# 🐛👾 bugsy 👾🐛

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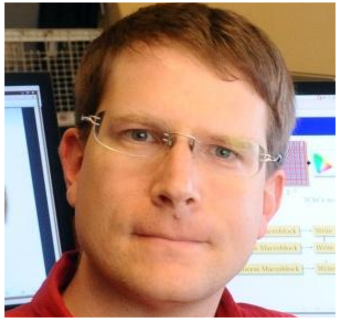
## the (ideal) team

Stephen A.

TESTER


Edwards

SYSTEM ARCHITECT

Stefén

MANAGER

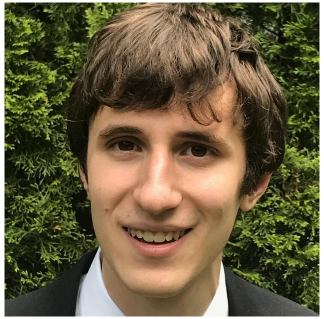
S. Edwards

SYSTEM ARCHITECT

Stephen

LANGUAGE GURU

## the (actual) team



Michael

TESTER

Evan

SYSTEM ARCHITECT

Sofía

MANAGER

Ben

SYSTEM ARCHITECT

Jason

LANGUAGE GURU

## origins

- There was once a guinea pig named bugsy...

He didn’t do too much, but everyone liked him and he is a good role model and our inspiration for ‘bugsy’, the language.

FUN FACT:

the ‘A’ in Stephen A. Edwards stands for AST!

## outline

- “the team”
- bugsy overview
- compiler architecture
- testing
- classes
- arrays
- future work
- demonstration

FUN FACT:

