

Stitch Language Final Reportd

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Introduction

Most "modern" programming languages trace their origins back decades to before the advent of cheap, general purpose multicore CPUs. They were designed for a distinctly mono-threaded environment. While libraries and enhancements to mainstay languages such as C/C++ and Java have added multithreading capabilities, it remains in many ways bolted on kludge. While newer frameworks such as Node.js provide more integral support for asynchronous operations, they lack the depth of support and power of a fully compiled language. With Stitch, we aim to build a language that has the power and flexibility of a fully compiled C style language, while having native threading support for modern multithreaded applications. Our goal is to create a translator from Stitch to C.

Stitch is inspired by C, which has a very well known syntax, and has been one of the most widely used languages since it was released over forty years ago. Stitch is a general purpose language that supports all standard mathematical and logical operations. Like C, Stitch is strongly typed, and whitespace does not matter. In addition to the standard C primitive types (`int`, `double`, `char`, etc.)

Stitch is able to provide an easy to use, clear paradigm for multithreaded operations by strictly limiting when and how they can be invoked. This is done through the `stitch` loop. The body of this loop is automatically split into multiple threads, and the program will not continue until all threads have returned. Using a simple loop paradigm, similar to well know control structures like `while` and `for` loops, allows for an easy learning curve, and clear easy to read code. It also allows the compiler to easily see what code needs to be run in a threaded manner, and to efficiently generate the threaded code.

The underlying method by which Stitch runs multithreaded code is C's `pthread` library. The Stitch compiler will wrap the body of the `stitch` loop in a function. This function will be executed in parallel using `pthreads`. Variable scoping inside the threads is also handled by the compiler. Each threads is passed a C `struct` that contains all non-local variables needed by the block of code that is being multithreaded. This prevents clobbering issues without needing to resort to `mutex` locks. The only exceptions to this rule are accumulators, which are very limited in scope, and arrays, which can be sliced and piecewise accessed by different threads concurrently.

Language Tutorial

Running The Stitch Compiler:

When inside the ocaml folder, type *makeallinordertogeneratethestitchexecutable*. Running *./singer filename.stch* from the home directory will output a C program called *filename.stch.c* which gets compiled in *singer* with the appropriate C libraries and runtime headers into an executable of the same file name. *Singer* needs to be in the home directory in order to access the compiler executable and runtime headers correctly, if it needs to be moved then those directory accesses need to be updated.

Hello World

This is the popular "hello world" program written in Stitch. As can be seen below, it's almost identical to how it would be written in C, except without the `#include` statement and the syntax of the `print` function.

```
1 int main()  
2 {  
3     print("hello world");  
4     return 0;  
5 }
```

Matrix multiplication

If you want to use the multithreaded feature of Stitch, then simply use the stitch loop. Matrix multiplication is shown using the stitch loop below.

```
1 int main() {
2
3     int a[5][5] = { {1, 2, 3, 4, 5},
4                     {1, 2, 3, 4, 5},
5                     {1, 2, 3, 4, 5},
6                     {1, 2, 3, 4, 5},
7                     {1, 2, 3, 4, 5} };
8
9     int b[5][5] = { {1, 1, 1, 1, 1},
10                    {2, 2, 2, 2, 2},
11                    {3, 3, 3, 3, 3},
12                    {4, 4, 4, 4, 4},
13                    {5, 5, 5, 5, 5} };
14
15     int c[5][5];
16
17     int i = 0;
18     int j = 0;
19     int k = 0;
20
21     stitch i from 0 to 5 by 1: {
22
23         for(j = 0; j < 5; j = j + 1) {
24
25             for(k = 0; k < 5; k = k + 1) {
26
27                 c[i][j] = c[i][j] + a[i][k] * b[k][j];
28             }
29         }
30     }
31
32     for(j = 0; j < 5; j = j + 1) {
33
34         for(k = 0; k < 5; k = k + 1) {
35
36             print(c[j][k]);
37         }
38     }
39
40
41     return 0;
42 }
```

Language Reference Manual

Project Plan

Planning

We arranged weekly meetings with our language advisor Professor Edwards to discuss progress and issues that we countered. The immediate feedbacks we received from him were extremely helpful in the development of the language, especially when we were heading in the wrong directions. We had weekly meetings as well where all of us got together and worked on the project. During the meetings we split up the work, often two people working together on the same thing. Initially this worked really well since all of us were new with OCaml. Later, we divided up the work on an individual level such as implementing some functionality or writing some specific tests.

Style Guide

While programming our compiler we tried to follow these general guidelines:

- Ocaml style guidelines, such as indentation and formatting
- Tried to keep lines limited to 80 characters, if this wasn't possible due to unreadability, then we used 120 characters as the hard limit.
- Unlike Ocaml, we named variables in all lowercase and used underscores as a delimiter
- Used 4-space indentation for each program

Project Timeline

September 30 Proposal submitted

October 26 LRM submitted, scanner and parser with 1 shift/reduce error

November 16 Working scanner, parser, ast without arrays/stitch loops,
'Hello, Word' works

November 30 Finished semantic analyzer and cast

December 8 Finished c code generator with arrays added

December 14 Stitch loops working

December 21 Final Presentation

December 22 Code cleanup and Final Report submitted

Team Roles and Responsibilities

Rashedul Haydar	-	Manager
Tim Waterman	-	Language Guru
Dan Cole	-	System Architect
Megan Skrypek	-	Tester

While we had assigned roles, the responsibilities became much more fluid as the project progressed. During the initial planning phase we all discussed the structure and components of the language. Later on, we also worked together on the semantic analyzer, C generator, and the variety of tests used for the test suite.

Software Development Environment

- Version Control
 - Git
- Languages
 - OCaml (4.02.3) for parser, scanner, ast, semantic analysis
 - GCC for compiling generated C code
 - bash for test suite and singer
 - Python (2.7.5) for image curve generator
 - L^AT_EX for reports and documentation
- Text Editors
 - VIM
 - Sublime

Project Log

commit 14fcbbf36913eeba32454705951f590629df1ae1

Merge: f86f952 cd73bf1

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Mon Dec 21 12:27:34 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit f86f952f4ed913c92bc2b3d96d028ec7d1b554e7

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Mon Dec 21 12:27:29 2015 -0500

updated demo and presentation

commit cd73bf1546f50a0d761cd73c237e5adc6cd58935

Author: Tim Waterman <watermantium@gmail.com>

Date: Mon Dec 21 12:14:34 2015 -0500

Getting everything up pre-demo

commit 7726285bd6845f42de94c180d981660829932ac7

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Mon Dec 21 12:11:17 2015 -0500

updated presentation and demo

commit 219855f53fdf111f06eb251c678126fe991525fe

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Mon Dec 21 12:08:27 2015 -0500

updated presntation

commit e34dfe37af0d6b8e38d138b08e95f0495c3ced2f

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Mon Dec 21 11:09:20 2015 -0500

generated C for matrix multiplication added

commit e28346bb1af89c7959e2ea6309c3d4922651b9fc
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Mon Dec 21 10:56:32 2015 -0500

added matrix multiplication code

commit 6b9558e962acaa2f7a2ceb2dc585a72fce937bcb
Author: Tim Waterman <watermantium@gmail.com>
Date: Mon Dec 21 02:13:42 2015 -0500

Got demo to work with no C code cheats

commit 833ab002702eb5b56b652087165fb424dbae01cb
Author: Tim Waterman <watermantium@gmail.com>
Date: Mon Dec 21 01:27:49 2015 -0500

Starting testing with + accumulators

commit b8434f0eb623b9ffee29834955d6df9bd966c057
Author: Tim Waterman <watermantium@gmail.com>
Date: Mon Dec 21 00:14:15 2015 -0500

Stitch loop scoping issues worked out

commit 5c465f254dd3266f7dbe482ae6c451ccc9524c67
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 23:57:31 2015 -0500

Made a better matrix mult test; updated sems

commit 6d19c76c540b35ba8814c9f3b703fa7d1d21a485
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 21:50:28 2015 -0500

Added matmult output

commit 55d411d2608ceb6180e82de2e2401e7c34a48a90
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 21:48:56 2015 -0500

Matrix multiplication test working

commit 7bd1175b3e6aa95bc47918a6811abbdea525ce94
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 21:34:36 2015 -0500

Working on scoping issues

commit b1ba4625bbd4613eefc6ed4871e364a22cf7e29c
Merge: a978103 5a49906
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 20:35:05 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit a9781034f1f1dd44de3ac97fe08fcf570818e847
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 20:35:00 2015 -0500

added open_r and open_w

commit 5a49906dd846b14931a3e2c4aef86a73a58b0590
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 20:32:14 2015 -0500

Finished matrix init -> stitch

commit c909820ba855fce2ca8a62a94dd186aa51d80197
Merge: 62cbf0a eca869c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 20:19:10 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit eca869cb0f88e9615b4e4cdad106c259a07fd181
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 20:19:04 2015 -0500

Fixed 1D array init passing

commit 62cbf0a8d1c68cbbd8a7c67a1ce79ce00330a8c1
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 20:19:02 2015 -0500

minor fix

commit 6455582db726d6f5dd7e2dc7df0a96c0031e9b53
Merge: 3d2ceff c16ede4
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 19:57:53 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 3d2ceffe122c54c3b87f5d878060b7644319a2cb
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 19:57:51 2015 -0500

Finished stch_stmt checking

commit c16ede42f887a33020826c38f19451e1a7a8e96c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 19:56:27 2015 -0500

fixed paren issues

commit 1d273b474db7be10ec9c9ec3095e752ab28149a3
Merge: 4c6e669 8bd704e
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 19:50:10 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 4c6e669fa31ea9667d8a96b9670393b6c4e63fed
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 19:50:08 2015 -0500

Added some more generator testing

commit 8bd704ed2da598867247fe681028b4bc72469083

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Dec 20 19:43:46 2015 -0500

removed func3

commit 39eafcbec26b5abdf473b24a59bc6f7e56ed34bc

Merge: 78c76df 03244dd

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Dec 20 19:42:43 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 78c76dfd0801089d8f41cb25fb7708bd5d824ffb

Merge: 38d630a d30b9bf

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Dec 20 19:42:36 2015 -0500

removed fib1

commit 03244dde2357d2cf0763b0c043d3ae3f7d54e9ec

Merge: 02836f8 d30b9bf

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Dec 20 19:41:43 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 02836f8476fb79c41b6b85fba37f56e69919eae5

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Dec 20 19:41:41 2015 -0500

Fixed array passing bug

commit 38d630a36e0cbbce22473bd3a30475b78f4e98c5

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Dec 20 19:41:21 2015 -0500

added tests

```
commit d30b9bf0e270d8143e2113eaeafb791ebbd8ef2c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 19:39:52 2015 -0500
```

```
    minor fix on 4
```

```
commit f515cf5f229418bef8d9530c1f65ef907ad88c38
Merge: 7fb08e9 200acf2
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 19:27:28 2015 -0500
```

```
    Merge branch 'master' of https://github.com/danhcole/4115
    _lang
```

```
commit 7fb08e934101b3837ee3d105ac06d42357ae54a9
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 19:27:18 2015 -0500
```

```
    2D arrays are working
```

```
commit 200acf257512624f312e6bd58b5b74ccf6a4d1ee
Merge: c36a877 aaaa5ce
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 19:07:28 2015 -0500
```

```
    Merge branch 'master' of https://github.com/danhcole/4115
    _lang
```

```
commit c36a8772a17c1a1774704f8b9b2aa472199d955a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 19:07:21 2015 -0500
```

```
    recursion wont work
```

```
commit aaaa5ce4829084dcf6751e96cfd8360031d7a5e2
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Sun Dec 20 18:38:27 2015 -0500
```

```
    added _ntests/array3.stch, array4.stch, and matrixinit2.stch
```

```
commit 9957b7448d9e6fa3427d38785ee8a6a7da5b6634
```

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Sun Dec 20 17:47:41 2015 -0500

added _tests/fib1.stch

commit 9847733e91ccd9d62bd444f8085ba6821f5b057a

Merge: 588cc44 515be64

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sun Dec 20 17:43:42 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 588cc44363e5e2809436a3b4baf4dfa90efe1f39

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sun Dec 20 17:43:39 2015 -0500

fixed recursion

commit 515be640f660365dd4ef70a62865a9f9bb9e7322

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Dec 20 17:43:14 2015 -0500

Can print locals in stitch loops

commit 0fcd77f0c164c463a99f1166662419b806c35141

Merge: 89b2f31 aceffe8

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Sun Dec 20 17:36:47 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 89b2f31208a2116d9b3af94c7da2537a77580f42

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Sun Dec 20 17:36:34 2015 -0500

added _/tests/func4 and func5.stch

commit aceffe8260737f1a83e5ce8c40f0efda6fe3fbel

Merge: 02d3734 3c88e1c

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Dec 20 17:34:58 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 02d37343356e0b50624e7996a9b83e2d3d961eda

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Dec 20 17:34:51 2015 -0500

More code gen

commit 3c88e1c76fa14e81cc087364f249c83e50143ace

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Dec 20 17:34:19 2015 -0500

renamed gcd added stitch4 output txt

commit 8c3fbe3a7588c1715967ac2e278e3273988016f9

Merge: 5f94a5a fa7c23e

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Dec 20 17:23:19 2015 -0500

Fixing the merge

commit 5f94a5a12f071674e2943f908bbc0d6f2ef3cf55

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Dec 20 17:21:18 2015 -0500

Stitch statement parsing overhaul

commit fa7c23ed6dbfc50cca96c6bc445591c2fd7d9f43

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sun Dec 20 16:58:46 2015 -0500

fixed .gitignore; char can now cast to int

commit 2e19c6d01c184a93898a82205a152202a2018bdd

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Dec 20 16:55:05 2015 -0500

```

    fixed escaped characters

commit 50a5d3ee12a1a96f4d5db00ea87fa9e26017f428
Author: Rashedul Haydar <rh2712@columbia.edu>
Date:    Sun Dec 20 16:49:34 2015 -0500

    updated all tests to have correct return statements

commit 0354d0c3b716d48a1d5d6eea3f619d12e726c6ea
Merge: 7413e98 3fe7525
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:    Sun Dec 20 16:33:15 2015 -0500

    Merge branch 'master' of https://github.com/danhcole/4115
    _lang

commit 7413e982270eb9db48be5ca875d06a15445df65b
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:    Sun Dec 20 16:32:57 2015 -0500

    check for return on non-void function

commit 3fe7525d89f8244769ddcc90b9679dc962286068
Author: Rashedul Haydar <rh2712@columbia.edu>
Date:    Sun Dec 20 16:01:57 2015 -0500

    added _ntests/vardecl1.stch, cant identifier starting with _
    or a number

commit 1446057a4c0c33c04434dd7ca02b9257908a0a92
Merge: 29c3e59 1895079
Author: Tim Waterman <watermantium@gmail.com>
Date:    Sun Dec 20 15:33:05 2015 -0500

    Merge branch 'master' of https://github.com/danhcole/4115
    _lang

commit 29c3e594d2e8672ea9c39be374bb5732efdd314b
Author: Tim Waterman <watermantium@gmail.com>
Date:    Sun Dec 20 15:32:59 2015 -0500

```

```
Fixed issue with var being removed too late from stitch

commit 1895079fa4b0a460c0d2166d24d01f3984784322
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Sun Dec 20 15:25:49 2015 -0500

    added _tests/for1.stch

commit 350b17670a0b795902fc008094bc429d8aadf3b3
Merge: c79809b 1c46608
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 15:15:51 2015 -0500

    Merge branch 'master' of https://github.com/danhcole/4115
    _lang

commit c79809b7070dc507bd5c00756504e8cddecf12562
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 15:15:46 2015 -0500

    Adding gen stuff

commit 1c46608678604b7a6c09626205e00d62ee22f28c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 15:05:06 2015 -0500

    fixed function ordering problem

commit ccae33c4a21f924abac64ed695b8e6298581147f
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Dec 20 14:59:01 2015 -0500

    Working on stitch loop verification

commit c447d69eb709f5becdfff2f0d500e609603df306
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 14:39:08 2015 -0500

    updated presentation and demo

commit 492a1ce0c48c369b9681892acd891d6bb950395e
```

Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 13:56:02 2015 -0500

added presentation pdf

commit 655acdd240fe5ef42ebb6b6f3859f9f9807d0b6a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 13:55:24 2015 -0500

updated file2 test

commit 3954666f247f91a72988b0b63b457b63a66dbce9
Merge: 6a93ff4 2a5a23a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 13:54:58 2015 -0500

merge conflict

commit 6a93ff45d27458df206a0dea2cb3cbfe64a61820
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Dec 20 13:53:42 2015 -0500

updated presnetation, file tests

commit 2a5a23a7d8781a1aced8576bfac4da22477cfae0
Author: ms4985 <ms4985@columbia.edu>
Date: Sun Dec 20 02:18:58 2015 -0500

added more tests

commit 0d603b1e8406269ede1fc9a6ea4d6b714a4fa53d
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Dec 19 23:06:32 2015 -0500

file IO works

commit 2557e441e0b3a4cc0c92b1d6a08ca9cadfb19c8a
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Sat Dec 19 21:26:09 2015 -0500

added _ntests/arith3.stch, checks that you cant add chars to

```

    ints. Added _ntests/func2.stch, funcs w/o return type cause
    error.

commit 0cd0268a41ddbccc67a8f5bb21ffc17ef5f168fc3
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Dec 19 19:14:51 2015 -0500

    updated gitignore

commit e2b2651405022319038790b7ad8ef7e4fa22db72
Merge: 58aa1b4 443c22f
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Dec 19 19:13:18 2015 -0500

    Merge branch 'master' of https://github.com/danhcole/4115
    _lang

commit 58aa1b46b935835ab04af99604a6dc27c602fe35
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Dec 19 19:13:15 2015 -0500

    added FILE type

commit 443c22fd1528c3b2999c3d0a55d94f12f474443d
Author: Tim Waterman <watermantium@gmail.com>
Date: Sat Dec 19 19:08:05 2015 -0500

    More things now get screened before the struct

commit aae955dc54a06202de85586105c8ec2938e24a8e
Merge: eff5c5e d82e06d
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Dec 19 18:43:23 2015 -0500

    Merge branch 'master' of https://github.com/danhcole/4115
    _lang

commit eff5c5ea368de4d4899219c3aa1b13a52c74bb02
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Dec 19 18:43:05 2015 -0500

```

```
    added 2nd image for presentation , added new if test

commit d82e06d6b78ffba3105b7e9d97e94d9b18eb5e48
Author: Tim Waterman <watermantium@gmail.com>
Date:   Sat Dec 19 18:42:36 2015 -0500

    Local stitch variables should not be put inside the struct
    now

commit 97eb3628befb3c8785eaf214599c6554fec22d84
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Sat Dec 19 18:14:55 2015 -0500

    added presentation files

commit 067fe06aebdbd31d572c7e9a9471a21dfe4b2c91
Author: Rashedul Haydar <rh2712@columbia.edu>
Date:   Sat Dec 19 17:21:07 2015 -0500

    no more CONST and NULL in our language , also added global
    variable negative test

commit 66b262cfb5e01506bc9a449168e25e623b254d75
Author: Rashedul Haydar <rh2712@columbia.edu>
Date:   Sat Dec 19 16:39:59 2015 -0500

    break works , tested in _tests/break1.stch

commit 3736edbef0dc5ff3df06cf3931f17a9ee63056f0
Author: Tim Waterman <watermantium@gmail.com>
Date:   Sat Dec 19 16:08:16 2015 -0500

    Closer to getting array passing

commit 8f9e8967ffe7a06afa88f83b89ca0d90453f793a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Sat Dec 19 15:50:30 2015 -0500

    fixed unmatched accumulator tokens

commit 83bd3d36ae7130ec9160026054692aea835c8c2f
```

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Sat Dec 19 15:49:03 2015 -0500

added mod operator to ops1.stch, checked logical operators in
ops2.stch

commit 32662a7565735324058e8c84c7b2ed6405d0d3df

Merge: a5c3d93 7280502

Author: Tim Waterman <watermantium@gmail.com>

Date: Sat Dec 19 15:31:00 2015 -0500

Merging changes

commit a5c3d9353644b6884ab83be67ab67a370004ff81

Author: Tim Waterman <watermantium@gmail.com>

Date: Sat Dec 19 15:30:51 2015 -0500

Arrays are passing through

commit 7280502f0656cc75d20a6793279e7ff3e722897b

Merge: 40f096c a51ed05

Author: ms4985 <ms4985@columbia.edu>

Date: Sat Dec 19 15:24:34 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 40f096ce70eae7a48b09365befa0659c2d428d65

Author: ms4985 <ms4985@columbia.edu>

Date: Sat Dec 19 15:24:24 2015 -0500

added negative print test

commit a51ed052e8f8ddc8c70f0c7523e9e0464d4727c5

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Sat Dec 19 15:21:23 2015 -0500

added _ntests/float1.stch, fails with multiple decimals in
floating points

commit 60e63537836e38c965420a8279f50bfa699b3f80

Author: Tim Waterman <watermantium@gmail.com>
Date: Sat Dec 19 14:22:24 2015 -0500

Passing arrays into multithreaded apps working 50%

commit dc56ccfb9de14951ef1a494f96db0088c21d75bf
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Dec 18 18:24:25 2015 -0500

added accumulator types intap, intam floatap floatam

commit df57730b475a7471e135f494c4a9afd1cc3b8ec5
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Dec 18 14:32:14 2015 -0500

fixed a testing issue

commit 11079547757834808d3e19b46d78deb6ae0b7877
Merge: b738f24 9fcef18
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Dec 18 13:44:47 2015 -0500

fixed merge conflict in stitch3_out.txt

commit b738f24919d8724e864fa1f58955760b32668df7
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Dec 18 13:43:47 2015 -0500

potential merge conflict

commit 9fcef180124171ce21c9d27bf58f191538457163
Author: Tim Waterman <watermantium@gmail.com>
Date: Fri Dec 18 11:09:03 2015 -0500

Passing variables into stitch

commit 3d587d1264a84e7a586ce82829da6d95dcb2bad8
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Dec 18 00:21:10 2015 -0500

fixed ordering on stitch2func matching

commit 96864c17443d2f972286b0a3724af83ffcd965bd
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 23:48:53 2015 -0500

really added tests

commit 95cfc40432d3caf3e740a466bf44427c9b54b5ae
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 23:46:55 2015 -0500

nested stitch loops work; added stitch tests 3 - 6

commit 2900c7f1c23a728b60e616407df48721046b868a
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 17 23:17:24 2015 -0500

Stitch test 2 output fixed

commit a3537de8df1f2357baa55e2d8157d733785d79bf
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 23:16:59 2015 -0500

fixed invalid return, fixed non-block stitch issues

commit 1aa8fd9f41f3b8cfc60d4d0716404e6b3bfa80aa
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 17 23:10:00 2015 -0500

Working on multiple stitch loops

commit 081dc99c0659dd4a6f652a32d0e57f5bc6918f95
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 23:09:40 2015 -0500

updated stitch2_out

commit 24a32f26e74a09b81f22ad720380f362d98200a1
Merge: f7318f8 93e2ac7
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 23:03:58 2015 -0500

merge fix

commit f7318f8d4fd5ef755a7d7e7c753c5a0a861ee2a2
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 23:02:52 2015 -0500

updated tests

commit 93e2ac70401a32852dbf28a6c4aa45e2ba4508db
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 17 23:02:27 2015 -0500

Added multiple threadpools

commit ec977e821cfb62b6fb0bd8eae89fc4b289637494
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 22:45:44 2015 -0500

removed struct/access; cleaned up old code

commit 503f05282e3f4493873eccbb92a2277b35046d97
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 17 22:37:57 2015 -0500

Fixed stitch loops with fnames

commit 847bb3dc7381561e48c479054c71257c41b266e3
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 22:34:10 2015 -0500

stch func naming works

commit d12ff2fa167e3016acb45fa3d5cf6377fd27bab6
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 17 22:25:49 2015 -0500

updating stch func gen

commit d4acce8abd070fe0795ca20a08ecea821828dab6
Author: Tim Waterman <watermantium@gmail.com>

Date: Thu Dec 17 22:24:53 2015 -0500

Reworked structs to access stitch variables

commit 5408089ef6734ef9c569f425aa10f316a1b54045

Author: Tim Waterman <watermantium@gmail.com>

Date: Wed Dec 16 14:08:58 2015 -0700

Its going through syntactically , need to get variables passed in from headers

commit 64e35c5bfd99f33d705cd78041d642907d736c9d

Author: Tim Waterman <watermantium@gmail.com>

Date: Wed Dec 16 13:51:47 2015 -0700

Changing names correctly sometimes. Still not general enough

commit 747815f55365df192317f9c8a91e4697001cf050

Author: Tim Waterman <watermantium@gmail.com>

Date: Tue Dec 15 10:35:39 2015 -0500

Adjusted the variables in the generated for loops to be general

commit fc59e0265f8298ab26ba60417a6db8edca7acb95

Author: Tim Waterman <watermantium@gmail.com>

Date: Tue Dec 15 10:26:29 2015 -0500

Added thread blocking. Im an idiot

commit 5faf89299826880b76d63d469365b98e1a370395

Author: Tim Waterman <watermantium@gmail.com>

Date: Mon Dec 14 23:59:11 2015 -0500

Done for tonight

commit 91111abcda95102d45379e3d55fce9ba2d9b3f89

Author: Tim Waterman <watermantium@gmail.com>

Date: Mon Dec 14 23:50:07 2015 -0500

Still working on accessing passed in vars

commit ed3d01241778a94fcc5fb2912f542c84030f7fce

Author: Tim Waterman <watermantium@gmail.com>

Date: Mon Dec 14 23:29:43 2015 -0500

Need to figure out how to change the names of the variables
in the stitch loops statement list

commit a051d852d2ab208436e673a6ec66e1a2e8f2a3af

Author: Tim Waterman <watermantium@gmail.com>

Date: Mon Dec 14 22:46:43 2015 -0500

Started to get threaded stitch working. Threadcount is a
little wonky

commit 4b5101dbf24f5099115cf3a9a34b610f20818e02

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sun Dec 13 19:04:34 2015 -0500

stitch body now turns into a function, still need to get the
nameing down

commit d523668973ee4357d92582fe0aa1abf91f3f8991

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sat Dec 12 20:50:04 2015 -0500

redid the way that stitch funcs are passed, still need to
generate the functions in the c_gen

commit 06ff138f3564f568a93df0d64a531eabb7542268

Author: Daniel Cole <dhc2131@columbia.edu>

Date: Sat Dec 12 14:20:03 2015 -0500

Update README.md

commit d45dd0e7e39b0075f69b07dfac6e04547537ad11

Author: Tim Waterman <watermantium@gmail.com>

Date: Fri Dec 11 23:44:27 2015 -0500

Started stitch->for code generation

```
commit 77bd9795055f04e9afc69cbd2b7f99577716da07
Merge: 05e6fbb bce1cd4
Author: Tim Waterman <watermantium@gmail.com>
Date:   Fri Dec 11 21:43:51 2015 -0500
```

