Boomslang

Nathan Cuevas
Robert Kim
Nikhil Kovelamudi
David Steiner

Boomslang in a Nutshell

- Python-inspired **syntax**
- **static type checking** for **safety** and **readability**
- **Enhanced** object oriented features
    - Auto-generated constructors with required and optional parameters
    - Operator overloading syntax
    - Automatic to_string methods
- Automatic coercion between appropriate types (e.g. int and float)

A Boomslang is a large, venomous snake found in Africa
Boom = tree
Slang = snake

Motivation for **Boomslang**

- We wanted a language that was **fun and breezy to write in**
- Safe, readable, and opinionated
- We wanted to reduce boilerplate so that object-oriented programming wasn’t such a chore
- We wanted a solid set of fully-baked features
    - Arrays
    - Nulls
    - Primitive data types
    - Classes and generics
    - …Many more

Boomslang in Depth

- Types
  - Primitives are int, long, float, char, string, bool, void
  - Class
  - Array (can be array of arrays)
  - Null
- A program is a sequence of one of three things
  - Statement
  - Function declaration
  - Class declaration

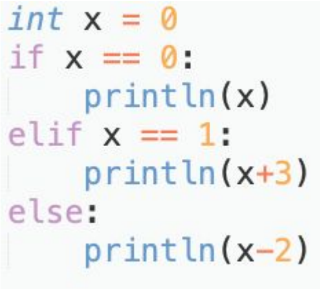
Boomslang in **More** Depth

- Strongly and statically typed - no type inferencing or duck typing
- Mutual recursion is allowed. Objects can reference other objects or themselves. Functions can call other functions or themselves. Classes and functions do **not** need to be defined before they are used.
- Compile and runtime exceptions
- Strings are first class: This means you can write things like “foo” == “bar” (false), “string” + “bar” (“stringbar”)

Key Features

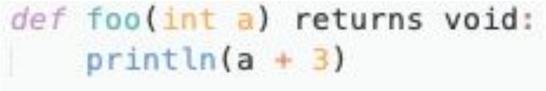
Syntax

- **If, Elif, and Else** operate similarly to Python
- **Function Declaration**
  - Return type declaration required for non-void return. Formal types required
- **Loops** are a hybrid of for and while loops
  - Loop *(do this every loop)* while *(boolean expression passes)*
  - Statement after “loop” keyword can be omitted for pure while loop
- Variables declared inside functions/classes are **local variables** and outside are **global variables**
- **No main() function**



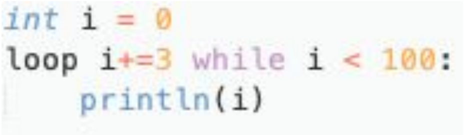
```
int x = 0
if x == 0:
    println(x)
elif x == 1:
    println(x+3)
else:
    println(x-2)
```

if/else branches



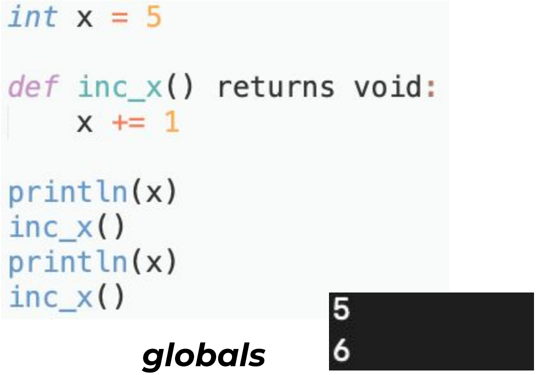
```
def foo(int a) returns void:
    println(a + 3)
```

function declaration



```
int i = 0
loop i+=3 while i < 100:
    println(i)
```

loops



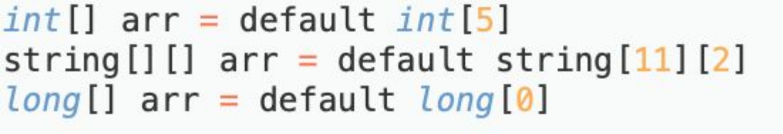
```
int x = 5

def inc_x() returns void:
    x += 1

println(x)
inc_x()
println(x)
inc_x()
```

```
5
6
```

globals

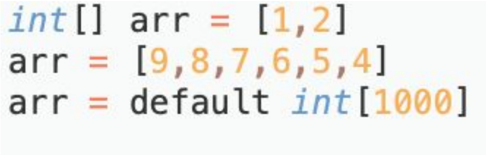
Arrays

- arrays supported for each available type
- Arrays can be initialized with default values, using the default construct
- Boomslang supports multidimensional arrays and array reassignment
- len() can dynamically get runtime size of the arrays



