COMSW4115 Programming Language & Translators

Final Project

MASL

Multi-Agent
Simulation
Language

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MASL OVERVIEW

WHAT & WHY

Motivation

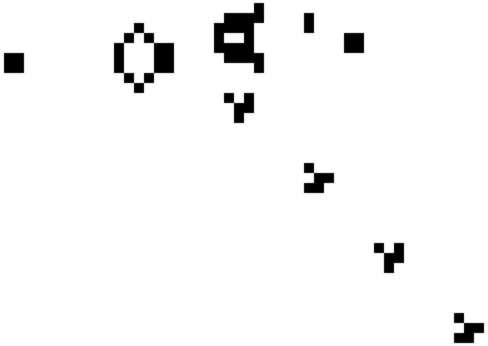
The Agent-Based Model (ABM)

- A system where the interactions between autonomous agents (individuals) are simulated
- Global patterns and effects of such interactions as a whole can be observed and assessed
- Example: Game of Life (as a cellular automaton), Boids, Heatbugs
- Applications: Physical world reality simulation, cryptology, etc.

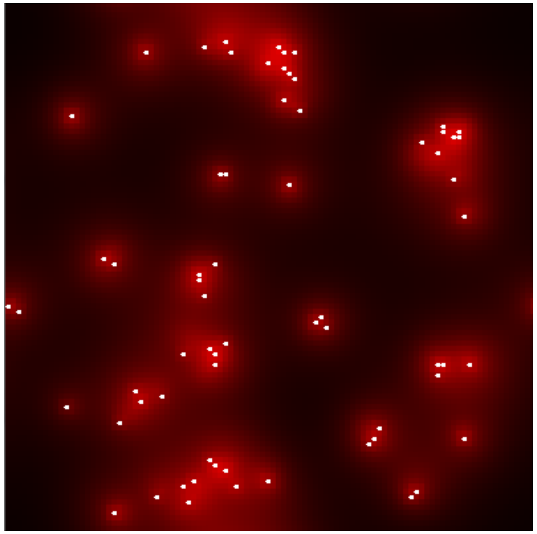
Motivation

Examples of cellular automata

- Conway's Game of Life



- Heatbugs



Motivation

MASL – Multi-Agent Simulation Language

- ❖ Facilitate building ABMs without having to start from scratch or engaging complex domain toolkits
- ❖ Particularly, we focus on developing cellular automata.

Features of MASL

- Imperative programming language
- Static and strong typing system
- Functions as first class objects
- Compound types supported: objects and lists
- Objects as state machines
- Simple simulation environment

Features of MASL

Why state machines?

- ❖ Each individual in the system will act according its observation of local environment as well as its inner state. State machines are a perfect model for this.

What is a simulation?

- ❖ In a simulation, individuals will update themselves (take actions) and visually illustrated. All these individuals will be represented using objects and stored in lists for the simulation environment to step through.

A SHORT TUTORIAL

ON MASL

Basic Data Types & Lists

Basic Data Types

- Integer (32-bit) `int i = 19;`
- Double (64-bit) `double pi = 31.4e-1;`
- Char `char c = ‘a’;`
- Boolean `bool flag = true;`

Lists

- Defining a list `[int] fib = [int] {1, 1, 2, 3, 5, 8};`
- A string is essentially a list of char elements:

```
[char] str = “hello world”;
```

Functions as First Class Objects

Functions in MASL can be stored in variables, and used like a variable.

```
int max(int a, int b) {
    if (a > b) {
        return a;
    }

    return b;
}

fun ((int, int):int) f = max;
```

Objects as State Machines

An class consists of

- Any number of statements that defines members of its instances and does initialization upon instantiation (equivalent to a constructor), and
- Any number of states.

```
class Guard {

    state Defend {
        if(enemySighted()) this->Attack;
    }

    state Attack {
        if(!enemyEliminated()) shot();
        else this->Defend;
    }

    bool enemySighted() { /*...*/ }
    bool enemyEliminated() { /*...*/ }
}
```

An object is an instance of a class.

```
Class Guard g = class Guard();
if(g@Attack) { /*...*/ }
```