Merging with dans changes

```
commit 05e6fbb5b5b9300a1abcd9b06e7100b22b1f83be
Author: Tim Waterman <watermantium@gmail.com>
Date:   Fri Dec 11 21:43:48 2015 -0500
```

Started work on for loop generation

```
commit bce1cd4399d50deff099affeee6f48fba0719002
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Fri Dec 11 21:21:47 2015 -0500
```

little to no progress on the stch funcs

```
commit 4ed3f45d1f620971673d20dcfab4ac7545eece87
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Fri Dec 11 20:20:06 2015 -0500
```

still working on stitch funcs

```
commit a23221534f8b6f860e571e88a4793dff2df32f70
Merge: 1ed3d07 1dff7ec
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Fri Dec 11 17:23:56 2015 -0500
```

Merge branch 'master' of https://github.com/danhcole/4115_lang

```
commit 1ed3d07b8e35de80116f300f5d6f2c9fb57c3571
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Fri Dec 11 17:23:53 2015 -0500
```

added stch_funcs

```
commit 1dff7ec6565c32c511260eb196435f15968e7d29
Author: Tim Waterman <watermantium@gmail.com>
```

Date: Fri Dec 11 11:53:23 2015 -0500

Finished matrix init. Need to remove debug statements later

commit 9c032762654796bff9347609ac1f218cb6ad8f47

Merge: a905ad3 952e6d6

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Dec 10 19:47:33 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit a905ad3de0802fe63588b511849e7475713dfa96

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Dec 10 19:47:28 2015 -0500

updated some tests, fixed list rev issue

commit 952e6d66e6601f9263c9cc39d1a95c190cca605d

Author: Tim Waterman <watermantium@gmail.com>

Date: Thu Dec 10 19:46:54 2015 -0500

Matrix init working 90%. Working on typechecking

commit 7163ee62b65f8b609cb7ad5face70e4bc61a5d38

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Thu Dec 10 19:43:00 2015 -0500

added negate2 and negate3.stch

commit 148ca6dc15be4eb4eae58d011e4c78d2e4105729

Author: ms4985 <ms4985@columbia.edu>

Date: Thu Dec 10 19:41:23 2015 -0500

fixed recl test

commit 3e1db6e827105d913f01ef45877adc34db0f83f8

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Dec 10 19:24:40 2015 -0500

removed microc binary

commit ab1a394db56d434412ecd96343a0c8a30b2b4564
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 10 19:23:47 2015 -0500

fixed snafu

commit 744381b513e3ba3fa008c3e99bb76901fed54b68
Author: ms4985 <ms4985@columbia.edu>
Date: Thu Dec 10 19:16:44 2015 -0500

added stitch and rec tests

commit a052841944b13bebaa4b6cd148d9efc5cbd409f8
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Thu Dec 10 19:16:01 2015 -0500

added more tests

commit 4c9136b74b462cffa92ad6245ae75e5c0e9d20ca
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 10 19:12:56 2015 -0500

working on stitch loops

commit f3cca0c68daf4fe582005673f22ca4c393c45cd4
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 10 18:42:04 2015 -0500

updated stitch test

commit bb69889b8a08cb305318f24ab411627cb6bdc818
Merge: 4fc0380 9d063bc
Author: ms4985 <ms4985@columbia.edu>
Date: Thu Dec 10 18:39:12 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 4fc038006a974131c958da7ac365a53c4e54aa7c
Author: ms4985 <ms4985@columbia.edu>

Date: Thu Dec 10 18:39:00 2015 -0500

added stitch loop test

commit 9d063bc7cbea95c3489fd2e65f78f4fb26105509

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Dec 10 18:38:29 2015 -0500

stitch loops redone in cast/analyzer/generator

commit e42e03b0b7c0c8e89400d1f2ecbd35d9b415da56

Merge: 4a3e470 20b60c4

Author: Tim Waterman <watermantium@gmail.com>

Date: Thu Dec 10 16:50:20 2015 -0500

"Merging with the syntax changes"

commit 4a3e4705a2f8cb2eb032cb79fe769ce545e03ebf

Author: Tim Waterman <watermantium@gmail.com>

Date: Thu Dec 10 16:49:59 2015 -0500

Added matrix checking. Now only init is missing

commit 20b60c4d0df664954390b5fda8bb422fada8255e

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Dec 10 14:18:26 2015 -0500

fix minor formatting

commit a449e53de6a31c9e6cf93e14dc00732152145260

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Dec 10 14:11:11 2015 -0500

fix conflict

commit a0e0636fcffbb966df1f9ef0f8019a9e97da48a7

Merge: f85e09e 209b7ed

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Dec 10 14:08:03 2015 -0500

Merge branch 'master' of <https://github.com/danhcole/4115>


```

_lang

commit f85e09eeeb95251cfda76330ac68dd55a716df6a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 10 14:07:13 2015 -0500

    bit of code cleanup in the sem-an, make it a bit more
    readable

commit 209b7edfb790ec5b8e94cfe3e40b6c121f2e8906
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 10 13:47:37 2015 -0500

    Array assignment in . 1D arrays should work 100% now

commit 121ba6810a11910ca7f1ca581c9f45773ad98edb
Merge: d55cb3b 0948ea2
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 10 13:16:10 2015 -0500

    Fixed merging issues

commit d55cb3b258de506e980ff64067fa72bb39726d1e
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 10 13:12:07 2015 -0500

    Fixing matching issue with arrays; error messages not
    accurate

commit 0948ea2b5805d2856e43f584aa6df84dd89d124c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Wed Dec 9 18:09:11 2015 -0500

    questions about matching

commit 10cd1cb8fba3f2dfcbed3e071a71e9d21d096bf6
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Wed Dec 9 17:17:09 2015 -0500

    test suite now echos total number of tests and how many
    passed

```

commit 68326e9c504acff661b2ad5bb384d5b3bc4b2d2e
Merge: cd26dcf ae9e8b6
Author: Tim Waterman <watermantium@gmail.com>
Date: Wed Dec 9 16:21:40 2015 -0500

Pushing the negative array tests after merge

commit cd26dcf1753f24f1ba0ce9216aee5f0bc43bf0ce
Author: Tim Waterman <watermantium@gmail.com>
Date: Wed Dec 9 16:21:30 2015 -0500

Pushing array negative tests

commit ae9e8b6eba22a76202dfcc73b03e546af22ad511
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Dec 8 18:47:54 2015 -0500

minor commenting

commit 28ec92af50354d748234b76847a993123e5a9e6a
Author: Tim Waterman <watermantium@gmail.com>
Date: Tue Dec 8 16:35:29 2015 -0500

Added size checking for array init

commit a88a2a4d696ee1ec8464ab4bec5a80056c8a451a
Author: Tim Waterman <watermantium@gmail.com>
Date: Tue Dec 8 15:55:32 2015 -0500

Array initialization working

commit b116aa4bd0ee75feec5a11df97bbe1ddd93c0112
Merge: e052491 aadd3b9
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Dec 8 14:14:47 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit e052491cdb41118329d8f028314fb300d3c2c5de

Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Dec 8 14:14:40 2015 -0500

added exit() + tests; added commenting tests

commit aadd3b987c848a1fc97d17524376ff6d3519bed6
Author: Tim Waterman <watermantium@gmail.com>
Date: Tue Dec 8 14:05:32 2015 -0500

Added array indexing to the print statement

commit 17e1a695296b3dd1cb19110b1a1d4a81678a3f64
Author: Tim Waterman <watermantium@gmail.com>
Date: Tue Dec 8 13:57:00 2015 -0500

Added in array indexing expressions. Need to add them to
print

commit 93272f2330e441ac28906db16dab3067503dacd6
Author: Tim Waterman <watermantium@gmail.com>
Date: Mon Dec 7 23:04:52 2015 -0500

Added more array items. Working on 1D array init

commit 05ca28f77603d036ed9b4adf9023c473926e9fff
Author: Tim Waterman <watermantium@gmail.com>
Date: Mon Dec 7 21:18:18 2015 -0500

Added two dimension array decls, working all the way through

commit 39a8a4d403c7083a6049569b97a7f7ae9ae4dd88
Merge: 73bc7ff 3527842
Author: Tim Waterman <watermantium@gmail.com>
Date: Mon Dec 7 19:06:26 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 73bc7ff3374bf6492fd0cc24ce4f342e03ac1914
Author: Tim Waterman <watermantium@gmail.com>
Date: Mon Dec 7 19:06:15 2015 -0500

```

    One dimensional array declarations working, parse->print

commit 3527842aa87c50070f6b76ddafc6768e548479e7
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Mon Dec 7 17:17:26 2015 -0500

    file cleanup for negative tests

commit 9b083ee0ff021608921800c4a355de2f901db6dc
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Mon Dec 7 17:17:12 2015 -0500

    updated negative tests

commit 6470897bd762270847c1f1768906851d6d57b5f8
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Mon Dec 7 17:03:00 2015 -0500

    test suite works with negative testing (goes in _ntests);
    updated headers

commit 8f0482eb4b19acd7a8a4c8e6e758a2541703a7b4
Author: Daniel Cole <dhc2131@columbia.edu>
Date:   Mon Dec 7 16:24:01 2015 -0500

    Update README.md

commit 5ca219aa8fa3b010b76f13087198ee7baf54a2ae
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Sun Dec 6 17:28:30 2015 -0500

    error() added Stitch. Added hello2 test to confirm this

commit cf3e7898576149a1d37a52f30a36cc898e13a460
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Sun Dec 6 17:08:57 2015 -0500

    print works

commit bbd481ecf6e544fb3d6796b30f75ef1c6dc22f93

```

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sun Dec 6 16:35:05 2015 -0500

print works for int, float, char, string, id; does not work
for other expr

commit 6f52d3db9df12d425aeb0a7686579766afbde676

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sat Dec 5 17:37:09 2015 -0500

print works for ints now, updated all tests accordingly

commit 8049b3dc74d171068c6b6c79cafaf272c7013caf

Author: Tim Waterman <watermantium@gmail.com>

Date: Fri Dec 4 22:02:46 2015 -0500

Quick fix for if statements. Need to rethink how we print

commit d8cb215629af8f4eb180de00cfb578b91f9ebd0d

Author: Tim Waterman <watermantium@gmail.com>

Date: Fri Dec 4 21:41:55 2015 -0500

Fixed the stitch compiler chain, started adding print

commit 25791cdb3d156e9bc3e21b729222013338243af5

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Fri Dec 4 13:49:11 2015 -0500

working on c_call - find_func_sig working (?)

commit d514d8c32ea80308150b8391a8c3d9d1a2be49c0

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Fri Dec 4 13:41:01 2015 -0500

working on c_call - find_func_sig

commit 8dfea1a4056bce6cfa0077746ce7a0cd9cc048ae

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Fri Dec 4 13:34:03 2015 -0500

working on c_call - need to finish func args

commit c6afbb284ad07a4782191f0ee2d6a57776e7a0ce
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Dec 4 11:47:27 2015 -0500

added better error for check_assign2, tweaked cleanup of test suite

commit 01a92d5332fd6be8b381c92124d059797149c379
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Dec 4 01:40:21 2015 -0500

fixed assign

commit 0d18e5f2dc10a4b42bc9be3a04bbd306cbaeee42
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 21:27:09 2015 -0500

Debugging variable issues

commit b41f84754f9e2e01e7ccf665bf95488a7692ae30
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 20:51:12 2015 -0500

For loops correctly accept expr_opt

commit c07013b4c847fdc45bca258c705c3fb517d1c495
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 20:49:53 2015 -0500

Added testing file

commit 2cdd1126be26fd365d05714654f86f9c8b04ad47
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 20:38:05 2015 -0500

Generator issues, but everything seems to compile

commit 308b52d1d7fe1fd1c8c85d53786d07ff0b151928
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 20:27:00 2015 -0500

```

    fixed gen

commit 479c8701c4df07f1f37653b9d5013ef21b2c2fa5
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 20:15:58 2015 -0500

    Started the C code generation file

commit 9a6bcf3ecd6ea00a525d4dd2bbff7411896e1a16
Merge: e6246b0 95fde55
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 19:53:26 2015 -0500

    Fixed merge bullshit

commit e6246b0ed9654c03d8617998a22b81f6b9f97877
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 19:51:26 2015 -0500

    Stitch thing working

commit 95fde554d5d23170047438a8f47c2abb8340db65
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 19:49:55 2015 -0500

    sm-an works again

commit cdb0b1ac080b6b897e0c89f335f18195c543576b
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 19:36:34 2015 -0500

    Makefile and compiler edit

commit 7f15f7f49eef9ef9d18ae1eb0e82ea2fdad05a7d
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Thu Dec 3 19:35:03 2015 -0500

    added check_for

commit 61f94774363231958a4dd178850459c9a0348f27

```

Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 19:31:19 2015 -0500

working on program

commit 93ea0d82be4bb0d166e65b30b108a98b91633070
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 18:39:29 2015 -0500

making progress

commit ebfa2ec2e5af5e9ad9956b2fa564fb6dd5d3d508
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 18:21:14 2015 -0500

w

commit 67e40f8420c6d7f8df9cff3f0763d905713d371d
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 17:49:37 2015 -0500

w

commit a07af01a4af200d1773db6ba89bad67b1eae974c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 17:40:53 2015 -0500

fixed

commit 86db74aff9b3f8ce04b91284c85e3150ad368362
Merge: d7f53b2 07a24c3
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 17:25:06 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit d7f53b2e53407b5cea1a5ddbf94e457d7ad3bea5
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Dec 3 17:24:58 2015 -0500

working on sm

commit 07a24c353a57e3e50d5cc91e356faa2408a2bdc2
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 16:49:28 2015 -0500

Checked if expressions, while semantic checking done

commit 09a146ab66b698bcedab996f2481847d5beeb315
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Dec 3 16:33:34 2015 -0500

If semantic checking checks for int type expr

commit a367ac78d4acbd95110ad958d4fa8d41180055cf
Author: Tim Waterman <watermantium@gmail.com>
Date: Wed Dec 2 20:05:25 2015 -0500

Semantic checker compiling with the pieces we have, a lot has
been commented out

commit c68b1dfa5fb2bf8e469f1c6f6b0ec972aedd2f3
Author: Tim Waterman <watermantium@gmail.com>
Date: Wed Dec 2 19:11:00 2015 -0500

Fixed optional error

commit 19d4e043bfae7acee69c090495e91220219bc6bf
Merge: af3a9ec ca26c84
Author: Tim Waterman <watermantium@gmail.com>
Date: Wed Dec 2 17:57:32 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit af3a9ec4dbb6806eba0b31d7063d677efa905844
Author: Tim Waterman <watermantium@gmail.com>
Date: Wed Dec 2 17:57:23 2015 -0500

Fixed compile stuff

```
commit ca26c84fd8e274c1db816d3db9330c39a52b473c
Merge: f8be026 83f1175
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Wed Dec 2 17:48:48 2015 -0500
```

```
    Merge branch 'master' of https://github.com/danhcole/4115
    _lang
```

```
commit f8be0264b1d229d54bd13b82deb87814179af5c7
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Wed Dec 2 17:48:40 2015 -0500
```

```
    updated makefile
```

```
commit 83f1175e536b841796b971324361aa78659fc6ac
Merge: 53282cb 153fff7
Author: ms4985 <ms4985@columbia.edu>
Date:   Wed Dec 2 16:13:04 2015 -0500
```

```
    Merge branch 'master' of https://github.com/danhcole/4115
    _lang
```

```
commit 53282cb6ab31b0a1ae299be89a8c8b160f8fe299
Author: ms4985 <ms4985@columbia.edu>
Date:   Wed Dec 2 16:12:58 2015 -0500
```

```
    fixed up sem tests
```

```
commit 153fff71062d4532dd8d2dade9aad2d58401fc34
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Wed Dec 2 16:10:39 2015 -0500
```

```
    updated comments
```

```
commit 3acc1a9c8200480e57791b250e92c44de5a0e42a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Wed Dec 2 15:02:22 2015 -0500
```

```
    commented sem_an, still need to do check_for, fix
    check_var_decl
```

commit 50f444b4ee818db79e5af2f86d10c33fc219b1a2
Author: Tim Waterman <watermantium@gmail.com>
Date: Wed Dec 2 14:37:09 2015 -0500

Added back access operator and struct keyword

commit 24723bb66ce7c484bbd1d3eec2c582d1e76ff049
Author: Tim Waterman <watermantium@gmail.com>
Date: Tue Dec 1 23:39:09 2015 -0500

Arrays now can assign individual elements

commit 87bdbbe5804eb72d1c4d4f0a6cb00dbf21e9f92c
Author: Tim Waterman <watermantium@gmail.com>
Date: Tue Dec 1 23:10:06 2015 -0500

Initial array declaration passing parser tests

commit a6f399113c32bac2915678d66ea64a3f5d878973
Author: Tim Waterman <watermantium@gmail.com>
Date: Tue Dec 1 12:55:27 2015 -0500

Fixed pretty printing of chars from ast

commit 53166bf86b82e5994464cfc71b9ff1a69e52c094
Author: ms4985 <ms4985@columbia.edu>
Date: Tue Dec 1 11:05:06 2015 -0500

added the actual semantic checks to test

commit b44f18dd7fa5e2c32d5fede5298f184de76f9ab4
Author: ms4985 <ms4985@columbia.edu>
Date: Tue Dec 1 10:59:14 2015 -0500

added simple semantic analysis tests

commit 07a81ef1ecfb6d069966a363d0dbcba5dd35b9c4
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Mon Nov 30 12:11:38 2015 -0500

semantic analyzer compiles, still need gen code

commit 5e1fba16104839ac3964bbf7cb73198416e61192
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Mon Nov 30 12:04:15 2015 -0500

finished sm-an

commit 2aefc5892f392b9d6833fbd1932ac183f03e6423
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 29 17:08:26 2015 -0500

need to still add init_env and chck_program

commit c1d8dff46a438722f3d181b29451d32b899a7713
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 29 16:46:31 2015 -0500

working on sem-an

commit 3df7000bffe087e4d01d21b3b7dd4dd19ed00965
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Nov 24 13:20:22 2015 -0500

working on sem-an

commit 135caf8726134865d43f8ed6a65ebdcad98b313e
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Nov 24 13:05:15 2015 -0500

started on semantic analysis

commit bd34b67afac6cf13c42b59d984e32bb1deab2bd4
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 22 20:21:05 2015 -0500

created cast, added type dataType refactored the ast for
consistency

commit 79b9ebc687898a82a6f012cd69d9e65632251bec
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 22 19:21:01 2015 -0500

```

    started on env and complier

commit 2eb53e0ac96e5fc98d4a7728c7247578b730b7ad
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Nov 19 18:06:00 2015 -0500

    updated .gitignore, added makefile for stch_headers library

commit 34301c36c591a75e5ee0ae8c7682d13091966a9d
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Nov 19 18:04:48 2015 -0500

    Added new loop tests

commit 7bb3f01fb70b60d35bb1d748605e20737757b1cf
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Nov 19 17:57:16 2015 -0500

    added function test 6 - check for empty return

commit b491f3d154bda7dbf9d91620a46491ee8c12f9e3
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Nov 19 17:56:10 2015 -0500

    fixed some stuff

commit 8171503e3921b3e15907bf06770c9bf47f0ad811
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Nov 19 13:41:46 2015 -0500

    removed gen code diffing from test suite

commit 2fbbb1d5a434528ff40a6205f50ef1d616a53901
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Nov 19 13:14:49 2015 -0500

    Update README.md

commit bf76fbf0e0040e5ae8e3dbb170d3b2e3f9a8a9d8
Author: Tim Waterman <watermantium@gmail.com>

```

Date: Tue Nov 17 21:20:24 2015 -0500

Fixed shift/reduce error caused by stitch loop. All tests
still work

commit c2892cf56d57fe0aca1aaaa17a69766431094100

Author: Rashedul Haydar <rhaydar8@gmail.com>

Date: Tue Nov 17 15:46:25 2015 -0500

updated meeting notes

commit 33fa100ab44678da625a69ea7c9acb64cfefdc4d

Author: Daniel Cole <dhc2131@columbia.edu>

Date: Tue Nov 17 15:07:03 2015 -0500

Update meetingNotes.md

commit 4c46e088822371df43782b93cd61bacf62a02c5a

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Tue Nov 17 12:01:17 2015 -0500

added two new tests

commit b5d767afb03ba0b1d3e058b49e528a1f9d7b7aab

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sun Nov 15 21:40:38 2015 -0500

added fucn1 targets

commit efc6214ac58989d432b07dc0b42a950321ad25bf

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Sun Nov 15 21:35:15 2015 -0500

fixed newline issue , removed .dSYM

commit 876191de3d0b7a13324b69c837228ac13289cde0

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Nov 15 21:30:47 2015 -0500

AST changes to allow vdecls

```
commit 6edbc79588c29679de29a66d52a2ea9ae9ceb71d
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 15 21:29:58 2015 -0500
```

```
updated gitignore
```

```
commit a656e75075fea22e29fbc0855eb76f9caa6ce17f
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 15 21:25:02 2015 -0500
```

```
tester now recompiles everything
```

```
commit 856235421ca473adb5e661a6ffbea7565b862aa7
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 15 21:15:15 2015 -0500
```

```
added new tests (spoiler, we pass)
```

```
commit 7cfbd96c49b9a5b7d7e06e45f40cbbf2123ee99e
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Nov 15 20:48:02 2015 -0500
```

```
Changed ast to use printf
```

```
commit 1740d751c0d627fb4018e5887b1d7d7f3eb1849a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 15 20:45:22 2015 -0500
```

```
added dummy files for _log and _bin
```

```
commit 892ca104b7aacf09a887b6d892666e9e0cf1d0cb
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Nov 15 20:27:58 2015 -0500
```

```
fixed int x = 3 error
```

```
commit 27f59871b4707649cb1b6deee7c9ccc421c781b7
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Nov 14 00:07:56 2015 -0500
```

```
test suite now works, also folded in color, etc. from parse
```

tester

commit e9cf2179c20fafba171fe9cc4389213cf41c2370
Author: Tim Waterman <watermantium@gmail.com>
Date: Fri Nov 13 12:16:20 2015 -0500

Fixed tester cases, shift reduce still happening

commit 7fb2182fa4c9569011cfade64c772468633cb984
Author: Tim Waterman <watermantium@gmail.com>
Date: Fri Nov 13 00:19:56 2015 -0500

Made ptest more extendable with functions

commit 000a738da56f1e36a2b1fa686672388d86370d9f
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Nov 12 23:42:58 2015 -0500

Colorized output of ptest suite

commit 682a5728a1d43a323c2900ecbfc990ba34edccd6
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Nov 12 22:50:04 2015 -0500

fixed 8 SR errors

commit 490aa2fdb761d84878860fc2056e84f7d37ff937
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Nov 12 22:43:02 2015 -0500

