JO - JSON Object Language

Reference Manual

Team

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1. INTRODUCTION

JSON or JavaScript Object Notation is an open standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs. It is used as lightweight data interchange format to transmit data between a server and web application. JSON is also emerging as a preferred format in "NoSQL" databases. While languages like Python and Java have libraries to handle JSON data, they are not a native aspect of the language. JSON is presently a data format, rather than something fundamental to the language, like the object of an object oriented language, or the function of a functional language. With rise of trends in Big Data, Internet of Things, No-SQL databases, we believe that our language can provide a platform for building applications for these technologies with ease.

JO is simple yet powerful language to handle and manipulate JSON data. The language will treat JSON object as first class citizens and provide built-in functions that operate on these objects. These basic functions can be used to define complex libraries and applications like merging JSON, finding diff in JSON, SQL like queries on JSON objects. Our language attempts to facilitate any data operations by handling a lot of the business logic of handling JSON and their manipulations under the hood, and allowing the programmer to use JSON in a more native and intuitive way.

2. Language Tutorial

2.1 Program Execution

All programs in JO require a main function. The main function is called first upon executing a program and has no return statement.

```
func main ()
        [your code]
end
```

To Compile and run a JO program, run the following shell script:

To compile and run a JO program, run the following script:

```
./runjo.sh <file-name>
```

2.2 Variable Initialization

Variables are declared using the "=" sign. The type is inferred and does not need to be specified upon declaration. The following is an example declaration of each type supported in JO.

String	a = "Hello World"
Number	b = 10
JSON	c = #{"name":"harsha"}#
List	d = [4,6,"seven"]
Boolean	e = true
null	f = null

2.3 Operators

2.3.1 Basic Operators

The following comparison operators work on all data types.

If a = 3 and b = 2:

Equality	a == b	returns false
Not Equals	a != b	returns true

JO supports mathematical operations on Numbers.

Addition	a ++ b	returns 5
Subtraction	a -- b	returns 1
Multiplication	a ** b	returns 6
Division	a // b	returns 1.5
Modulo	a %% b	returns 1
Greater Than	a > b	returns true
Less Than	a < b	returns false

Greater Than Equal To	a >= b	return true
Less Than Equal To	a <= b	return false

Strings can be concatenated together into one string.

If a = "Hello " and b = "World"

String Concatenation	a ++ b	returns "Hello World"

Lists can be concatenated together into one list.

If a = ["a", "b", "c"] and b = ["d"]

List Concatenation	a ++ b	returns ["a", "b", "c", "d"]

Multiple variables can be concatenated together to form one list where each variable is an element of that list.

If a = "a" and b = ["b", "c"]

List Concatenation	a + b	returns ["a", ["b", "c"]]

Any data type can be printed to standard out using the print function. If a JSON is printed, the print function "pretty prints" the JSON.

If a = 5 and b = #{"name":"harsha","courses":[1,"PLT",true]}#

Print Number	print(a)	prints: 5

Print JSON	print (b)	prints:
		{
		    "courses":[
		    1,
		    "PLT",
		    true
		    ],
		    "name":"harsha"
		}

Print List	print([1,2,3])	[1,2,3]

2.3.2 Operations on Non-Primitive Types

To access an element in a JSON, use "[]" following the JSON, with the string key inside the "[]".

If a = #{"name":"harsha","courses":[1,"PLT",true]}#

Element Access	a["name"]	returns: "harsha"

To access an element in a List, use "[]" following the List, with the index key inside the "[]". The indexes start with 0 and goes till List length minus one.

If a = [1,2,3,4]

Element Access	a[1]	returns: 2

To assign an element in a JSON, you access the key using the above notation and then use the assignment operator "=" to assign an element to that key.

If a = #{"a":"b"}#

Element Assignment	a["c"] = "d"	results in the JSON: #{"a":"b", "c":"d"}#

To remove an Element from a JSON, you can use JSON - "string key"

If a = #{"a":"b", "c":"d"}#

Element Removal	a - "c"	results in the JSON: #{"a":"b"}#

To remove an Element from a List, you can use LIST - element or LIST - LIST

If a = ["a", "b", "c"] , b = ["b", "c"] , d = "c"

Element Removal	a - d	results in the List: ["a", "c"]
List Removal	a - b	results in the List: ["a"]

To see the data type contained within a JSON, use the typeStruct function. This returns a string that shows the entire JSON, with each element being replaced by a string of its data type.

If a = #{"name":"harsha", "number":12223, "list":[], "json":{"name":"harsha"}, "boolean":true}#

typeStruct	a.typeStruct	results in the String: { String : String, String : Number, String : List, String : { String : String }, String : Boolean }

2.4 Control Flow

JO contains if...else statements to control whether a block of code executes. close if..else.. statements with the keyword "end".

if (5 == 5)
   print ("true")
else
  print ("false")
end
	prints: true

```
l = [1,2,3,4]
if (5 in l)
    print ("true")
else
   print ("false")
end
```

prints: false

JO contains a for loop. For loops operate by iterating over each element in a list. Close for loops with the keyword "end"

If a = [2,3,4]

```
for i in a
    print (i)
end
```

prints:
234

2.5 Function Declaration

Use the "func" keyword to define a function. The format is: func functionName(arguments). Close functions with the keyword "end".

Below is an example of the GCD algorithm being defined.

```
func findGCD(a,b)
    if(b == 0)
        return a
    end
    return findGCD(b, a%%b)
end
```

3. Language Manual

3.1 Introduction

JSON or JavaScript Object Notation is an open standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs. It is used as lightweight data interchange format to transmit data between a server and web application. JSON is also emerging as a preferred format in "NoSQL" databases. While languages like Python and Java have libraries to handle JSON data, they are not a native aspect of the language. JSON is presently a data format, rather than something fundamental to the language, like the object of an object oriented language, or the function of a functional language. With rise of trends in Big Data, Internet of Things, No-SQL databases, we believe that our language can be provide a platform for building applications for these technologies with ease.

JO is simple yet powerful language to handle and manipulate JSON data. The language will treat JSON object as first class citizens and provide built-in functions that operate on these objects. These basic functions can be used to define complex libraries and applications like merging JSON, finding diff in JSON, SQL like queries on JSON objects. Our language attempts to facilitate any data operations by handling a lot of the business logic of handling JSON and their manipulations under the hood, and allowing the programmer to use JSON in a more native and intuitive way.

3.2 Lexical Convention

3.2.1 Comments

The characters /* introduce a multi-line comment, which terminates with the characters */. Multi-line comments cannot be nested within multi-line comments. Single line comments are also written in the same way as multi-line comments, with /* and */ appearing on the same line.

```
/* single line comments look like this */

/* this is

    how a multiple

    line comment looks like */


/* this however

  /* does not */

  works */
```

3.2.2 Tokens

A token is a string of ASCII characters that is always at least 1 character long. There are different types of tokens in JO. These are described below.

3.2.2.1 Identifiers
An identifier consists of a letter followed by other letters, digits and underscores. The letters are the ASCII characters a-z and A-Z. Digits are ASCII characters 0-9. The language is case sensitive. An identifier can not begin with "loopVar".

letter → [‘a’-‘z’ ‘A’-‘Z’]

digit → [‘0’-‘9’]

underscore → ‘_’

identifier → letter (letter | digit | underscore)*

3.2.2.2 Keywords
Keywords are identifiers reserved by the language. Thus, they are not available for re-definition or overloading by users.

Keyword	**Description**
Number, String, Bool, Json, List	Data types
true, false, null	Literals
for, if , else, elsif , end	statement constructs
func, return	function declaration constructs
print type typestruct read makeString	in-built functions

3.2.2.3 Literals
Literals are expressions with fixed value. In the language there is capability for String, Number, Bool literals

digit → [‘0’-‘9’]

decimal → ‘.’

String Literal → (.)+

Number Literal → (-)? (digit)+ (decimal)? (digit)+

Bool Literal → true | false

3.2.2.4 Newlines
"EOL" is taken as a newline character.

3.2.2.5 Whitespace
Whitespace consists of any sequence of blank and tab characters. Whitespace is used to separate tokens and format programs. The compiler ignores all whitespace. As a result, indentations are insignificant.

3.3. Types and Type Inference

3.3.1 Primitive Types

There are four types of primitives in JO language. These are Bool, Number, String and Null.