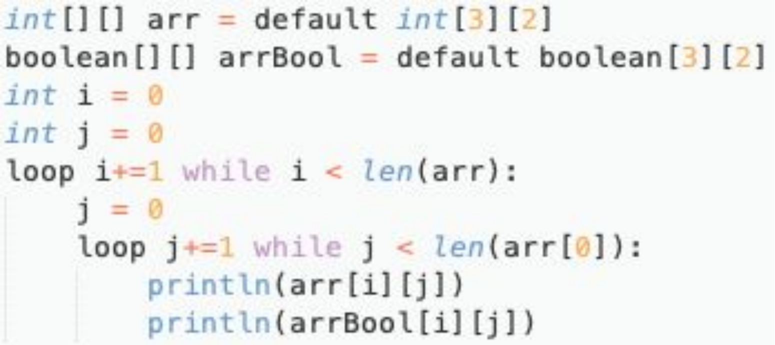
```
int[] arr = default int[5]
string[][] arr = default string[11][2]
long[] arr = default long[0]
```

default construct



```
int[] arr = [1,2]
arr = [9,8,7,6,5,4]
arr = default int[1000]
```

array reassignment

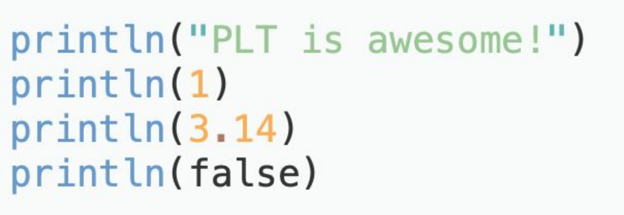


```
int[][] arr = default int[3][2]
boolean[][] arrBool = default boolean[3][2]
int i = 0
int j = 0
loop i+=1 while i < len(arr):
    j = 0
    loop j+=1 while j < len(arr[0]):
        println(arr[i][j])
        println(arrBool[i][j])
```

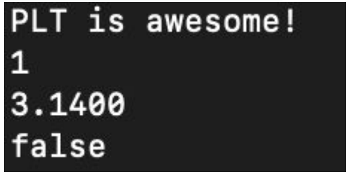
multidimensional arrays and len()

Functions (1)

- **Useful Built-In Functions**
  - polymorphic println() function
  - type conversion functions such as int_to_float() and float_to_string()
  - concat_strings() function that can be implicitly called with ‘+’

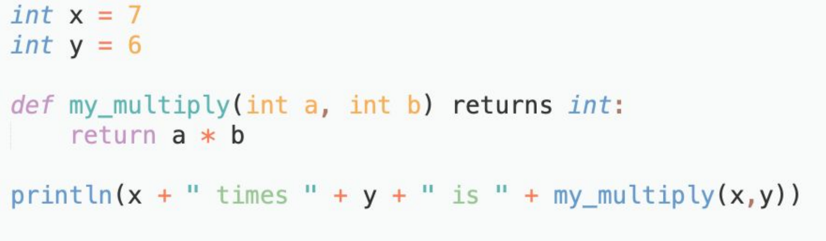


```
println("PLT is awesome!")
println(1)
println(3.14)
println(false)
```

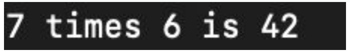


```
PLT is awesome!
1
3.1400
false
```

polymorphic printing



```
int x = 7
int y = 6

def my_multiply(int a, int b) returns int:
    return a * b

println(x + " times " + y + " is " + my_multiply(x,y))
```

