, num: 5, do, var: x, :=, var: x, *, var: y, ;, var: y, :=, var: y, +, num: 1, ;, od]

parse



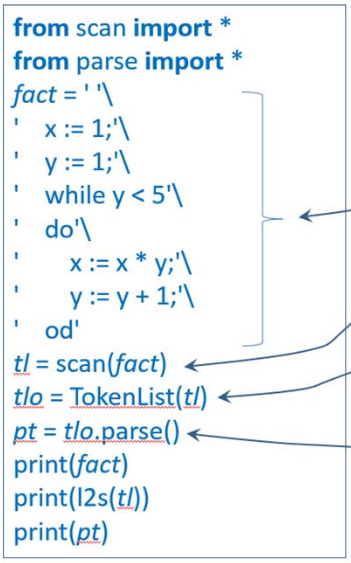
Scanner and parser for Minila

- The following files are available at the course website:
  - parse.py
  - scan.py
  - token2.py
  - tname.py
  - misc.py
- parse.py imports parseTree.py in which the classes of parse trees are defined, and scan.py imports misc.py in which procedure l2s is defined.
- In parse.py, a class TokenList is defined and one of its methods is parse():

  tlo = TokenList(*a list of tokens*)

  pt = *tlo*.parse()

Scanner and parser for Minila



```
from scan import *
from parse import *
fact = ' '\
'   x := 1;'\
'   y := 1;'\
'   while y < 5'\
'   do'\
'      x := x * y;'\
'      y := y + 1;'\
'   od'
tl = scan(fact)
tlo = TokenList(tl)
pt = tlo.parse()
print(fact)
print(l2s(tl))
print(pt)
```

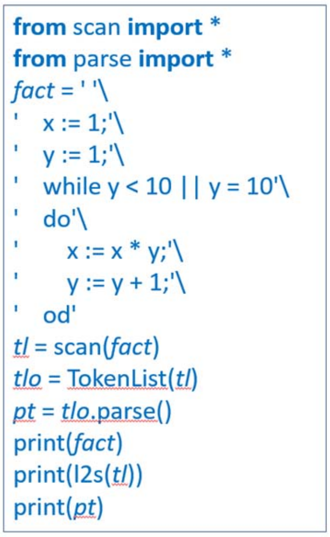
The program that computes 4! is written as a string referred to as *fact*.

scan converts *fact* to a list of tokens referred to as *tl*.

A TokenList object referred to as *tlo* is made with *tl*.

parse checks whether *tl* conforms to the Minila syntax and constructs a parse tree referred to as *pt* if so.

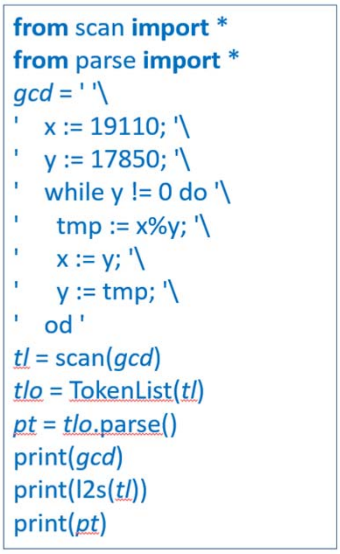
Scanner and parser for Minila



```
from scan import *
from parse import *
fact = ' '\
'   x := 1;'\
'   y := 1;'\
'   while y < 10 || y = 10'\
'   do'\
'      x := x * y;'\
'      y := y + 1;'\
'   od'
tl = scan(fact)
tlo = TokenList(tl)
pt = tlo.parse()
print(fact)
print(l2s(tl))
print(pt)
```

The program computes 10!.

Scanner and parser for Minila



```
from scan import *
from parse import *
gcd = ' '\
'   x := 19110; '\
'   y := 17850; '\
'   while y != 0 do '\
'     tmp := x%y; '\
'     x := y; '\
'     y := tmp; '\
'   od '
tl = scan(gcd)
tlo = TokenList(tl)
pt = tlo.parse()
print(gcd)
print(l2s(tl))
print(pt)
```

The program computes the greatest common divisor of the following two integers:
19110 and 17850

Scanner and parser for Minila

```
from scan import *
from parse import *
isPrime = ' '\
'   x := 119; '\
'   y := 2; '\
'   r := 1; '\
'   f := 1; '\
'   while f do '\
'      if x % y = 0 '\
'      then f := 0; '\
'             r := 0; '\
'      else y := y+1; fi '\
'      if x = y then f := 0; else fi '\
'   od '
```

```
tl = scan(isPrime)
tlo = TokenList(tl)
pt = tlo.parse()
print(isPrime)
print(l2s(tl))
print(pt)
```

The program checks whether 119 is a prime number.

Scanner and parser for Minila

```
from scan import *
from parse import *
sr = ' '\
'   v0 := 20000000000000000; '\
'   v1 := 0; '\
'   v2 := v0; '\
'   while v1 != v2 do '\
'     if (v2-v1)%2 = 0 '\
'       then v3 := v1+(v2-v1)/2; '\
'       else v3 := v1+(v2-v1)/2+1; '\
'     fi '\
'     if v3*v3 > v0 '\
'       then v2 := v3-1; '\
'       else v1 := v3; '\
'     fi '\
'   od '
```

```
tl = scan(sr)
tlo = TokenList(tl)
pt = tlo.parse()
print(sr)
print(l2s(tl))
print(pt)
```

The program calculates the positive integral part of the following integer: 20000000000000000