3.3.1.1 Bool

Bool type can either carry a value of true or false. Booleans are considered their own type, meaning that an expression that uses a boolean operator and a non-boolean variable will cause an error. For example -

```
a = true

If (a && 10) will cause error.
```

3.1.2 Number

A Number in JO is a double- precision floating-point format storing numbers in 64 bits, where the number (the fraction) is stored in bits 0 to 51, the exponent in bits 52 to 62, and the sign in bit 63:1.7E +/- 308 (15 digits). All numeric types will be stored as Number in JO. Hence, Number contains decimal part by default.

3.3.1.3 String

A string is a sequence of characters surrounded by double quotes ‘‘ ’’.

3.3.1.4 Null

null is an empty data type. For example -

```
a = null
```

3.3.2 Non-Primitive Types

There are two types of non-primitive types or complex data types in JO Language. They are explained below -

3.3.2.1 List

List is an ordered data type of primitive or complex data types. So a list can contain another list as one of its element along with JSON type as element and other Primitive types as elements in the list. Lists are enclosed in []. For example

```
["apple", 45, {"name":"harris"} ]
```

3.3.2.2 JSON

JSON or JavaScript Object Notation is an open standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs. JSON is declared within '#' character, ##.

For example -

```
#{
"Name": { "First":"Arpit", "Last":"Gupta" },
"School": "Columbia",
"Age": 22,
"Courses": [ "PLT", "ML" ]
}#
```

3.3.3 Type Inference

Data types in JO are expressed using a finite and well-defined set of data types. However when writing a JO program, the data types are not explicitly declared. JO has dynamic type-inference. Assignment statement can update the type of a datatype.

```
func test(l)
      print (l – “d”)
      return null
end

func main ()
      e = [“a”,”c”,’d”]
      test(e)
      e = 5
end
```

3.4. Operators

3.4.1 Type of Operators

3.4.1.1 Object Operators

Operator	Description
+	Concatenation, works on any data type arguments, returns list Example 1. 5 + 2 = [5 , 2] 2. [5, 2] + 3 = [[5, 2] , 3] 3. JsonA + JsonB = [JsonA, JsonB]
-	Usage : *A* - *B*, works when *A* is a Json or List Removes attributes from A which exactly matches with B Valid Data types - • Json - String (here Operand B acts on the key of Json, rather than Json itself) • List - List (removes the list if it exists as an element in other List) • List - String • List - Json • List - Number Example 1. { {“name”: {first:chase, last:larson}}, marks: [2,3]} - "name" = {marks: [2,3]} 2. ["able", ["barista", "carrie"]] - ["barista", "carrie"] = ["able"] 3. ["able", "barista", "carrie"] - ["barista", "carrie"] = ["able", "barista", "carrie"]
[]	1. [ ] access values for attributes. Works on Json and List objects • a = json1["Name"] , returns the value at the attribute. • json1["Name"] = "Arpit" , stores value "Arpit" for attribute "Name" • a = list1[2], returns 3rd element stored in List • list1[3] = #{"name" : "arpit"}#, stores Json object at index 3, size of list at this time must be greater than equal to 4. 2. [ ] - constructs a new list
==	Compare two same data types. Returns true if their values match else false
!=	Compare two same data types. Returns false if their values match else true
=	Assignment Operator Usage: A = B, where A is a object and B is an expression
.	Calls function on an object
#{}#	Constructs a Json object

3.4.1.2 Mathematical Operators

All Mathematical Operators are only valid for Type Number.

Operator	Description	Example
++	Addition	2 ++ 2 results in 4
--	Subtraction	2 -- 2 results in 0
**	Multiplication	2 ** 2 results in 4
//	Division	2 // 2 results in 1
>	Greater Than	2 > 1 results in true
<	Less Than	2 < 1 results in false
%%	Modulo	7 % 3 results in 1

3.4.1.3 String Operators

Operator	Description	Example
++	String concatenation	"JS" ++ "ON" results in "JSON"

3.4.1.4 List Operators

Operator	Description	Example
++	List concatenation	[1] ++ [2] results in [1 , 2]

3.4.1.5 Logical Operators

All Logical Operators only valid for type Bool.

Operator	Description	Example
&&	Logical And	if A and B are true, (A && B) is true
||	Logical Or	if A or B are true, (A || B) is true
!	Logical Negation	if A is false, !A is true

3.4.1.6 Membership Operators

Operator	Description	Example
in	Results in true if variable is in given list	A in B: results in true if variable A is found in list B.
not in	Results in true if variable is not in given list	A not in B: results in true if variable A is not found in list B

3.4.2 Operator Precedence

All operators are evaluated left to right except !, in and not in. !, in and not in have right associativity

The below sequence of operator is in decreasing order of precedence. The operators on the same line have same precedence.

in , not in , !

+ , -

* *, //

< , > , <= , >= , %%

== , !=

&& , ||

3.5. Expressions

An expression contains at least one operand and zero or more operators that return a value. Operands may be constants, variables, and functions.

Parentheses can be used to group sub-expressions, with the innermost sub-expression being evaluated first. For example -

(2 ++ 2) // ((3 -- 1) ** 2)

3 -- 1 is evaluated to 2 first. Then 2 ++ 2 and 2 ** 2 are both evaluated to 4. Finally 4 // 4 is evaluated resulting in 1.

3.5.1 Function Declaration

The declaration specifies the name of the function, list of parameters

The *func* keyword is used signify the declaration of a function. The general form is:

```
func <function_name> (<parameters>)

    <function_body>

   return <arg>

end
```

The keyword *func* must be followed by a space, with the *function name* following. Then the list of *parameters* must be on the same line and enclosed by parentheses. The parameters are separated by commas. Following the closing parentheses, a new line must start before the *function body*.

The *function body* is a series of statements that specifies what the function actually does. It must be on a new line following the function declaration. The function body must contain a *return* statement.

The *return statement* is the keyword *return* followed by the expression to be returned from the function. For a function that should not return anything, it should return null. main() function is not required to have a return statement.

For example:

```
func sum(x, y)

   return ( x ++ y)

end
```

3.5.2 Function Call

You call a function by using its name and supplying any required parameters. If no parameters are required by the function, the parenthesis is still required.

General Form:

<function_name> (<parameters>)

For example:

```
foo (5, A)
```

Here the function ‘foo’ is called with the parameters ‘5’ and ‘A’ (here ‘A’ is a variable that has been declared previously).

3.6. Statements

You write statements to cause action and to control flow within your program.

3.6.1 Assignment Statement

An assignment statement consists of a modifiable variable name followed by the assignment operator “=” followed by a valid expression.

```
/* declares a json*/
var = #{ “name” : “Arpit Gupta” , “role” : “Language Guru” } #

/* declares a list*/

var = [ “Arpit” , “Abhinav”  , “Harsha” , “Chase” ]
```

3.6.2 Expression Statement

An expression statement executes the specified expression.

For example -

    2 ++ 3

    foo (2, 3)

Expression statements are useful when they have some sort of side effect, such as calling a function or storing a variable.

3.6.3 If...else… statement

The *if … else* statement is used to execute part of your program only under certain conditions. The general form is:

```
if (<condition>)
     <then-statement(s)>

else if (<condition>)
     <then-statement(s)>
     end
else
     <else-statement>

end
```

The *then-statement* is executed if the condition evaluates to true. The else statement is optional, and it executes only if the condition evaluates to false.

The *condition* must be on the same line and immediately following the *if* keyword. The *condition* must be a boolean expression.

The *then statement* must start on a new line following the <condition>. If an *else* clause is included, the else statement must be on its own line and the *else statement* must be on a new line following the *else* keyword.

The entire statement must terminate with the *end* keyword.

3.6.4 For statement

The *for* statement is used to iterate over list, executing a block of code. The general form is:

```
for <iterative expression>
  <statement>
end
```

The iterative expression must be of the form:

```
<variable> in <List>
```

The *statement* is executed once for each element in the list. The iterative expression must be on the same line as the keyword *if*. The *statement* must be on a new line following the iterative expression. The statement must end with the keyword *end*.

For example -

```
listVar = [1,2,3]

for x in listVar

     y = x ++ 1   /* increment value by one and stores in y */

end
print(x)
/*throws error as x is not defined outside the scope of for */
```

3.7. Scope

For example, the following program results in an error:

If an object or variable is declared within a function, if-else or a for statement block then it is only visible

```
globalVar = 5

func test()

      for x in varList

         if (x > 1)

            y = x

         end

         z = y

      end

      globalVar = 55  /* Not allowed globalVar are constant */

end
```

within that block. Otherwise, the object or variable is visible across the program.