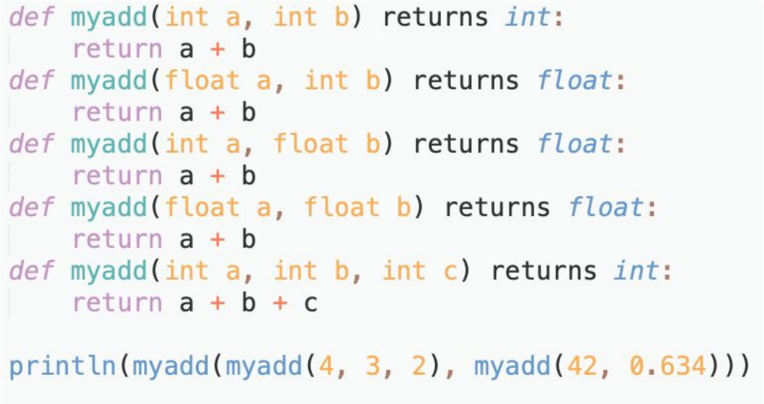


```
7 times 6 is 42
```

string concat using ‘+’

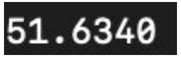
Functions (2)

- **Function overloading**
- all functions/methods support **standard and mutual recursion**

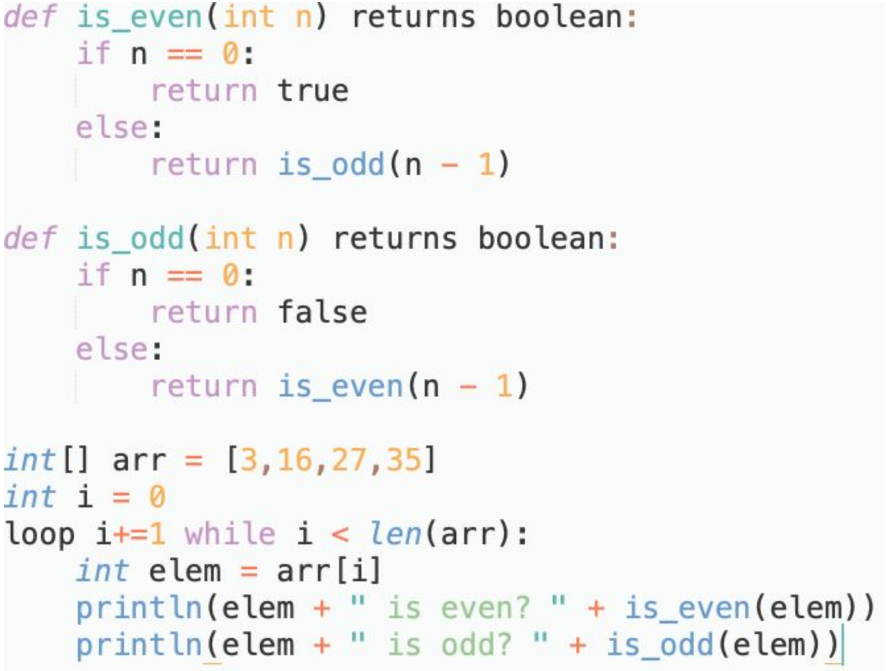


```
def myadd(int a, int b) returns int:
    return a + b
def myadd(float a, int b) returns float:
    return a + b
def myadd(int a, float b) returns float:
    return a + b
def myadd(float a, float b) returns float:
    return a + b
def myadd(int a, int b, int c) returns int:
    return a + b + c

println(myadd(myadd(4, 3, 2), myadd(42, 0.634)))
```

function overloading

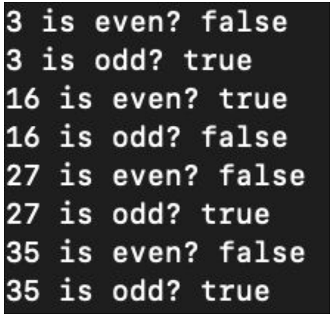


```
51.6340
```



```
def is_even(int n) returns boolean:
    if n == 0:
        return true
    else:
        return is_odd(n - 1)

def is_odd(int n) returns boolean:
    if n == 0:
        return false
    else:
        return is_even(n - 1)

int[] arr = [3,16,27,35]
int i = 0
loop i+=1 while i < len(arr):
    int elem = arr[i]
    println(elem + " is even? " + is_even(elem))
    println(elem + " is odd? " + is_odd(elem))
```