Ptests report what they are; while/stitch added

commit d24d0d3645b6fa931632aab38e5b89473ed35d8
Author: ms4985 <ms4985@columbia.edu>
Date: Thu Nov 12 22:18:06 2015 -0500

added test doc

commit c6dee2286fb8c13976c8d4c7c342a762811a9b5d
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Nov 12 22:17:41 2015 -0500


```
hello , world

commit ef6c05f24695a445c963fd69a6f9ca89848a4eb6
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Nov 12 22:02:01 2015 -0500

Parser test script updated

commit 71d238926bffe47ecf9d150e01ac641de54fad5c
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Nov 12 21:55:39 2015 -0500

Stitch includes headers

commit f4bf3f3c98f8526dbb90b8c8a924059df688f941
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Nov 12 21:48:51 2015 -0500

functions working

commit a9a66840ce6149982bbfc426a2444bb3430fc506
Merge: 80823a2 a41a639
Author: ms4985 <ms4985@columbia.edu>
Date: Thu Nov 12 21:45:24 2015 -0500

Merge branch 'master' of https://github.com/danhcole/4115
_lang

commit 80823a268592ff0e7ef847970d3fd349e7f9eca6
Author: ms4985 <ms4985@columbia.edu>
Date: Thu Nov 12 21:45:10 2015 -0500

added more tests

commit a41a639f64cd7ce4928e429964cdd38bc2875bd2
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Nov 12 21:28:45 2015 -0500

minor fix
```

commit 2788f4c6905199da5809b05604683aead1f52021

Author: ms4985 <ms4985@columbia.edu>

Date: Thu Nov 12 21:28:13 2015 -0500

added test suite for parser

commit a7c5865238d584ddfa294f3e74a949e71bae8c52

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Nov 12 20:48:20 2015 -0500

working on functions

commit 7e594a1be51209e15a2036e42d675c57abeaadcd

Merge: 337987d 453f44c

Author: Tim Waterman <watermantium@gmail.com>

Date: Thu Nov 12 20:47:42 2015 -0500

Fixed stitch.ml issue

commit 337987de8088fb08547c57def1e1a38a4445acec

Author: Tim Waterman <watermantium@gmail.com>

Date: Thu Nov 12 20:45:13 2015 -0500

Stitch.ml taking in filename

commit 453f44c460ce2284d3bbb6746969955484a8de44

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Nov 12 19:30:40 2015 -0500

unordered vdecl statments works

commit c611d232489da46e7980218d78a36d28d3a82786

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Nov 12 19:05:52 2015 -0500

restructured vdecls

commit d7a3b80647b4b5ee1f8422d2df0c0619842556bd

Author: Daniel Cole <takeitfromthedan@gmail.com>

Date: Thu Nov 12 18:14:18 2015 -0500

```
    added stitch to pretty print

commit 372687d8979d718aa95c77d80043ca6167bc15dc
Author: Rashedul Haydar <rhaydar8@gmail.com>
Date:   Tue Nov 10 19:09:15 2015 -0500

    fixed formatting

commit ed6e4eb55757b017f2314121e009a6b463e05127
Author: Rashedul Haydar <rhaydar8@gmail.com>
Date:   Tue Nov 10 19:08:04 2015 -0500

    added notes from 11/10 meeting

commit cd71c4551c3dcca992c8a558a43e3fc41aa24e57
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Tue Nov 10 16:15:16 2015 -0500

    compiler compiles (with nothing in it_
    )

commit 6d743a00b1cbf24b92b34eaddef8c9cd6d69a2c3
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Tue Nov 10 15:37:34 2015 -0500

    2 more errors fixed

commit 6dba4d67453ecb49007b733ad32ae9412fe3698e
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Tue Nov 10 15:21:01 2015 -0500

    updated

commit 31538c38a2cd5f4537ff694a536f0f4173f4d0eb
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Tue Nov 10 13:44:33 2015 -0500

    fixed some issues

commit 68c76a75ffef4e3ba3ac323f3b44c2b23a38c76e
Author: Daniel Cole <takeitfromthedan@gmail.com>
```

```
Date: Tue Nov 10 12:28:33 2015 -0500

added Makefile

commit d4b388634339bf16d57a8819d4e803545fb5db20
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Nov 10 11:43:35 2015 -0500

test update 2

commit 87a91772064c8e9c6b0ebf32bd65ddd22ee14b44
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Nov 10 11:42:21 2015 -0500

test update 1

commit 7adba58bdd0c1a33c393b8b8636759ab57e7d0f1
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Nov 10 01:47:55 2015 -0500

updated test script

commit a26d8ff170dbf9f72e9930afe0920464f4505be4
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Nov 10 01:42:58 2015 -0500

test suite added

commit 23eb1db66e5506a86aaebc06a0b94b2b909d2b18
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Nov 10 01:40:37 2015 -0500

tests

commit 450976a82bf9a87cb4686f4827f8fc4d6197d8aa
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Mon Nov 9 18:06:59 2015 -0500

Delete hello1_target.c

commit 85e07a535c066c960b7da02da713c58b11574e25
```

Author: Daniel Cole <dhc2131@columbia.edu>
Date: Mon Nov 9 18:06:45 2015 -0500

Delete stch_headers.h

commit 3615729f345a3aa9049607c163c6021dc038740b
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Mon Nov 9 18:05:53 2015 -0500

started work on testing

commit 736cb3ac8ed69d787e37299afdbdafce2eec822e
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Mon Nov 9 17:07:46 2015 -0500

hw test target

commit 78e30de0b28a2dec1a323eee367b006436cf50b4
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Mon Nov 9 15:52:21 2015 -0500

Update stch_compiler.ml

commit 387cf5404148befd486af3268fd9ce394376c4c5
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Mon Nov 9 15:22:54 2015 -0500

Create stch_compiler.ml

commit 997ff10affded68449ea05e3cedbeb290ea17acc
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Mon Nov 9 15:21:47 2015 -0500

Create hello2.stch

commit ac2ab8a9a9cf0b094acf5e897812d75fefdd6d30
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Mon Nov 9 15:16:28 2015 -0500

Create hello1.stch

```
commit 3baf3d29959ee88b8bb4afa3542c351947e17965
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Mon Nov 9 10:54:22 2015 -0500
```

```
stch c headers and func defs added
```

```
commit c86292b09b0ddc5ba33a71cd86471c4a318ecfa2
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Sun Nov 8 20:06:36 2015 -0500
```

```
Update stch_headers.h
```

```
commit d23f256f266c4573c5f9bc83bc4ad0416b76c20f
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Sun Nov 8 20:01:46 2015 -0500
```

```
runtime questions for 4/10
```

```
commit 6b47151d175862256a05adf28b96b690a706a13e
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Nov 5 17:47:35 2015 -0500
```

```
Update stch_headers.h
```

```
commit 47eea775ef5cd9719b20b540683f9cffe16173b
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Nov 5 13:16:49 2015 -0500
```

```
Started work on header
```

```
This header file will be auto-included at the beginning of
any c file generated by the Stitch compiler.
```

```
It should include all includes, defines, and structs needed
by every Stitch-C program. Program specific functions will be
generated separately.
```

```
commit bad6110bf902b80c6d6dab96e9361b3a422edd31
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Nov 5 12:13:16 2015 -0500
```

```
removed bitwise , unary operators

commit a7ae8c95120edee5c1a3fec12c7ffb9d57ea9606
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Nov 5 12:12:01 2015 -0500

removed bitwise , unary operators

commit 2568ef7fd2a282c838dc9605768a21a04510d1f1
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Nov 5 12:08:32 2015 -0500

removed bitwise , unary operators

commit 3febda5584311329ff4ce362a669b3e513a34cd5
Author: Rashedul Haydar <rhaydar8@gmail.com>
Date: Wed Nov 4 21:43:15 2015 -0500

added my notes from meeting

commit 279aade3ad61b3cb653b32e5b98b92e5ca6f2058
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Tue Nov 3 15:23:42 2015 -0500

Update meetingNotes.md

commit 29e5576bae82533f51bcb7939d5e901f503beeb8
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Sun Nov 1 15:39:23 2015 -0500

arrays work without any shift/reduce errors

commit 30551c08218c896be4888779dec8455f7e716122
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Sun Nov 1 14:51:48 2015 -0500

fixed typos in arrays

commit c1f2800dd4f252149b00288c921c8001775dbcd7
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Sun Nov 1 14:46:50 2015 -0500
```

```

    started to add arrays

commit 10725757d0c9b2e95172eac8f86fbd58b6c0ef52
Author: ms4985 <ms4985@columbia.edu>
Date:   Thu Oct 29 19:36:02 2015 -0400

    took out Call from ast

commit 54c7cd249afffb534054d1115ad9569c7eddaa8
Author: Rashedul Haydar <rh2712@columbia.edu>
Date:   Thu Oct 29 19:10:10 2015 -0400

    fixed parser, no more shift/reduce errors. need to add arrays
    still.

commit 633eb9c0ea5b060e4dd6e1c724148f39d811370b
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date:   Thu Oct 29 18:50:49 2015 -0400

    updated typenames, updated gitignore, added singer

commit ff2e47bf4b1be678470743b896eafacff701d0a8
Merge: f04092d 53193cf
Author: Rashedul Haydar <rh2712@columbia.edu>
Date:   Thu Oct 29 18:43:20 2015 -0400

    Merge branch 'master' of http://github.com/danhcole/4115\_lang

commit f04092d2d0feb89c8ecb6fe910ba5b3d51d70eb2
Author: Rashedul Haydar <rh2712@columbia.edu>
Date:   Thu Oct 29 18:42:47 2015 -0400

    got rid of ftype

commit 53193cf3451f67dedc5d2fa74150ddc9dd73f433
Author: Daniel Cole <dhc2131@columbia.edu>
Date:   Thu Oct 29 12:52:43 2015 -0400

    Create testDoc.md

```


commit 700b222ad81847077ae826d37ae73fa846c97584
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Oct 29 12:27:32 2015 -0400

updated meeting times , added link to LRM

commit afaada4a0582941f3997cd30c996616e7515f81a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Oct 29 12:24:59 2015 -0400

fixed gitignore , started basic compiler toolchain

commit ef0afdbc41a3fac03b12d60fdcf00721247efb97
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Wed Oct 28 18:09:16 2015 -0400

added .gitignore , trying to keep things clean

commit 79b78ad499571f143162585822d321307965a471
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Tue Oct 27 17:11:03 2015 -0400

Update meetingNotes.md

commit 3c0d24d7c9a0be915a8ec0c0a1bd4f6f5702a959
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Oct 27 14:14:01 2015 -0400

fixed dotproduct

commit b969752af73c8f4f775615c75be026381f13eb2c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Oct 27 13:03:53 2015 -0400

dotproduct updated

commit 311db285615ede90022bd1da46c685d6c74510d7
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Tue Oct 27 11:57:14 2015 -0400

removed .* operator

commit 0f4f13a52d9a05594e2403db0f54f5deada242e7

Merge: 6ee4639 313a484

Author: Tim Waterman <watermantium@gmail.com>

Date: Mon Oct 26 14:03:45 2015 -0400

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 6ee4639e42850fdd4d23f866123e48f0c4c227df

Author: Tim Waterman <watermantium@gmail.com>

Date: Mon Oct 26 14:03:01 2015 -0400

Fixed myAdd, working on matrix mult

commit 313a4846a39797db7f10fb758665416f029c29c8

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Sun Oct 25 16:57:29 2015 -0400

most of the parser is done, have 4 shift/reduce errors

commit cec57449b85e151ac636ce3d91cc114b1290e2b0

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 16:48:54 2015 -0400

backtracked

commit 29e73d01c4d40260d8799672a57ea411d15a8c9a

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 16:46:47 2015 -0400

assign now takes a vdecl

commit 3ac86e93cbb8bbf670cebbbc8f20add795b066151

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 16:36:15 2015 -0400

added a vdecl struct to account for multiple typenames

commit f8932cf5aa574b393f11f22a8784f028ddd86b01

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 16:00:05 2015 -0400

added stitch stmt

commit 24be4c050448c6e1c3149884483d1457bc44f6e5

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 15:38:44 2015 -0400

minor fix

commit 02441f86411db60084a486b1f8aa22a40a93ef90

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 15:37:09 2015 -0400

minor fix

commit ddfcd2f74fb474922dd7fbb90dde18a55f037da4

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 15:36:33 2015 -0400

fixed unary types

commit db2373159a068a8f3175cd8e16127de19a4c2732

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 15:29:31 2015 -0400

added data types and fixed fn names

commit ce4ebcb7a3c699e7a4396707dc4b7609890920e2

Author: ms4985 <ms4985@columbia.edu>

Date: Sun Oct 25 14:47:55 2015 -0400

added stitch ops

commit e4778813c18a3a4dcfc6729cf6d3695519d9347f

Author: Rashedul Haydar <rh2712@columbia.edu>

Date: Sun Oct 25 14:19:03 2015 -0400

added all associative operators

commit 353fa76c5504261f3eb526528e3e1173ebfbde7f

Author: Rashedul Haydar <rhaydar8@gmail.com>
Date: Sun Oct 25 13:51:47 2015 -0400

updated parser

commit 186cf5ccc8d56277996cc438e599d84a218ed3e9
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Oct 25 13:20:03 2015 -0400

actually save the updated scanner first...

commit 06fecf11ab9e99ecc1a918dc07bc44975545211e
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Oct 25 13:19:13 2015 -0400

updated scanner

commit 4cd70880397079e114f45268e920d021621c8643
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Oct 24 17:31:53 2015 -0400

minor scanner fix

commit 25ba2f17e58d1733dc6dcd274d18276c557ed694
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Sat Oct 24 17:25:02 2015 -0400

Update README.md

commit a5a2637934fa321c1cc7ead3489eaf6ff5daaca3
Author: Tim Waterman <watermantium@gmail.com>
Date: Sat Oct 24 13:28:02 2015 -0400

Adding N to each element - finished

commit 0d507d027e00a643f846030c150c5673d3769769
Author: Tim Waterman <watermantium@gmail.com>
Date: Sat Oct 24 12:57:02 2015 -0400

Pthread skeleton working

```
commit e906286b4ce487ee70979398308967083254cfba
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Oct 24 12:21:46 2015 -0400
```

updated scanner

```
commit 2c3592b23232c5ac1e6e369d98cace990ecf9aa7
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Fri Oct 23 19:50:00 2015 -0400
```

Update dotproduct.stch

```
commit af945319fb88f0158beb1da35b902f7b23d7cb56
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Fri Oct 23 19:46:46 2015 -0400
```

Update dotproduct.stch

```
commit 7d705960d1fe7c9c208f5969ab35a72dd6cf194c
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Fri Oct 23 19:45:12 2015 -0400
```

Create dotproduct.stch

```
commit 09c1e8527116e18d64f6db1545948cdeae90dc3
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Fri Oct 23 19:28:15 2015 -0400
```

Update ideas.md

```
commit c83c68aec8a2565f0b5ada270bcacc21c87e0a50
Merge: edbe1d9 308e8b5
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Oct 23 18:01:54 2015 -0400
```

Merge branch 'master' of https://github.com/danhcole/4115_lang

```
commit edbe1d939afbb7c1a7350c7c5b4e70794d584a14
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Fri Oct 23 18:01:46 2015 -0400
```

```
scanner mostly done, parser started

commit 308e8b521e95b896cc172b621e0ec776a3d5921a
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Oct 22 18:17:55 2015 -0400

Update ideas.md

commit 4e97fbf8cd985882cacfd187ac9cd89dadeca68f
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Oct 22 12:48:32 2015 -0400

Update ideas.md

commit 74380b1db70f1ac201a4defd9970df7b7fb7b5b5
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Oct 22 12:36:40 2015 -0400

Create ideas.md

commit ddf5d1e7fd533e11d0de8bf86cd7ff120fbf1f87
Author: Tim Waterman <watermantium@gmail.com>
Date: Wed Oct 21 17:04:20 2015 -0400

Added microc sample code

commit ef9f52ca748e31aedef7cb00b69c27f1566d96c0b
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Tue Oct 20 15:34:04 2015 -0400

Update meetingNotes.md

commit c1a12e6d4897d9d6b115897ce809c1490f2e4187
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Sun Oct 18 16:04:56 2015 -0400

Update TODO.md

commit 83422c57deb7b0f60b9ee1b6c70c104590a2bc36
Author: Daniel Cole <dhc2131@columbia.edu>
```

Date: Sun Oct 18 16:03:38 2015 -0400

Rename TODO to TODO.md

commit ffe0d8f1291fed06c4a2c13f45b0186d5ec956d9

Author: Daniel Cole <dhc2131@columbia.edu>

Date: Sun Oct 18 16:03:21 2015 -0400

10/20

commit 1d46f16bf292decf7f4a1a0175863557880a1fe3

Author: Daniel Cole <dhc2131@columbia.edu>

Date: Sun Oct 18 15:55:04 2015 -0400

questions for 10/20

commit 21154b8fc5419395982feb757cd854945c85f80a

Author: Tim Waterman <watermantium@gmail.com>

Date: Sun Oct 18 15:45:36 2015 -0400

Examples changed

commit 57c0774b562cae68ce2f3ada374ac46fb4415c60

Author: Daniel Cole <dhc2131@columbia.edu>

Date: Sun Oct 18 15:44:13 2015 -0400

Update examples.stch

commit 49217d102ca937c72e7ace9e915c16a5affb2501

Author: Daniel Cole <dhc2131@columbia.edu>

Date: Sun Oct 18 15:07:01 2015 -0400

Create examples.stch

commit 117b5f74a9449bd7a7475330a508bb9d6278b69e

Author: Daniel Cole <dhc2131@columbia.edu>

Date: Sun Oct 18 15:02:24 2015 -0400

Update LoopExample.stch

commit 0931cc4540a6940cd9eb78e4b6a8ef497f190de1

Author: Daniel Cole <dhc2131@columbia.edu>
Date: Fri Oct 16 00:16:23 2015 -0400

Update LoopExample.stch

commit 9a681ac387d7e8bc22cb499d5c847537f76651f6
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Fri Oct 16 00:05:35 2015 -0400

Update meetingNotes.md

commit 69795aec00cccf4cb233ae3763959a945bf7e682
Author: Tim Waterman <watermantium@gmail.com>
Date: Thu Oct 15 22:48:25 2015 -0400

Some early thoughts on syntax stuff

commit ccb5b7c49431e859085a857bd0ad6e7cc75f2e0d
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Oct 15 17:23:26 2015 -0400

Update meetingNotes.md

commit a4ddfb53c3ec166017acbc2046707e5c1d423f39
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Thu Oct 15 17:22:19 2015 -0400

cleaned up notes, reorg.

commit 337e1fc431a6d35c40877fc4870a39ab63825a99
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Thu Oct 15 10:18:30 2015 -0400

Update MeetingNotes.txt

commit 5f9c8b7e5eeb4eadd07ef9adae9adaf9b0c85dc4
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Wed Oct 14 20:46:55 2015 -0400

converted to txt file, rtf was being weird

commit 23d0ffc8bae17563caedde534f5000a6aa677049
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Wed Oct 14 20:41:21 2015 -0400

added ReferenceManual folder

commit e8080df7a4f04e2f1c815d793e6af917697fce7f
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Wed Oct 14 20:38:26 2015 -0400

added MeetingNotes.txt

commit 8437e3700a5150c23251534466f2fcd9a17fccd1
Author: Rashedul Haydar <rh2712@columbia.edu>
Date: Wed Oct 14 20:35:46 2015 -0400

added MeetingNotes.rtf

commit 2b813a4768920b48f359dcfed3783c8f9cfd0729
Author: Tim Waterman <watermantium@gmail.com>
Date: Mon Oct 12 00:25:18 2015 -0400

Started matrix mult. Pthread structure is done. Need to
finish later

commit d536c21195dfd58aec354876d08fa33c469f8b88
Author: Rashedul Haydar <rhaydar8@gmail.com>
Date: Sun Oct 11 21:24:26 2015 -0400

Updated First step section

commit d9e2dd310598b609ae5b671838e7201575e431c3
Author: ms4985 <ms4985@columbia.edu>
Date: Thu Oct 8 18:31:02 2015 -0400

Create openMP_example_link

commit cd0e4e90156605fd5823f613e808c8ab21425fa3
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Tue Oct 6 14:52:46 2015 -0400

Create meetingNotes.md

commit 28c98405da3a936dc96c30cb28ae1695a7ce265a
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Wed Sep 30 15:49:06 2015 -0400

remade pdf

commit 096049cfc34a57a32fb1e15c5dda0dbe1050c23f
Author: Rashedul Haydar <rhaydar8@gmail.com>
Date: Wed Sep 30 15:44:49 2015 -0400

Corrected typos

commit 2a108e23e604dc41ea2503829faf1893e680958b
Author: Rashedul Haydar <rhaydar8@gmail.com>
Date: Wed Sep 30 15:43:38 2015 -0400

Corrected typo and added roles

commit 3af13488ec582d1d724f881e3fa2880850f7e505
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Mon Sep 28 08:41:56 2015 -0400

updated pdf

commit 5cd818cf0dc19a72e27a3313ce775f56968290f2
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Sep 27 23:24:55 2015 -0400

Ex3 edited

commit bb8f808bd5b0f476e1367b25cac299a8ec765f85
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Sep 27 17:13:15 2015 -0400

fixed examples , need example program

commit fd87df4bae7efa64a7559c26b64c4eeae810e2db
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Sep 27 12:39:23 2015 -0400

minor changes

commit b2b4242a0aca8edb1b53aa81270aa0595c3cc385
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Sep 27 12:13:58 2015 -0400

added para RE async keyword

commit 92a02644f4372f4e83d60e3b5814b2069a9ff94d
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Sep 27 12:01:27 2015 -0400

added code example

commit ae8de78c1fd46f0e97b330a8d2b0ffbfa94732eb
Merge: 1dc3887 10c6456
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Sep 27 11:52:01 2015 -0400

Merge branch 'master' of https://github.com/danhcole/4115_lang

commit 1dc3887de4b592953bd64898d30061ae630d86f9
Author: Tim Waterman <watermantium@gmail.com>
Date: Sun Sep 27 11:51:49 2015 -0400

Code snippet added

commit 10c64566f531bf806d9f08c51054fb95d5737a61
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sun Sep 27 11:51:47 2015 -0400

small changes to .tex

commit f9c5317d8450c748a4cf81ca45cfd28f1a3f1d28
Author: Rashedul Haydar <rhaydar8@gmail.com>
Date: Sat Sep 26 21:52:32 2015 -0400

Fixed typos

commit 6da5e19dfaab76bbd201fb71df4558cf991fa18b
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Sat Sep 26 21:42:24 2015 -0400

added rough draft of the proposal language

commit e13d614a71d90849f35c1ba97f016a8781adc514
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Wed Sep 16 14:41:38 2015 -0400

Markdown is hard

commit 813e51459a7a552d72a5e584887e1b93f9199eb6
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Sep 15 12:58:54 2015 -0400

1st meeting time

commit 30e38166da5a57f2c946d66312df0bb68760033c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Sep 15 11:52:48 2015 -0400

updated w/ links to last semesters projects

commit 9ea75aaf3e11cdbef823e997ade807c76afe94c
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Sep 15 09:49:18 2015 -0400

minor update to readme

commit 62b7ea6a2e751c08874c7212167b3a6287b173c5
Author: Daniel Cole <takeitfromthedan@gmail.com>
Date: Tue Sep 15 09:46:55 2015 -0400

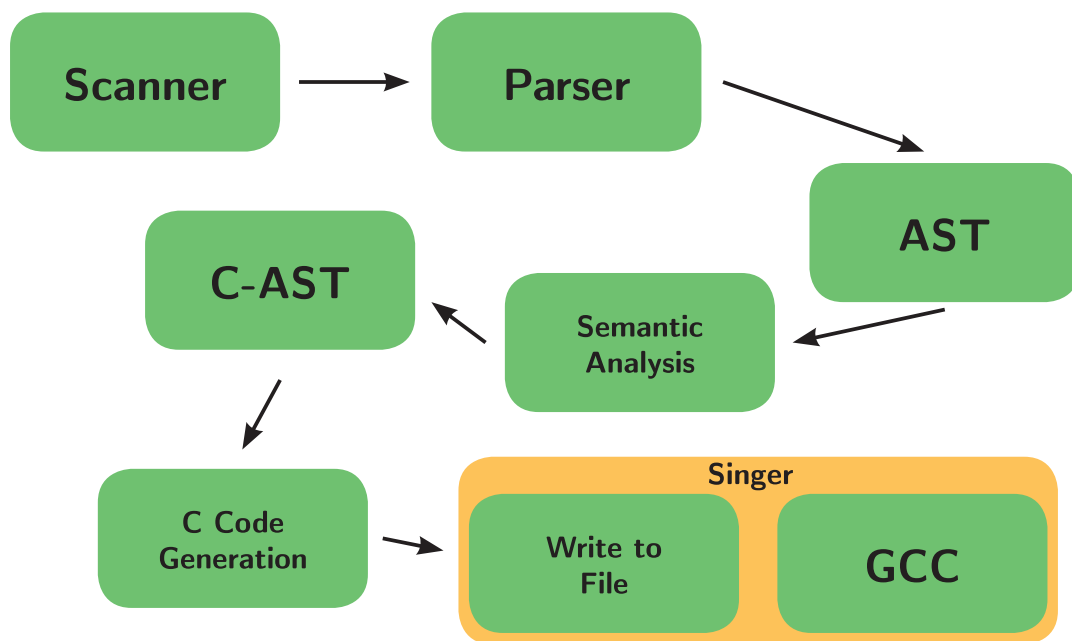
added link to class page

commit e63c1d0b41a77938f668162dc8ba785e47458a62
Author: Daniel Cole <dhc2131@columbia.edu>
Date: Tue Sep 15 09:25:17 2015 -0400

Initial commit

Architectural Design

Block Diagram



Interface Description

Scanner

`stch_scanner.mll`

The scanner is written in OCamlLex. It takes input from the source file, and tokenizes it into keywords, identifiers, and literals. It scans over and removes both single line and multi-line comments, as well as all whitespace not in string literals. Any token that is not a keyword, or does not meet the criteria for an identifier or literal will throw a scanner error.

Parser/AST

`stch_parser.mly`

`stch_ast.ml`

The parser is written in OCamlYacc. It takes the tokens from the scanner, and using the grammar defined in the parser and the datatypes defined in the AST, generates an abstract syntax tree. The rules in the parser insure that code that passes this step is syntactically correct, although not necessarily semantically correct. Any error at this stage will throw a syntax error. The AST file also contains pretty printing functions for all datatypes defined therein.

Semantic Checking/CAST

`stch_ast.mll`

`stch_semantic.ml`

`stch.cast.mli`

Stitch first runs the AST through the semantic analyzer. This pass insures that the code is semantically valid. The output of the semantic analyzer is another AST, a C language AST. The major difference here is that the CAST carries with it a Stitch Environment, which has, most importantly, a list of declared functions, and a symbol table, which contains all declared identifiers and their type. Stitches symbol table also contains information on the expression that the identifier references, which is used in the C code generation to build pthread related code.