The variable *y* only has scope within the *if* block, because that is the smallest block within which it is declared. The NUMBER z cannot be assigned to the NUMBER y, because the program can't "see" the y outside of the *if* statement.

3.8. Built-in Functions

JO provides utility functions which assists in JSON manipulation. Below are the functions built-in the language.

3.8.1 Read

By using the read function one can read file from specified path. This file will be parsed and returned as a Json Object. Individual elements in the file have to be comma separated. Each file is parsed into one List.

Below is the file contents of file “path/to/file.txt”

3.8.2 Write

```
{“name”:”harsha” , “itemList”:[1,”PLT”,true]}
```

```
input = write(varName , “path/to/file.txt”) /* appends to file */
```

Write function always append to the file whose path is specified.

3.8.3 Print

Print function prints to standard output. Print can take any type as input. If the input is a JSON object then the print function outputs a pretty print of JSON object.

```
print (<expr>) /* prints to standard output */

print (a)
```

3.8.4 Type

Type returns a String of the data type of a variable.

8.5 TypeStruct

This is a utility function built inside JSON. It returns a String containing the data type of the attribute-values stored in JSON object.

```
/* Find Json attribute-value data types */

myJSON = #{ "name": { "first": "chase", "last": "larson" }, "age" :
23 }#

myJSON.typeStruct() /* returns String of  { String : { String:
String, String: String}, String: Number } */
```

3.8.6 AttrList

This is a utility function built inside JSON. It returns a List of String containing the keys in Json Object

```
/* */

myJSON = { "name": { "first": "chase", "last": "larson" }, "age" :
23 }

myJSON.attrList() /* returns the List [“name” , “last”] */
```

3.8.7 makeString

makeString takes any data type supported in JO as input and returns a String data type.

```
/* Convert to String */

makeString(5) /* returns “5” */

makeString(aJson)
```

4. Project Plan

4.1 Process

4.1.1 Planning

Weekly meetings were held to discuss what aspects of the project needed to completed next. These meetings were held both in person and over Google Hangout. During these meetings we discussed the status of the project and outlined what needed to be accomplished next. Each member was then assigned to complete part of what was outlined.

4.1.2 Specification

All aspects of the LRM were discussed during group meetings and then the work of writing what was discussed was divided between the team members. After the LRM was completed and the development process began, there were many times that some ambiguity needed to be cleared or that certain elements of the specification needed to be changed. These changes were discussed in our meetings and noted.

4.1.3 Development

For development, we utilized Git to allow each member to develop independently. We first worked to get one complete feature, print, functioning end-to-end. Once we had this feature fully implemented, we looked at our LRM and prioritized each feature. We then iterated over fully implementing each feature.

4.1.4 Testing

As each feature was developed, a unit test was created to test the full implementation of the feature. Because we had different members working on the front end and back end of each feature, we also ran independent tests on the front and back end. The front end checked to make sure the correct c++ code was generated and the back end checked to make sure that the c++ code generated produced the correct final output. Testing on multiple levels allowed members to work on the same feature at different paces.

4.2 Style Guide

As this was the first project we had done using OCaml, we did not initially have a style guide. As time went on, several style practices were adopted to maximize readability and minimize the time required for a team member to understand new code.

- Variables and functions are declared using camel case.
- File names are written in Pascal case.
- Use utility functions to minimize function length.
- All necessary headers should be included in the CPlusPlusCompiler.h file. This file would then be the only file required to include.

4.3 Software Environment

Environments used for Development: Mac OS X, Ubuntu.

Languages used in Development: OCaml, C++.

Version Control: Git hosted on github.

Other Tools: Bash shell scripts, Makefiles.

4.3 Team Roles

To help make sure the project went forward efficiently, we assigned each team member a role. The member in this role was given the final say when it came to topics that fell under their role. We also assigned a backup to each role. This was done just in case a situation arose where a team member was unable to fulfil their role at a given time. These roles were especially important in the early stages of the project as we discussed the details of the language, the environment we would use, and the plan for how we would go forward with the work.

Members assigned to each role:

Role	Main	Backup
Manager	Chase	Abhinav
Language Guru	Arpit	Chase
System Architect	Abhinav	Sriharsha
Verification & Validation	Sriharsha	Arpit

When it came to writing code, we divided the code into 2 sections: front end (the scanner, parser and type inference) and back end (generation of c++).

Members that were primarily responsible for these sections:

Front End:	Abhinav, Sriharsha
Back End:	Arpit, Chase

4.4 Timeline

The table below shows when the major milestones were complete.

Date	Milestone
2014-09-24	Proposal Due
2014-10-27	LRM Due
2014-11-16	Full Scanner and Parser
2014-11-23	"Hello World" program
2014-12-12	GCD program
2014-12-17	Final Project Due

The following 2 charts show when code was being pushed to the repository and how substantial the changes were. The first shows the number of commits that were pushed per day over time. The second shows the number of lines of code that were added and deleted over time.

Fig. 1: Commits over time.

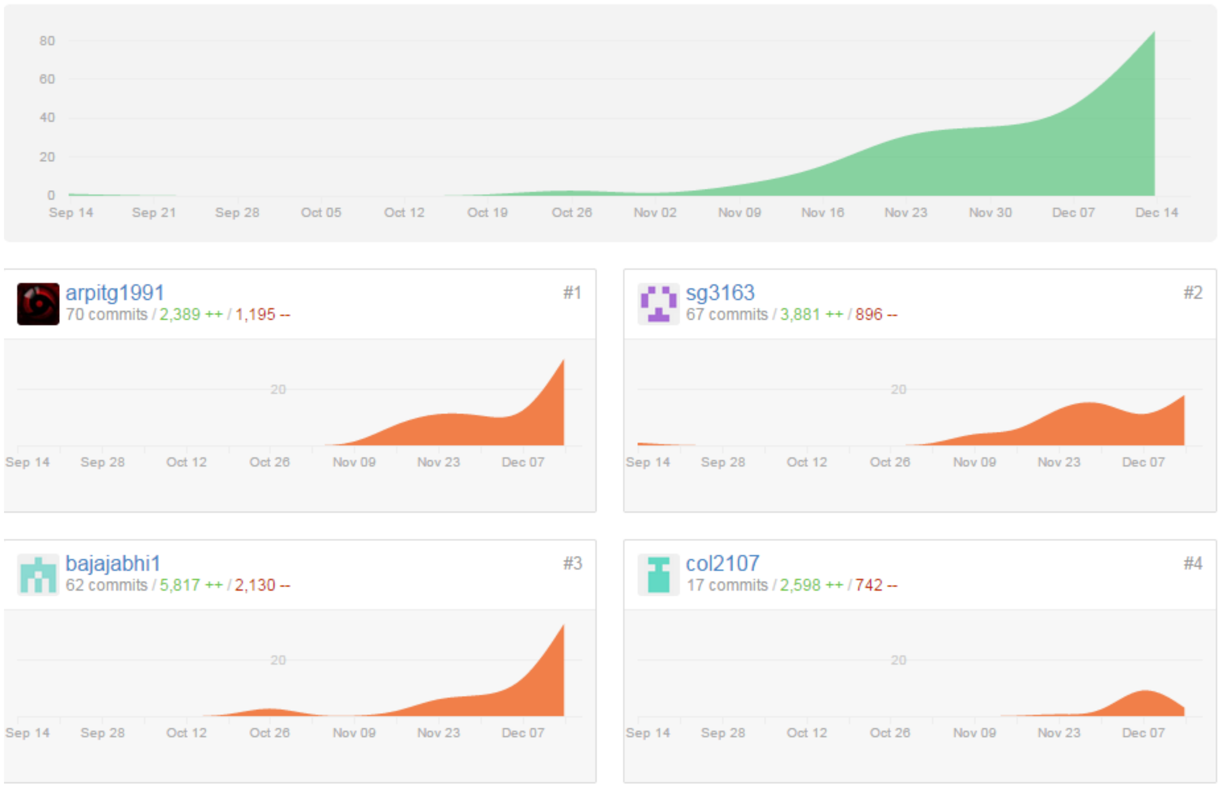
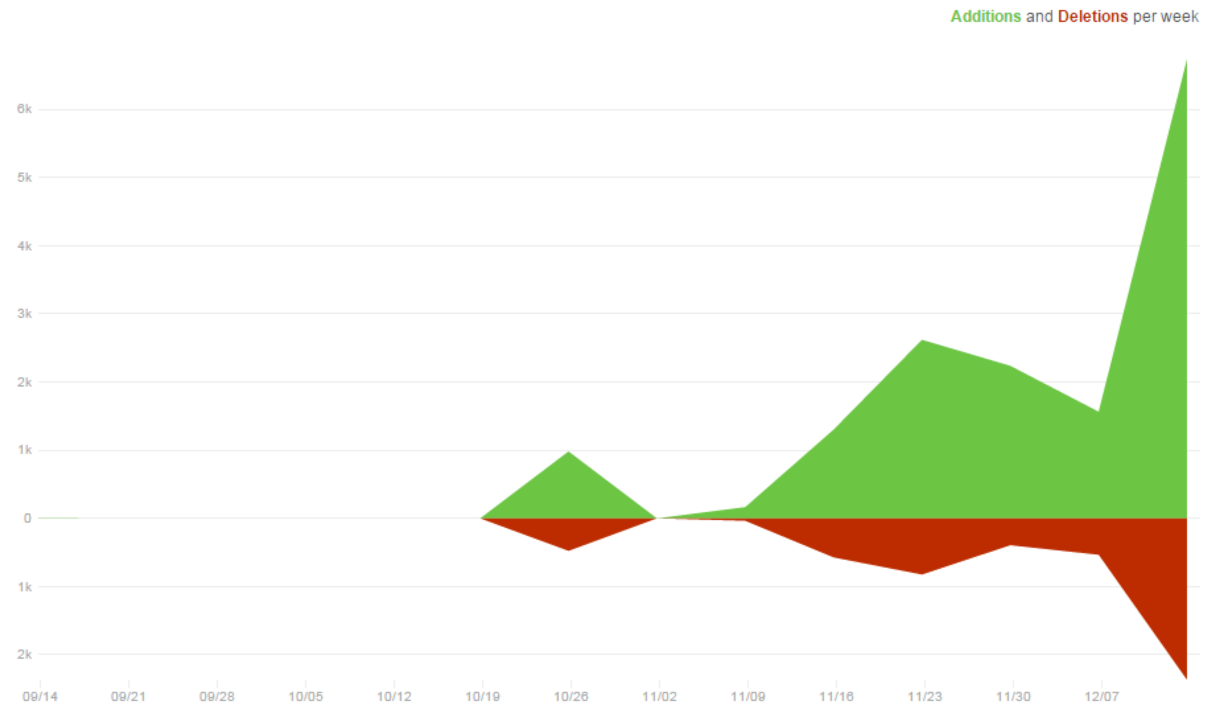