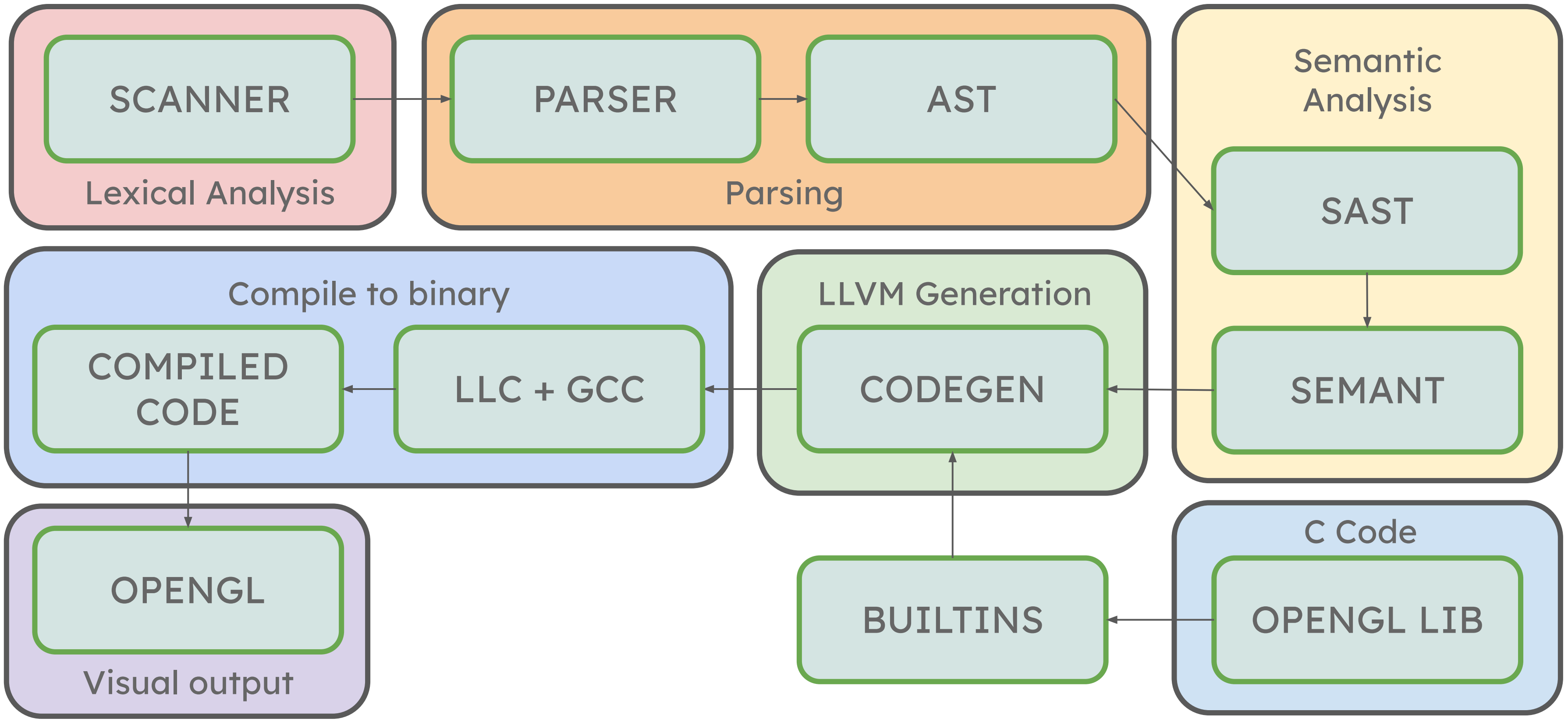
the ‘A’ in AST stands for a**hole

JK -- amazing(;

## bugsy overview

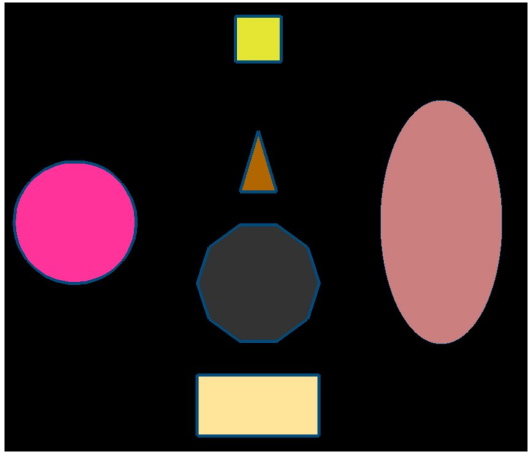
- a simple drawing language inspired by p5.js*
- object-oriented design using a blend of Python and Java syntax
  - classes, arrays, boolean logic
- allows for easy creation of shapes using an OpenGL backend
  - shapes: circles, ellipses, squares, rectangles, triangles, regular polygons, lines
  - animation: moveTo, rotateBy, scaleBy
  - stroke, stroke size, and fill: colors passed in as strings (ex: “0.3 0.6 0.1” RGB values)
- forget ints and floats – **nums** will *ease* your programming experience!

# compiler architecture



## openGL library

- custom library connecting openGL to bugsy
- shape structures created to hold information about each type of shape
  - parameters: shape type, shape ID, x, y, r, w, h, x1, x2, y1, ...
- unique ID strings generated every time a new shape is created
  - used when animating, loops through array of shapes to check if we are redrawing the right shape at the right time/place



## openGL library

| openGL | bugsy |
|---|---|
| display()<br>(including glFlush() and everything in main()) | draw() |
| glColor3f() | rgb() |
| glBegin(GL_QUADS) | rect()<br>square() with extra parameters |
| glBegin(GL_TRIANGLES) | triangle() |
| glBegin(GL_POLYGON) | regagon() with extra parameters |
| glutInitWindowSize() &<br>glutInitWindowPosition() | canvas() |
| Custom function (we have one, another one linked below) | circle()<br>ellipse() with different parameters |
| glBegin(GL_LINES) | line() |

## testing

- Test suite that compares an output to an existing file
- Challenge with testing visuals
- Approach: Add a print function to the OpenGL C code that prints out stats of the shape to confirm the program works as intended
- Pass in a DEBUG flag so that the window can close

```
if(strcmp(getenv("DEBUG"), "1") != 0) {
        glutMainLoop();
}
```

## nums

- Why num?
  - Simplicity and flexibility
  - Less need to worry about type errors
- Is this even possible?
  - Yes, thanks to `build_fptoui`

## returning 0

- Successful main function should return 0 *in LLVM*
  - Always best to check in LLVM since that’s about as low as we are concerned for bugsy (one step above assembly code!)

