The Pyth Language

Lecture 5

Administrivia

- Project #1 now available on-line
- Please make sure you have registered your team (and also have electronically registered with us as well)

Historical Background

- Pyth comes from Python, a popular “scripting language”
- Python comes from ABC, a simple and powerful language for teaching & prototyping

Features of Pyth

- Type-safe language, with both dynamic and static typing
- Object-oriented features based on exemplars
- Convenient built-in types for sequences, strings, and mappings (dictionaries)
- Clean, indentation-based statement grouping

Program structure

- Program is a sequence of statements
- Each statement is either
  - One or more simple statements on a line, separated by ;'s, ending in newline
  - A compound statement
  - A type declaration (new in Pyth) + newline
  - An import statement + newline

Simple Statements I: Pass

- Pass does nothing:

```
def f (n):
    pass      # Must be statement here
```

Simple Statements II: Print

- To print values separated by spaces:

```
     print “x,y =“, 3, 4
  =>   x,y = 3 4
```

- To print values without newline at end:

```
     print “x,y =“,     # Extra comma does it
     print 3; print 4
  =>   x,y = 3
       4
```

Printing to a file

```
print >> sys.stderr, “You made an error”
```

- Prints to file sys.stderr (the standard error output)
- Otherwise like ordinary print.

Simple Statements III: Assignment

- Simple cases like C++ or Java:

```
x = 3;    A[i] = 2;  q.r = y + 2; z += 1
```

- But we also have:

```
a, b = 1, 10   # a=1; b = 10
(a,b) = 1, 10  # Same thing
x, a[0], y = a3ElementList
a, (b, c), d = [ 1, (2,3), 4 ]
```

Compound Statements I: if

- Simplest form looks familiar (fewer ()’s):

```
if 0 > x > 20: print “too big”; x = 20
elif x > 10: print “OK”
else: print “too small”
```

- But only list of simple statements possible after “:” with this form

Indentation and suites

- For more complicated “thens” or “elses”, use indentation:

```
if x > 0:
    y = f(x)
    if y > 0:
        print “y is”, y
else:                   # Matches first if
    print “x is negative”
```

Indentation and suites II

- Instead of { … }, Pyth (like Python) uses indentation.
- General form:

```
Line with indentation N:
    Statement with indentation N'>N
    More lines indented > N
Line with indentation N
```

- Each more-indented line adds a left bracket
- Each less-indented line adds a right bracket for each unbalanced more-indented lines

Indentation and suites III

- Tabs indent to multiple of 8 spaces
- Inconsistent indenting is an error:

```
if x < 0:
        print x
    print y         # Error
```

Compound Statements II: While

- While is almost as in Java, modulo parentheses and suites:

```
while n > 0:
    s += A[n]
    n -= 1;
```

- break and continue as in Java (but no label)

While with else

- A new twist: end-of-loop code
- Executes only if test terminates loop:

```
while i < N:
    if P(A[i]): break
    i += 1
else:
    print “Error: didn’t find it.”
```

Compound Statements III: For

- For loop is like Java 5's "for (String S: L)"
- Works for any type with `__getindex__` operation, including built-in sequences:

```
someList = [2, 3, 5, 7, 11, 13, 17 ];
for p in someList:
    if x % p == 0: break
else: print "Maybe", x, "is prime?"
```

Fancier for statements

- The for statement performs assignment statements to control variables, so…

```
pairs = ( (“boy”, “girl”), (“fish”, “bike”))
for left, right in pairs:
    print left, “is to”, right, “as”
```

```
=> boy is to girl as
   fish is to bike as
```

Importing

- In Pyth (not Python), importing is just textual inclusion:

```
        import foo
```

- Looks for file named “foo.py” in any directory in “search path” (see project 1).
- Importing same name twice has no effect the second time
- Only allowed at outer level of program.

Definitions I: Constants

- The declaration

```
        def name = expression
```

  evaluates expression and makes name a constant with that value.
- (This is not like Python)

Definitions II: Constant functions

- To create a new function (or method) value:

```
def gcd (x, y):
    if x == y: return x
    elif x > y: return gcd (x % y, y)
    else: return gcd (y, x)
```

- Functions always return value, but it is the value None by default.