Fig. 2: Additions and Deletions over time.



4.5 Project Log

The following is the git log showing the date, author, and subject of each commit.

```
2014-12-17 - arpitg1991 - Code Freeze. May the force be with you!.
2014-12-17 - arpitg1991 - Code Freeze. Tonight we dine in hell.
2014-12-17- Sriharsha Gundappa - merged code
2014-12-17- Sriharsha Gundappa - reading-test-cases
2014-12-17 - arpitg1991 - updated file read
2014-12-17 - bajajabhi1 - merging after ocaml was drunk
2014-12-17 - bajajabhi1 - ocaml is drunk and prints 5 to 5.
2014-12-17 - arpitg1991 - trying to revert back again, once more
2014-12-17 - bajajabhi1 - adding analyzer file
2014-12-17 - bajajabhi1 - merged
2014-12-17 - bajajabhi1 - changed filename of typecheck to analyzer
2014-12-17 - arpitg1991 - Merging g branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-17 - arpitg1991 - reverting back to plder style of attribute list
2014-12-17 - bajajabhi1 - reverting incorrect change
2014-12-17 - bajajabhi1 - added negative num support and sample prog for data proc
2014-12-17 - bajajabhi1 - added support for float numbers
2014-12-17 - bajajabhi1 - added support for float
2014-12-17 - Sriharsha Gundappa - Some more test cases
2014-12-17 - Sriharsha Gundappa - more test cases
2014-12-17 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall
merged
2014-12-17 - Sriharsha Gundappa - Test cases for Concatenation and Negation Operators
2014-12-17 - bajajabhi1 - mergedMerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-17 - bajajabhi1 - added dataprocessing example
2014-12-17 - Abhinav Bajaj - changing Merge.jo, changing getAttrList(), it works, it works
2014-12-17 - Abhinav Bajaj - Merging g branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-17 - Abhinav Bajaj - Now attrlist works in for statements too, Phew
2014-12-16 - Sriharsha Gundappa - Custom Function and Element Access
2014-12-16 - Sriharsha Gundappa - Comparison and Mathematical Operators
2014-12-16 - Sriharsha Gundappa - Comparison and Mathematical Operators
2014-12-16 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall
merging
2014-12-16 - Sriharsha Gundappa - Nested if and for
2014-12-16 - bajajabhi1 - clean up
2014-12-16 - bajajabhi1 - clean up
2014-12-16 - Arpit Gupta - Merge pull request #17 from sg3163/func
2014-12-16 - Sriharsha Gundappa - Formatted testcases
```

2014-12-16 - bajajabhi1 - cleaned up function local
2014-12-16 - Sriharsha Gundappa - modified test files
2014-12-16 - Sriharsha Gundappa - Adding Negative Testcases
2014-12-16 - Abhinav Bajaj - removing func locals
2014-12-16 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall merging
2014-12-16 - Sriharsha Gundappa - Scope test cases
2014-12-16 - Abhinav Bajaj - mergedMerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-16 - Abhinav Bajaj - added notype handling for operators
2014-12-16 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall Merged function
2014-12-16 - Sriharsha Gundappa - Resolving Confilct
2014-12-16 - Arpit Gupta - Mergn to master g branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-16 - Arpit Gupta - bring runCplusCplus back to life
2014-12-16 - Sriharsha Gundappa - Fixing test cases
2014-12-16 - Abhinav Bajaj - added attrlist to for_expr
2014-12-16 - Abhinav Bajaj - In and Not IN are binary operators now
2014-12-16 - Abhinav Bajaj - mergedMerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-16 - Abhinav Bajaj - if in can take expr in expr now
2014-12-16 - Arpit Gupta - addinf ++ for list
2014-12-16 - Arpit Gupta - finalisign merge.jo
2014-12-16 - Arpit Gupta - updating merge.jo
2014-12-16 - Arpit Gupta - Mergng element assign g branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-16 - Abhinav Bajaj - updated type checking for elementAccess
2014-12-16 - Arpit Gupta - updating merge.jo
2014-12-16 - Arpit Gupta - adding notype for element access
2014-12-16 - Arpit Gupta - merging merge.jo
2014-12-16 - Abhinav Bajaj - i am awesome - decl done
2014-12-16 - Arpit Gupta - changing merge.jo
2014-12-16 - Arpit Gupta - Merging correction in Element acess g branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-16 - bajajabhi1 - Merge pull request #16 from sg3163/decl
2014-12-16 - Abhinav Bajaj - corrected typecheck
2014-12-16 - Abhinav Bajaj - merge
2014-12-16 - Arpit Gupta - Mergng g branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-16 - Arpit Gupta - do not remember
2014-12-16 - Arpit Gupta - updating merge
2014-12-16 - Arpit Gupta - do not remember
2014-12-16 - Abhinav Bajaj - mergedMerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-16 - Abhinav Bajaj - corrected typecheck for attrList()
2014-12-16 - Abhinav Bajaj - locals can be reassigned and decl is not required

2014-12-15 - Arpit Gupta - changing print for lists

2014-12-15 - Arpit Gupta - merging element assign test case Merge branch 'master' of https://github.com/sg3163/plt2014fall

2014-12-15 - Abhinav Bajaj - test case for ElementAssign

2014-12-15 - Arpit Gupta - adding element access upport forC++

2014-12-15 - Abhinav Bajaj - added element assign and update getElementByOcaml foraccess

2014-12-15 - Arpit Gupta - adding element access for list and json

2014-12-15 - Abhinav Bajaj - trying to rmove decl

2014-12-15 - Chase Larson - Reverting typeStruct to not recurse into Lists

2014-12-15 - Chase Larson - typeStruct goes into ListType.

2014-12-15 - Chase Larson - typeStruct. Modified Read to take Json.