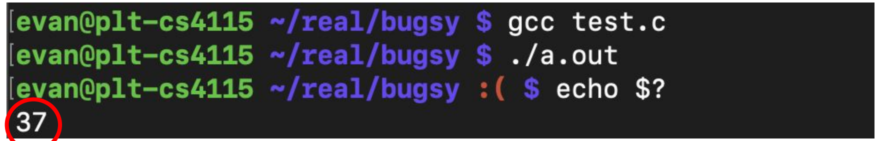
C Program:

```
double main(){

    int x = 0;

    return 0.0;

}
```

**Don’t do this!**

LLVM:

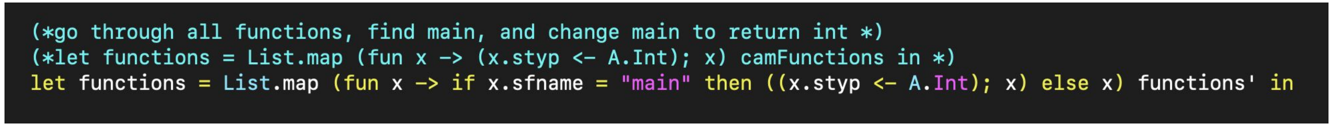
```
define dso_local double @main() #0 {
 %1 = alloca i32, align 4
 store i32 0, i32* %1, align 4
 ret double 0.000000e+00
}
```



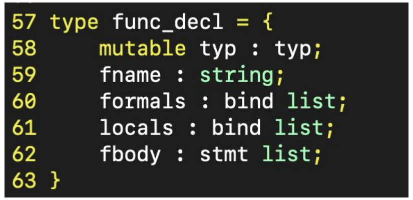
```
evan@plt-cs4115 ~/real/bugsy $ gcc test.c
evan@plt-cs4115 ~/real/bugsy $ ./a.out
evan@plt-cs4115 ~/real/bugsy :( $ echo $?
37
```

# solution (pt. 1)

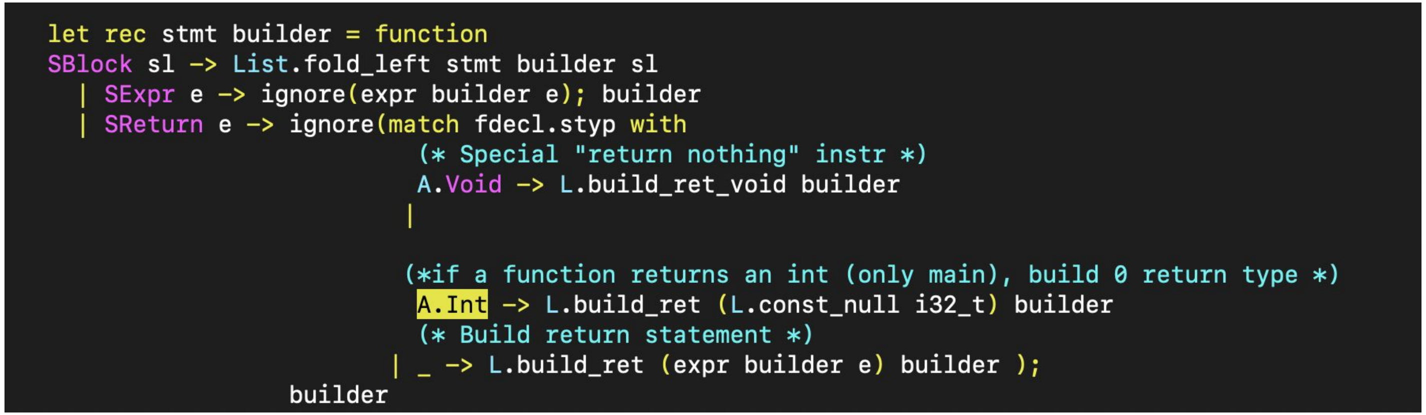
- Codegen!
  - Insert a return 0 at the end of the main() function:



```
(*go through all functions, find main, and change main to return int *)
(*let functions = List.map (fun x -> (x.styp <- A.Int); x) camFunctions in *)
let functions = List.map (fun x -> if x.sfname = "main" then ((x.styp <- A.Int); x) else x) functions' in
```



