Caml tail

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Motivation

Want to do an interesting project

Don’t know anything about Ocaml

Let’s make an Ocaml-like language!

Our Goal & Challenges

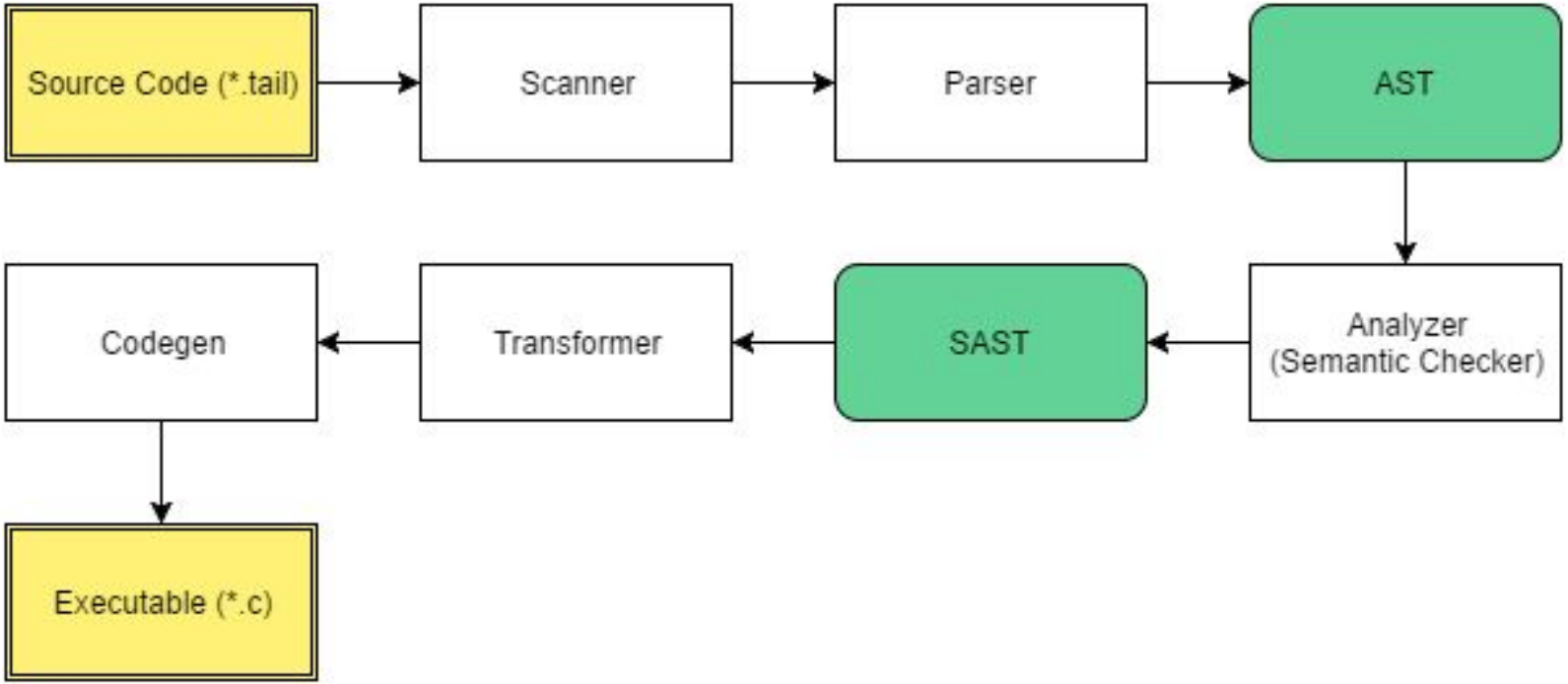
Create a functional language that handles assignments, functions, and scoping in a similar way to Ocaml.

Compile to C.

