Macaw

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Team Members

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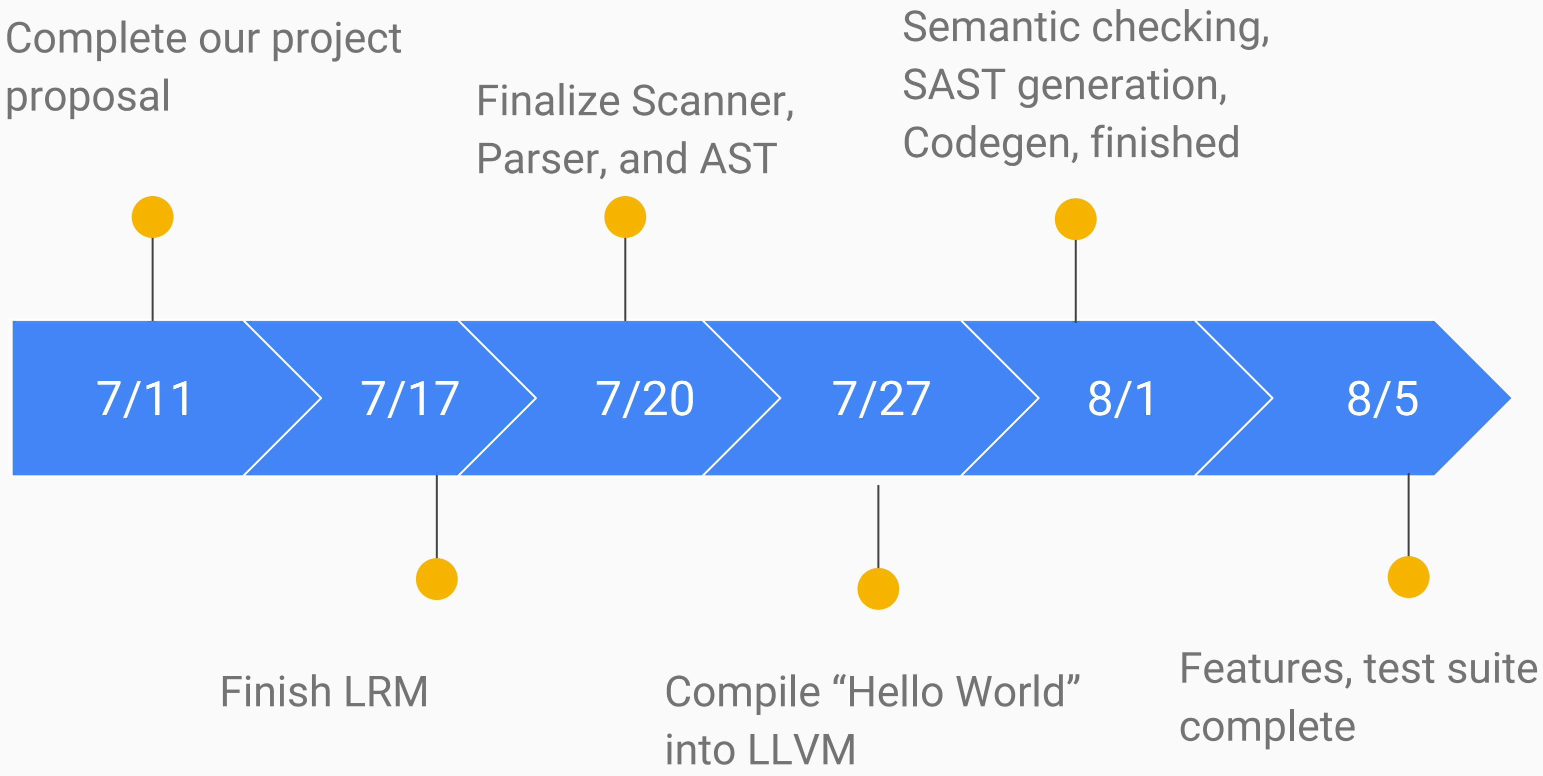
Introduction

Macaw is a mathematical calculation language with native support for matrix data types.

- Strongly typed
- Imperative
- Supports if/else/for/while flow controls
- Functions
- Operator overloading

Project Plan



Complete our project proposal
Finalize Scanner, Parser, and AST
Semantic checking, SAST generation, Codegen, finished
7/11
7/17
7/20
7/27
8/1
8/5
Finish LRM
Compile “Hello World” into LLVM
Features, test suite complete

Language Overview / Tutorial

A Macaw program is written as series of functions and imperative statements. Function definitions and variable declarations must be made prior to referencing them.

#Does not compile

```
foo("Hello World");

void foo (string s){
    print(s);
}
```

#Compiles

```
void foo (string s){
    print(s);
}

foo("Hello World");
```

Language Overview / Tutorial

Data Types

number - Floating point numbers for arithmetic operations.

string - Character strings used for printing statements to the console. Can be stored in variables or used as constants.

matrix - Two dimensional arrays of numbers.

- Built-in support - initialization, access, insertion
- Standard library functions implemented.
- Accessed using [row, column] or [flattened] indexing.
    - [flattened] indexing - counted across columns, then rows.

Language Overview / Tutorial

```
# string concatenation is destructive

string foo(string s) {
    return strcat("Hello ", s);
}

print(foo("World!")); #prints 'Hello World!'
```

```
# testing additive expressions, subtraction

matrix a <- [1,2,3;4,5,6];

matrix b <- [1,2,3;4,5,6];

matrix c <- a - b;

print(c[5]); # prints 0.00
```

More interesting features

- Matrix Support
- Operator Overloading
- Function Overloading
- Statements are valid at the root (outside the functions)

Some things our language can do

```
# mixed variables in overloads

number operator + (string s, number b) {
    print(b);
    print(s);

    return 0;
}

number a <- "Hello World!" + 6;
print(a);

#prints the following:
#6.000
#Hello World!
#0.000
```

```
# global variable modifications are visible in functions
# variables are passed by value

number a <- 7;

number foo(number x) {
    x <- x * 5;

    printnl("value of a in function: "); print(a);
    printnl("value of x: "); print(x);

    return 2;
}

number b <- foo(a);

printnl("a is unchanged: "); print(a);
printnl("return value of foo: "); print(b

#prints the following:
#value of a in function: 7.000
#value of x: 35.000
#a is unchanged: 7.000
#return value of foo: 2.000
```

Interlude Math Demos

Architecture

Scanner/Parser/AST:

- Scanner reads in source files and tokenizes them.
- Parser processes tokens into abstract syntax tree.
- Abstract syntax tree represents Macaw program

Semantic Checker (aka Evaluator):

- Receives AST and checks validity of semantics and syntax
  - Declarations, Types
- Create structure for the list of statements and functions.

SAST:

- Result of the semantic transformation of the AST
- Passed to codegen for code emission

Codegen (aka Compilator):

- Takes SAST and emits LLVM code.
- No logic or decision-making (except resolving data types); mechanically translates SAST to LLVM IR.

Testing Process

- Language reference manual used to devise test cases and scenarios.
    - Both success scenarios and expected failure scenarios
    - Write unit tests that **should** pass/fail.
- System architects implemented features, wrote test programs.
- Testers broke down test programs into component unit tests.
- “Test all” script implemented to run regressions.

Lessons Learned -- Our most important takeaways

- Chris: Complex project, project management, testing
- Yi: Learned about the language design process, testing to break the language
- William: Matrix time management, planning language architecture
- Joseph: TDD, Semantic checking/transforming is surprisingly powerful

Live Demo -- The coolest things we can do

Questions?