Code Generation

`c_generator.ml`

The CAST, which as already been semantically analyzed is now pretty printed. The bulk of the work to add multithreading is done here. The C generator performs multiple passes on the CAST. First any non-`main` functions are printed. Then any `stitch` loops are analyzed, and their statements are turned into a function. Finally, `main` is printed. This insures proper scoping of functions, and that all functions declared before `main` can be called in any `Stitch` block. To convert `stitch` loops to multithreaded `pthread` code, the C generator first takes the body of the loop and transforms it into a function. The generator also builds a custom `struct` for each `stitch` loop, that contains all in-scope, non-local variables that the loop will need access too. It then generates the `pthread` specific code, as well as a `for` loop that creates and runs the threads. The function containing the code body, as well as the structure containing all needed variables is passed into the `pthread`.

Test Plan

GCD

```
1 int gcd(int a, int b) {
2     while (a != b) {
3         if (a > b) {
4             a = a - b;
5         }
6         else {
7             b = b - a;
8         }
9     }
10    return a;
11 }
12
13 int main() {
14     int x = 1;
15     int y = 10;
16
17     int z = gcd(x,y);
18
19     print(z);
20
21     return 0;
22 }
```

Listing 1: Stitch

GCD

```
1 #include "stch_headers.h"
2
3
4 int gcd(int b, int a)
5 {
6     while ((a != b)) {
7         if ((a > b))
8         {
9             a = (a - b);
10        }
11        else
12        {
13            b = (b - a);
14        }
15    }
16    return a;
17 }
18
19
20
21
22
23 int main()
24 {
25     int x = 1;
26     int y = 10;
27     int z = gcd(x, y);
28     printf("%d\n", z);
29     return 0;
30 }
```

Listing 2: C

Stitch loop Matrix Multiplication

```
1 int main() {
2
3     int i = 0;
4     int test = 6;
5
6     int a[6][6];
7     int k = 0;
8     int j = 0;
9
10    for(k = 0; k < 6; k = k + 1) {
11        for(j = 0; j < 6; j = j + 1) {
12            a[k][j] = 0;
13        }
14    }
15
16    stitch i from 0 to 6 by 1: {
17
18        int j;
19        for(j = 0; j < 6; j = j + 1) {
20            a[i][j] = a[i][j] + 10;
21        }
22    }
23
24    for(j = 0; j < 6; j = j + 1) {
25        for(k = 0; k < 6; k = k + 1) {
26            print(a[j][k]);
27        }
28    }
29
30    return 0;
31
32 }
```

Listing 3: Stitch

Stitch loop Matrix Multiplication

```
1 #include "stch_headers.h"
2
3
4
5 struct stch_rangeInfo_0 {
6     int begin;
7     int end;
8     int stepSize;
9     int k;
10    int (* a)[6];
11    int test;
12
13
14 };
15
16 void *_0 (void *vars) {
17     int i = 0;
18     for(i = ((struct stch_rangeInfo_0 *)vars)->begin; i < ((struct
        stch_rangeInfo_0 *)vars)->end; i++) {
19     {
20     int j;
21     for (j = 0 ; j < 6 ; j = j + 1) {
22     ((struct stch_rangeInfo_0 *)vars)->a[i][j] = ((struct stch_rangeInfo_0 *)vars
        )->a[i][j] + 10;
23     }
24     }
25
26     }
27     return (void*)0;
28 }
29
30 int main()
31 {
32     int i = 0;
33     int test = 6;
34     int a[6][6];
35     int k = 0;
36     int j = 0;
37     for (k = 0 ; (k < 6) ; k = (k + 1)) {
38     for (j = 0 ; (j < 6) ; j = (j + 1)) {
39     a[k][j] = 0;
40     }
41     }
42
43     pthread_t *threadpool_0 = malloc(NUMTHREADS * sizeof(pthread_t));
44     struct stch_rangeInfo_0 *info_0 = malloc(sizeof(struct stch_rangeInfo_0) *
```

```

    NUMTHREADS);
45 int thread_0 = 0;
46 for(i = 0; i < 6; i = i+6/NUMTHREADS) {
47     info_0[thread_0].begin = i;
48     info_0[thread_0].k = k;
49     info_0[thread_0].a = a;
50     info_0[thread_0].test = test;
51
52     if((i + 2*(6/NUMTHREADS)) > 6) {
53         info_0[thread_0].end = 6;
54         i = 6;
55     }
56     else {
57         info_0[thread_0].end = i + 6/NUMTHREADS;
58     }
59     int e = pthread_create(&threadpool_0[thread_0], NULL, _0, &info_0[thread_0]);
60     if (e != 0) {
61         perror("Cannot create thread!");
62         free(threadpool_0); //error, free the threadpool
63         exit(1);
64     }
65     thread_0++;
66 }
67
68 //loop and wait for all the threads to finish
69 for(i = 0; i < NUMTHREADS; i++) {
70     pthread_join(threadpool_0[i], NULL);
71 }
72 //now we loop and resolve any accumulators
73 for(i = 0; i < NUMTHREADS; i++) {
74
75 }
76
77 for (j = 0 ; (j < 6) ; j = (j + 1)) {
78     for (k = 0 ; (k < 6) ; k = (k + 1)) {
79         printf("%d\n", a[j][k]);
80     }
81 }
82 return 0;
83 }

```

Listing 4: C

Test Suite Log

Full test code supplied in appendix

```
*****  
* Positive Tests *  
*****  
Starting Test ./_tests/accum1.stch
```

COMPILE SUCCESSFUL!

DIFFing Output

TEST SCESSFUL!

Starting Test ./_tests/arith1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SCESSFUL!

Starting Test ./_tests/arith2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SCESSFUL!

Starting Test ./_tests/array1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST Sccessful!

Starting Test ./_tests/arrayassign.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST Sccessful!

Starting Test ./_tests/break1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST Sccessful!

Starting Test ./_tests/collatz.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST Sccessful!

Starting Test ./_tests/collatz2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST Sccessful!

Starting Test ./_tests/comment1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST Sccessful!

Starting Test ./_tests/comment3.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST Sccessful!

Starting Test ./_tests/escape.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST Sccessful!

Starting Test ./_tests/exit1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/file1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/file2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/for1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/func1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/func2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/func4.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/func5.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/gcd.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/hello1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/hello2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/if1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/if2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test `./_tests/if3.stch`

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test `./_tests/main.stch`

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test `./_tests/matmult.stch`

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test `./_tests/matrix1.stch`

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test `./_tests/matrixinit.stch`

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test `./_tests/matrixstitch.stch`

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test `./_tests/negate.stch`

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test `./_tests/ops1.stch`

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/ops2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/sem2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/stitch1.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/stitch2.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/stitch3.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/stitch4.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/stitch5.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/stitch6.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

Starting Test ./_tests/stitch7.stch

COMPILE SUCCESSFUL!

DIFFing Output

TEST SUCCESSFUL!

* Negative Tests *

Starting Negative Test ./_ntests/arith3.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/array2.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/array3.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/array4.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/arrayinit1.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/arrayinit2.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/char1.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/comment2.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/comment4.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/error.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/exit2.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/file1.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/float1.stch

TEST Sccessful!

Starting Negative Test ./_ntests/func1.stch

TEST Sccessful!

Starting Negative Test ./_ntests/func2.stch

TEST Sccessful!

Starting Negative Test ./_ntests/globalvar1.stch

TEST Sccessful!

Starting Negative Test ./_ntests/if1.stch

TEST Sccessful!

Starting Negative Test ./_ntests/if2.stch

TEST Sccessful!

Starting Negative Test ./_ntests/matrixinit.stch

TEST Sccessful!

Starting Negative Test ./_ntests/matrixinit2.stch

TEST SCESSFUL!

Starting Negative Test ./_ntests/negate2.stch

TEST SCESSFUL!

Starting Negative Test ./_ntests/negate3.stch

TEST SCESSFUL!

Starting Negative Test ./_ntests/print.stch

TEST SCESSFUL!

Starting Negative Test ./_ntests/sem1.stch

TEST SCESSFUL!

Starting Negative Test ./_ntests/sem3.stch

TEST SCESSFUL!

Starting Negative Test ./_ntests/stitch1.stch

TEST SCESSFUL!

Starting Negative Test ./_ntests/stitch4.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/unfunc.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/vardecl1.stch

TEST SUCCESSFUL!

Starting Negative Test ./_ntests/void1.stch

TEST SUCCESSFUL!

Passed 71 / 71 tests

Test Description

We started with a basic hello world program and then started adding cases such as basic arithmetic, comparison and logical operations, conditionals, comments, functions etc. Once we were able to get the basics passing the test suite, we moved on to semantic checking, arrays (1D and 2D), file I/O, and stitch loops. We added negative tests for certain features for a more comprehensive testing suite.

Positive Tests

- Basic arithmetic
- Comparison ops
- Logical ops, negate
- Conditional statements
 - Nested variable declarations
 - Nested conditional statements
- Comments- single and multiple lines
- Functions- single, multiple, gcd
- Break, exit
- Type checking
- 1D arrays, initializing and assigning
- 2D arrays (matrices), initializing and assigning
- File I/O
- Stitch Loops
- Matrix multiplication
- Escaped characters
- Accumulators

Negative Tests

- Arithmetic with mismatched types
- Type checking with void
- Negate with floats, chars
- Global variables
- Comments
- Functions
 - Initializing variables as arguments
 - No return type
 - Declaring functions inside functions
 - Calling undeclared functions
- Arrays
 - Initializing, accessing, size parameter as expression
- Matrices
 - Initializing, accessing
- Print/error with wrong type
- File I/O
- Invalid conditionals
- Stitch Loops
 - Undeclared iterator variable
 - No curly braces around statement block

Test Automation

The test suite `stch_testSuite.sh` first makes the compiler, then iterates through each test in the positive tests folder, calling the tool chain `?Singer?. ?Singer?` runs the compiler on the test program, generating the `c` code, and compiling the `c` program with the appropriate runtime headers and `c` libraries. The test suite then checks if the file compiled, and prints the appropriate response to the screen and the log. It compares the difference between the output generated by the executable and the expected output, and prints the result to the screen and to the log. The negative tests are iterated through in a similar way, however the test only passes if the compilation fails. Finally, the test suite cleans up all the target programs, generated output, and executables.

Tests were added by all members of our team as they were needed. The test script is located in the appendix.

Lessons Larned

Rashedul Haydar

For a semester long project it's very important to try to get at least parts of the project done each week. Thankfully, we planned enough to have progress each week on the project. Having the weekly meetings with our advisor really pushed us to get something done every week. Even with the incremental progress, the last two weeks of the project was still crazy.

Megan Skrypek

I learned how important planning and communication is in tackling a large project like this. Having weekly meetings to work on components of the project as well as discuss future plans really helped us manage our time. Working on key components as a team really helped every member understanding the overall flow of the project, instead of only handling individual components. Some advice for future teams would be to start as early as possible, if you get stuck in the beginning it is very difficult to finish on time since each piece of the compiler builds on one another.

Daniel Cole

First and foremost, this was an amazing learning opportunity. Beyond learning the PLT related topics of compiler design, I learned group management, how to work on large scale, long term projects, how to integrate code written by multiple people, and how to partition tasks. One of the big challenges was the long scale of the project. Keeping everything moving, and everyone motivated when the deadline was far away was not always easy. The periodic milestones, as well as the weekly checkins help immensely.

Because so much of our language focused on the C code generation, when we got to that point, (from the end of November on), it became much harder to split up the work, as most work at this point was dependent on previous work, and had to be completed in sequence. For instance, matrices needed arrays done first, and the Stitch loop bodies needed the Stitch functions done first. Along with other classwork, this was the biggest issue we had with balancing the workload.

I'd also like to confirm pretty much everything you said at the beginning of the semester, especially regarding OCaml. It wasn't until around the time I finished up the semantic analyzer that I fully appreciated why you had us work in this language. While it won't be my first choice for most projects going forwards, for this type of thing, it is 100% the best language I can imagine.

Tim Waterman

Code

stch_scanner.mll

```

1 { open Stch_parser }
2
3 rule token = parse
4   [ ' ' '\t' '\r' '\n' ] { token lexbuf }
5   | "//" { sline_comment lexbuf }
6   | "/*" { block_comment lexbuf }
7   | ';' { SEMI }
8   | ':' { COLON }
9   | '\'' { SQUOTE }
10  | '"' { DQUOTE }
11  | '(' { LPAREN }
12  | ')' { RPAREN }
13  | '[' { LSQUARE }
14  | ']' { RSQUARE }
15  | '{' { LBRACE }
16  | '}' { RBRACE }
17  | ',' { COMMA }
18  | '*' { TIMES }
19  | '/' { DIVIDE }
20  | '+' { ADD }
21  | '-' { SUBTRACT }
22  | '%' { MOD }
23  | '=' { ASSIGN }
24  | "==" { EQUAL }
25  | '!' { NEGATE }
26  | "!=" { NE }
27  | "&&" { AND }
28  | "||" { OR }
29  | '>' { GT }
30  | ">=" { GE }
31  | '<' { LT }
32  | "<=" { LE }
33  | "if" { IF }
34  | "else" { ELSE }
35  | "while" { WHILE }
36  | "for" { FOR }
37  | "stitch" { STITCH }
38  | "from" { FROM }
39  | "to" { TO }
40  | "by" { BY }
41  | "break" { BREAK }
42  | "return" { RETURN }
43  | "void" { TVOID }
44  | "int" { TINT }
45  | "float" { TFLOAT }
46  | "char" { TCHAR }
47  | "int_ap" { TINTAP }
48  | "int_am" { TINTAM }
49  | "float_ap" { TFLOATAP }
50  | "float_am" { TFLOATAM }
51  | "FILE" { TFILE }
52  | ['-' '+']? ['0' - '9']+ as i_litr { INT(int_of_string i_litr) }
53  | ['-' '+']? ['0' - '9']? '.' ['0' - '9']* as f_litr { FLOAT(float_of_string f_litr) }

```

```

54 | '''([^''']) as ch_litr)''' { CHAR(ch_litr)}
55 | '''([\\"''][\\"' 't' 'n'] as esc_ch)''' { ESCAPE(esc_ch)}
56 | '''([^''']* as st_litr)''' { STRING(st_litr)}
57 | ['a'-'z' 'A'-'Z']['a'-'z' 'A'-'Z' '0'-'9' '-'']* as litr { ID(litr) }
58 | eof { EOF }
59 | - as char { raise (Failure("illegal character " ^ Char.escaped char))}
60
61 and sline_comment = parse
62   '\n' { token lexbuf }
63   | - { sline_comment lexbuf }
64
65 and block_comment = parse
66   "*/" { token lexbuf }
67   | - { block_comment lexbuf }

```

stch_parser.mly

```
1 %{ open Stch_ast %}
2
3 %token SEMI SQUOTE DQUOTE COLON LPAREN RPAREN LSQUARE RSQUARE LBRACE RBRACE
4 %token COMMA TIMES DIVIDE ADD SUBTRACT MOD
5 %token ASSIGN EQUAL NEGATE NE
6 %token AND OR
7 %token GT GE LT LE
8 %token FROM TO BY
9 %token IF ELSE WHILE FOR STITCH BREAK RETURN TVOID TINT TFLOAT TCHAR TINTAP TINTAM
   TFLOATAP TFLOATAM TFILE
10 %token VOID
11 %token <int> INT
12 %token <char> CHAR
13 %token <string> ESCAPE
14 %token <float> FLOAT
15 %token <string> STRING
16 %token <string> ID
17 %token EOF
18
19 %nonassoc NOELSE
20 %nonassoc ELSE
21 %right ASSIGN
22 %left OR
23 %left AND
24 %left EQUAL NE
25 %left LT GT LE GE
26 %left ADD SUBTRACT
27 %left TIMES DIVIDE MOD
28 %right NEGATE
29
30 %start program
31 %type <Stch_ast.program> program
32
33 %%
34
35 program:
36   /*decls EOF {$1}*/ { [], [] }
37   | program stmt SEMI { ($2 :: fst $1), snd $1 }
38   | program fdecl { fst $1, ($2 :: snd $1) }
39
40 fdecl:
41   type_name ID LPAREN formals_opt RPAREN LBRACE stmt_list RBRACE
42   { { fdecl_type = $1;
43       fdecl_name = $2;
44       fdecl_formals = $4;
45       body = List.rev $7; } }
46
47 type_name:
48   TINT { Tint }
49   | TFLOAT { Tfloat }
50   | TCHAR { Tchar }
51   | TVOID { Tvoid }
52   | TINTAP { Tintap }
53   | TINTAM { Tintam }
```

```

54 | TFLOATAP      { Tfloatap }
55 | TFLOATAM      { Tfloatam }
56 | TFILE         { Tfile }
57
58 formals_opt:
59   /* nothing */ { [] }
60 | formal_list { List.rev $1 }
61
62 formal_list:
63   vdecl { [$1] }
64 | formal_list COMMA vdecl { $3 :: $1 }
65
66 vdecl:
67   type_name ID
68   {{
69     vdecl_type = $1;
70     vdecl_name = $2;
71   }}
72
73 arraydecl:
74   type_name ID LSQUARE expr_opt RSQUARE
75   {{
76     arraydecl_type = $1;
77     arraydecl_name = $2;
78     arraydecl_size = $4;
79   }}
80
81 matrixdecl: /* two dimensional array implementation */
82   type_name ID LSQUARE expr_opt RSQUARE LSQUARE expr_opt RSQUARE
83   {{
84     matrixdecl_type = $1;
85     matrixdecl_name = $2;
86     matrixdecl_rows = $4;
87     matrixdecl_cols = $7;
88   }}
89
90
91 stmt_list:
92 /*nothing*/ { [] }
93 | stmt_list stmt { $2 :: $1 }
94
95 stmt:
96   expr SEMI { Expr($1) }
97 | vdecl SEMI { Vdecl($1) }
98 /* One dimensional array stuff */
99 | arraydecl SEMI { ArrayDecl($1) }
100 | arraydecl ASSIGN LBRACE actuals_opt RBRACE SEMI
101   { ArrayInit($1, $4) }
102 /* Two dimensional array statements */
103 | matrixdecl SEMI { MatrixDecl($1) }
104 | matrixdecl ASSIGN LBRACE matrix_rev_list RBRACE SEMI
105   { MatrixInit($1, $4) }
106 | RETURN expr_opt SEMI { Return($2) }
107 | LBRACE stmt_list RBRACE { Block(List.rev $2) }
108 | IF LPAREN expr RPAREN stmt %prec NOELSE { If($3, $5, Block([])) }
109 | IF LPAREN expr RPAREN stmt ELSE stmt { If($3, $5, $7) }
110 | FOR LPAREN expr_opt SEMI expr_opt SEMI expr_opt RPAREN stmt
111   { For($3,$5,$7,$9) }

```

```

112 | WHILE LPAREN expr RPAREN stmt      { While($3, $5) }
113 | STITCH expr FROM expr TO expr BY expr COLON stmt
114 | { Stitch($2,$4,$6,$8,$10) }
115 | vdecl ASSIGN expr SEMI            { Assign($1, $3) }
116 | BREAK SEMI                       { Break }
117
118 expr_opt:
119   /*nothing*/ { Noexpr }
120 | expr      { $1 }
121
122 expr:
123 /*Primitives*/
124 | INT      { Int($1) }
125 | FLOAT    { Float($1) }
126 | CHAR     { Char($1) }
127 | ESCAPE   { Escape($1)}
128 | ID       { Id($1) }
129 | STRING   { String($1) }
130 /*Array*/
131 | ID LSQUARE expr RSQUARE ASSIGN expr { Array_Item_Assign($1, $3, $6) }
132 | ID LSQUARE expr RSQUARE            { Array_Index_Access($1, $3) }
133 /*Matrix */
134 | ID LSQUARE expr RSQUARE LSQUARE expr RSQUARE ASSIGN expr
135 | { Matrix_Item_Assign($1, $3, $6, $9) }
136 | ID LSQUARE expr RSQUARE LSQUARE expr RSQUARE
137 | { Matrix_Index_Access($1, $3, $6) }
138 /*Arithmetic*/
139 | expr ADD expr { Binop($1, Add, $3) }
140 | expr SUBTRACT expr { Binop($1, Subtract, $3) }
141 | expr TIMES expr { Binop($1, Times, $3) }
142 | expr DIVIDE expr { Binop($1, Divide, $3) }
143 | expr MOD expr { Binop($1, Mod, $3) }
144 /*Comparison*/
145 | expr EQUAL expr { Binop($1, Equal, $3) }
146 | expr NE expr { Binop($1, Ne, $3) }
147 | expr LT expr { Binop($1, Lt, $3) }
148 | expr LE expr { Binop($1, Le, $3) }
149 | expr GT expr { Binop($1, Gt, $3) }
150 | expr GE expr { Binop($1, Ge, $3) }
151 /*Logical*/
152 | expr OR expr { Binop($1, Or, $3) }
153 | expr AND expr { Binop($1, And, $3) }
154 /*Unary*/
155 | NEGATE expr { Negate($2)}
156 /*Miscellanenous*/
157 | ID LPAREN actuals_opt RPAREN { Call($1, $3) }
158 | LPAREN expr RPAREN { $2 }
159 | ID ASSIGN expr { Assign2($1, $3) }
160
161 matrix_rev_list:
162   matrix_list { List.rev $1 }
163
164 matrix_list:
165   LBRACE actuals_opt RBRACE { [$2] }
166 | matrix_list COMMA LBRACE actuals_opt RBRACE { $4::$1 }
167
168 actuals_opt:
169   /*nothing*/ { [] }

```



```
170 | actuals_list { List.rev $1 }
171
172 actuals_list :
173   expr          { [$1] }
174 | actuals_list COMMA expr {$3 :: $1 }
```

stch_ast.ml

```
1 type op = Add | Subtract | Times | Divide | Mod | Equal | Ne | Lt | Le | Gt | Ge
2         | Or | And
3 type dataType = Tint | Tfloat | Tchar | Tvoid | Tstring | Tintap | Tintam | Tfloatap
4             | Tfloatam | Tfile
5 type vdecl = {
6   vdecl_type : dataType;
7   vdecl_name : string;
8 }
9
10 type expr =
11   Int of int
12 | Float of float
13 | Char of char
14 | Escape of string
15 | Id of string
16 | String of string
17 | Binop of expr * op * expr
18 | Negate of expr
19 | Call of string * expr list
20 | Assign2 of string * expr
21 | Array_Item_Assign of string * expr * expr
22 | Array_Index_Access of string * expr
23 | Matrix_Item_Assign of string * expr * expr * expr
24 | Matrix_Index_Access of string * expr * expr
25 | Access of string * string
26 | Noexpr
27
28 type arraydecl = {
29   arraydecl_type : dataType;
30   arraydecl_name : string;
31   arraydecl_size : expr;
32 }
33
34 type matrixdecl = {
35   matrixdecl_type : dataType;
36   matrixdecl_name : string;
37   matrixdecl_rows : expr;
38   matrixdecl_cols : expr;
39 }
40
41 type stmt =
42   Block of stmt list
43 | Vdecl of vdecl
44 | Expr of expr
45 | Return of expr
46 | If of expr * stmt * stmt
47 | For of expr * expr * expr * stmt
48 | While of expr * stmt
49 | Stitch of expr * expr * expr * expr * stmt
50 | Assign of vdecl * expr
51 | ArrayDecl of arraydecl
```

```

54 | ArrayInit of arraydecl * expr list
55 | MatrixDecl of matrixdecl
56 | MatrixInit of matrixdecl * expr list list
57 | Break
58
59 type fdecl = {
60   fdecl_type : dataType;
61   fdecl_name : string;
62   fdecl_formals : vdecl list;
63   body : stmt list;
64 }
65
66 type program = stmt list * fdecl list
67
68 (* Pretty printer, used for testing, and in parts of the c-generator *)
69 let string_of_dataType = function
70   Tint -> "int"
71   | Tfloat -> "float"
72   | Tchar -> "char"
73   | Tvoid -> "void"
74   | Tstring -> "char *"
75   | Tintap -> "int"
76   | Tintam -> "int"
77   | Tfloatap -> "float"
78   | Tfloatam -> "float"
79   | Tfile -> "FILE *"
80
81 let rec string_of_expr = function
82   Int(l) -> string_of_int l
83   | Float(l) -> string_of_float l
84   | Char(l) -> "\"" ^ String.make 1 l ^ "\""
85   | Escape(l) -> "\"" ^ l ^ "\""
86   | Id(s) -> s
87   | String(s) -> "\"" ^ s ^ "\""
88   | Binop(e1, o, e2) ->
89     string_of_expr e1 ^ " " ^
90     (match o with
91     Add -> "+" | Subtract -> "-" | Times -> "*" | Divide -> "/"
92     | Equal -> "==" | Ne -> "!="
93     | Lt -> "<" | Le -> "<=" | Gt -> ">" | Ge -> ">="
94     | Or -> "||" | And -> "&&" | Mod -> "%" ) ^ " " ^
95     string_of_expr e2
96   | Negate(e) -> "!" ^ string_of_expr e
97   | Call(f, el) -> (match f with "print" -> "printf" | _ -> f) ^ "(" ^ String.concat
98     ", " (List.map string_of_expr el) ^ ")"
99   | Assign2(i, e) -> i ^ " = " ^ string_of_expr e ^ ";\n"
100   | Array_Item_Assign(id, ind, e) -> id ^ "[" ^ string_of_expr ind ^ "] = " ^
101     string_of_expr e
102   | Array_Index_Access(id, index) -> id ^ "[" ^ string_of_expr index ^ "]"
103   | Matrix_Item_Assign(id, row, col, ex) -> id ^ "[" ^ string_of_expr row ^ "]" ^
104     string_of_expr col ^ "] = " ^ string_of_expr ex
105   | Matrix_Index_Access(id, row, col) -> id ^ "[" ^ string_of_expr row ^ "]" ^
106     string_of_expr col ^ "]"
107   | Access(f, s) -> f ^ "." ^ s
108   | Noexpr -> ""
109
110 let string_of_vdecl vdecl = string_of_dataType vdecl.vdecl_type ^ " " ^ vdecl.
111   vdecl_name