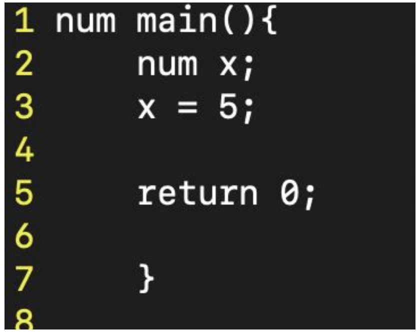
```
type func_decl = {
    mutable typ : typ;
    fname : string;
    formals : bind list;
    locals : bind list;
    fbody : stmt list;
}
```



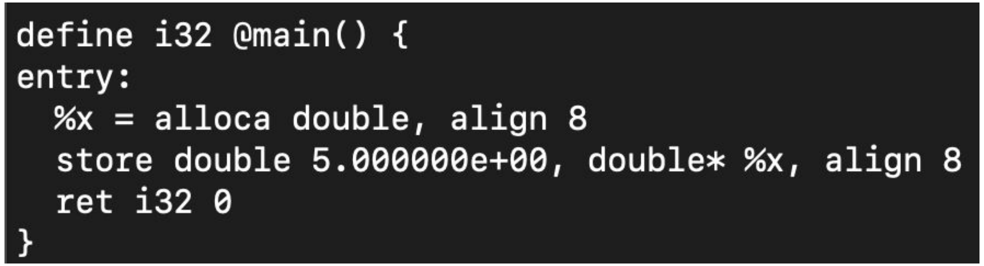
```
let rec stmt builder = function
SBlock sl -> List.fold_left stmt builder sl
  | SExpr e -> ignore(expr builder e); builder
  | SReturn e -> ignore(match fdecl.styp with
                        (* Special "return nothing" instr *)
                        A.Void -> L.build_ret_void builder
                       |

                       (*if a function returns an int (only main), build 0 return type *)
                        A.Int -> L.build_ret (L.const_null i32_t) builder
                        (* Build return statement *)
                      | _ -> L.build_ret (expr builder e) builder );
            builder
```

## solution (pt. 2)

- Does this work, and how do we know?
    - Yes -- LLVM!



```
num main(){
      num x;
      x = 5;

      return 0;

      }

```



```
define i32 @main() {
entry:
  %x = alloca double, align 8
  store double 5.000000e+00, double* %x, align 8
  ret i32 0
}
```

## arrays

Seems like it should be simple enough…

```
| SArrayAccess(a, e, l) -> let valu = (expr builder e) in
L.build_load (L.build_gep (lookup a) [|L.const_int i32_t 0; valu |]
a builder) a builder
```

This won't work… why?

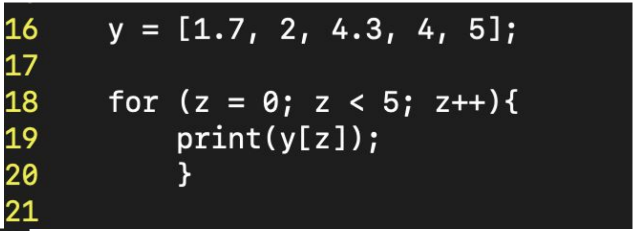
Alright, seems like an easy enough fix…
(cast as float)

```
| SArrayAccess(a, e, l) -> let valu = L.const_fptosi  (expr builder e) i32_t in
L.build_load (L.build_gep (lookup a) [|L.const_int i32_t 0; valu |] a builder) a builder
```

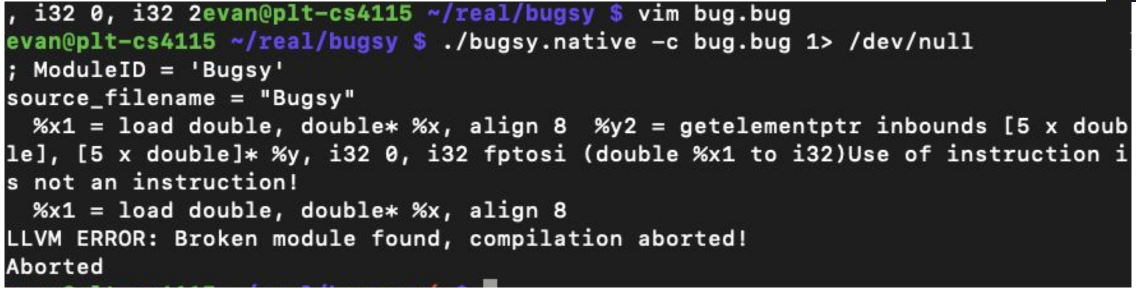
Works fine for constant (i.e. arr[5])