2014-12-15 - Arpit Gupta - adding addToJson i.e. myJson[arpit]

2014-12-15 - Arpit Gupta - addign merge.jo

2014-12-15 - Sriharsha Gundappa - Terminating program execution if oCaml Compilation fails

2014-12-15 - Arpit Gupta - fixing case for prettyPrint

2014-12-15 - Abhinav Bajaj - updated access to handle expression in it

2014-12-15 - Abhinav Bajaj - function has notype args,typechecking updated for notype, for loop var has notype,fixed gcd

2014-12-14 - Abhinav Bajaj - mergedMerge branch 'master' of https://github.com/sg3163/plt2014fall

2014-12-14 - Arpit Gupta - adding != operator

2014-12-14 - Abhinav Bajaj - mergedMerge branch 'master' of https://github.com/sg3163/plt2014fall

2014-12-14 - Arpit Gupta - adding != operator

2014-12-14 - Abhinav Bajaj - mergedMerge branch 'master' of https://github.com/sg3163/plt2014fall

2014-12-14 - Arpit Gupta - adding != operator

2014-12-14 - Abhinav Bajaj - mergeMerge branch 'master' of https://github.com/sg3163/plt2014fall

2014-12-14 - Arpit Gupta - adding != operator

2014-12-14 - Abhinav Bajaj - corrected test case for type() and makeString()

2014-12-14 - Abhinav Bajaj - main is mandatory

2014-12-14 - Abhinav Bajaj - gerge branch 'master' of https://github.com/sg3163/plt2014fall

2014-12-14 - Abhinav Bajaj - updated type()

2014-12-14 - Abhinav Bajaj - update type()

2014-12-14 - Arpit Gupta - Merge branch 'master' of https://github.com/sg3163/plt2014fall

2014-12-14 - Arpit Gupta - updating testfiles

2014-12-14 - Sriharsha Gundappa - Changing the expected values

2014-12-14 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall test

2014-12-14 - Sriharsha Gundappa - Modified GCD Program

2014-12-14 - Sriharsha Gundappa - Modified GCD Program

2014-12-14 - Arpit Gupta - fixed testNotOperator.exp true and False both must start with smalll

2014-12-14 - Arpit Gupta - fixed pretty-print, now print for json always pretty printsl

2014-12-14 - Arpit Gupta - fixed minus-operator for list in Ocaml

2014-12-14 - Sriharsha Gundappa - Adding GCD
2014-12-14 - Sriharsha Gundappa - Refined all Testcases, added expected outputs
2014-12-14 - Abhinav Bajaj - trying to check main
2014-12-14 - Arpit Gupta - adding getJoType()
2014-12-14 - Arpit Gupta - adding minus for JSON too
2014-12-14 - Arpit Gupta - adding contains(), findIndex, minus()
2014-12-14 - Arpit Gupta - adding find for lists , contains()
2014-12-14 - Abhinav Bajaj - gerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-14 - Abhinav Bajaj - removed the return mainfunc
2014-12-14 - Arpit Gupta - adding == operator
2014-12-14 - Arpit Gupta - adding == operator for all types! Phew
2014-12-13 - Abhinav Bajaj - gerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-13 - Abhinav Bajaj - for update, access update,attrlist update
2014-12-13 - Chase Larson - cleaned up comments
2014-12-13 - Chase Larson - Added write
2014-12-13 - Chase Larson - Added read
2014-12-13 - Arpit Gupta - adding things to TODO list
2014-12-13 - Arpit Gupta - prettyPrint done
2014-12-13 - Arpit Gupta - merging branch-arpit to include PrettyPrint
2014-12-13 - Arpit Gupta - adding PrettyPrint
2014-12-13 - Arpit Gupta - merging
2014-12-13 - Arpit Gupta - chanign todo
2014-12-13 - Chase Larson - Claiming File Handling
2014-12-13 - Chase Larson - added more test cases for Logical Operators
2014-12-13 - Abhinav Bajaj - gerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-13 - Arpit Gupta - adding makeString
2014-12-13 - Arpit Gupta - adding makeString
2014-12-13 - Abhinav Bajaj - gerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-13 - Abhinav Bajaj - updated code for logical, makestring
2014-12-13 - Chase Larson - Added Logical operators
2014-12-12 - Chase Larson - claiming item from TODO list
2014-12-12 - Chase Larson - Merge branch 'cpplib'
2014-12-12 - Chase Larson - Comparison Operators now Return BoolType
2014-12-12 - Arpit Gupta - changing TODO
2014-12-12 - Chase Larson - Comparison Operators for NumType
2014-12-12 - Chase Larson - Added Mod operator
2014-12-12 - Abhinav Bajaj - update operators, added && and ||, updated typecheck messages
2014-12-12 - Abhinav Bajaj - mergedeerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-12 - Abhinav Bajaj - trying new add
2014-12-12 - Chase Larson - Fixed error with comma
2014-12-12 - Chase Larson - Mathematical operators

2014-12-11 - Chase Larson - Merge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-11 - Sriharsha Gundappa - Type Checking on operators
2014-12-11 - Sriharsha Gundappa - Modified test script
2014-12-11 - Chase Larson - Merge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-11 - Chase Larson - Added +=, -=, *=, /=, String Concat, and getBoolValue
2014-12-10 - Sriharsha Gundappa - Merge branch 'harshadec4'
2014-12-10 - Abhinav Bajaj - updated pending items
2014-12-10 - Abhinav Bajaj - added IfIn support
2014-12-09 - Abhinav Bajaj - added String concat test file
2014-12-09 - Abhinav Bajaj - adding string concat and mergedMerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-09 - Abhinav Bajaj - added String concatenation
2014-12-09 - Sriharsha Gundappa - merging
2014-12-09 - Abhinav Bajaj - merged
2014-12-09 - Sriharsha Gundappa - Adding Pretty Print Json testcase and updated pending items for c++
2014-12-09 - Abhinav Bajaj - not operator done
2014-12-09 - Arpit Gupta - Update PendingItems.txt
2014-12-09 - sg3163 - Merge pull request #12 from sg3163/harshadec4
2014-12-09 - Sriharsha Gundappa - Adding Type and MakeString function code
2014-12-09 - Sriharsha Gundappa - Adding Type and MakeString function code
2014-12-09 - Abhinav Bajaj - Item -conv exr to Bool Type when inside If- done, small fixes in type checking in operators
2014-12-08 - sg3163 - Merge pull request #11 from sg3163/harshadec4
2014-12-08 - Sriharsha Gundappa - Added parenthesis to Print
2014-12-08 - Sriharsha Gundappa - Added Null Code, Null and Bool to List and Json
2014-12-08 - Arpit Gupta - adding to do list
2014-12-05 - Arpit Gupta - adding List concatenation
2014-12-05 - Arpit Gupta - changing for loop and adding print via iterator in cPlusPlusCompiler.cpp
2014-12-05 - Arpit Gupta - changing for loop and adding print via iterator in cPlusPlusCompiler.cpp
2014-12-04 - Arpit Gupta - changing for loop in jp.ml and changing loop over list in cPlusPlusCompiler.h
2014-12-04 - Arpit Gupta - adding ListType parser Merge branch 'arpit'
2014-12-04 - Arpit Gupta - adding ListType parser
2014-12-04 - sg3163 - Merge pull request #10 from sg3163/harshadec4
2014-12-04 - Sriharsha Gundappa - modified Print
2014-12-04 - Sriharsha Gundappa - Pending Items
2014-12-04 - Sriharsha Gundappa - Negative test cases
2014-12-04 - Arpit Gupta - Adding foe loop logic in C++ code Merge branch 'master' of https://github.com/sg3163/plt2014fall
2014-12-04 - Arpit Gupta - adding For loop logic in C++ code
2014-12-04 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall
2014-12-04 - Sriharsha Gundappa - Removing compilation warning from c++

2014-12-04 - Arpit Gupta - "merging arpit branch. functionality for element add and element acces is now available " Merge branch 'arpit'

2014-12-04 - Arpit Gupta - adding element access and element add functionalities

2014-12-04 - Sriharsha Gundappa - Resolving ocaml Compiler warning

2014-12-04 - Sriharsha Gundappa - Resolving ocaml Compiler warning

2014-12-04 - Arpit Gupta - moving functions around

2014-12-03 - Arpit Gupta - Merging branch arpit, with JsonType, ListType Merge branch 'master' into arpit

2014-12-03 - Arpit Gupta - Adding List to CustType

2014-12-03 - Abhinav Bajaj - fixed issues

2014-12-03 - bajajabhi1 - Merge pull request #8 from sg3163/abhinav

2014-12-03 - Abhinav Bajaj - Merge branch 'abhinav' of https://github.com/sg3163/plt2014fall into abhinav