```

```

107
108 let string_of_arraydecl arraydecl = string_of_dataType arraydecl.arraydecl_type ^ "
    " ^ arraydecl.arraydecl_name ^ "[" ^
    string_of_expr arraydecl.arraydecl_size ^ "]"
109
110
111 let string_of_matrixdecl m = string_of_dataType m.matrixdecl_type ^ " " ^ m.
    matrixdecl_name ^ "[" ^
112     string_of_expr m.matrixdecl_rows ^ "]" ^ string_of_expr m.matrixdecl_cols ^ "]"
113
114 let string_of_arraylist el = "{" ^ String.concat ", " (List.map string_of_expr el) ^
    "}"
115
116 let rec string_of_matrixlist (seed: string) el = match el with
117 | [] -> seed ^ "}"
118 | head::tail -> string_of_matrixlist (seed ^ string_of_arraylist head ^ ",\n")
    tail
119
120 let rec string_of_stmt = function
121 | Block(stmts) ->
122     "{" ^ "\n" ^ String.concat "" (List.map string_of_stmt stmts) ^ "}\n"
123 | Expr(expr) -> string_of_expr expr ^ ";\n";
124 | Vdecl(v) -> string_of_dataType v.vdecl_type ^ " " ^ v.vdecl_name ^ ";\n";
125 | Return(expr) -> "return " ^ string_of_expr expr ^ ";\n";
126 | If(e, s, Block([])) -> "if (" ^ string_of_expr e ^ ")\n" ^ string_of_stmt s
127 | If(e, s1, s2) -> "if (" ^ string_of_expr e ^ ")\n" ^
    string_of_stmt s1 ^ "else\n" ^ string_of_stmt s2
128 | For(e1, e2, e3, s) ->
    "for (" ^ string_of_expr e1 ^ " ; " ^ string_of_expr e2 ^ " ; " ^
    string_of_expr e3 ^ ") " ^ string_of_stmt s
129 | While(e, s) -> "while (" ^ string_of_expr e ^ ") " ^ string_of_stmt s
130 | Stitch(e1, e2, e3, e4, s) ->
    "stitch " ^ string_of_expr e1 ^ " from " ^ string_of_expr e2 ^ " to " ^
    string_of_expr e3 ^ " by " ^ string_of_expr e4 ^ " : " ^ string_of_stmt s
131 | Assign(v, e) -> string_of_vdecl v ^ " = " ^ string_of_expr e ^ ";\n"
132 | ArrayDecl(a) -> string_of_arraydecl a ^ ";\n"
133 | ArrayInit(arraydecl, el) -> string_of_arraydecl arraydecl ^ " = " ^
    string_of_arraylist el ^ ";\n"
134 | MatrixDecl(m) -> string_of_matrixdecl m ^ ";\n"
135 | MatrixInit(mdecl, li) -> string_of_matrixdecl mdecl ^ " = " ^
    string_of_matrixlist "{ " li ^ " };\n"
136 | Break -> "break;"
137
138
139
140
141
142
143 let string_of_fdecl fdecl =
144     string_of_dataType fdecl.fdecl_type ^ " " ^ fdecl.fdecl_name ^ "(" ^ String.concat
    ", " (List.map string_of_vdecl fdecl.fdecl_formals) ^ ")\n" ^
    String.concat "" (List.map string_of_stmt fdecl.body) ^
145     "}" ^ "\n"
146
147
148 let string_of_program (stmts, funcs) =
149     String.concat "" (List.map string_of_stmt stmts) ^ "\n" ^
150     String.concat "\n" (List.map string_of_fdecl funcs)

```

stch_semantic.ml

```
1 (*
2 Semantic Analyzer
3 December 2015
4 Authors: Dan Cole, Tim Waterman
5
6 Takes the AST and runs semantic analysis on it, turning it into
7 a C-AST
8 *)
9
10 open Stch_ast
11 open Stch_cast
12 exception Error of string
13
14 (* Globals for procedurally generating suffix for stitch items *)
15 type stch_name_gen = { mutable name : int }
16 let sn = {name = 0;}
17
18 (* symbol table -> string *)
19 let string_of_symTable (syms: symTable) = let str = "SymTable: \n" ^
20     String.concat "\n" (List.map (fun (typ, name, _) -> "[" ^
21     Stch_ast.string_of_dataType typ ^ " " ^ name ^ "]" ) syms.vars) ^ "\n"
22 in print_endline str
23
24 (* find a variable (and associated type) in the symbol table *)
25 let rec find_variable (scope: symTable) name =
26   try
27     List.find (fun (_, s, _) -> s = name ) scope.vars
28   with Not_found -> match scope.parent with
29     Some(parent) -> find_variable parent name
30   | _ -> raise (Error("Bad ID " ^ name)) (* in general, any type mismatch raises an
31     error *)
32
33 (* check to see if a function has been defined *)
34 let rec find_func (funcs: c_fdecl list) fname =
35   try
36     List.find ( fun fn -> fn.fdecl_name = fname ) funcs
37   with Not_found -> raise (Error ("Function call not recognized: " ^ fname))
38
39 (* type check binary operations *)
40 (* for now, Stitch does not support type coercion, so binops must be int/int or flt/
41    flt *)
42 let check_binop (lhs: dataType) (rhs: dataType) (env: stch_env) : (Stch_ast.dataType
43 ) =
44   match (lhs, rhs) with
45     (Tint, Tint) -> Tint
46   | (Tfloat, Tfloat) -> Tfloat
47   | (_, _) -> raise (Error("Incompatable data types for binop"))
48
49 (* check variable declaration, returns a C-Vdecl *)
50 let check_vdecl (decl: vdecl) (env: stch_env) =
51   let invalid = List.exists (fun (_, s, _) -> s = decl.vdecl_name) env.scope.vars in
52   if invalid then
53     raise (Error("Variable already declared"))
54   else
```

```

52     env.scope.vars <- (decl.vdecl_type, decl.vdecl_name, C_Noexpr)::env.scope.vars
53     ;
54     let v = { Stch_cast.vdecl_type = decl.vdecl_type;
55               Stch_cast.vdecl_name = decl.vdecl_name } in
56       C_Vdecl(v)
57 (* same as check_vdecl, except that it returns a triple of vdecl, datatype, name *)
58 let check_vdecl_t (decl: vdecl) (env: stch_env) =
59   let invalid = List.exists (fun (_, s, _) => s = decl.vdecl_name) env.scope.vars in
60   if invalid then
61     raise (Error("Variable already declared"))
62   else
63     env.scope.vars <- (decl.vdecl_type, decl.vdecl_name, C_Noexpr)::env.scope.vars
64     ;
65     let v = { Stch_cast.vdecl_type = decl.vdecl_type;
66               Stch_cast.vdecl_name = decl.vdecl_name } in
67       v, v.vdecl_type, v.vdecl_name
68 (* type check an expression and put into c_ast *)
69 let rec check_expr (e: expr) (env: stch_env) : (Stch_cast.c_expr * Stch_ast.dataType
70   ) =
71   match e with
72   (* primitives get a free pass *)
73   | Int(1)   -> C_Int(1), Tint
74   | Float(1) -> C_Float(1), Tfloat
75   | Char(1)  -> C_Char(1), Tchar
76   | Escape(1) -> C_Escape(1), Tchar
77   | String(1) -> C_String(1), Tstring
78   (* For ID's, check to see if the variable has been declared, if it has, get the
79     name and type *)
80   | Id(1) ->
81     let var = try find_variable env.scope 1
82               with Not_found -> raise (Error("Undefined Identifier" ^ 1))
83     in
84     let (typ, vname, _) = var in
85     C_Id(vname, typ), typ
86   (* other exprs need to call their respective check functions *)
87   | Binop(lhs, o, rhs) -> binop_ret lhs o rhs env
88   | Negate(1) -> check_negate 1 env
89   | Call(f, b) -> check_call f b env
90   | Assign2(lhs, rhs) -> check_assign2 lhs rhs env
91   | Array_Index_Access(name, index) -> check_array_index name index env
92   | Array_Item_Assign(name, index, ex) -> check_array_item_assign name index ex env
93   | Matrix_Index_Access(name, row, col) -> check_matrix_index name row col env
94   | Matrix_Item_Assign(name, row, col, ex) -> check_matrix_item_assign name row col
95     ex env
96   | Noexpr -> C_Noexpr, Tvoid
97   | _ -> C_Noexpr, Tvoid (* Can remove when everything else is added *)
98
99   (* check negation. As of now, only ints and floats can be negated *)
100   and check_negate (e: expr) (env: stch_env) =
101     let exp = check_expr e env in
102     match snd exp with
103     | Tint -> C_Negate((fst exp)), Tint
104     | Tfloat -> C_Negate((fst exp)), Tfloat
105     | _ -> raise (Error("Cannot negate type " ^ string_of_dataType (snd exp)))
106
107   (* check the binop return type*)

```

```

105 and binop_ret (lhs: expr) (o: op) (rhs: expr) (env: stch_env) : (Stch_cast.c_expr
    * Stch_ast.dataType) =
106   let (lhs, t1) = check_expr lhs env
107   and (rhs, t2) = check_expr rhs env in
108
109   match o with
110   | Add -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
111   | Subtract -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
112   | Times -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
113   | Divide -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
114   | Mod -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
115   | Equal -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
116   | Ne -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
117   | Lt -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
118   | Le -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
119   | Gt -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
120   | Ge -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
121   | Or -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
122   | And -> C_Binop(lhs, o, rhs), check_binop t1 t2 env
123
124   (* check assign2 (i.e. expr assign) *)
125   and check_assign2 (lhs: string) (rhs: expr) (env: stch_env) : (Stch_cast.c_expr *
    Stch_ast.dataType) =
126     let (t1, _, _) = find_variable env.scope lhs
127     and (rhs, t2) = check_expr rhs env in
128     if t1 = t2 || (t1 = Tintap && t2 = Tint) then
129       C_Assign2(lhs, rhs), t2
130     else if t1 = Tint && t2 = Tchar then
131       C_Assign2(lhs, rhs), t1
132     else
133       raise (Error("Type mismatch on variable assignment " ^ lhs ^
134         "\nExpected: " ^ string_of_dataType t1 ^ " Got: " ^ string_of_dataType t2))
135
136   (* Checking array access by index. Index should be an int, we just need to make
    sure that the
137   array exists. We could also conceivably rewrite this later to do bounds checking
    *)
138   and check_array_index (n: string) (index: expr) (env: stch_env) =
139     let var = find_variable env.scope n in
140     let (typ, vname, _) = var in
141     let (e, t) = check_expr index env in match t with
142     | Tint -> C_Array_Index(vname, e, typ), typ
143     | _ -> raise (Error("Cannot index into an array with type " ^
    string_of_dataType t))
144
145   (* Checking matrix access by indices. They should both be ints, row and col.
    Also we need to check that the variable exists first
146   *)
147   and check_matrix_index (n: string) (row: expr) (col: expr) (env: stch_env) =
148     let var = find_variable env.scope n in
149     let (typ, vname, _) = var in
150     let (erow, trow) = check_expr row env in
151     let (ecol, tcoul) = check_expr col env in match (trow, tcoul) with
152     | (Tint, Tint) -> C_Matrix_Index(vname, erow, ecol, typ), typ
153     | _ -> raise (Error("Cannot index into an array with types " ^ string_of_expr
    row ^ ", " ^
154     string_of_expr col))
155
156

```

```

157
158 (* Checking the array assignment to a specific index. Will validate the lhs as a
    valid access, and
159 then will make sure the rhs has the proper type for assignment
160 *)
161 and check_array_item_assign (name: string) (index: expr) (rhs: expr) (env:
    stch_env) =
162   let var = find_variable env.scope name in
163   let (typ, vname, _) = var in
164   let (e, t) = check_expr index env in
165   if t <> Tint then
166     raise(Error("Cannot index into an array with type " ^ string_of_dataType t))
167   else
168     let (erhs, trhs) = check_expr rhs env in
169     (* Hacky for now, allowing anything to store into a int or char array *)
170     if trhs <> typ && (typ <> Tint && typ <> Tchar) then
171       raise(Error("Type mismatch on array item assignment"))
172     else
173       C.Array.Item.Assign(vname, e, erhs), typ
174
175 and check_matrix_item_assign (name: string) (row: expr) (col: expr) (rhs: expr) (
    env: stch_env) =
176   let var = find_variable env.scope name in
177   let (vtyp, vname, _) = var in
178   let (erow, trow) = check_expr row env in
179   let (ecol, tcol) = check_expr col env in
180   if trow <> Tint || tcol <> Tint then
181     raise(Error("Cannot index into a matrix with non-int values"))
182   else
183     let (erhs, trhs) = check_expr rhs env in
184     if trhs <> vtyp then
185       raise(Error("Type mismatch on matrix item assignment"))
186     else
187       C.Matrix.Item.Assign(vname, erow, ecol, erhs), vtyp
188
189 (* check function call *)
190 and check_call (f: string) (el: expr list) (env: stch_env) =
191   let l_expr_type = List.map (fun e -> check_expr e env) el in
192   let func_ret = find_func env.funcs f in
193   let args_l = find_func_sig f l_expr_type func_ret in
194   C.Call(func_ret.fdecl_name, args_l), func_ret.fdecl_type
195
196 (* function signature verify *)
197 and find_func_sig (f: string) (opts: (c_expr * dataType) list) (func_ret: c_fdecl)
    = match f with
198   (* special handling for built-in functions
199    Not all built-ins need this (eg exit() ) *)
200   "print" -> (let arg = List.hd opts in
201     match (snd arg) with
202     | Tint -> (fst arg)::[]
203     | Tfloat -> (fst arg)::[]
204     | Tchar -> (fst arg)::[]
205     | Tstring -> (fst arg)::[]
206     | Tintap -> (fst arg)::[]
207     | Tintam -> (fst arg)::[]
208     | _ -> raise (Error("Invalid print type: " ^ string_of_dataType (snd
        arg))))
209   | "error" -> (let arg = List.hd opts in

```



```

210         match (snd arg) with
211         | Tint -> (fst arg)::[]
212         | Tfloat -> (fst arg)::[]
213         | Tchar -> (fst arg)::[]
214         | Tstring -> (fst arg)::[]
215         | _ -> raise (Error("Invalid error type: " ^ string_of_dataType (snd
                                arg)))
216     (* All other functions *)
217     | _ -> try
218         let formal = func_ret.fdecl.formals in
219         let cexpr = List.map2 (fun (opt: c_expr * dataType) (formal: c_vdecl) ->
220             let opt_typ = snd opt in
221             let formal_type = formal.vdecl.type in
222             if opt_typ = formal_type then
223                 fst opt
224             else
225                 C_Noexpr) opts formal in
226         let matched = List.exists (fun e -> e = C_Noexpr) cexpr in
227         if matched then
228             find_func_sig f opts func_ret
229         else
230             cexpr
231         with Invalid_argument(x) ->
232             raise (Error("Wrong number of args in function call " ^ f))
233
234     (* Helper function for array initialization. This function will recursively traverse
235        a list of
236        expressions and try to type match them with the type of the array they're being
237        added into.
238        This function is called from check_array_init further down in the code
239        *)
240     let rec check_init_vals (name: arraydecl) (el: expr list) (t: dataType) (env:
241         stch_env) =
242         match el with
243         | [] -> name
244         | head::tail -> let (ex, typ) = check_expr head env in
245             if typ = t then
246                 check_init_vals name tail typ env
247             else
248                 raise(Error("Types of array initialization do not match"))
249
250     (* Checking the types for matrix initialization *)
251     let rec check_matrix_rows (name: matrixdecl) (el: expr list) (t: dataType) (env:
252         stch_env) =
253         match el with
254         | [] -> name
255         | head::tail -> let (exp, typ) = check_expr head env in
256             if typ = t then begin
257                 check_matrix_rows name tail typ env
258             end
259             else
260                 raise(Error("Types of matrix init do not match"))
261
262     (* Check that all the matrix rows are the proper length *)
263     let rec check_matrix_vals (name: matrixdecl) (el: expr list list) (ncols: int) (t:
264         dataType) (env: stch_env) =
265         match el with
266         | [] -> name

```

```

262 | head::tail ->
263   if ncols <> List.length head then begin
264     raise(Error("Rows are not matching length in matrix decl"))
265   end
266   else
267     let m = check_matrix_rows name head t env in
268     check_matrix_vals m tail ncols t env
269
270 (* Generate the names for the struct and the anonymous pthread functions *)
271 let gen_name (sn : stch.name-gen) =
272   let i = sn.name in
273   sn.name <- i+1; "_" ^ string_of_int i
274
275 let get_id_from_expr (ex: expr) = match ex with
276 | Id(l) -> l
277 | _ -> "_null"
278
279 (* typecheck a statement *)
280 let rec check_stmt (s: Stch.ast.stmt) (env: stch.env) = match s with
281 | Block(ss) ->
282   let scope' = { parent = Some(env.scope); vars = []; } in
283   let env' = { env with scope = scope' } in
284   let ss = List.map (fun s -> check_stmt s env') ss in
285   scope'.vars <- List.rev scope'.vars;
286   C_Block(scope', ss)
287 | Vdecl(v) -> check_vdecl v env
288 | Expr(e) -> let (e,t) = check_expr e env in C_Expr(t, e)
289 | ArrayDecl(a) -> check_array_decl a env
290 | ArrayInit(a, el) -> check_array_init a el env
291 | MatrixDecl(m) -> check_matrix_decl m env
292 | MatrixInit(mdecl, el) -> check_matrix_init mdecl el env
293 | Return(e) -> check_return e env
294 | If(e, s1, s2) -> check_if e s1 s2 env
295 | For(e1, e2, e3, s) -> check_for e1 e2 e3 s env
296 | While(e, s) -> check_while e s env
297 | Stitch(e1, e2, e3, e4, s) -> check_stitch e1 e2 e3 e4 s env
298 (* stmt assign needs to be fixed *)
299 | Assign(v, e) -> check_assign v e env
300 | Break -> C_Break
301
302 (* check assign (i.e. stmt assign) *)
303 and check_assign (lhs: vdecl) (rhs: expr) (env: stch.env) =
304   let (v, t1, _) = check_vdecl_t lhs env
305   and (rhs, t2) = check_expr rhs env in
306   if t1 = t2 || (t1 = Tintap && t2 = Tint) then
307     C_Assign(v, rhs)
308   else
309     raise (Error("Type mismatch on variable assignment " ^ string_of_vdecl lhs))
310
311 (* typecheck return (not return type, but keyword 'return') *)
312 and check_return (e: expr) (env: stch.env) =
313   if env.in_func then
314     let (e,t) = check_expr e env in
315     if t = env.retType then
316       C_Return(t, e)
317     else
318       raise (Error("Incompatable return type. Expected type " ^
319         string_of_dataType env.retType ^

```

```

320         ", found type " ^
321         string_of_dataType t))
322     else
323         raise (Error("Invalid 'return' call"))
324
325 and check_array_decl (a: arraydecl) (env : stch_env) =
326
327     (* create a variable declaration out of the array declaration so we can check
328        for it *)
329     let ve = { Stch_ast.vdecl_type = a.arraydecl_type;
330               Stch_ast.vdecl_name = a.arraydecl_name } in
331
332     (* check to see if the variable is not already declared *)
333     let invalid = List.exists (fun (_, s, _) -> s = ve.vdecl_name) env.scope.vars in
334     if invalid then
335         raise (Error("Variable " ^ ve.vdecl_name ^ " already declared"))
336     else
337         (* if it isn't, put it in the scope, and make a new c_arraydecl
338            after you typematch the size expression *)
339
340         (* If we have an arraydecl, we want the C_EXPR in the symtable to be an index
341            operation, so we can
342            get the size information when we are passing the symtable to the code
343            generator
344            This is a bit hacky, but it should work for what we need it to
345            *)
346         let (ex, ty) = check_expr a.arraydecl_size env in
347         env.scope.vars <- (ve.vdecl_type, ve.vdecl_name, C_Array_Index(ve.vdecl_name,
348                               ex, ve.vdecl_type))::env.scope.vars;
349         let (ex, typ) = check_expr a.arraydecl_size env in
350         match typ with
351         | Tfloat -> raise (Error("Invalid array size type, expects int"))
352         | Tchar -> raise (Error("Invalid array size type, expects int"))
353         | Tstring -> raise (Error("Invalid array size type, expects int"))
354         | Tvoid -> raise (Error("Invalid array size type, expects int"))
355         (* else it's a void or an int, and it's allowed *)
356         | _ -> let v = { Stch_ast.arraydecl_type = ve.vdecl_type;
357                         Stch_ast.arraydecl_name = ve.vdecl_name;
358                         Stch_ast.arraydecl_size = a.arraydecl_size } in C_Array_Decl(v)
359
360     (* checking the array initialization. This will be done in 3 steps
361        1. Check to see if the array can be declared as a new variable
362        2. Make sure that all the args in the list are the same type
363        3. Make sure that the type in the list matches the type
364        4. Make sure that the size of the list matches the size of the decl (low
365           priority for now)
366        *)
367     and check_array_init (a: arraydecl) (el: expr list) (env: stch_env) =
368     (* first step: check that we have a valid array decl *)
369     let invalid = List.exists (fun (_,s,-) -> s = a.arraydecl_name) env.scope.vars
370     in
371     if invalid then
372         raise (Error("Variable " ^ a.arraydecl_name ^ " already declared"))
373     else begin
374         let (ex, ty) = check_expr a.arraydecl_size env in
375         env.scope.vars <- (a.arraydecl_type, a.arraydecl_name,
376                           C_Array_Index(a.arraydecl_name, ex, a.arraydecl_type))::env.scope.vars;
377

```

```

372 (* now that we know it's valid, check the types of the list *)
373 let s = a.arraydecl_size in
374 let i = string_of_expr s in
375 let typ = a.arraydecl_type in
376 (* try to match the init size with the list size.
377    Init size must be an int constant, by C rules *)
378 try
379   if int_of_string i = List.length el then
380     let ret = check_init_vals a el typ env in
381     if ret = a then
382       C.ArrayInit({Stch_cast.arraydecl_name = a.arraydecl_name;
383                    Stch_cast.arraydecl_type = a.arraydecl_type;
384                    Stch_cast.arraydecl_size = a.arraydecl_size;}, el)
385     else
386       raise(Error("Error parsing the list of array init args"))
387   else
388     raise(Error("Size mismatch in array initialization"))
389   with
390   | _ -> raise(Error("Cannot initialize array with a variable"))
391 end
392 and check_matrix_init (m: matrixdecl) (el: expr list list) (env: stch_env) =
393   (* First, we need to check that we have a valid declaration by checking for
394      vdecl_t *)
395   (* Check the size of the cols and rows, make sure they match the list counts
396      rows = total # of sublists
397      cols = length of the sublists (must be all the same length)
398      *)
399   let invalid = List.exists (fun (_,s,-) -> s = m.matrixdecl_name) env.scope.vars
400   in
401   if invalid then
402     raise (Error("Variable " ^ m.matrixdecl_name ^ " already declared"))
403   else begin
404     let (exr, ty) = check_expr m.matrixdecl_rows env in
405     let (exc, ty2) = check_expr m.matrixdecl_cols env in
406     env.scope.vars <- (m.matrixdecl_type, m.matrixdecl_name,
407                        C.MatrixIndex(m.matrixdecl_name, exr, exc, m.matrixdecl_type))::env.
408                        scope.vars;
409     let typ = m.matrixdecl_type in
410     let errorstring = "Error with " in
411     let rows = string_of_expr m.matrixdecl_rows in
412     let cols = string_of_expr m.matrixdecl_cols in
413     try
414       if int_of_string rows = List.length el && int_of_string cols > -1 then
415         (* Inside here need to call my functions from above for matrix stuff *)
416         let ret = check_matrix_vals m el (int_of_string cols) typ env in
417         if ret = m then
418           C.MatrixInit( {Stch_cast.matrixdecl_name = m.matrixdecl_name;
419                          Stch_cast.matrixdecl_type = m.matrixdecl_type;
420                          Stch_cast.matrixdecl_rows = m.matrixdecl_rows;
421                          Stch_cast.matrixdecl_cols = m.matrixdecl_cols}, el)
422         else begin
423           (* print_string "HELLO"; *)
424           raise(Error(errorstring ^ "checking return value of list iter"))
425         end
426       else begin
427         (* print_string "HELLO2"; *)
428         raise(Error(errorstring ^ "Int of string statement failure"))