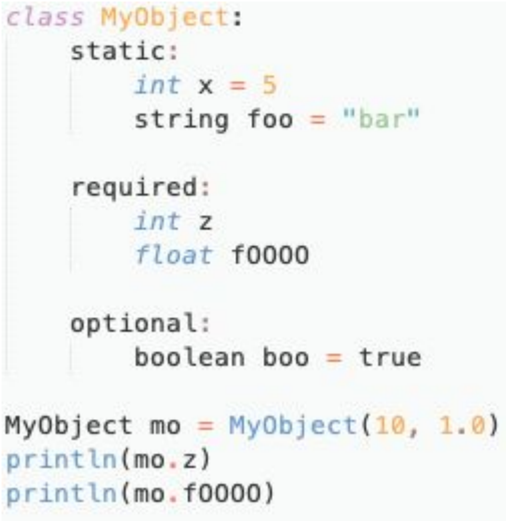
mutual recursion



```
3 is even? false
3 is odd? true
16 is even? true
16 is odd? false
27 is even? false
27 is odd? true
35 is even? false
35 is odd? true
```

Classes (1)

- **Class Constructors** are both familiar and unfamiliar
- Static variables are modeled in LLVM as global variables (MyObject.x is a global variable named “@MyObject.x”)
- Required and optional variables are instance variables. What is the difference between them?



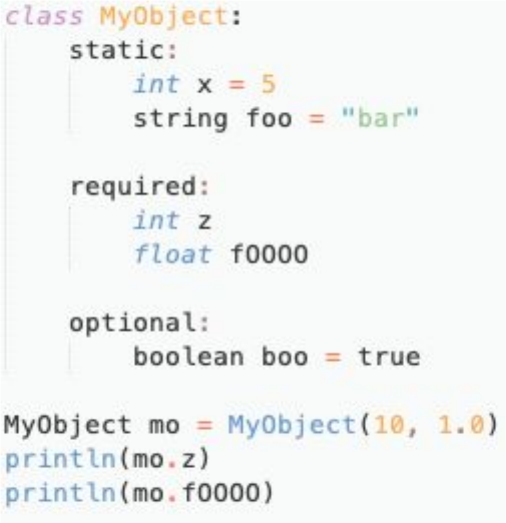
```
class MyObject:
    static:
        int x = 5
        string foo = "bar"

    required:
        int z
        float f0000

    optional:
        boolean boo = true

MyObject mo = MyObject(10, 1.0)
println(mo.z)
println(mo.f0000)
```

2 constructors are automatically generated:

```
def construct(int z, float fOOOO):
        self.z = z
        self.fOOOO = fOOOO
        self.boo = true

def construct(int z, float fOOOO, boolean boo):
        self.z = z
        self.fOOOO = fOOOO
        self.boo = boo
```

Classes (2)

- Classes also come with a **built-in automatic to_string method**



```
class MyObject:
    static:
        int x = 5
        string foo = "bar"

    required:
        int z
        float fOOOO

    optional:
        boolean boo = true

MyObject mo = MyObject(10, 1.0)
println(mo.z)
println(mo.fOOOO)
```