Foreign functions

- To define a Pyth function with a C function:

```
def newdir (name): import "mkdir"
```

- We'll make extensive use of this to implement all the built-in methods of Pyth.

Local variables and scope I

- Local variable is defined by assigning to it:

```
outer = 2   # outer defined everywhere
def f (q):  # q defined in body of f
    x = 2    # x defined in body of f
    def g ():
        x = 6   # NEW x, local to g
        print x, y  # will print 6 3
    y = 3; g ()
    print outer, x   # will print 2 2
```

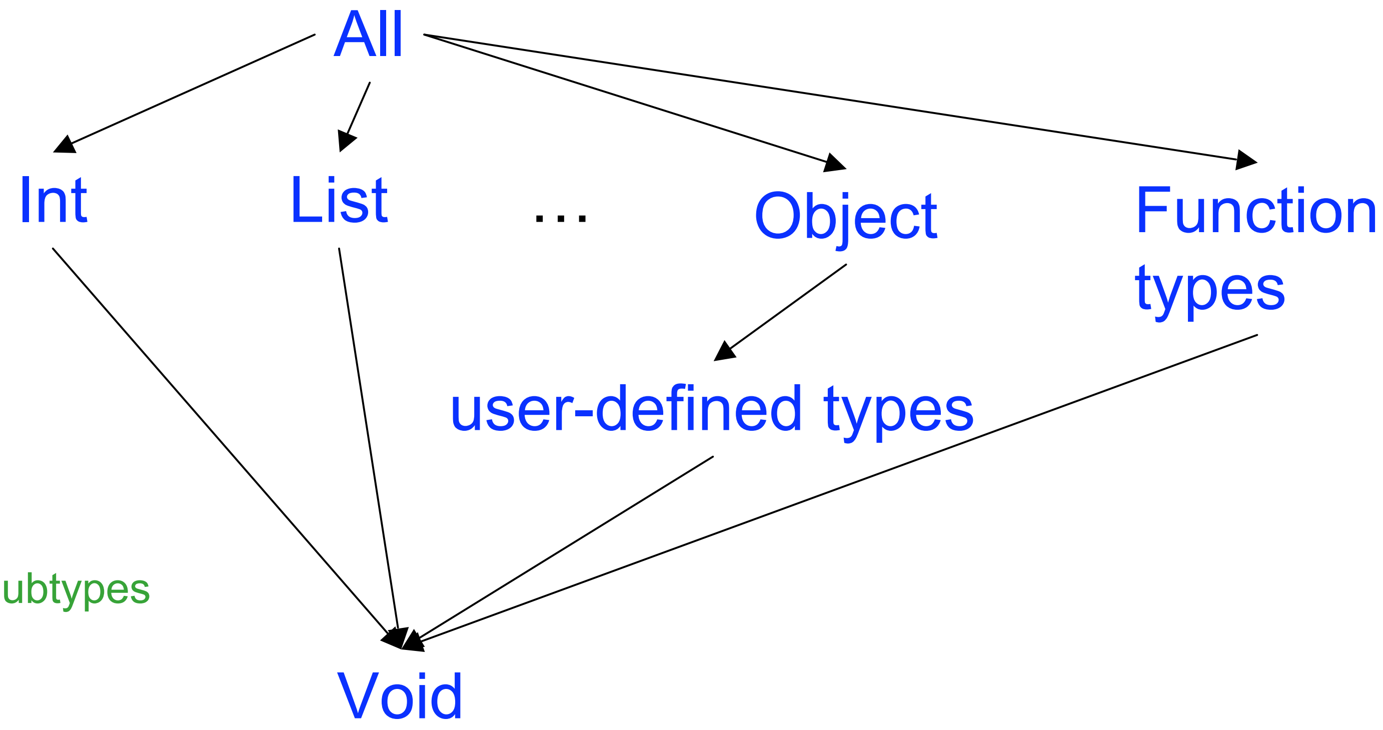
Local variables and scope II: Global

- Can assign to outer-level variables in function by declaring them global:

```
errs = 0      # process can change this
def process (x):
    global errs
    if x < 0: errs += 1; return
    …
```