More on Lists

Lists are able to accommodate elements of any data types.

```
[class Programmer] team = /*...*/;

[[double]] matrix = {
    [double] { 1, 0, 0}
    [double] { 0, 1, 0}
    [double] { 0, 0, 1}
};
```

A `for`-loop using list iterator:

```
for (int n : list) {
    sum = sum + n;
}
```

Equivalent to:

```
for (int i = 0; i < list.size(); i = i + 1) {
    sum = sum + list:[i];
}
```

Functions can be applied to elements of a list.

```
int n = list:.count(fun (int n):bool { return n > 3; });
```

MASL Simulation

A MASL program is essentially a simulation. Currently we only support the simulation of cellular machines.

```
class Cell {
    /* ... */
}

[class Cell] container;

/* Fill in the container. */

// Set the attributes of the simulation environment.
cellSize = 10;
nx = 100;
ny = 100;
interval = 100;

run(container);
```

Code Sample

Greatest Common Divider

```
int gcd(int a, int b) {
    if (b == 0) {
       return a;
         }
    else {
       return gcd(b, a % b);
   }
}

printInt(gcd(2,14));
```

Filtering a list

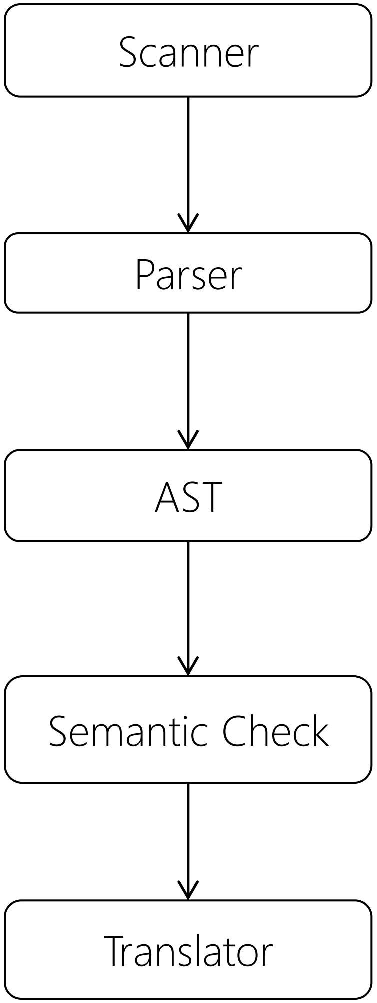
```
bool isEvenNum(int num) {
    return (num%2 == 0);
}

[int] list = [int]{1, 2, 3, 4, 5, 6};
[int] evenList = list:.filter(isEvenNum);
for(int i : evenList) {
    printInt(i);
}
```