# arrays (pt.2)

- What about variables?
    - Difficult interfacing LLVM with moe



```
    y = [1.7, 2, 4.3, 4, 5];

    for (z = 0; z < 5; z++){
        print(y[z]);
        }

```

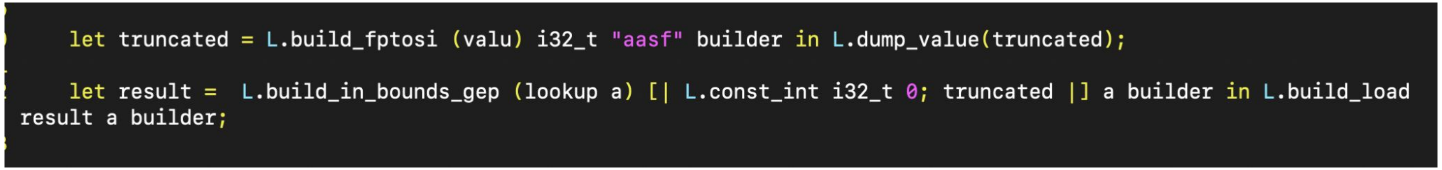


```
, i32 0, i32 2evan@plt-cs4115 ~/real/bugsy $ vim bug.bug
evan@plt-cs4115 ~/real/bugsy $ ./bugsy.native -c bug.bug 1> /dev/null
; ModuleID = 'Bugsy'
source_filename = "Bugsy"
  %x1 = load double, double* %x, align 8  %y2 = getelementptr inbounds [5 x doub
le], [5 x double]* %y, i32 0, i32 fptosi (double %x1 to i32)Use of instruction i
s not an instruction!
  %x1 = load double, double* %x, align 8
LLVM ERROR: Broken module found, compilation aborted!
Aborted
```

FUN FACT:

Hans Montero is *a ray* of sunshine

2 lines of code in 24 hours:



```
    let truncated = L.build_fptosi (valu) i32_t "aasf" builder in L.dump_value(truncated);

    let result =  L.build_in_bounds_gep (lookup a) [| L.const_int i32_t 0; truncated |] a builder in L.build_load
 result a builder;
```

Root of the problem: https://llvm.org/doxygen/Verifier_8cpp_source.html

## future work

- group shapes → with classes!
- RGB color object rather than a string
  - rgb(100, 200, 40) vs. “0.5 0.2 0.1”
- irregular polygons
- simultaneous animations
  - combining rotation, translation, and scaling at once for one object
  - allowing multiple objects to be animated synchronously
- garbage collection
- inheritance
- exceptions

FUN FACT:

2 hours of sleep *can* be enough (or it was today anyway!)!

## future work: classes

- call-site adjustment
- method lifting constructors and class methods
- each instance has its own variables and can use the class methods

syntax ex:

```
class ~bankAccount {
    string name;
    num bal;
// method_lifting -> ~bankAccount_constructor(string n)
    constructor(string n) {
          name = n;
          bal = 0;
    }
   //method_lifting -> ~bankAccount_deposit(self, num
amt)
    void deposit(num amt) {
          bal += amt;
    }
}
```

```
num main (){
    ~bankAccount b = new ~bankAccount("Stephen");
    b.deposit(5); // ~bankAccount_deposit(b, 5);
}
```

FUN FACT:

classes are more fun when they're not over zoom!

## lessons learned

- make sure the whole **pipeline** works before writing hundreds of lines of code on one file !! we ran into this when creating the library
- make more **progress** sooner → bugs come up and halt progress, we had an idealistic idea of how much work was left → cut features
- set **realistic** goals → we started with an idea to get a robotic arm to move, then thought we would try drawing chemical formulas, but it turns out drawing shapes was hard enough
- more **planning** in the early stages of the project

## 🐛👾 demo 👾🐛

## 🐛👾 questions? 👾🐛

thank you for an amazing semester!!!