```

```

427     end
428     with
429     | _ -> begin
430         (* print_string "HELLO3"; *)
431         raise(Error(errorstring ^ "try/with failure"))
432     end
433 end
434
435 and check_matrix_decl (m: matrixdecl) (env: stch_env) =
436
437     (* create a variable declaration out of the array declaration so we can check
438        for it *)
439     let mat = { Stch_ast.vdecl_type = m.matrixdecl_type;
440                 Stch_ast.vdecl_name = m.matrixdecl_name} in
441
442     (* check to see if the variable is not already declared *)
443     let invalid = List.exists (fun (_, s, _) -> s = mat.vdecl_name) env.scope.vars
444     in
445     if invalid then
446         raise (Error("Variable " ^ mat.vdecl_name ^ " already declared"))
447     else
448         (* if it isn't, put it in the scope, and make a new c_arraydecl
449            after you typematch the size expression *)
450         let (exr, ty) = check_expr m.matrixdecl_rows env in
451         let (exc, ty) = check_expr m.matrixdecl_cols env in
452         env.scope.vars <- (mat.vdecl_type, mat.vdecl_name,
453                             C_Matrix_Index(mat.vdecl_name, exr, exc, mat.vdecl_type))::env.scope.vars;
454         let (row, typerow) = check_expr m.matrixdecl_rows env in
455         let (col, typecol) = check_expr m.matrixdecl_cols env in
456         match (typerow, typecol) with
457         | (Tfloat, _) -> raise (Error("Invalid matrix row type, expects int"))
458         | (Tchar, _) -> raise (Error("Invalid matrix row type, expects int"))
459         | (Tstring, _) -> raise (Error("Invalid matrix row type, expects int"))
460         | (_, Tstring) -> raise (Error("Invalid matrix col type, expects int"))
461         | (_, Tfloat) -> raise (Error("Invalid matrix col type, expects int"))
462         | (_, Tchar) -> raise (Error("Invalid matrix col type, expects int"))
463         | (Tint, Tvoid) -> raise (Error("Invalid matrix row type, expects int"))
464         | (Tvoid, Tint) -> raise (Error("Invalid matrix row type, expects int"))
465         | (Tvoid, Tvoid) -> raise (Error("Invalid matrix decl. Must be 2 ints"))
466         (* else it's a void or an int, and it's allowed *)
467         | _ -> let v = { Stch_cast.matrixdecl_type = mat.vdecl_type;
468                         Stch_cast.matrixdecl_name = mat.vdecl_name;
469                         Stch_cast.matrixdecl_rows = m.matrixdecl_rows;
470                         Stch_cast.matrixdecl_cols = m.matrixdecl_cols} in
471                     C_MatrixDecl(v)
472
473     (* Typechecking the expression of an "if" statement *)
474     and check_if (ex: expr) (th: stmt) (el: stmt) (en : stch_env) =
475         let (e, t) = check_expr ex en in
476         if t = Tint || t = Tfloat || t = Tchar then
477             let s1 = check_stmt th en in
478             let s2 = check_stmt el en in
479             C_If(e, s1, s2)
480         else
481             raise (Error("If clause has expression of type " ^ string_of_dataType t))
482

```

```

483
484 (* typecheck the for loop *)
485 and check_for (e1: expr) (e2: expr) (e3: expr) (st: stmt) (env: stch_env) =
486   let (ex1, t1) = check_expr e1 env in
487   let (ex2, t2) = check_expr e2 env in
488   let (ex3, t3) = check_expr e3 env in
489   if t1 <math>\Diamond</math> Tint && t1 <math>\Diamond</math> Tvoid then
490     raise (Error("For Loop: First expression not of type int."))
491   else begin
492     if t2 <math>\Diamond</math> Tint && t2 <math>\Diamond</math> Tvoid then
493       raise (Error("For Loop: Second expression not of type int."))
494     else begin
495       if t3 <math>\Diamond</math> Tint && t3 <math>\Diamond</math> Tvoid then
496         raise (Error("For Loop: Third expression not of type int."))
497       else begin
498         let s = check_stmt st env in
499         C_For(ex1, ex2, ex3, s)
500       end
501     end
502   end
503
504
505
506 (* Go through the body of a stitch loop and create an environment of all the
   variables used, so we know
507 what needs to be passed in
508 NOTE: VDECLS and ARRAYDECLS/MATRIXDECLS should NOT be added here, because those
   are local in the stitch
509 loop and should not be copied *)
510
511 and check_stitch_body (el: c_stmt list) (table: symTable) (env: stch_env) = match
512   el with
513   | [] -> table
514   | head::tail ->
515     (match head with
516       (* The symtable of block here consists of all the variables that I do not want
517        to put in the struct,
518        so we just pass the list through *)
519       | C_Block(t, b) -> check_stitch_body b table env
520       | C_Vdecl(a) -> let n = a.vdecl_name in
521         let table' = {Stch_cast.parent = table.parent; Stch_cast.vars =
522           List.filter ( fun (typ,nm,ex) -> nm <math>\Diamond</math> n ) env.scope.vars } in
523         check_stitch_body tail table' env
524       | C_ArrayDecl(a) -> let n = a.arraydecl_name in
525         let table' = {Stch_cast.parent = table.parent; Stch_cast.vars =
526           List.filter ( fun (typ,nm,ex) -> nm <math>\Diamond</math> n ) env.scope.vars } in
527         check_stitch_body tail table' env
528       | C_MatrixDecl(m) -> let n = m.matrixdecl_name in
529         let table' = {Stch_cast.parent = table.parent; Stch_cast.vars =
530           List.filter ( fun (typ,nm,ex) -> nm <math>\Diamond</math> n ) env.scope.vars } in
531         check_stitch_body tail table' env
532       | C_Assign(v, r) -> let n = v.vdecl_name in
533         let table' = {Stch_cast.parent = table.parent; Stch_cast.vars =
534           List.filter ( fun (typ,nm,ex) -> nm <math>\Diamond</math> n ) env.scope.vars } in
535         check_stitch_body tail table' env
536       | C_ArrayInit(a, el) -> let n = a.arraydecl_name in
537         let table' = {Stch_cast.parent = table.parent; Stch_cast.vars =

```

```

537     List.filter ( fun (typ,nm,ex) -> nm <> n ) env.scope.vars } in
538     check_stitch_body tail table' env
539   | C_MatrixInit(m, el) -> let n = m.matrixdecl_name in
540     let table' = {Stch_cast.parent = table.parent; Stch_cast.vars =
541       List.filter ( fun (typ,nm,ex) -> nm <> n ) env.scope.vars } in
542     check_stitch_body tail table' env
543
544   (* else I want to keep them in the symtable, continue down the list *)
545   | _ -> check_stitch_body tail table env
546 )
547
548
549 (* Iterate through all the variables, adding them to one symtable *)
550 and iterate_vars (data: (dataType * string * c_expr) list) (table: symTable) =
551   match data with
552   | [] -> table
553   | head::tail -> ignore(table.vars <- head::table.vars);
554     iterate_vars tail table
555
556 (* Bounce up each symtable level, constructing one large symtable with all the
557   variables *)
558 and check_all_envs (el: c_stmt list) (currTable: symTable) (newTable: symTable)
559   (env: stch_env) =
560   ignore(iterate_vars currTable.vars newTable); (* add all the vars to the
561     current table *)
562   match currTable.parent with (* then check the parent *)
563   | None -> newTable
564   | Some(parent) -> check_all_envs el parent newTable env
565
566 (* Typechecking the expressions of a Stitch Loop *)
567 and check_stitch (var : expr) (start : expr) (s_end : expr) (stride : expr) (body
568   : stmt) (env : stch_env) =
569   let (var', t1) = check_expr var env in
570   let name = get_id_from_expr var in
571   let (start', t2) = check_expr start env in
572   let (s_end', t3) = check_expr s_end env in
573   let (stride', t4) = check_expr stride env in
574   if t1 <> Tint then raise (Error("Stitch: First expression not of type int.))
575   else begin
576     if t2 <> Tint then raise (Error("Stitch: Second expression not of type int.))
577     else begin
578       if t3 <> Tint then raise (Error("Stitch: Third expression not of type int.))
579       )
580     else begin
581       if t4 <> Tint then raise (Error("Stitch: Fourth expression not of type int
582         "))
583     else begin
584       let body' = [(check_stmt body env)] in
585       let n' = check_all_envs body' env.scope {Stch_cast.parent = None;
586         Stch_cast.vars = []} env in
587       let t' = check_stitch_body body' n' env in
588       let scope' = {Stch_cast.parent = env.scope.parent;
589         Stch_cast.vars = List.filter (fun (t, n, e) -> n <> name) t'.vars } in
589       C_Stitch(var', start', s_end', stride', gen_name sn, body', scope')
590     end
591   end

```

```

587     end
588   end
589 end
590
591 (* typecheck the while loop *)
592 and check_while (e: expr) (s: stmt) (env: stch_env) =
593   let (e,t) = check_expr e env in
594   if t = Tint then
595     let s' = check_stmt s env in C.While(e,s')
596   else
597     raise (Error("Invalid 'while' expression"))
598
599 let check_formals (decl: vdecl) (env: stch_env) =
600   match decl.vdecl_type with
601   | dataType -> env.scope.vars <- (decl.vdecl_type, decl.vdecl_name, C.Noexpr)::env.
602     scope.vars;
603     let v = { Stch_cast.vdecl_type = decl.vdecl_type;
604               Stch_cast.vdecl_name = decl.vdecl_name } in v
605
606 let check_for_ret (body: stmt list) =
607   if (List.exists ( fun ( s ) -> match s with
608     | Return(a) -> true
609     | _ -> false ) body) then ""
610   else
611     raise (Error("Control reaches the end of nonvoid function. "))
612
613 (* typecheck a function declaration *)
614 let check_fdecl (func: Stch_ast.fdecl) (env: stch_env) : c_fdecl =
615   if env.in_func then
616     raise (Error ("Cannot declare a function within another function"))
617   else
618     let env' = { env with scope = {parent = Some(env.scope); vars = []};
619               retType = func.fdecl_type; in_func = true} in
620     let f_formals = (List.rev (List.map (fun x -> check_formals x env') func.
621       fdecl_formals)) in
622     let f = { Stch_cast.fdecl_name = func.fdecl_name;
623               Stch_cast.fdecl_type = func.fdecl_type;
624               Stch_cast.fdecl_formals = f_formals;
625               Stch_cast.body = ( List.map (fun x -> check_stmt x env') func.body );}
626     in
627     match func.fdecl_type with
628     | Tvoid -> env.funcs <- f::env.funcs; f
629     | _ -> ignore(check_for_ret func.body); env.funcs <- f::env.funcs; f
630
631 (* typecheck the ast env *)
632 let init_env : (stch_env) =
633   let init_funcs = [{ fdecl_type = Tvoid;
634                       fdecl_name = "print";
635                       fdecl_formals = [ {vdecl_type = Tstring; vdecl_name = "c"}; ];
636                       body = [];
637                     };
638                     {fdecl_type = Tvoid;
639                       fdecl_name = "error";
640                       fdecl_formals = [ {vdecl_type = Tstring; vdecl_name = "c"}; ];
641                       body = [];
642                     }];

```



```

642     {fdecl_type = Tvoid;
643       fdecl_name = "exit";
644       fdecl_formals = [ {vdecl_type = Tint; vdecl_name = "c"}; ];
645       body = [];
646     };
647
648
649     {fdecl_type = Tfile;
650       fdecl_name = "open_r";
651       fdecl_formals = [ {vdecl_type = Tstring; vdecl_name = "fn"}; ];
652       body = [];
653     };
654
655     {fdecl_type = Tfile;
656       fdecl_name = "open_w";
657       fdecl_formals = [ {vdecl_type = Tstring; vdecl_name = "fn"}; ];
658       body = [];
659     };
660
661     {fdecl_type = Tint;
662       fdecl_name = "read";
663       fdecl_formals = [ {vdecl_type = Tfile; vdecl_name = "f"}; {vdecl_type =
664         Tchar; vdecl_name = "a"}; ];
665       body = [];
666     };
667
668     {fdecl_type = Tint;
669       fdecl_name = "write";
670       fdecl_formals = [ {vdecl_type = Tfile; vdecl_name = "f"}; {vdecl_type =
671         Tchar; vdecl_name = "a"}; ];
672       body = [];
673     };
674   ] in (* Need to add builtin functions here *)
675   let init_scope = { parent = None; vars = []; } in
676   { funcs = init_funcs;
677     scope = init_scope;
678     retType = Tvoid;
679     in_func = false;
680   }
681
682 (* check the programc *)
683 let check_prog (prog: Stch_ast.program) : (Stch_cast.c_program) =
684   let env = init_env in
685   { Stch_cast.stmts = (List.map (fun x -> check_stmt x env) (fst prog));
686     Stch_cast.funcs = (List.map (fun x -> check_fdecl x env) (List.rev (snd prog)));
687     Stch_cast.syms = env.scope;
688   }

```

stch_cast.ml

```
1 open Stch_ast
2
3 type c_expr =
4   C_Int of int
5   | C_Float of float
6   | C_Char of char
7   | C_Escape of string
8   | C_Id of string * dataType
9   | C_String of string
10  | C_Binop of c_expr * op * c_expr
11  | C_Negate of c_expr
12  | C_Call of string * c_expr list
13  | C_Assign2 of string * c_expr
14  | C_Array_Index of string * c_expr * dataType
15  | C_Matrix_Index of string * c_expr * c_expr * dataType
16  | C_Array_Item_Assign of string * c_expr * c_expr
17  | C_Matrix_Item_Assign of string * c_expr * c_expr * c_expr
18  | C_Noexpr
19
20 type symTable = {
21   parent: symTable option;
22   mutable vars: (dataType * string * c_expr) list;
23 }
24
25 type c_vdecl = {
26   vdecl_type : dataType;
27   vdecl_name : string;
28 }
29
30 type c_arraydecl = {
31   arraydecl_type : dataType;
32   arraydecl_name : string;
33   arraydecl_size : expr;
34 }
35
36 type c_matrixdecl = {
37   matrixdecl_type : dataType;
38   matrixdecl_name : string;
39   matrixdecl_rows : expr;
40   matrixdecl_cols : expr;
41 }
42
43 type c_stmt =
44   C_Block of symTable * c_stmt list
45   | C_Vdecl of c_vdecl
46   | C_ArrayDecl of c_arraydecl
47   | C_ArrayInit of c_arraydecl * expr list
48   | C_MatrixInit of c_matrixdecl * expr list list
49   | C_MatrixDecl of c_matrixdecl
50   | C_Expr of dataType * c_expr
51   | C_Return of dataType * c_expr
52   | C_If of c_expr * c_stmt * c_stmt
53   | C_For of c_expr * c_expr * c_expr * c_stmt
54   | C_While of c_expr * c_stmt
```

```

55 (* stitch <var> from <start> to <end> by <stride>:<code>*)
56 | C_Stitch of c_expr * c_expr * c_expr * c_expr * string * c_stmt list * symTable
57 | C_Assign of c_vdecl * c_expr
58 | C_Break
59
60 type c_fdecl = {
61     fdecl_type    : dataType;
62     fdecl_name    : string;
63     fdecl_formals  : c_vdecl list;
64     body          : c_stmt list;
65 }
66
67 type stch_env = {
68     mutable funcs: c_fdecl list;
69     scope: symTable;
70     retType: dataType;
71     in_func: bool;
72 }
73
74 type c_program = {
75     stmts : c_stmt list;
76     funcs : c_fdecl list;
77     syms  : symTable;
78 }

```

c_generator.ml

```
1 (*
2 C Code Generator
3 December 2015
4 Authors: Dan Cole & Tim Waterman
5
6 Takes the CAST and Generates the corresponding C Code
7 *)
8
9 open Stch_ast
10 open Stch_cast
11 exception Error of string
12
13 let string_of_c_dataType = function
14   Tint -> "int"
15 | Tfloat -> "float"
16 | Tchar -> "char"
17 | Tvoid -> "void"
18 | Tstring -> "char *"
19 | Tintap -> "int"
20 | Tintam -> "int"
21 | Tfloatap -> "float"
22 | Tfloatam -> "float"
23 | Tfile -> "FILE *"
24
25 (* Generates the c code for the corresponding expression from our CAST *)
26 let rec string_of_c_expr = function
27   C.Int(l) -> string_of_int l
28 | C.Float(l) -> string_of_float l
29 | C.Char(l) -> "\"" ^ String.make 1 l ^ "\""
30 | C.Escape(l) -> "\"" ^ l ^ "\""
31 | C.Id(s, t) -> s
32 | C.String(s) -> "\"" ^ s ^ "\""
33 | C.Binop(e1, o, e2) ->
34   "(" ^ string_of_c_expr e1 ^ " " ^
35   (match o with
36     Add -> "+" | Subtract -> "-" | Times -> "*" | Divide -> "/"
37   | Equal -> "==" | Ne -> "!="
38   | Lt -> "<" | Le -> "<=" | Gt -> ">" | Ge -> ">="
39   | Or -> "||" | And -> "&&" | Mod -> "%" ) ^ " " ^
40   string_of_c_expr e2 ^ ")"
41 | C.Negate(e) -> "!" ^ string_of_c_expr e
42
43 (* For call, we need to match our various built-in functions *)
44 | C.Call(f, el) -> (match f with "print" -> "printf"
45   | "error" -> "fprintf"
46   | "open_r" -> "fopen"
47   | "open_w" -> "fopen"
48   | "read" -> "fread"
49   | "write" -> "fwrite"
50   | _ -> f) ^
51   "(" ^ String.concat ", " (match f with "print" -> print_2_fprint
52     (List.hd el)
53     | "error" ->
54       error_2_fprintf (List.
```

```

53 | hd el)
54 | "open_r" ->
55 |   open_2_fopen_r (List.
56 |     hd el)
57 | "open_w" ->
58 |   open_2_fopen_w (List.
59 |     hd el)
60 | "read" -> read_2_fread
61 |   el
62 | "write" ->
63 |   write_2_fwrite el
64 | -> List.map
65 |   (string_of_c_expr el) ^
66 |   ")")
67 | C.Assign2(i, e) -> i ^ " = " ^ string_of_c_expr e
68 | C.Array_Item_Assign(id, ind, e) -> id ^ "[" ^ string_of_c_expr ind ^ "]" = " ^
69 |   string_of_c_expr e
70 | C.Array_Index(a, i, t) -> a ^ "[" ^ string_of_c_expr i ^ "]"
71 | C.Matrix_Index(m, r, c, t) -> m ^ "[" ^ string_of_c_expr r ^ "]" ^
72 |   string_of_c_expr c ^ "]"
73 | C.Matrix_Item_Assign(m, r, c, e) -> m ^ "[" ^ string_of_c_expr r ^ "]" ^
74 |   string_of_c_expr c ^ "]" = " ^ string_of_c_expr e
75 | C.Noexpr -> ""
76
77 (* Converting from read to the C function fread() *)
78 and read_2_fread (el: c_expr list) =
79   let file = List.hd el in
80   let arr = List.hd (List.rev el) in
81   match file with
82   | C.Id(s, t) -> (match t with
83   | Tfile -> (match arr with
84   | C.Id(s', t') -> (s' ^ ", sizeof(" ^ s' ^ ")", sizeof(" ^
85   |   string_of_c_dataType t' ^ ")", " ^ s)::[]
86   | -> raise(Error("Invalid argument type for read: " ^
87   |   string_of_c_expr arr)))
88   | -> raise(Error("Invalid argument type for read: " ^
89   |   string_of_c_expr file)))
90   | -> raise(Error("Invalid argument for read: " ^ string_of_c_expr
91   |   file))
92
93 (* Converting for write to the C function fwrite() *)
94 and write_2_fwrite (el: c_expr list) =
95   let file = List.hd el in
96   let arr = List.hd (List.rev el) in
97   match file with
98   | C.Id(s, t) -> (match t with
99   | Tfile -> (match arr with
100   | C.Id(s', t') -> (s' ^ ", sizeof(" ^ s' ^ ")", sizeof(" ^
101   |   string_of_c_dataType t' ^ ")", " ^ s)::[]
102   | -> raise(Error("Invalid argument type for read: " ^
103   |   string_of_c_expr arr)))
104   | -> raise(Error("Invalid argument type for read: " ^
105   |   string_of_c_expr file)))
106   | -> raise(Error("Invalid argument for read: " ^ string_of_c_expr
107   |   file))
108
109 (* Converting the two open functions *)
110 and open_2_fopen_r (e: c_expr) = match e with

```

```

91     C_String(1) -> ("\" ^ 1 ^ "\", \"r+\") ::[]
92 | -> raise (Error("Invalid argument for open: \" ^ string_of_c_expr e))
93
94 and open_2_fopen_w (e: c_expr) = match e with
95 | C_String(1) -> ("\" ^ 1 ^ "\", \"w+\") ::[]
96 | -> raise (Error("Invalid argument for open: \" ^ string_of_c_expr e))
97
98 (* Generating print statements based on args *)
99 and print_2_fprint (e: c_expr) = match e with
100 | C_Int(1) -> ("\"%d\\n\", \" ^ string_of_c_expr e)::[]
101 | C_Float(1) -> ("\"%f\\n\", \" ^ string_of_c_expr e)::[]
102 | C_Char(1) -> ("\"%c\\n\", \" ^ string_of_c_expr e)::[]
103 | C_String(1) -> ("\"%s\\n\", \" ^ string_of_c_expr e)::[]
104 | C_Array_Index(a, i, t) -> (match t with
105 | Tint | Tintap | Tintam -> ("\"%d\\n\", \" ^ a ^
106 | Tfloat | Tfloatap | Tfloatam -> ("\"%f\\n\", \"
107 | Tchar -> ("\"%c\\n\", \" ^ a ^ \"[\" ^
108 | Tstring -> ("\"%s\\n\", \" ^ a ^ \"[\" ^
109 | Tvoid -> raise (Error("Invalid print type Void
110 | Tfile -> raise (Error("Invalid print type File
111 | C_Matrix_Index(m, r, c, t) -> (match t with
112 | Tint | Tintap | Tintam -> ("\"%d\\n\", \" ^ m ^
113 | Tfloat | Tfloatap | Tfloatam -> ("\"%f\\n\", \"
114 | Tchar -> ("\"%c\\n\", \" ^ m ^ \"[\" ^
115 | Tstring -> ("\"%s\\n\", \" ^ m ^ \"[\" ^
116 | Tvoid -> raise (Error("Invalid print type void
117 | Tfile -> raise (Error("Invalid print type file
118 | C_Id(1, t) -> (match t with
119 | Tint | Tintap | Tintam -> ("\"%d\\n\", \" ^ string_of_c_expr
120 | Tfloat | Tfloatap | Tfloatam -> ("\"%f\\n\", \" ^
121 | Tchar -> ("\"%c\\n\", \" ^ string_of_c_expr e)::[]
122 | Tstring -> ("\"%s\\n\", \" ^ string_of_c_expr e)::[]
123 | Tvoid -> raise (Error("Invalid print type Void: \" ^
124 | Tfile -> raise (Error("Invalid print type File: "))
125 | C_Binop(lhs, o, rhs) -> (match o with
126 | Add -> (match lhs with
127 | C_Int(1) -> ("\"%d\\n\", \" ^
128 | string_of_c_expr lhs ^ "+" ^
129 | string_of_c_expr rhs)::[]

```

```

132 | C_Float(1) -> ("\"%f\\n\", " ^
      string_of_c_expr lhs ^ "+" ^
      string_of_c_expr rhs)::[]
133 | C_Id(1, t) -> (match t with
134 | Tint | Tintap |
      Tintam ->
      ("\"%d\\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
135 | Tfloat | Tfloatap
      | Tfloatam ->
      ("\"%f\\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
136 | Tchar -> ("\"%c\\n
      \", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
137 | Tstring -> ("\"%s
      \\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
138 | Tvoid -> raise (
      Error(" Invalid
      print type Void:
      " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs))
139 | Tfile -> raise (
      Error(" Invalid
      print type File:
      ")))
140 | - -> raise (Error(" Invalid add in
      function call"))
141 )
142 | Subtract -> (match lhs with
143 | C_Int(1) -> ("\"%d\\n\", " ^
      string_of_c_expr lhs ^ "-" ^
      string_of_c_expr rhs)::[]
144 | C_Float(1) -> ("\"%f\\n\", " ^
      string_of_c_expr lhs ^ "-" ^
      string_of_c_expr rhs)::[]
145 | C_Id(1, t) -> (match t with
146 | Tint | Tintap |
      Tintam ->
      ("\"%d\\n\", "

```

```

147         string_of_c_expr
            lhs ^ "-" ^
            string_of_c_expr
            rhs)::[]
| Tfloat | Tfloatap
| Tfloatam ->
  ("\"%f\\n\", " ^

148         string_of_c_expr
            lhs ^ "-" ^
            string_of_c_expr
            rhs)::[]
| Tchar -> ("\"%c\\n
            \"\", " ^
            string_of_c_expr
            lhs ^ "-" ^
            string_of_c_expr
            rhs)::[]
149 | Tstring -> ("\"%s
            \\n\", " ^
            string_of_c_expr
            lhs ^ "-" ^
            string_of_c_expr
            rhs)::[]
150 | Tvoid -> raise (
            Error(" Invalid
            print type Void:
            " ^

            string_of_c_expr
            lhs ^ "-" ^
            string_of_c_expr
            rhs))
151 | Tfile -> raise (
            Error(" Invalid
            print type File:
            ")))
152 | - -> raise (Error(" Invalid add in
            function call"))
153 )
154 | Times -> (match lhs with
155   C_Int(1) -> ("\"%d\\n\", " ^
            string_of_c_expr lhs ^ "*" ^
            string_of_c_expr rhs)::[]
156 | C_Float(1) -> ("\"%f\\n\", " ^
            string_of_c_expr lhs ^ "*" ^
            string_of_c_expr rhs)::[]
157 | C_Id(1, t) -> (match t with
158   Tint | Tintap |
            Tintam ->
            ("\"%d\\n\", " ^

            string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs)::[]
159 | Tfloat | Tfloatap
            | Tfloatam ->