2014-12-03 - Abhinav Bajaj - access updated, shift reduce resolved

2014-12-03 - bajajabhi1 - Merge pull request #7 from sg3163/master

2014-12-03 - Arpit Gupta - converting form library json type to our own JsonType

2014-12-03 - Abhinav Bajaj - local

2014-12-03 - bajajabhi1 - Merge pull request #6 from sg3163/abhinav

2014-12-03 - Abhinav Bajaj - Comparison operator tests

2014-12-03 - Abhinav Bajaj - correction of typecheck and mod

2014-12-03 - sg3163 - Merge pull request #5 from sg3163/harshadec3

2014-12-03 - Sriharsha Gundappa - modified clean all

2014-12-03 - bajajabhi1 - Merge pull request #4 from sg3163/abhinav

2014-12-03 - Abhinav Bajaj - added comminus and complus

2014-12-03 - Sriharsha Gundappa - Adding Testcases for Operators, Conditions etc

2014-12-03 - Sriharsha Gundappa - Addition Testcase

2014-12-03 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall

2014-12-03 - sg3163 - Merge pull request #3 from sg3163/harshanov30

2014-12-03 - Abhinav Bajaj - removed unnecessary files

2014-12-02 - Arpit Gupta - adding logic to loop over JSON objects

2014-12-01 - Sriharsha Gundappa - Merge branch 'harshanov30'

2014-12-01 - Sriharsha Gundappa - Adding Attribute List

2014-12-01 - Sriharsha Gundappa - Adding Attribute List

2014-11-30 - Sriharsha Gundappa - Merge branch 'harshanov30'

2014-11-30 - Sriharsha Gundappa - TypeStruct code

2014-11-30 - Sriharsha Gundappa - TypeStruct code

2014-11-30 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall

2014-11-30 - Sriharsha Gundappa - removing .o files

2014-11-30 - PRANAV BHALLA - merging wjth master Merge branch 'master' of https://github.com/sg3163/plt2014fall into arpit

2014-11-30 - PRANAV BHALLA - merging with head ierge branch 'master' of https://github.com/sg3163/plt2014fall

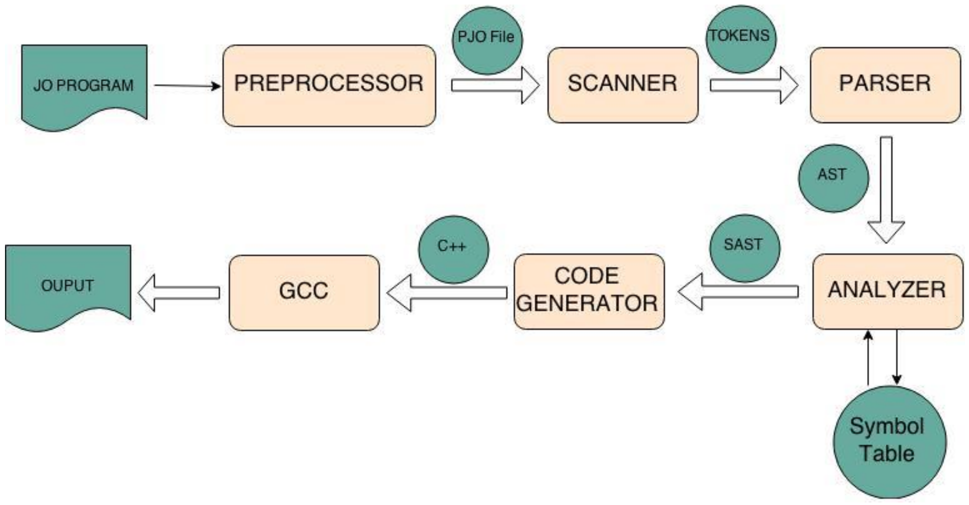
2014-11-30 - Sriharsha Gundappa - Started with Merge function
2014-11-30 - Sriharsha Gundappa - added testcases for Json and List parsing
2014-11-30 - PRANAV BHALLA - Merge branch 'arpit'
2014-11-30 - PRANAV BHALLA - no change
2014-11-30 - Sriharsha Gundappa - merging with arpit2- for loop code
2014-11-29 - Sriharsha Gundappa - Json and List parsing
2014-11-28 - Sriharsha Gundappa - List and Json Element Access
2014-11-27 - arpitg1991@gmail.com - removing str.cma
2014-11-26 - arpitg1991@gmail.com - removing output files
2014-11-26 - arpitg1991@gmail.com - removing putput files
2014-11-26 - arpitg1991@gmail.com - resolving merge conflicts
2014-11-26 - arpitg1991@gmail.com - resolving merge conflicts
2014-11-26 - arpitg1991@gmail.com - adding for
2014-11-26 - Sriharsha Gundappa - Test Files for Function calling
2014-11-26 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall
2014-11-26 - Sriharsha Gundappa - Individual test file to run one file
2014-11-26 - Sriharsha Gundappa - Function Call from Function, Statement Reverse
2014-11-26 - bajajabhi1 - Merge pull request #2 from bajajabhi1/master
2014-11-26 - Abhinav Bajaj - updated assign output
2014-11-26 - Abhinav Bajaj - done ifelse
2014-11-26 - arpitg1991@gmail.com - Revert "cleaning"
2014-11-26 - arpitg1991@gmail.com - cleaning
2014-11-25 - arpitg1991@gmail.com - adding code for for
2014-11-24 - Sriharsha Gundappa - Complete Test function to check print
2014-11-24 - Sriharsha Gundappa - Print from Main working with complete test case
2014-11-24 - Abhinav Bajaj - merge
2014-11-24 - Abhinav Bajaj - updated testall
2014-11-24 - Abhinav Bajaj - dded test jo file
2014-11-24 - Abhinav Bajaj - gerge branch 'master' of https://github.com/sg3163/plt2014fall
2014-11-24 - Abhinav Bajaj - dding test jo
2014-11-24 - arpitg1991@gmail.com - changing string parsing
2014-11-24 - Abhinav Bajaj - added ifelse
2014-11-24 - Sriharsha Gundappa - removed cpp
2014-11-24 - Sriharsha Gundappa - main function
2014-11-24 - Chase Larson - Added Parsing to/from JSON and String
2014-11-23 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall test
2014-11-23 - Abhinav Bajaj - print only takes customtype now
2014-11-23 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall merging
2014-11-23 - Sriharsha Gundappa - func change

2014-11-23 - arpitg1991@gmail.com - Merge branch 'master' of https://github.com/sg3163/plt2014fall
2014-11-23 - arpitg1991@gmail.com - adding print mapping from ocaml to c++
2014-11-23 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall merge Reqd
2014-11-23 - Sriharsha Gundappa - Function parsing, Json quote regex replace
2014-11-23 - Sriharsha Gundappa - Function parsing, Json quote regex replace
2014-11-23 - arpitg1991@gmail.com - Merge branch 'master' of https://github.com/sg3163/plt2014fall
2014-11-23 - arpitg1991@gmail.com - changing to static methods
2014-11-23 - bajajabhi1 - Merge pull request #1 from bajajabhi1/ifelse
2014-11-23 - Abhinav Bajaj - space removed after namespace decl
2014-11-23 - Sriharsha Gundappa - removing semicolon and adding more test case
2014-11-23 - Sriharsha Gundappa - print function
2014-11-23 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall
2014-11-23 - Sriharsha Gundappa - Adding function
2014-11-23 - arpitg1991@gmail.com - adding print to strType and Numtype
2014-11-22 - Sriharsha Gundappa - Adding Bool, Json and List types
2014-11-22 - arpitg1991@gmail.com - spitting cpp code for int string
2014-11-22 - arpitg1991@gmail.com - adding running commands and changing jo.ml
2014-11-22 - arpitg1991@gmail.com - adding running commands, and changing jo.ml"
2014-11-21 - Abhinav Bajaj - somethign is working
2014-11-20 - Sriharsha Gundappa - typecheck.ml Nov 20th 10:00 PM
2014-11-20 - Sriharsha Gundappa - Working version of Ast
2014-11-20 - arpitg1991@gmail.com - addiing parse code
2014-11-19 - arpitg1991 - Revert "commiting 2nd style"
2014-11-19 - Pranav Bhalla - commiting 2nd style
2014-11-19 - arpitg1991 - modifying parser
2014-11-19 - arpitg1991 - changing scanner
2014-11-16 - Sriharsha Gundappa - Merge branch 'master' of https://github.com:443/sg3163/plt2014fall
2014-11-16 - arpitg1991 - cpplus
2014-11-16 - Sriharsha Gundappa - Parser for scanner.mll
2014-11-16 - arpitg1991 - c++compiler
2014-11-16 - arpitg1991 - removing duplicate files
2014-11-16 - arpitg1991 - adding c plus plus compiler stuff
2014-11-16 - arpitg1991 - a
2014-11-16 - guptaar - adding cplusplusCode
2014-11-15 - Sriharsha Gundappa - Full Scanner
2014-11-12 - Sriharsha Gundappa - Test All and Clean All test script.
2014-11-12 - Sriharsha Gundappa - Adding scanner code
2014-11-12 - Sriharsha Gundappa - Reverting back to c++ from Java
2014-11-10 - Sriharsha Gundappa - Java Code generation, json and List declaration
2014-11-01 - Abhinav Bajaj - added stmts

```
2014-11-01 - Abhinav Bajaj - preprocess added
2014-11-01 - Abhinav Bajaj - added gitignore
2014-11-01 - Abhinav Bajaj - added makefile, shell script
2014-11-01 - Abhi - initial  commit
2014-09-15 - sg3163 - Initial  commit
```