DEVELOPING

MASL

Compiler Implementation

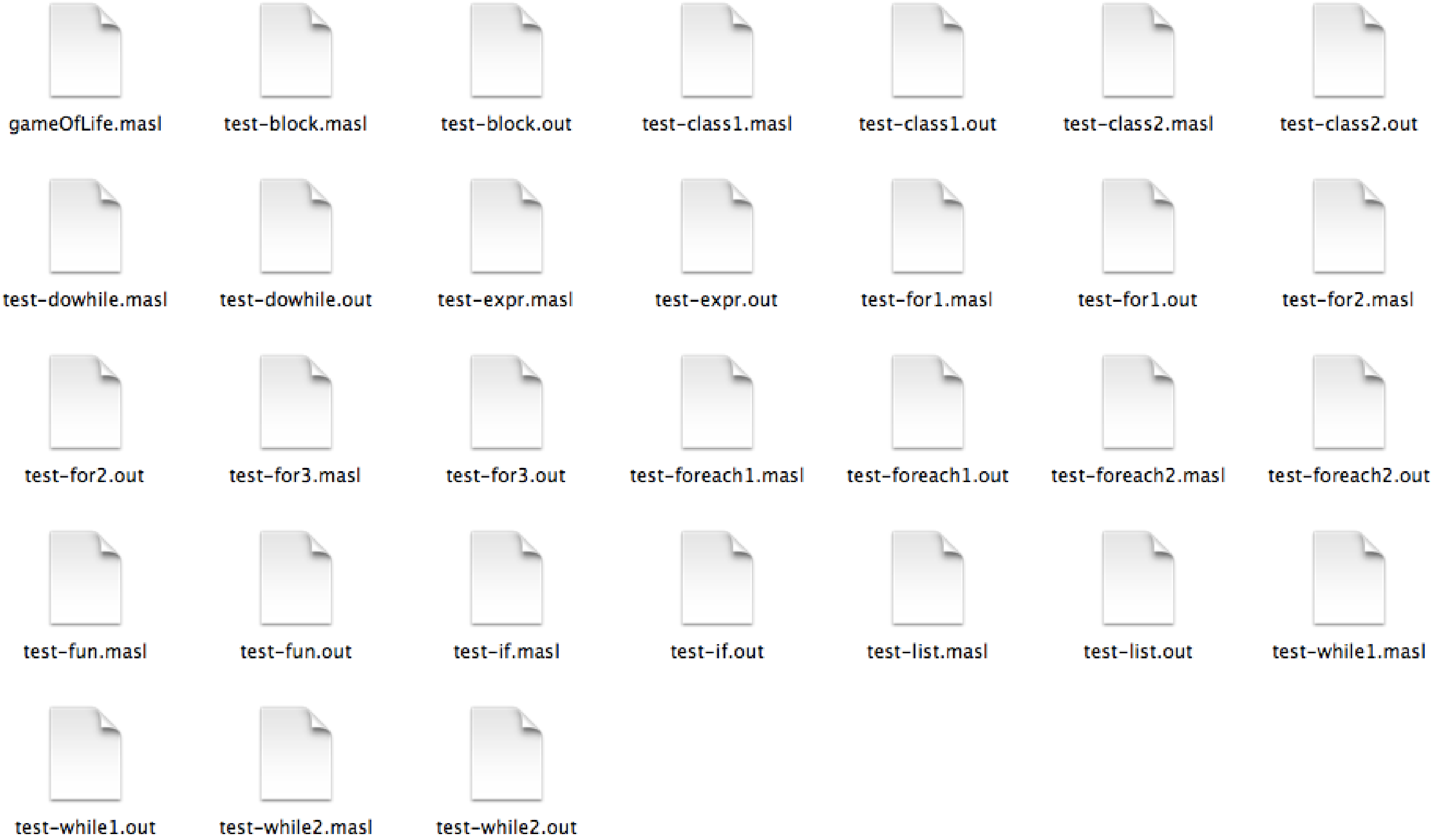
- Scanner recognizes the tokens
- Parser checks the syntax correctness of the token strings building up the program
- AST is generated after parsing
- Check the semantic correctness of the program
- Translate MASL into Java source, and then compile it into Java bytecode



Java Classes for Runtime Support

`MaslList`	Base class of all MASL list types.
`MaslFunction`	Base class of all MASL function types.
`MaslClass`	Base class of all MASL class types.
`MaslSimulation`	Base class of MASL simulation environment.

Unit Tests for Individual Features



gameOfLife.masl
test-block.masl
test-block.out
test-class1.masl
test-class1.out
test-class2.masl
test-class2.out
test-dowhile.masl
test-dowhile.out
test-expr.masl
test-expr.out
test-for1.masl
test-for1.out
test-for2.masl
test-for2.out
test-for3.masl
test-for3.out
test-foreach1.masl
test-foreach1.out
test-foreach2.masl
test-foreach2.out
test-fun.masl
test-fun.out
test-if.masl
test-if.out
test-list.masl
test-list.out
test-while1.masl
test-while1.out
test-while2.masl
test-while2.out

SUMMARY

LESSONS LEARNED

COLLABORATION

- ❖ A repository on GitHub was established for the collaboration of this project.
- ❖ Establish code framework and module-wide interfaces first, then divide the work and develop in parallel.
- ❖ Exchange ideas in group meetings or communicate with instant messaging tools while coding.
- ❖ Each member is responsible for an individual part and has good knowledge about others’ work.

PROJECT PLAN

- Start simple. Start early.
- Experiment with code while designing the language.
- Interfaces between modules should be well defined from the beginning.
- Perform unit tests frequently and thoroughly.
- Expect failure to implement some features…