```



```

160         string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs)::[]
| Tchar -> ("\"%c\\n", " ^
            string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs)::[]
161 | Tstring -> ("\"%s
            \\n\", " ^
            string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs)::[]
162 | Tvoid -> raise (
            Error(" Invalid
            print type Void:
            " ^
            string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs))
163 | Tfile -> raise (
            Error(" Invalid
            print type File:
            ")))
164 | - -> raise (Error(" Invalid add in
            function call"))
165 )
166 | Divide -> (match lhs with
167   C_Int(1) -> ("\"%d\\n\", " ^
            string_of_c_expr lhs ^ "/" ^
            string_of_c_expr rhs)::[]
168 | C_Float(1) -> ("\"%f\\n\", " ^
            string_of_c_expr lhs ^ "/" ^
            string_of_c_expr rhs)::[]
169 | C_Id(1, t) -> (match t with
170   Tint | Tintap |
            Tintam ->
            ("\"%d\\n\", " ^
            string_of_c_expr
            lhs ^ "/" ^
            string_of_c_expr
            rhs)::[]
171 | Tfloat | Tfloatap
            | Tfloatam ->
            ("\"%f\\n\", " ^
            string_of_c_expr
            lhs ^ "/" ^
            string_of_c_expr
            rhs)::[]
172 | Tchar -> ("\"%c\\n", " ^
            string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs)::[]

```

```

173                                     \", \" ^
                                     string-of-c-expr
                                     lhs ^ \"/\" ^
                                     string-of-c-expr
                                     rhs)::[]
174 | Tstring -> (\"\\\"%s
                                     \\n\\\", \" ^
                                     string-of-c-expr
                                     lhs ^ \"/\" ^
                                     string-of-c-expr
                                     rhs)::[]
175 | Tvoid -> raise (
                                     Error(\" Invalid
                                     print type Void:
                                     \" ^
                                     string-of-c-expr
                                     lhs ^ \"/\" ^
                                     string-of-c-expr
                                     rhs))
176 | Tfile -> raise (
                                     Error(\" Invalid
                                     print type File:
                                     \"))
177 | _ -> raise (Error(\" Invalid add in
                                     function call\"))
178 )
179 | Equal -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \"==\" ^ string-of-c-expr rhs)::[]
180 | Ne -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \"!=\" ^ string-of-c-expr rhs)::[]
181 | Lt -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \"<\" ^ string-of-c-expr rhs)::[]
182 | Le -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \"<=\" ^ string-of-c-expr rhs)::[]
183 | Gt -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \">\" ^ string-of-c-expr rhs)::[]
184 | Ge -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \">=\" ^ string-of-c-expr rhs)::[]
185 | Or -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \"||\" ^ string-of-c-expr rhs)::[]
186 | And -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \"&&\" ^ string-of-c-expr rhs)::[]
187 | Mod -> (\"\\\"%d\\n\\\", \" ^ string-of-c-expr lhs ^
                                     \"%\" ^ string-of-c-expr rhs)::[]
188 )
189 | _ -> raise (Error(\" Invalid expr in print statement: \" ^ string-of-c-expr e))
190 (* Generating the error function based on parameters *)
191 and error_2_fprintf (e: c_expr) = match e with
192   C_Int(1) -> (\"stderr, \\\"%d\\n\\\", \" ^ string-of-c-expr e)::[]
193 | C_Float(1) -> (\"stderr, \\\"%f\\n\\\", \" ^ string-of-c-expr e)::[]
194 | C_Char(1) -> (\"stderr, \\\"%c\\n\\\", \" ^ string-of-c-expr e)::[]
195 | C_String(1) -> (\"stderr, \\\"%s\\n\\\", \" ^ string-of-c-expr e)::[]
196 | C_Id(1, t) -> (match t with
197   Tint | Tintap | Tintam -> (\"stderr, \\\"%d\\n\\\", \" ^
                               string-of-c-expr e)::[]
198 | Tfloat | Tfloatap | Tfloatam -> (\"stderr, \\\"%f\\n\\\", \" ^
                               string-of-c-expr e)::[]

```

```

199 | Tchar -> ("stderr, \"%c\\n\", " ^ string_of_c_expr e)::[]
200 | Tstring -> ("stderr, \"%s\\n\", " ^ string_of_c_expr e)
      ::[]
201 | Tvoid -> raise (Error("Invalid print type Void: " ^
      string_of_c_expr e))
202 | Tfile -> raise (Error("Invalid print type File: "))
203 | C_Binop(lhs, o, rhs) -> (match o with
204 |   Add -> (match lhs with
205 |     C_Int(l) -> ("stderr, \"%d\\n\", " ^
      string_of_c_expr lhs ^ "+" ^
      string_of_c_expr rhs)::[]
206 |     C_Float(l) -> ("stderr, \"%f\\n\", " ^
      string_of_c_expr lhs ^ "+" ^
      string_of_c_expr rhs)::[]
207 |     C_Id(l, t) -> (match t with
208 |       Tint | Tintap |
      Tintam -> ("
      stderr, \"%d\\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
209 |       Tfloat | Tfloatap
      | Tfloatam -> ("
      stderr, \"%f\\n
      \", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
210 |       Tchar -> ("stderr,
      \"%c\\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
211 |       Tstring -> ("
      stderr, \"%s\\n
      \", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
212 |       Tvoid -> raise (
      Error("Invalid
      print type Void:
      " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs))
213 |       Tfile -> raise (
      Error("Invalid
      print type File:
      "))
214 | - -> raise (Error("Invalid add in
      function call"))

```

```

215 )
216 | Subtract -> (match lhs with
217   C_Int(1) -> ("stderr , \"%d\\n\", " ^
                string_of_c_expr lhs ^ "-" ^
                string_of_c_expr rhs)::[]
218 | C_Float(1) -> ("stderr , \"%f\\n\", " ^
                string_of_c_expr lhs ^ "-" ^
                string_of_c_expr rhs)::[]
219 | C_Id(1, t) -> (match t with
220   Tint | Tintap |
                Tintam -> ("
                stderr , \"%d\\
                n\", " ^
                string_of_c_expr
                lhs ^ "-" ^
                string_of_c_expr
                rhs)::[]
221 | Tfloat | Tfloatap
                | Tfloatam -> ("
                stderr , \"%f\\n
                \", " ^
                string_of_c_expr
                lhs ^ "-" ^
                string_of_c_expr
                rhs)::[]
222 | Tchar -> ("stderr ,
                \"%c\\n\", " ^
                string_of_c_expr
                lhs ^ "-" ^
                string_of_c_expr
                rhs)::[]
223 | Tstring -> ("
                stderr , \"%s\\n
                \", " ^
                string_of_c_expr
                lhs ^ "-" ^
                string_of_c_expr
                rhs)::[]
224 | Tvoid -> raise (
                Error(" Invalid
                print type Void:
                " ^
                string_of_c_expr
                lhs ^ "-" ^
                string_of_c_expr
                rhs))
225 | Tfile -> raise (
                Error(" Invalid
                print type File:
                ")))
226 | - -> raise (Error(" Invalid add in
                function call"))
227 )
228 | Times -> (match lhs with
229   C_Int(1) -> ("stderr , \"%d\\n\", " ^
                string_of_c_expr lhs ^ "*" ^
                string_of_c_expr rhs)::[]
230 | C_Float(1) -> ("stderr , stderr , \"%f\\

```

```

231         n\", \" ^ string_of_c_expr lhs ^ \"*\"
232         ^ string_of_c_expr rhs)::[]
| C_Id(l, t) -> (match t with
| Tint | Tintap |
| Tintam -> (\"
| stderr, \"\%d\\
n\", \" ^
string_of_c_expr
lhs ^ \"*\" ^
string_of_c_expr
rhs)::[]
233 | Tfloat | Tfloatap
| Tfloatam -> (\"
| stderr, \"\%f\\n
\", \" ^
string_of_c_expr
lhs ^ \"*\" ^
string_of_c_expr
rhs)::[]
234 | Tchar -> (\"stderr,
\", \" ^
string_of_c_expr
lhs ^ \"*\" ^
string_of_c_expr
rhs)::[]
235 | Tstring -> (\"
| stderr, \"\%s\\n
\", \" ^
string_of_c_expr
lhs ^ \"*\" ^
string_of_c_expr
rhs)::[]
236 | Tvoid -> raise (
Error(\" Invalid
print type Void:
\" ^
string_of_c_expr
lhs ^ \"*\" ^
string_of_c_expr
rhs))
237 | Tfile -> raise (
Error(\" Invalid
print type File:
\")))
238 | - -> raise (Error(\" Invalid add in
function call\"))
239 )
240 | Divide -> (match lhs with
241 | C_Int(l) -> (\"stderr, \"\%d\\n\", \" ^
string_of_c_expr lhs ^ \"/\" ^
string_of_c_expr rhs)::[]
242 | C_Float(l) -> (\"stderr, \"\%f\\n\", \" ^
string_of_c_expr lhs ^ \"/\" ^
string_of_c_expr rhs)::[]
243 | C_Id(l, t) -> (match t with
244 | Tint | Tintap |
| Tintam -> (\"
| stderr, \"\%d\\

```

```

n\, " ^
string_of_c_expr
lhs ^ "/" ^
string_of_c_expr
rhs)::[]
245 | Tfloat | Tfloatap
| Tfloatam -> ("
stderr, \"%f\\n
\", " ^
string_of_c_expr
lhs ^ "/" ^
string_of_c_expr
rhs)::[]
246 | Tchar -> (" stderr,
\"%c\\n\", " ^
string_of_c_expr
lhs ^ "/" ^
string_of_c_expr
rhs)::[]
247 | Tstring -> ("
stderr, \"%s\\n
\", " ^
string_of_c_expr
lhs ^ "/" ^
string_of_c_expr
rhs)::[]
248 | Tvoid -> raise (
Error(" Invalid
print type Void:
" ^
string_of_c_expr
lhs ^ "/" ^
string_of_c_expr
rhs))
249 | Tfile -> raise (
Error(" Invalid
print type File:
"))
250 | - -> raise (Error(" Invalid add in
function call"))
251 )
252 | Equal -> (" stderr, \"%d\\n\", " ^
string_of_c_expr lhs ^ "==" ^ string_of_c_expr
rhs)::[]
253 | Ne -> (" stderr, \"%d\\n\", " ^ string_of_c_expr
lhs ^ "!=" ^ string_of_c_expr rhs)::[]
254 | Lt -> (" stderr, \"%d\\n\", " ^ string_of_c_expr
lhs ^ "<" ^ string_of_c_expr rhs)::[]
255 | Le -> (" stderr, \"%d\\n\", " ^ string_of_c_expr
lhs ^ "<=" ^ string_of_c_expr rhs)::[]
256 | Gt -> (" stderr, \"%d\\n\", " ^ string_of_c_expr
lhs ^ ">" ^ string_of_c_expr rhs)::[]
257 | Ge -> (" stderr, \"%d\\n\", " ^ string_of_c_expr
lhs ^ ">=" ^ string_of_c_expr rhs)::[]
258 | Or -> (" stderr, \"%d\\n\", " ^ string_of_c_expr
lhs ^ "|" ^ string_of_c_expr rhs)::[]
259 | And -> (" stderr, \"%d\\n\", " ^ string_of_c_expr
lhs ^ "&&" ^ string_of_c_expr rhs)::[]

```

```

260 | Mod -> ("stderr", "%d\\n", " ^ string_of_c_expr
      lhs ^ "%" ^ string_of_c_expr rhs)::[]
261 )
262 | _ -> raise (Error("Invalid expr in print statement: " ^ string_of_c_expr e))
263
264 (*
265 String of stitch expression is for use exclusively inside stitch loops.
266 It takes in a structname and a symbol table in addition to the corresponding
      expression.
267 The structname is used to prepend onto variables that exist inside the symtable (
      which means
268 that the variables are passed into the function externally)
269 *)
270 let rec string_of_stch_expr (structname: string) (table: symTable) (exp: c_expr) =
      match exp with
271 | C.Int(l) -> string_of_int l
272 | C.Float(l) -> string_of_float l
273 | C.Char(l) -> "\"" ^ String.make l l ^ "\""
274 | C.Id(s, t) -> (* structname ^ "->" ^ s *)
      if List.exists( fun(_,n,-) -> n = s) table.vars then
275     structname ^ "->" ^ s
276     else
277     s
278 | C.Escape(l) -> "\"" ^ l ^ "\""
279 | C.String(s) -> "\"" ^ s ^ "\""
280 | C.Binop(e1, o, e2) ->
      (string_of_stch_expr structname table e1) ^ " " ^
281     (match o with
282     | Add -> "+" | Subtract -> "-" | Times -> "*" | Divide -> "/"
283     | Equal -> "==" | Ne -> "!="
284     | Lt -> "<" | Le -> "<=" | Gt -> ">" | Ge -> ">="
285     | Or -> "||" | And -> "&&" | Mod -> "%" ) ^ " " ^
286     (string_of_stch_expr structname table e2)
287 | C.Negate(e) -> "!" ^ string_of_stch_expr structname table e
288 | C.Call(f, el) -> (match f with
289     | "print" -> "printf"
290     | "error" -> "fprintf"
291     | _ -> f) ^ "(" ^ String.concat ", " (match f with
292     | "print" -> print_2_fprintf (List.hd el) structname table
293     | "error" -> error_2_fprintf (List.hd el) | _ -> List.map string_of_c_expr
294     el) ^ ")"
295
296 (* Now we need to check to see if the id's are in the table *)
297 | C.Assign2(i, e) ->
      if List.exists( fun(_,s,-) -> s = i) table.vars then
298     structname ^ "->" ^ i ^ " = " ^ string_of_stch_expr structname table e
299     else
300     i ^ " = " ^ string_of_stch_expr structname table e
301 | C.Array.Item.Assign(id, ind, e) ->
      if List.exists( fun(_,s,-) -> s = id) table.vars then
302     structname ^ "->" ^ id ^ "[" ^ string_of_stch_expr structname table ind ^
303     "]" ^ " = " ^ string_of_stch_expr structname table e
304     else
305     id ^ "[" ^ string_of_stch_expr structname table ind ^
306     "]" ^ " = " ^ string_of_stch_expr structname table e
307 | C.Array.Index(a, i, t) ->
      if List.exists( fun(_,s,-) -> s = a) table.vars then
308     structname ^ "->" ^ a ^ "[" ^ string_of_stch_expr structname table i ^ "]"
309     else
310

```

```

313     a ^ "[" ^ string_of_stch_expr structname table i ^ "]"
314 | C_Matrix.Index(m, r, c, t) ->
315     if List.exists( fun(_,s,-) -> s = m) table.vars then
316         structname ^ "->" ^ m ^ "[" ^ string_of_stch_expr structname table r ^
317         "]" ^ string_of_stch_expr structname table c ^ "]"
318     else
319         m ^ "[" ^ string_of_stch_expr structname table r ^
320         "]" ^ string_of_stch_expr structname table c ^ "]"
321 | C_Matrix.Item.Assign(m, r, c, e) ->
322     if List.exists( fun(_,s,-) -> s = m) table.vars then
323         structname ^ "->" ^ m ^ "[" ^ string_of_stch_expr structname table r ^
324         "]" ^ string_of_stch_expr structname table c ^ "]" = " ^ string_of_stch_expr
325         structname table e
326     else
327         m ^ "[" ^ string_of_stch_expr structname table r ^
328         "]" ^ string_of_stch_expr structname table c ^ "]" = " ^ string_of_stch_expr
329         structname table e
330 | C_Noexpr -> ""
331
332 and print_2_fprint (e: c_expr) (structname: string) (table: symTable) = match
333     e with
334 | C_Int(1) -> ("\"%d\\n\", " ^ (string_of_stch_expr structname table e))::[]
335 | C_Float(1) -> ("\"%f\\n\", " ^ string_of_c_expr e)::[]
336 | C_Char(1) -> ("\"%c\\n\", " ^ string_of_c_expr e)::[]
337 | C_String(1) -> ("\"%s\\n\", " ^ string_of_c_expr e)::[]
338 | C_Array.Index(a, i, t) -> (match t with
339     Tint | Tintap | Tintam -> ("\"%d\\n\", " ^ a ^
340     "[" ^ string_of_c_expr i ^ "]" )::[]
341 | Tfloat | Tfloatap | Tfloatam -> ("\"%f\\n\", "
342     ^ a ^ "[" ^ string_of_c_expr i ^ "]" )::[]
343 | Tchar -> ("\"%c\\n\", " ^ a ^ "[" ^
344     string_of_c_expr i ^ "]" )::[]
345 | Tstring -> ("\"%s\\n\", " ^ a ^ "[" ^
346     string_of_c_expr i ^ "]" )::[]
347 | Tvoid -> raise (Error("Invalid print type Void
348     : " ^ a ^ "[" ^ string_of_c_expr i ^ "]" ))
349 | Tfile -> raise (Error("Invalid print type File
350     : " ))))
351 | C_Matrix.Index(m, r, c, t) -> (match t with
352     Tint | Tintap | Tintam -> ("\"%d\\n\", " ^ m ^
353     "[" ^ string_of_c_expr r ^ "]" ^
354     string_of_c_expr c ^ "]" )::[]
355 | Tfloat | Tfloatap | Tfloatam -> ("\"%f\\n\", "
356     ^ m ^ "[" ^ string_of_c_expr r ^ "]" ^
357     string_of_c_expr c ^ "]" )::[]
358 | Tchar -> ("\"%c\\n\", " ^ m ^ "[" ^
359     string_of_c_expr r ^ "]" ^
360     string_of_c_expr c ^ "]" )::[]
361 | Tstring -> ("\"%s\\n\", " ^ m ^ "[" ^
362     string_of_c_expr r ^ "]" ^
363     string_of_c_expr c ^ "]" )::[]
364 | Tvoid -> raise(Error("Invalid print type void
365     in matrix printing"))
366 | Tfile -> raise (Error("Invalid print type File
367     : " ))))
368 | C_Id(1, t) -> (match t with
369     Tint | Tintap | Tintam -> ("\"%d\\n\", " ^ (
370     string_of_stch_expr structname table e))::[]

```



```

355 | Tfloat | Tfloatap | Tfloatam -> ("\"%f\\n\", " ^
      string_of_stch_expr structname table e)::[]
356 | Tchar -> ("\"%c\\n\", " ^ string_of_c_expr e)::[]
357 | Tstring -> ("\"%s\\n\", " ^ string_of_c_expr e)::[]
358 | Tvoid -> raise (Error("Invalid print type Void: " ^
      string_of_c_expr e))
359 | Tfile -> raise (Error("Invalid print type File: "))
360 | C_Binop(lhs, o, rhs) -> (match o with
361     Add -> (match lhs with
362         C_Int(l) -> ("\"%d\\n\", " ^
      string_of_c_expr lhs ^ "+" ^
      string_of_c_expr rhs)::[]
363 | C_Float(l) -> ("\"%f\\n\", " ^
      string_of_c_expr lhs ^ "+" ^
      string_of_c_expr rhs)::[]
364 | C_Id(l, t) -> (match t with
365     Tint | Tintap |
      Tintam ->
      ("\"%d\\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
366 | Tfloat | Tfloatap
      | Tfloatam ->
      ("\"%f\\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
367 | Tchar -> ("\"%c\\n
      \", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
368 | Tstring -> ("\"%s
      \\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
369 | Tvoid -> raise (
      Error("Invalid
      print type Void:
      " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs))
370 | Tfile -> raise (
      Error("Invalid
      print type File:
      "))
371 | - -> raise (Error("Invalid add in
      function call"))

```

```

372 )
373 | Subtract -> (match lhs with
374   C_Int(1) -> ("\"%d\\n\", " ^
               string_of_c_expr lhs ^ "-" ^
               string_of_c_expr rhs)::[]
375 | C_Float(1) -> ("\"%f\\n\", " ^
                  string_of_c_expr lhs ^ "-" ^
                  string_of_c_expr rhs)::[]
376 | C_Id(1, t) -> (match t with
377   Tint | Tintap |
               Tintam ->
               ("\"%d\\n\", " ^
               string_of_c_expr
               lhs ^ "-" ^
               string_of_c_expr
               rhs)::[]
378 | Tfloat | Tfloatap
   | Tfloatam ->
   ("\"%f\\n\", " ^
   string_of_c_expr
   lhs ^ "-" ^
   string_of_c_expr
   rhs)::[]
379 | Tchar -> ("\"%c\\n
              \", " ^
              string_of_c_expr
              lhs ^ "-" ^
              string_of_c_expr
              rhs)::[]
380 | Tstring -> ("\"%s
                \\n\", " ^
                string_of_c_expr
                lhs ^ "-" ^
                string_of_c_expr
                rhs)::[]
381 | Tvoid -> raise (
   Error(" Invalid
   print type Void:
   " ^
   string_of_c_expr
   lhs ^ "-" ^
   string_of_c_expr
   rhs))
382 | Tfile -> raise (
   Error(" Invalid
   print type File:
   ")))
383 | - -> raise (Error(" Invalid add in
                    function call"))
384 )
385 | Times -> (match lhs with
386   C_Int(1) -> ("\"%d\\n\", " ^
               string_of_c_expr lhs ^ "*" ^
               string_of_c_expr rhs)::[]
387 | C_Float(1) -> ("\"%f\\n\", " ^
                  string_of_c_expr lhs ^ "*" ^

```

```

388         string_of_c_expr rhs)::[]
389     | C_Id(1, t) -> (match t with
                                Tint | Tintap |
                                Tintam ->
                                    ("\"%d\\n\", \" ^
                                        string_of_c_expr
                                        lhs ^ "*" ^
                                        string_of_c_expr
                                        rhs)::[]
390     | Tfloat | Tfloatap
        | Tfloatam ->
            ("\"%f\\n\", \" ^
                string_of_c_expr
                lhs ^ "*" ^
                string_of_c_expr
                rhs)::[]
391     | Tchar -> ("\"%c\\n
        \", \" ^
            string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs)::[]
392     | Tstring -> ("\"%s
        \\n\", \" ^
            string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs)::[]
393     | Tvoid -> raise (
        Error(" Invalid
        print type Void:
        \" ^
            string_of_c_expr
            lhs ^ "*" ^
            string_of_c_expr
            rhs))
394     | Tfile -> raise (
        Error(" Invalid
        print type File:
        \")))
395     | - -> raise (Error(" Invalid add in
        function call"))
396 )
397 | Divide -> (match lhs with
398     C_Int(1) -> ("\"%d\\n\", \" ^
        string_of_c_expr lhs ^ "/" ^
        string_of_c_expr rhs)::[]
399     | C_Float(1) -> ("\"%f\\n\", \" ^
        string_of_c_expr lhs ^ "/" ^
        string_of_c_expr rhs)::[]
400     | C_Id(1, t) -> (match t with
401         Tint | Tintap |
            Tintam ->
                ("\"%d\\n\", \" ^
                    string_of_c_expr

```

```

402         lhs ^ "/" ^
            string_of_c_expr
            rhs)::[]
        | Tfloat | Tfloatap
        | Tfloatam ->
            ("\"%f\\n\", " ^
            string_of_c_expr
            lhs ^ "/" ^
            string_of_c_expr
            rhs)::[]
403         | Tchar -> ("\"%c\\n
            \", " ^
            string_of_c_expr
            lhs ^ "/" ^
            string_of_c_expr
            rhs)::[]
404         | Tstring -> ("\"%s
            \\n\", " ^
            string_of_c_expr
            lhs ^ "/" ^
            string_of_c_expr
            rhs)::[]
405         | Tvoid -> raise (
            Error(" Invalid
            print type Void:
            " ^
            string_of_c_expr
            lhs ^ "/" ^
            string_of_c_expr
            rhs))
406         | Tfile -> raise (
            Error(" Invalid
            print type File:
            ")))
407         | - -> raise (Error(" Invalid add in
            function call"))
408     )
409     | Equal -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            "==" ^ string_of_c_expr rhs)::[]
410     | Ne -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            "!=" ^ string_of_c_expr rhs)::[]
411     | Lt -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            "<" ^ string_of_c_expr rhs)::[]
412     | Le -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            "<=" ^ string_of_c_expr rhs)::[]
413     | Gt -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            ">" ^ string_of_c_expr rhs)::[]
414     | Ge -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            ">=" ^ string_of_c_expr rhs)::[]
415     | Or -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            "||" ^ string_of_c_expr rhs)::[]
416     | And -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            "&&" ^ string_of_c_expr rhs)::[]
417     | Mod -> ("\"%d\\n\", " ^ string_of_c_expr lhs ^
            "%" ^ string_of_c_expr rhs)::[]
418     )
419     | - -> raise (Error(" Invalid expr in print statement: " ^ string_of_c_expr e))

```

```

420
421 and error_2_fprintf (e: c_expr) = match e with
422   C_Int(1) -> ("stderr, \"%d\\n\", " ^ string_of_c_expr e)::[]
423 | C_Float(1) -> ("stderr, \"%f\\n\", " ^ string_of_c_expr e)::[]
424 | C_Char(1) -> ("stderr, \"%c\\n\", " ^ string_of_c_expr e)::[]
425 | C_String(1) -> ("stderr, \"%s\\n\", " ^ string_of_c_expr e)::[]
426 | C_Id(1, t) -> (match t with
427   Tint | Tintap | Tintam -> ("stderr, \"%d\\n\", " ^
      string_of_c_expr e)::[]
428 | Tfloat | Tfloatap | Tfloatam -> ("stderr, \"%f\\n\", " ^
      string_of_c_expr e)::[]
429 | Tchar -> ("stderr, \"%c\\n\", " ^ string_of_c_expr e)::[]
430 | Tstring -> ("stderr, \"%s\\n\", " ^ string_of_c_expr e)
      ::[]
431 | Tvoid -> raise (Error("Invalid print type Void: " ^
      string_of_c_expr e))
432 | Tfile -> raise (Error("Invalid print type File: "))
433 | C_Binop(lhs, o, rhs) -> (match o with
434   Add -> (match lhs with
435     C_Int(1) -> ("stderr, \"%d\\n\", " ^
      string_of_c_expr lhs ^ "+" ^
      string_of_c_expr rhs)::[]
436 | C_Float(1) -> ("stderr, \"%f\\n\", " ^
      string_of_c_expr lhs ^ "+" ^
      string_of_c_expr rhs)::[]
437 | C_Id(1, t) -> (match t with
438   Tint | Tintap |
      Tintam -> ("
      stderr, \"%d\\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
439 | Tfloat | Tfloatap
      | Tfloatam -> ("
      stderr, \"%f\\n
      \", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
440 | Tchar -> ("stderr,
      \"%c\\n\", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
441 | Tstring -> ("
      stderr, \"%s\\n
      \", " ^
      string_of_c_expr
      lhs ^ "+" ^
      string_of_c_expr
      rhs)::[]
442 | Tvoid -> raise (
      Error("Invalid
      print type Void:

```

```

                                " ^
                                string_of_c_expr
                                lhs ^ "+" ^
                                string_of_c_expr
                                rhs))
443 | Tfile -> raise (
                                Error(" Invalid
                                print type File:
                                ")
                                )))
444 | - -> raise (Error(" Invalid add in
                                function call"))
445 )
446 | Subtract -> (match lhs with
447 | C_Int(1) -> (" stderr , \"%d\\n\", " ^
                                string_of_c_expr lhs ^ "-" ^
                                string_of_c_expr rhs)::[]
448 | C_Float(1) -> (" stderr , \"%f\\n\", " ^
                                string_of_c_expr lhs ^ "-" ^
                                string_of_c_expr rhs)::[]
449 | C_Id(1, t) -> (match t with
450 | Tint | Tintap |
                                Tintam -> ("
                                stderr , \"%d\\n\", " ^
                                string_of_c_expr
                                lhs ^ "-" ^
                                string_of_c_expr
                                rhs)::[]
451 | Tfloat | Tfloatap
                                | Tfloatam -> ("
                                stderr , \"%f\\n\", " ^
                                string_of_c_expr
                                lhs ^ "-" ^
                                string_of_c_expr
                                rhs)::[]
452 | Tchar -> (" stderr ,
                                \"%c\\n\", " ^
                                string_of_c_expr
                                lhs ^ "-" ^
                                string_of_c_expr
                                rhs)::[]
453 | Tstring -> ("
                                stderr , \"%s\\n\", " ^
                                string_of_c_expr
                                lhs ^ "-" ^
                                string_of_c_expr
                                rhs)::[]
454 | Tvoid -> raise (
                                Error(" Invalid
                                print type Void:
                                ")
                                ^
                                string_of_c_expr
                                lhs ^ "-" ^
                                string_of_c_expr
                                rhs))
455 | Tfile -> raise (

```

```

Error(" Invalid
print type File:
"))))
456 | - -> raise (Error(" Invalid add in
function call"))
457 )
458 | Times -> (match lhs with
459 | C_Int(l) -> (" stderr , \"%d\\n\" , " ^
string_of_c_expr lhs ^ "*" ^
string_of_c_expr rhs)::[]
460 | C_Float(l) -> (" stderr , stderr , \"%f\\n\" , " ^
string_of_c_expr lhs ^ "*" ^
string_of_c_expr rhs)::[]
461 | C_Id(l, t) -> (match t with
462 | Tint | Tintap |
Tintam -> ("
stderr , \"%d\\n\" , " ^
string_of_c_expr
lhs ^ "*" ^
string_of_c_expr
rhs)::[]
463 | Tfloat | Tfloatap
| Tfloatam -> ("
stderr , \"%f\\n\" , " ^
string_of_c_expr
lhs ^ "*" ^
string_of_c_expr
rhs)::[]
464 | Tchar -> (" stderr ,
\"%c\\n\" , " ^
string_of_c_expr
lhs ^ "*" ^
string_of_c_expr
rhs)::[]
465 | Tstring -> ("
stderr , \"%s\\n\" , " ^
string_of_c_expr
lhs ^ "*" ^
string_of_c_expr
rhs)::[]
466 | Tvoid -> raise (
Error(" Invalid
print type Void:
" ^
string_of_c_expr
lhs ^ "*" ^
string_of_c_expr
rhs))
467 | Tfile -> raise (
Error(" Invalid
print type File:
"))))
468 | - -> raise (Error(" Invalid add in
function call"))
469 )

```

```

470 | Divide -> (match lhs with
471 | C_Int(1) -> ("stderr, \"%d\\n\", " ^
      string_of_c_expr lhs ^ "/" ^
      string_of_c_expr rhs)::[]
472 | C_Float(1) -> ("stderr, \"%f\\n\", " ^
      string_of_c_expr lhs ^ "/" ^
      string_of_c_expr rhs)::[]
473 | C_Id(1, t) -> (match t with
474 | Tint | Tintap |
      Tintam -> ("
      stderr, \"%d\\n\", " ^
      string_of_c_expr
      lhs ^ "/" ^
      string_of_c_expr
      rhs)::[]
475 | Tfloat | Tfloatap
      | Tfloatam -> ("
      stderr, \"%f\\n
      \", " ^
      string_of_c_expr
      lhs ^ "/" ^
      string_of_c_expr
      rhs)::[]
476 | Tchar -> ("stderr,
      \"%c\\n\", " ^
      string_of_c_expr
      lhs ^ "/" ^
      string_of_c_expr
      rhs)::[]
477 | Tstring -> ("
      stderr, \"%s\\n
      \", " ^
      string_of_c_expr
      lhs ^ "/" ^
      string_of_c_expr
      rhs)::[]
478 | Tvoid -> raise (
      Error(" Invalid
      print type Void:
      " ^
      string_of_c_expr
      lhs ^ "/" ^
      string_of_c_expr
      rhs))
479 | Tfile -> raise (
      Error(" Invalid
      print type File:
      ")))
480 | - -> raise (Error(" Invalid add in
      function call"))
481 )
482 | Equal -> ("stderr, \"%d\\n\", " ^
      string_of_c_expr lhs ^ "==" ^ string_of_c_expr
      rhs)::[]
483 | Ne -> ("stderr, \"%d\\n\", " ^ string_of_c_expr
      lhs ^ "!=" ^ string_of_c_expr rhs)::[]
484 | Lt -> ("stderr, \"%d\\n\", " ^ string_of_c_expr

```



```

485         lhs ^ "<" ^ string_of_c_expr rhs)::[]
| Le -> ("stderr, \"%d\\n\\n\", " ^ string_of_c_expr
486       lhs ^ "<=" ^ string_of_c_expr rhs)::[]
| Gt -> ("stderr, \"%d\\n\\n\", " ^ string_of_c_expr
487       lhs ^ ">" ^ string_of_c_expr rhs)::[]
| Ge -> ("stderr, \"%d\\n\\n\", " ^ string_of_c_expr
488       lhs ^ ">=" ^ string_of_c_expr rhs)::[]
| Or -> ("stderr, \"%d\\n\\n\", " ^ string_of_c_expr
489       lhs ^ "||" ^ string_of_c_expr rhs)::[]
| And -> ("stderr, \"%d\\n\\n\", " ^ string_of_c_expr
490       lhs ^ "&&" ^ string_of_c_expr rhs)::[]
| Mod -> ("stderr, \"%d\\n\\n\", " ^ string_of_c_expr
491       lhs ^ "%" ^ string_of_c_expr rhs)::[]
492     )
493   | _ -> raise (Error("Invalid expr in print statement: " ^ string_of_c_expr e))
494
495
496 let string_of_c_vdecl vdecl = string_of_c_dataType vdecl.vdecl.type ^ " " ^ vdecl.
vdecl.name (* " " ^ vdecl.array_size ^ *)
497
498 let string_of_c_arraydecl arraydecl = string_of_c_dataType arraydecl.arraydecl.type
^ " " ^ arraydecl.arraydecl.name ^ "[" ^
499   string_of_c_expr arraydecl.arraydecl.size ^ "]"
500
501 (* print stitch variables will generate the C code to put the necessary variables
502   into the struct that gets passed to the pthread function. Most of these are
503   straightforward,
504   just copying the name into the struct. For matrices and arrays, we need to
505   generate special
506   pointer notation since we aren't copying these like the other variables
507   *)
508 let rec print_stitch_variables (seed: string) el = match el with
509 [] -> seed ^ "\\n"
510 | head::tail -> let (typ, name, exp) = head in
511   if exp = C_Noexpr then
512     print_stitch_variables (seed ^ (string_of_dataType typ) ^ " " ^ name ^
513       string_of_c_expr exp ^ ";\n") tail
514   else (match exp with
515     | C_Matrix_Index(nm,ro,col,dt) -> print_stitch_variables (seed ^ (
516       string_of_dataType typ) ^
517       " (* " ^ name ^ ")[" ^ string_of_c_expr col ^ "];\n") tail
518     | C_Array_Index(name, exp,typ) -> print_stitch_variables (seed ^
519       (string_of_dataType typ) ^ " *" ^ name ^ ";\n") tail
520     | _ -> raise(Error("How did we even get here?")) )
521
522 (* Assign stitch variables is like print_stitch_variables, except it generates the C
523   code to assign
524   the local variables into their counterparts in the structure that's passed in
525   It uses the same list and generates the same variables
526   *)
527 let rec assign_stitch_variables (seed: string) (structname: string) el = match el
528 with
529 [] -> seed ^ "\\n"
530 | head::tail -> let (typ, name, exp) = head in
531   assign_stitch_variables (seed ^ structname ^ "." ^ name ^ " = " ^ name ^ ";\n")
532     (structname) tail
533
534

```

```

527 (* This generates the loop after each stitch loops that will resolve the accumulator
    variables.
528 Right now this only works with int accumulators, as accumulators are unfinished at
    the time
529 of this submission
530 *)
531 let rec resolve_accums (seed: string) (structname: string) el = match el with
532 [] -> seed ^ "\n"
533 | head::tail -> let (typ, name, exp) = head in
534   (match typ with
535     (Tintap | Tfloatap) -> resolve_accums (seed ^ name ^ "+=" ^ structname ^ "." ^
        name ^ ";\n") structname tail
536   | _ -> resolve_accums seed structname tail)
537
538
539 let rec string_of_c_matrixlist (seed: string) el = match el with
540 [] -> seed ^ "}"
541 | head::tail -> string_of_c_matrixlist (seed ^ string_of_arraylist head ^ ",\n")
    tail
542
543 let string_of_c_matrixdecl m = string_of_c_dataType m.matrixdecl_type ^ " " ^ m.
    matrixdecl_name ^ "[" ^
544   string_of_expr m.matrixdecl_rows ^ "]" ^ string_of_expr m.matrixdecl_cols ^ "]"
545
546 (* Converts a stitch loop into a for loop that creates all the threading information
    .
547   Allocates the threadpool and the structpool, using the procedurally generated
    function suffix
548   *)
549 let convert_stitch_2_for var start s_end stride fname scope =
550 let size = string_of_c_expr s_end in
551 let threads = "\npthread_t *threadpool" ^ fname ^ " = malloc(NUMTHREADS * sizeof(
    pthread_t));\n" in
552
553 (* Assign the initial variables into the struct *)
554 let thread_assignment = "info" ^ fname ^ "[thread" ^ fname ^ ".begin = i;\n" ^
555   (assign_stitch_variables "" ("info" ^ fname ^ "[thread
556     " ^ fname ^ "]" scope.vars) ^
557   "if((" ^ string_of_c_expr var ^ " + 2*(" ^ size ^
558     "/NUMTHREADS)) > " ^ size ^ ") {\n" ^
559   "info" ^ fname ^ "[thread" ^ fname ^ ".end = " ^ size ^
560     ";\n" ^
561   string_of_c_expr var ^ " = " ^ size ^ ";\n" ^
562   "}\n" ^
563   "else {\n" ^
564   "info" ^ fname ^ "[thread" ^ fname ^ ".end = " ^
565     string_of_c_expr var ^ " + " ^ size ^ "/"
566     NUMTHREADS;\n" ^
567   "}\n" in
568
569 (* Code to generate the threadpool *)
570 let threadgen = "int e = pthread_create(&threadpool" ^ fname ^ "[thread" ^ fname ^ "],
    NULL, " ^ fname ^ ", &info" ^ fname ^ "[thread" ^ fname ^ "]);\n" ^
571   "if (e != 0) {\n" ^
572   "perror(\"Cannot create thread!\");\n" ^
573   "free(threadpool" ^ fname ^ "); //error, free the threadpool\n" ^
574   "exit(1);\n" ^
575   "}\n" in

```

```

571
572 (* Code that blocks and waits for the threads to finish *)
573 let threadjoin = "//loop and wait for all the threads to finish\n" ^
574   "for(" ^ string_of_c_expr var ^ " = 0; " ^ string_of_c_expr var ^
575   " < NUMTHREADS; " ^ string_of_c_expr var ^ "++) {\n" ^
576   "pthread_join(threadpool" ^ fname ^ "[" ^ string_of_c_expr var ^ "],\n" ^
577   "NULL);\n" ^
578   "}\n" in
579
580 (* The loop at the end to resolve any accumulators, if they were used *)
581 let accums = "//now we loop and resolve any accumulators\n" ^
582   "for(" ^ string_of_c_expr var ^ " = 0; " ^ string_of_c_expr var ^
583   " < NUMTHREADS; " ^ string_of_c_expr var ^ "++) {\n" ^
584   (resolve_accums "" ("info" ^ fname ^ "[" ^ string_of_c_expr var ^ "])\n" ^
585    scope.vars) ^
586   "}\n\n" in
587
588 let varinfo = "struct stch_rangeInfo" ^ fname ^ " *info" ^ fname ^ " = malloc(sizeof(\n" ^
589   struct stch_rangeInfo ^ fname ^ ") * NUMTHREADS);\n" in
590 let incr = string_of_c_expr s_end ^ "/" ^ "NUMTHREADS" in
591 let loop = threads ^ varinfo ^ "int thread" ^ fname ^ " = 0;\n" ^ "for(" in
592 loop ^ string_of_c_expr var ^ " = " ^ string_of_c_expr start ^ ";\n" ^
593   string_of_c_expr var ^ " < " ^
594   string_of_c_expr s_end ^ ";\n" ^ string_of_c_expr var ^ " = " ^ string_of_c_expr
595   var ^ "+" ^ incr ^
596   ") {\n" ^ thread_assignment ^ threadgen ^ "thread" ^ fname ^ "++;\n" ^ "}\n\n" ^
597   threadjoin ^ accums
598
599
600 (* String of c statements. The optional variable here is not ever used, but I'm
601   afraid to take it out
602   right before we submit in case it breaks anything
603   *)
604 let rec string_of_c_stmt ?structname:(structname="") (st: c_stmt)= match st with
605 | C.Block(_, stmts) ->
606   "{\n" ^ String.concat "" (List.map (string_of_c_stmt ~structname:"hello")
607   stmts) ^ "}\n"
608 | C.Expr(_, e) -> string_of_c_expr e ^ ";\n";
609 | C.Vdecl(v) -> string_of_c_dataType v.vdecl_type ^ " " ^ v.vdecl_name ^ ";\n";
610 | C.Return(_, c_expr) -> "return " ^ string_of_c_expr c_expr ^ ";\n";
611 | C.If(e, s, C.Block(_, [])) -> "if (" ^ string_of_c_expr e ^ ")\n" ^
612   string_of_c_stmt s
613 | C.If(e, s1, s2) -> "if (" ^ string_of_c_expr e ^ ")\n" ^
614   string_of_c_stmt s1 ^ "else\n" ^ string_of_c_stmt s2
615 | C.For(e1, e2, e3, s) ->
616   "for (" ^ string_of_c_expr e1 ^ " ; " ^ string_of_c_expr e2 ^ " ; " ^
617   string_of_c_expr e3 ^ ") " ^ string_of_c_stmt s
618 | C.While(e, s) -> "while (" ^ string_of_c_expr e ^ ") " ^ string_of_c_stmt s
619 | C.Stitch(var, start, s_end, stride, fname, scope) -> convert_stitch_2_for
620   var start s_end stride fname scope
621 | C.Assign(v, e) -> string_of_c_vdecl v ^ " = " ^ string_of_c_expr e ^ ";\n"
622 | C.ArrayDecl(a) -> string_of_c_arraydecl a ^ ";\n"
623 | C.ArrayInit(arraydecl, el) -> string_of_c_arraydecl arraydecl ^ " = {" ^ String.
624   concat ", " (List.map string_of_c_expr el) ^ "};\n"
625 | C.MatrixDecl(m) -> string_of_c_matrixdecl m ^ ";\n"
626 | C.MatrixInit(mdecl, li) -> string_of_c_matrixdecl mdecl ^ " = " ^
627   string_of_c_matrixlist "{ " li ^ " };\n"
628 | C.Break -> "break;"
629
630

```

```

617
618 (* This function will take in a structname, a symtable, and a list of statements.
619    It will check to see if the statements need to be prepended with the structname
        by
620    checking the symtable, and do so if it needs to
621    This function is only for stitch loops *)
622
623 let rec string_of_stch_stmt (structname: string) (table: symTable) (st: c_stmt) =
        match st with
624 | C_Block(_, stmts) ->
625     "{\n" ^ String.concat "" (List.map (string_of_stch_stmt structname table)
        stmts) ^ "}\n"
626 | C_Expr(_, e) -> string_of_stch_expr structname table e ^ ";\n";
627 | C_Vdecl(v) -> (* string_of_c_dataType v.vdecl.type ^ " " ^ v.vdecl_name ^ ";\n";
        *)
628     if List.exists( fun(_,s,-) -> s = v.vdecl_name) table.vars then
629         string_of_c_dataType v.vdecl.type ^ " " ^ structname ^ "->" ^ v.vdecl_name
        ^ ";\n"
630     else
631         string_of_c_dataType v.vdecl.type ^ " " ^ v.vdecl_name ^ ";\n"
632 | C_Return(_, c_expr) -> "return " ^ string_of_c_expr c_expr ^ ";\n";
633 | C_If(e, s, C_Block(_, [])) -> "if (" ^ string_of_stch_expr structname table e ^
634     ")\n" ^ string_of_stch_stmt structname table s
635 | C_If(e, s1, s2) -> "if (" ^ string_of_stch_expr structname table e ^ ")\n" ^
636     string_of_stch_stmt structname table s1 ^ "else\n" ^ string_of_stch_stmt
        structname table s2
637 | C_For(e1, e2, e3, s) ->
638     "for (" ^ string_of_stch_expr structname table e1 ^ " ; " ^
        string_of_stch_expr structname table e2 ^
639     " ; " ^ string_of_stch_expr structname table e3 ^ ") " ^
        string_of_stch_stmt structname table s
640 | C_While(e, s) -> "while (" ^ string_of_stch_expr structname table e ^ ") " ^
        string_of_stch_stmt structname table s
641 | C_Stitch(var, start, s_end, stride, fname, body, scope) -> convert_stitch_2_for
        var start s_end stride fname scope
642
643 (* Assign doesn't need to be checked, it is a variable declaration *)
644 | C_Assign(v, e) ->
645     string_of_c_vdecl v ^ " = " ^ string_of_stch_expr structname table e ^ ";\n"
646
647 (* Array declarations don't need to be checked for struct addition *)
648 | C_ArrayDecl(a) ->
649     string_of_c_arraydecl a ^ ";\n"
650
651 (* Array inits do not need to be checked for symtable locations *)
652 | C_ArrayInit(a, el) ->
653     string_of_c_arraydecl a ^ " = {" ^ String.concat ", " (List.map string_of_expr
        el) ^ "};\n"
654
655 (* Matrix declarations don't need to be checked *)
656 | C_MatrixDecl(m) -> (* string_of_c_matrixdecl m ^ ";\n" *)
657     string_of_c_matrixdecl m ^ ";\n"
658
659 | C_MatrixInit(mdecl, li) -> string_of_c_matrixdecl mdecl ^ " = " ^
        string_of_c_matrixlist "{ " li ^ "};\n"
660 | C_Break -> "break;"
661
662

```

```

663 (* Stitch to func will turn the contents of the stitch loop into a function that is
    passed through
664 to each thread. This will properly generate the for loop that runs at the top of
    the function,
665 with each thread starting and ending at locations determined by the initial
    division of labor
666 *)
667 let rec stitch2func = function
668   C.Block(_, stmts) ->
669     String.concat "" (List.map stitch2func stmts)
670 | C.If(e, s, C.Block(_, [])) -> stitch2func s
671 | C.If(e, s1, s2) -> stitch2func s2
672 | C.For(e1, e2, e3, s) -> stitch2func s
673 | C.While(e, s) -> stitch2func s
674 | C.Stitch(var, start, s_end, stride, fname, body, scope) ->
675   let inner = String.concat "\n" (List.map ((string_of_stch_stmt "((struct
    stch_rangeInfo" ^ fname ^ " *)vars)")) scope) body) in
676   "struct stch_rangeInfo" ^ fname ^ " {\n" ^ "int begin;\n" ^ "int end;\n" ^ "int
    stepSize;\n" ^
677   (print_stitch_variables "" scope.vars) ^ "\n};\n\n" ^ "void *" ^ fname ^ " (
    void *vars) {\n" ^
678   "int " ^ (string_of_c_expr var) ^ " = 0;\n for(" ^ (string_of_c_expr var) ^ " = ((
    struct stch_rangeInfo" ^
679   fname ^ " *)vars)->begin; " ^ (string_of_c_expr var) ^ " < ((struct stch_rangeInfo" ^
    fname ^
680   " *)vars)->end; " ^ (string_of_c_expr var) ^ "++) {\n" ^ inner ^ "\n}\nreturn (
    void*)0;\n}\n"
681 | _ -> ""
682
683 let string_of_stitch func = String.concat "" (List.map stitch2func func.body)
684
685 let string_of_c_fdecl fdecl = match fdecl.fdecl_name with
686   "main" -> ""
687 | _ -> string_of_c_dataType fdecl.fdecl_type ^ " " ^ fdecl.fdecl_name ^ "(" ^
688   String.concat ", " (List.map string_of_c_vdecl fdecl.fdecl_formals) ^ ")\n{\n" ^
689   String.concat "" (List.map string_of_c_stmt fdecl.body) ^ "}\n"
690
691
692 let string_of_main fdecl = match fdecl.fdecl_name with
693   "main" -> string_of_c_dataType fdecl.fdecl_type ^ " " ^ fdecl.fdecl_name ^ "(" ^
694   String.concat ", " (List.map string_of_c_vdecl fdecl.fdecl_formals) ^ ")\n{\n" ^
695   String.concat "" (List.map string_of_c_stmt fdecl.body) ^ "}\n"
696 | _ -> ""
697
698 let string_of_vars (_, s, _) = s
699
700 let string_of_c_program (prog : Stch_cast.c_program) =
701   String.concat "" (List.map string_of_c_stmt prog.stmts) ^ "\n" ^
702   String.concat "\n" (List.map string_of_c_fdecl prog.funcs) ^ "\n" ^
703   String.concat "\n" (List.map string_of_stitch prog.funcs) ^ "\n" ^
704   String.concat "\n" (List.map string_of_main prog.funcs) ^ "\n"

```

stitch.ml

```
1 (*-----*)
2 (* Parse and print the program *)
3 (*-----*)
4
5 let filename = Sys.argv.(1) ^ ".c" in
6
7 let in_channel = open_in Sys.argv.(1) in
8
9 let lexbuf = Lexing.from_channel in_channel in
10
11 let program = Stch_parser.program Stch_scanner.token lexbuf in
12 let finalcast = Stch_semantic.check_prog program in
13 let outprog = C_generator.string_of_c_program finalcast in
14
15 let headers = "#include \"stch_headers.h\"\n\n" ^ outprog
16   in Printf.fprintf (open_out filename) "%s" headers
```

Makefile

```
1 OBJS = stch_ast.cmo stch_parser.cmo stch_scanner.cmo stch_semantic.cmo c_generator.  
      cmo stitch.cmo  
2  
3 YACC = ocamlyacc  
4  
5 stitch: $(OBJS)  
6     ocamlc -o stitch $(OBJS)  
7  
8 stch_scanner.ml: stch_scanner.mll  
9     ocamllex stch_scanner.mll  
10  
11 stch_parser.ml stch_parser.mli: stch_parser.mly  
12     $(YACC) -v stch_parser.mly  
13  
14 %.cmo: %.ml  
15     ocamlc -c $<  
16  
17 %.cmi: %.mli  
18     ocamlc -c $<  
19  
20 .PHONY: clean  
21 clean:  
22     rm -f stitch stch_parser.ml stch_parser.mli stch_scanner.ml \  
23         *.cmo *.cmi *.out *.diff *.output stitch *.dSYM  
24  
25 .PHONY: all  
26 all: clean stitch  
27  
28 c_generator.cmo : stch_cast.cmi stch_ast.cmo  
29 c_generator.cmx : stch_cast.cmi stch_ast.cmx  
30 stch_ast.cmo :  
31 stch_ast.cmx :  
32 stch_parser.cmo : stch_ast.cmo stch_parser.cmi  
33 stch_parser.cmx : stch_ast.cmx stch_parser.cmi  
34 stch_scanner.cmo : stch_parser.cmi  
35 stch_scanner.cmx : stch_parser.cmx  
36 stch_semantic.cmo : stch_cast.cmi stch_ast.cmo  
37 stch_semantic.cmx : stch_cast.cmi stch_ast.cmx  
38 stitch.cmo :  
39 stitch.cmx :  
40 stch_parser.cmi : stch_ast.cmo  
41 stch_cast.cmi : stch_ast.cmo
```