5. Architectural Design

The architecture of the JO language compiler is depicted in the below diagram



5.1 PreProcessor

The preprocessor reads the input JO program and adds syntactic details such as braces and semicolons replacing the block ends represented by "end" as well. The output of preprocessor is <input_file_name>.pjo file.

5.2 Scanner

The scanner takes in a .pjo program file and outputs tokens according to the lexical rules of the JO language.

5.3 Parser

The parser takes in the tokens from the scanner and uses our grammatical rules to produce an abstract syntax tree.

5.4 Analyzer

The analyzer file takes in the abstract syntax tree as given by the parser and performs semantic checks, outputting a typed semantic abstract syntax tree. This file uses a symbol table in order to keep track of global and local variables, making sure that the program is in accordance to our scoping rules. Analyzer also checks that the arguments of operators are valid, that all variables and declared and initialized when they need to be, that two variables are not declared with the same name and that functions return a value. Only the main function is allowed not to return any thing. If any input program does not pass these checks then the compiler will raise an error and compilation will halt.

5.5 Symbol Table

The symbol table provides the functions for maintaining the environment during the program execution. It provides the below functions to maintain the environment:

- add_global: makes a global variable visible in the scope of the entire program.
- update_global: updates a global variable with new type information.

- add_function: makes a function name visible in the scope of the entire program.
- add_local: adds a local variable to the current scope only.
- update_local: updates a local variable with new type information.
- find_function: used to check if a particular function name is visible in the current scope.
- find_variable: used to check if a particular variable id is visible in the current scope

5.6 Code Generation

Code generation takes the input semantic abstract syntax tree and creates the C++ code by creating custom objects that represent the datatypes on C++ side. The code generation uses the C++ library that provides the basic functions corresponding to the operations supported in JO language. The C++ library also uses an open source code that helps in parsing the json standard format on runtime. There are base classes that the custom type objects inherit.

5.7 Team Contribution

While every team member worked on every component in some fashion (either as an author or as a debugger), the primary responsibility breakdown for each component is given above in section 4.3

6. Test Plan

6.1 **Test Suite Automation**

Shell Script is written to automate the code testing. There are 3 different test suites slightly varying depending on the purpose.

All three test suites executes below steps

i. Preprocess .jo file to .pjo file using makefile – **MakePreProc**
ii. Scan, Parse, Check Semantics, output C++ executable is done using makefile **Makefile**
iii. Execute C++ and output using makefile - **MakeFileCPP**

Different test suites are

i. **runjo.sh** – To run individual test-case and print out the final program output on screen. It also persists intermediate files like .pjo .cpp .o .output to assist in debugging. It removes the intermediate files upon next run.
If there is any parse error then script displays parse error
If there is any type checking error then script displays the type checking exception
If there is any error while running c++ code then script displays corresponding c++ error
If program runs successfully then script prints out the output.
Execution - ./runjo.sh testfiles/Merge.jo

ii. **test.sh** – To run individual test-case and compare it against the expected value. It goes through all the steps as done by runjo.sh and does an extra step of comparison with expected value. Script spits out error file in response to mismatch between expected out put and actual output
Execution - ./test.sh testfiles/Merge.jo

iii. **testall.sh –** It executes all the steps as of test.sh and does the extra step of running all the test-cases in test-file directory.
Execution - ./testall.sh

6.2 **Test Case Selection**

We have tried to make unit test cases for all features of the language. We have covered both Positive and Negative test cases. Most of the positive test cases are rich in feature, in the sense that each test class covers multiple test varieties. Below are the basic varieties of test cases created

Arithmetic/Mathematic (++, --, **, //, >, >=, <, <=, %%)
Creation of Types (List, Json, Number, Null, String, Bool)
Dynamic Type Casting
Comment (/* */)
Comparison (==, !=)
Logical (||, &&, !)
Concatenation (+)
String Concatenation (++)
Negation (-)
Function Calls

Scope Check
In and Not In Operators
If Else
For loops
Json and List Element Access
Json and List Element Assignment
File Read Function
File Write Function
MakeString Function
Print Function
JsonPrettyPrint
TypeStruct Function
Type Function
Complex test cases (GCD, Merge)

6.3 **Test Suites – 6.3.1 - testall.sh**

```
#!/bin/sh

if [ ! -f "./preprocessor" ]; then
    make -f MakePreProc >> make.log
fi

if [ ! -f "./jo" ]; then
   make -f Makefile >> make.log
fi

# jo exectutable
JO="./jo"

# preprocessor executable
PRE="./preprocessor"
TEST_BASE="testfiles"

# Compare <outfile> <reffile> <difffile>
# Compares the outfile with reffile.  Differences, if any, written to difffile
Compare() {
        difference=$(diff -b $1 $2)
        echo $difference
        if [ "$difference" != "" ]; then
                echo $difference > $3
        fi
}
```

```
function compileAndRun() {
       basename=`echo $1 | sed 's/.*\\///
                           s/.jo//'`
    echo "Running file $basename"
       reffile=`echo $1 | sed 's/.jo$//'`
    prepfile=$TEST_BASE/$basename'.pjo'
    #echo $prepfile
    basedir="`echo $1 | sed 's/\/[^\/]*$//'`/"

# gets the path of the test output file
       testoutput=`echo ${basedir}test_outputs/$basename.c.out`

    echo "Preprocessing '$1'"
       $PRE $1 $prepfile && echo "Preprocessor for $1 succeeded"

       echo "Compiling '$prepfile'"
       if [ ! -f $prepfile ]; then
              echo "$prepfile does not exist"
       return
       fi

# converting from JO to C++
    $JO $prepfile > "${reffile}.cpp" && echo "Ocaml to C++ of $1 succeeded"

       if [ ! -s ${reffile}.cpp ] ; then
              echo "Error in Compilation of ${reffile}"
              return
       fi ;

    # compliling the C++ file
    if [ -f "${reffile}.cpp" ]; then
              make inputfile=$basename -f MakeFileCPP
    else
       echo "Compiling $1 failed"
       return
    fi

       # running the binary
    if [ -f "${reffile}.out" ]; then
        eval ${reffile}.out >> ${reffile}.output
        Compare ${reffile}.output ${reffile}.exp ${reffile}.error

        rm -rf ${reffile}.fdlp
        rm -rf ${reffile}.pjo
        rm -rf ${reffile}.cpp
       rm -rf ${reffile}.out
        rm -rf ${reffile}.o
        rm -rf ${reffile}.output
        echo "ran $1 successfully"
    else
        echo "C++ to binary of ${reffile}.cpp failed"
    fi

}
files=$TEST_BASE/*.jo

for file in $files
do
       compileAndRun $file
done
```

6.3.2 Makefile1 – MakeCPP

```
CC  = gcc
CFLAGS   = -g -Wall

.PHONY: default
default: preproc

.PHONY: all
all:  clean preproc

.PHONY: clean
clean:
	rm -rf *.log  *.o *~ a.out* core preprocessor *.pjo

.PHONY: preproc
preproc: preprocessor.c
	$(CC) -o preprocessor preprocessor.c
```