Challenges:

Functional -> Imperative

Compiler Architecture



Language Features

Types

Int | Float | String | Bool | Unit | Lists

Operators

+ - * /

< > <= >= ==

&& || not

Control Flow

```
if (a == b) then
        let bool c = true
else
        let bool c = false
;
match a with
        b -> print_int(1)
        | c -> print_int(2)
        | _ -> print_int(0)
;
```

Builtins

```
print_int(3);
print_float(3.14);
print_string(“tail”);
print_bool(true);
```

Basic Language Parsing

Tail is made up of a list of **statements** separated by **semicolons.**

Every **statement** is essentially one of 3 types:

1. function assignment
2. variable assignment
3. expression

Expression Statements

Expressions do the bulk of the work in tail.

An **expression** statement goes to one of 4 things:

1. exprs (Literals, Binops, Uniops, Calls, Prepend)
2. Definitions (function or variable definitions within another expression)
3. Conditionals (IF expr THEN expr ELSE expr)
4. match expressions (MATCH expr WITH match_list)

Assignment Statements

Variable Assignments

Expression Definition

let int a = {int literal};

List Definition

let int [] a = [{literal list}];

Function Assignments

let int a (int b, string c) = fun {expression list} ;

Transformations

The **analyzer** goes through the AST for type checking and basic scope checking.

The **transformer** takes the SAST and produces a flattened, imperative version.

Codegen takes this and produces the C code.

Demo

Demo.tail

```
print_string("comment -> expected output, nothing");
(* Here is a demo with a match *)

print_string("");

let int add(int q, int s) = fun
        let int y = q + s in y;
;

let int c = 2;


let int matchDemo (int b) = fun
        let int a = add(b, c) in
        match a with
                1 -> print_int(1)
                | 2 -> print_int(2)
                | _ -> print_string("wildcard");
        0;
;

print_string("matchDemo(0) -> expected output, 2");
matchDemo(0);

print_string("");
print_string("matchDemo(-1) -> expected output, 1");
matchDemo(-1);

print_string("");
print_string("matchDemo(4) -> expected output, wildcard");
matchDemo(4);

let int a = 4;
let int b = 2;

print_string("");
```

```
#include <stdio.h>

#include <string.h>

int c = 2;
int a = 4;
int b = 2;
int d = 4 / 2;


int add (int q, int s) {
int y = (q) + (s) ;
return y;
}
int matchDemo (int b) {
int a = add(b, c) ;
switch(a){
        case(1) :
         printf("%d\n", 1);
         break;
case(2) :
         printf("%d\n", 2);
         break;
         default :
        printf("%s\n", "wildcard");
}
;
return 0;
}
int main(){
printf("%s\n", "comment -> expected output, nothing");
printf("%s\n", "");
printf("%s\n", "matchDemo(0) -> expected output, 2");
matchDemo(0) ;
printf("%s\n", "");
printf("%s\n", "matchDemo(-1) -> expected output, 1");
```

Output of demo.tail

```
jennifer@plt-sandwich:~/compiler$ ./tail < demo.tail > output.c; gcc output.c; ./a.out
comment -> expected output, nothing

matchDemo(0) -> expected output, 2
2

matchDemo(-1) -> expected output, 1
1

matchDemo(4) -> expected output, wildcard
wildcard

d = a/b where a is 4 and b is 2 -> expected output, 2
d =
2
jennifer@plt-sandwich:~/compiler$
```