Types and type declarations

- Pyth has a lattice of types:



arrows show subtypes

Types

- Types all have names:
  - Any
  - Int, Float, Bool, String, Tuple, Xrange, List, Dict, File, Object
  - Types introduced by user with “class…”
  - Function types: (Int, Int) -> Any
  - Void (the type of None)

Dynamic and Static Types

- Every value has a type; types checked at runtime (at latest) for legal operations
- Every variable has a static type, constraining types of values it may contain (like Java, C, C++, etc.)
- The type of variable's value is its dynamic type (always a subtype of static type).
- All of this is just like Java

Declaring Types

- By default, static type of variable, parameter, named constant is Any.
- def'ed functions by default have type

  (Any,…,Any) -> Any

- Can declare static type of any of these with:

```
x : Int
func : (Int, Int) -> Bool
```

- Last one also gives parameters types

Pre-Defined Types I: Simple Stuff

- Ints, Floats are as in Java
- Constant None is like null in Java
- Bool is like boolean in Java (constants True, False)
- String pretty much as in Java
  - But no "char" type: one-character strings double as characters

Pre-Defined Types II: Sequences

- Strings, Tuples, Lists, and Xranges are all sequence types.
- That is, one can write x[i] to get ith character; negative indices count from right. x[-1] is last item.
- + is concatenation
- Can slice sequences:
  - x[1: 3] contains x[1], x[2]
  - x[2:] contains everything from 2 on.

Tuples

- Tuples are *immutable:* can't modify elements
- Created with expression lists (in ()'s if needed):
  - (2, "a string", True, None, (1,2))
  - () # Empty
  - (2,) # One element

Lists

- Lists are mutable sequences.
- Create with *list display:*

```
    [ ]          # Empty
    [ 1, 2, "a string" ]
```

- Change with assignments:

```
  L = [ ] ; L += [1]; L += [3]   # Now L=[1,3]
  L[1] = 5; L[0: 1] = []  # L now [5]
  L[1:] = [9, 11, 13]  # L now [5, 9, 11, 13]
```

Xranges

- Xranges are immutable sequences of Ints.
- Useful in for loops:

```
for i in xrange (0, N):
    k += i
```

Dicts

- A Dict is a mutable mapping (like Java Map).
- Convenient syntax:

```
defns = { ‘apple’ : ‘fruit’, ‘car’ : ‘machine’ }
defns[‘cow’] = ‘animal’
if ‘cow’ in defns: print defns[‘cow’]
for key in defns:
    print key, ‘->’, defns[key]
```

User-defined Classes

- Pyth supports only single inheritance, no interfaces.
- To declare a class:

```
class Thing (ParentType):
    instanceVar = 3
    def instanceMethod (self, dir): …
    class def staticMethod (): …
    def __init__(self,x): … #Constructor
```

Using A Class

- Syntax for creating a Thing:

  Thing (3)

  creates a Thing and calls constructor (`__init__`) with new Thing and 3.

- Access to instance variables, methods, and class methods as in Java:

  x.instanceVar, x.instanceMethod('n'),

  Thing.staticMethod(), x.staticMethod()

Instance Methods I

- The "this" parameter is explicit in Pyth (and called "self" by convention):

```
    class Cls (Object):
        var = 0
        def Meth (self, x): self.var += x
```

- Usual method-calling syntax works by special dispensation:

```
    x.Meth (3)   ==>  (x.Meth) (x, 3)
```

Instance Methods II: Alternate Syntax

- If a name f is not otherwise defined, then

  f(x,…)

  is transformed into

  (x.f) (x, …)

- This strange convention is peculiar to Pyth and due entirely to your instructor's irritation with object-oriented syntax.

Initialization and Exemplars I

- The class definition

```
class Child (Parent):
    var = 3
    def f(self, x): ...
```

  creates a special *exemplar instance* of Child.
- Can refer to var in exemplar as Child.var

Initialization and Exemplars II

- When you create a new Child, its value of var is initialized from Child.var
- As a result,

```
x1 = Child ()
Child.var = 42
x2 = Child ()
print x1.var, x2.var
```

prints 3 42.

Operators

- Most Pyth expression operators are actually just shorthand for function calls.
- For example:

  x + y *is same as* __add__(x,y)

  x[i] *is same as* __getitem__(x,i)

- *A*s a result, you can define these operators on your own classes.