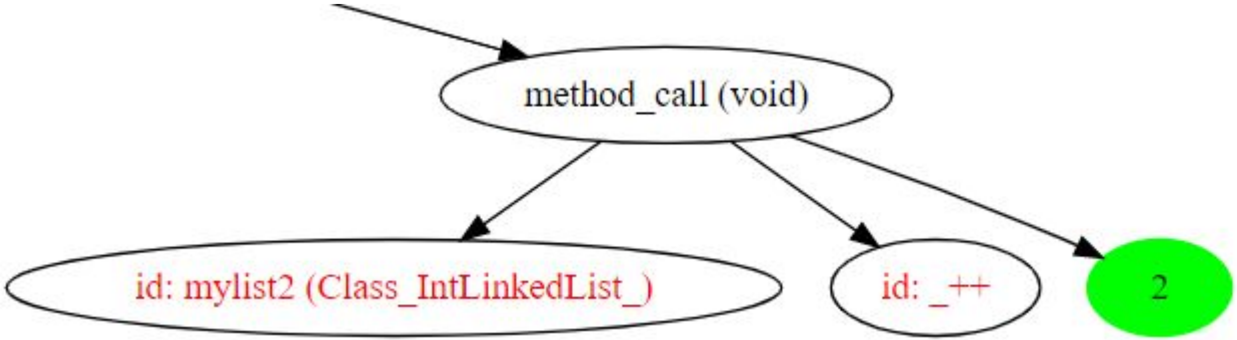
```
>println(mo)

MyObject:
x:5
foo:bar
z:10
fOOOO:1.0000
boo:true
```

LIVE DEMO

Classes (3)

- Classes allow for chaining any valid expressions, be they variables or functions
- So foo.var.func().var.var.func().func() could be a valid expression
- In addition to calling foo.mymethod(), we have a special syntax for **object operators**

>mylist ++ 2



LIVE DEMO

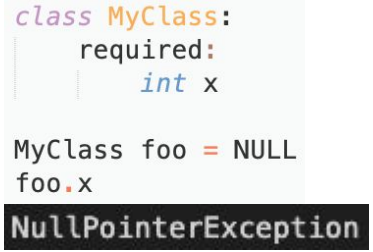
Classes (4)

- **Boomslang** also supports **generic classes**
- These classes cannot be used directly, be can be **instantiated to succinctly make new classes using the generic template**

LIVE DEMO

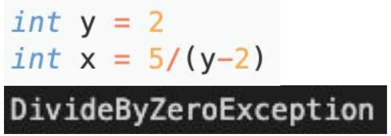
Exceptions

- Compile time checks for
  - **type compatibility**
  - **class/function declarations**
  - **variable initialization**
- Runtime checks for division by zero and null objects



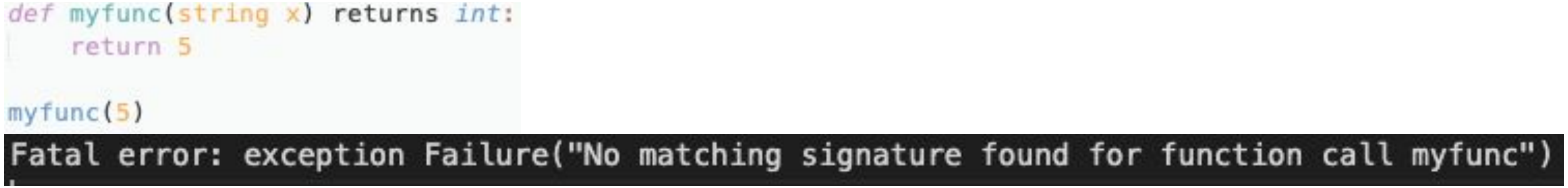
```
class MyClass:
    required:
        int x

MyClass foo = NULL
foo.x
```

```
NullPointerException
```



```
int y = 2
int x = 5/(y-2)
```

```
DivideByZeroException
```



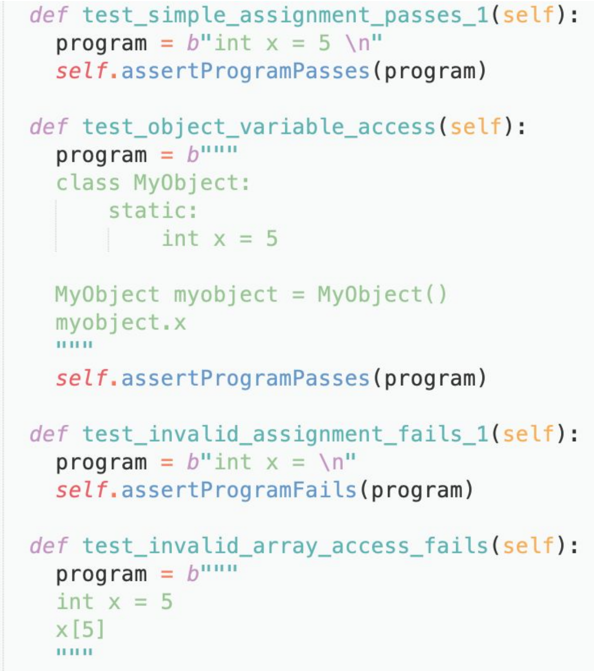
```
def myfunc(string x) returns int:
    return 5

myfunc(5)
```

```
Fatal error: exception Failure("No matching signature found for function call myfunc")
```