Demo2.tail

```
(* Hi, this is a funny demo *)

let int add(int q, int s) = fun
        let int y = q + s in y;
;

let int people = 4;
print_string("Number of people = 4");
let int sleep = 120;
print_string("Number of hours of sleep lost (conservative estimate) = 120");

let int total = add(people,sleep);
let int bugs = 20000;

print_string("Number of bugs = 20000");
print_string("When you add those all together and match on mix, you get: ");

let int matchDemo (int b) = fun
        let int mix = add(b, bugs) in
        match mix with
                1 -> print_int(1)
                | 20124 -> print_string("Output = tail")
                | _ -> print_string("wildcard");
        0;
;

matchDemo(total);

print_string("Number of things learned = uncountable");

(* matchDemo(-1); matchDemo(4); *)
```

```
#include <stdio.h>

#include <string.h>

int people = 4;
int sleep = 120;
int total = 120 + 4;
int bugs = 20000;


int add (int q, int s) {
int y = (q) + (s) ;
return y;
}
int matchDemo (int b) {
int mix = add(b, bugs) ;
switch(mix){
        case(1) :
         printf("%d\n", 1);
         break;
case(20124) :
         printf("%s\n", "Output = tail");
         break;
         default :
        printf("%s\n", "wildcard");
}
;
return 0;
}
int main(){
printf("%s\n", "Number of people = 4");
printf("%s\n", "Number of hours of sleep lost (conservative estimate) = 120");
printf("%s\n", "Number of bugs = 20000");
printf("%s\n", "When you add those all together and match on mix, you get: ");
matchDemo(total) ;
printf("%s\n", "Number of things learned = uncountable");
return 0;
}
```

Output of demo2.c

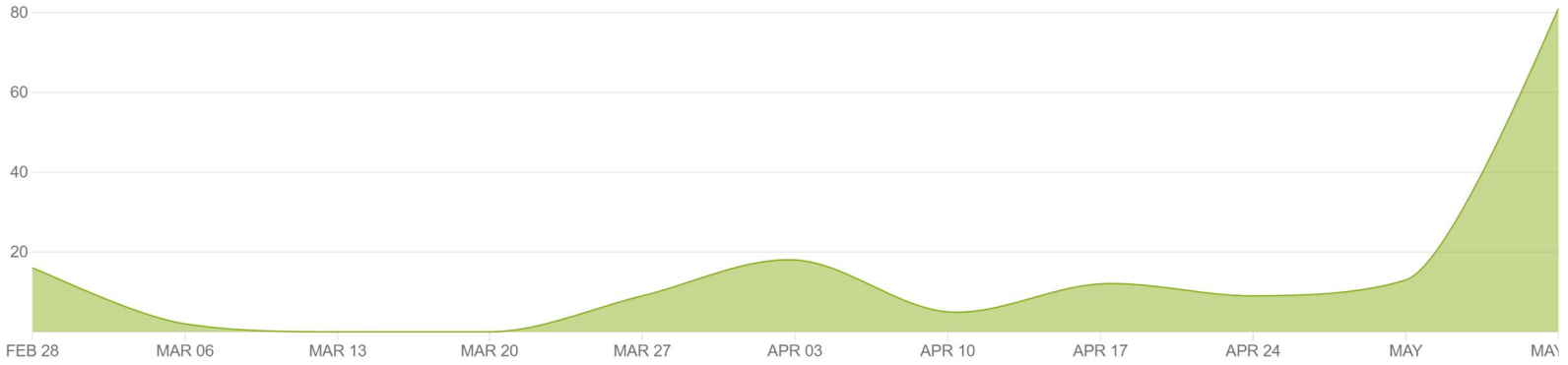
```
sandra@sandra-VirtualBox:~/Documents/compiler$ ./demo2
Number of people = 4
Number of hours of sleep lost (conservative estimate) = 120
Number of bugs = 20000
When you add those all together and match on mix, you get:
Output = tail
Number of things learned = uncountable
```

Testing

- Wrote tests for features that we implement to make sure they work as expected
  - Tests are either expected to compile and run (test-*.tail files) or fail to compile (fail-*.tail files)
- Wrote a bash script that inputs *.tail files to our compiler and outputs a test*.c file, and then evaluates the following shell commands:
  - gcc -o test* test*.c
  - (and if the above works) ./test*
- The test script outputs these evaluations, and reports how many of the files output the expected output

Workflow

1. Weekly Meetings
2. Git and Bitbucket
3. Group programming



Lessons Learned

- Starting early isn’t enough - make sure you keep up momentum throughout the semester!
- Make sure you know what you’re getting into before making important life (and project) decisions.
- OCaml is beautiful.
- You can’t learn LLVM in a night.
- Management is essential