Test-driven development

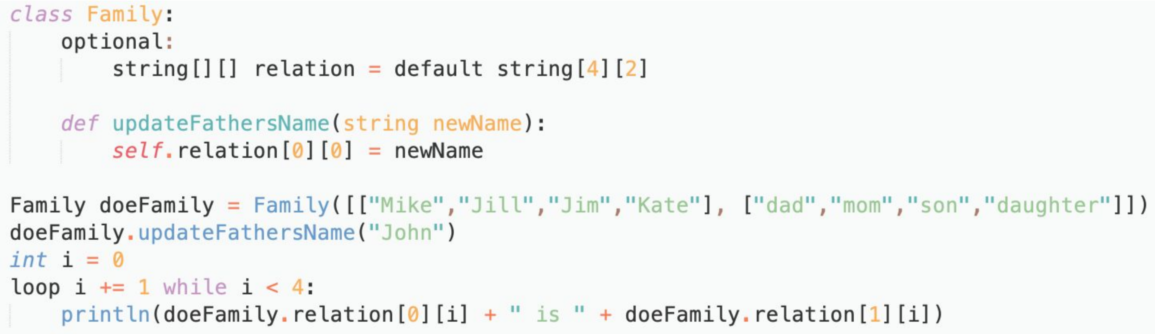
- Unit tests for lexer and parser utilizing the run_tests.py script (1018 lines of code)
- boomc shell script to test each file individually
- Over 250+ tests in the final repository
- REPL to troubleshoot issues
- Our AST and SAST are both able to be pretty printed as graphviz .dot files. ./boomslang.native -a and ./boomslang.native -s , respectively

Examples



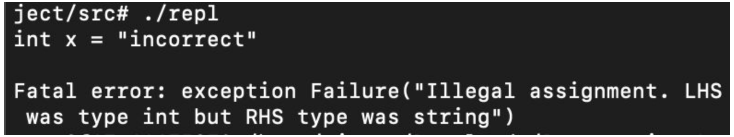
```
def test_simple_assignment_passes_1(self):
  program = b"int x = 5 \n"
  self.assertProgramPasses(program)

def test_object_variable_access(self):
  program = b"""
  class MyObject:
      static:
          int x = 5

  MyObject myobject = MyObject()
  myobject.x
  """
  self.assertProgramPasses(program)

def test_invalid_assignment_fails_1(self):
  program = b"int x = \n"
  self.assertProgramFails(program)

def test_invalid_array_access_fails(self):
  program = b"""
  int x = 5
  x[5]
  """
```

unit tests for lexer and parser



```
class Family:
    optional:
        string[][] relation = default string[4][2]

    def updateFathersName(string newName):
        self.relation[0][0] = newName

Family doeFamily = Family([["Mike","Jill","Jim","Kate"], ["dad","mom","son","daughter"]])
doeFamily.updateFathersName("John")
int i = 0
loop i += 1 while i < 4:
    println(doeFamily.relation[0][i] + " is " + doeFamily.relation[1][i])
```

final tests



```
ject/src# ./repl
int x = "incorrect"

Fatal error: exception Failure("Illegal assignment. LHS
 was type int but RHS type was string")
```

use repl for troubleshooting

Future Work

- Show the user the line number where error occurred
- Automatic garbage collection
- Support for static functions
- Ability to import from other modules
- Working REPL for codegen (current REPL only goes up to semant)
- List comprehensions
- Inheritance
- Improvements to coercions
- Remove NULL (less is more, and Maybe is better than NULL)

Thank You!

Questions?