6.3.3 Makefile2 – MakeFile

```
OBJS = parser.cmo scanner.cmo symboltable.cmo typecheck.cmo Str.cma
jo.cmo

.PHONY: default
default: jo

.PHONY: all
all: clean jo

jo: $(OBJS)
	ocamlc -o jo $(OBJS)

scanner.ml: scanner.mll
	ocamllex scanner.mll

parser.ml parser.mli: parser.mly
	ocamlyacc parser.mly

%.cmo: %.ml
	ocamlc -c $<

%.cmi: %.mli
	ocamlc -c $<

.PHONY: clean
clean:
	rm -rf jo parser.ml parser.mli scanner.ml *.cmo *.cmi *.log *.o
*~ a.out* core

# Generated by ocamldep *.ml *.mli
analyzer.cmo: symboltable.cmo ast.cmi sast.cmi
analyzer.cmx: symboltable.cmx ast.cmx sast.cmx
jo.cmo: scanner.cmo parser.cmi ast.cmi Str.cma
jo.cmx: scanner.cmx parser.cmx ast.cmi
parser.cmo: ast.cmi parser.cmi
parser.cmx: ast.cmi parser.cmi
scanner.cmo: parser.cmi
scanner.cmx: parser.cmx
parser.cmi: ast.cmi
Str.cma:
```

6.3.4 **Makefile3 – MakeFileCPP**

```
CC=g++

CFLAGS=-c -w
LFLAGS=-lm

SOURCES=testfiles/$(inputfile).cpp  cpp/JSON.cpp cpp/JSONValue.cpp
HEADERS=cpp/JSON.h cpp/JSONValue.h cpp/cPlusPlusCompiler.h

OBJECTS=$(SOURCES:.cpp=.o)

EXECUTABLE=testfiles/$(inputfile).out

all: $(SOURCES) $(EXECUTABLE)

$(EXECUTABLE): $(OBJECTS)
	$(CC) $(LFLAGS) $(OBJECTS) -o $@

.cpp.o:
	$(CC) $(CFLAGS) $< -o $@

clean:
			rm -f $(OBJECTS) $(EXECUTABLE) *~
```

6.4 **Example Test**

6.4.1 Merge.jo

```
func Merge (a,b)
    c = #{ }#

    for attr in a.attrList()
        if ( attr in b.attrList())
            if (type(a[attr]) == "Json"  && type(b[attr]) == "Json")

                c[attr] = Merge(a[attr],b[attr])
            else
                if (type(a[attr]) == "List"  && type(b[attr]) == "List")
                    c[attr] = a[attr] ++ b[attr]
                else
                    c[attr] = a[attr] + b[attr]
                end
            end
        else
            c[attr] = a[attr]
        end
    end
    for attr in b.attrList()
        if ( attr not in a.attrList()  )
            c[attr] = b[attr]
        end
    end
    return c
end

func MergeUtil (a,b)
    if ( type(a) != "Json" || type(b) != "Json")
        print("Both  the arguments must be JSON")
        return null
    end
    return Merge(a,b)
end

func main ()

a  = #{"name":"harsha",  "innerJson":{"sub":"PLT","mark":[5,6,7]}}#
b  = #{"name":"arpit",   "innerJson":{"sub":"OS","mark":[7,8,9]}}#
c = MergeUtil (a,b)
print (c)
    end
```

C++ Output (Merge.cpp)

```
#include <iostream>
#include "../cpp/cPlusPlusCompiler.h"
using namespace std;

CustType* Merge(CustType* a, CustType* b)
{ CustType* c = CustType::parse("{}","JSON");
for (vector<CustType*> :: iterator loopVarattr = (a-> getAttrList())->getListBegin();  loopVarattr !=
(a-> getAttrList())->getListEnd();   ++loopVarattr) {
 CustType* attr = *loopVarattr;
{ if ((b-> getAttrList()->contains(attr))->getBoolValue())
{ if ((*(*((a-> getElementByOcaml(attr))->getJoType()) == *(CustType::parse("Json","STRING")))
&& *(*((b-> getElementByOcaml(attr))->getJoType()) == *(CustType::parse("Json","STRING"))))-
>getBoolValue())
{ c->addByKey(attr,Merge(a-> getElementByOcaml(attr), b-> getElementByOcaml(attr)));
}else {
if ((*(*((a-> getElementByOcaml(attr))->getJoType()) == *(CustType::parse("List","STRING")))  &&
*(*((b-> getElementByOcaml(attr))->getJoType()) == *(CustType::parse("List","STRING"))))-
>getBoolValue())
{
c->addByKey(attr,CustType::add(a-> getElementByOcaml(attr),b-> getElementByOcaml(attr)));

}else
{
c->addByKey(attr,CustType::concat(a-> getElementByOcaml(attr),b-> getElementByOcaml(attr)));

} } }else
{
c->addByKey(attr,a-> getElementByOcaml(attr));

} } }
for (vector<CustType*> :: iterator loopVarattr = (b-> getAttrList())->getListBegin();  loopVarattr !=
(b-> getAttrList())->getListEnd();   ++loopVarattr) {
 CustType* attr = *loopVarattr;
{
if ((!(*(a-> getAttrList()->contains(attr)))))->getBoolValue())
{
c->addByKey(attr,b-> getElementByOcaml(attr));
}}}
 return c;}

CustType* MergeUtil(CustType* a, CustType* b)
{ if ((*(*((a)->getJoType()) != *(CustType::parse("Json","STRING")))  || *(*((b)->getJoType()) !=
*(CustType::parse("Json","STRING"))))->getBoolValue())
{ CustType::print(CustType::parse("Both  the arguments must be JSON","STRING"));
 return CustType::parse("null","NULL");
} return Merge(a, b);}

int main()
{ CustType* a =
CustType::parse("{\"name\":\"harsha\",\"innerJson\":{\"sub\":\"PLT\",\"mark\":[5,6,7]}}","JSON");
CustType* b =
CustType::parse("{\"name\":\"arpit\",\"innerJson\":{\"sub\":\"OS\",\"mark\":[7,8,9]}}","JSON");
CustType* c = MergeUtil(a, b);
CustType::print(c);  }
```

6.4.2 GCD Program (GCD.jo)

```
a = 45
b = 81

func findGCD(a,b)
            if(b == 0)
                        return a
             end
            return findGCD(b, a%%b)
end

func main ()
            print( findGCD(a,b) )
      end
```

GCD C++ code (GCD.cpp)

```
#include <iostream>
#include "../cpp/cPlusPlusCompiler.h"
using namespace std;

CustType* b = CustType::parse("81","NUMBER");

CustType* a = CustType::parse("45","NUMBER");

CustType* findGCD(CustType* a, CustType* b)
{
if ((*(b) == *(CustType::parse("0","NUMBER")))->getBoolValue())
{
 return a;
} return findGCD(b, CustType::mod(a,b));}

int main()
{
CustType::print(findGCD(a, b));
      }
```

7. Lessons Learned

7.1 Sriharsha Gundappa

I learnt a good deal of oCaml coding from the project. This is the first ever functional program I used in my life, so it to a while to get used to writing program in functional language. But definitely it is a good addition to your knowledge base. It provides you with a different perspective of solving problems. We planned at every step of project execution, divided tasks and conquered it. We continually reviewed the status of tasks and revised to match the end product, this helped in avoiding surprises in the end. Finally, It felt great to finish project in a short period of time and in an unknown language

Suggestion for teams - First and foremost, select motivated people in your team or get into a team of motivated people. Project gets harder or easier depending on the team you are in. Use a good version control system like git to host your files, get acquainted with it, create as much branches as required. There will always possibility of code getting messed up and you spending lot of time just debugging issues related to merging code. It helped a lot when working offline and also to merge conflicts. During the project execution, I suggest following Regex – (Plan, Code, Revise)* Code Cleanup Submit.

7.2 Chase Larson

Prioritize. When initially designing the language, have a clear idea of why you want to build the language you propose and focus on one thing you want it to be able to do better than any other language. This will help keep the design from including extraneous features. If something is not important to your main priority, then don't spend too much time or energy on it.

When developing, having a uniform coding style can really help speed up the time it takes to understand and/or debug code that someone else originally wrote.

7.3 Abhinav Bajaj

7.4 Arpit Gupta

It is better to design a language that does, one thThe most important lesson I learnt was never underestimate the power of recursion. I knew Json has recursive structure, but only once we started writing the code, did I fully realize that it is nothing but recursive structure. It also is the most beautiful thing, because at the end of the day, you are only dealing with numbers, string and booleans, everything else is just formatting.

It is better to design a language that does, one thing better than every other language , rather than having a language that tries to do everything, and does nothing extrordinarily. For most part of the project, we were trying to do the latter. It was only during the last week that we realized that is perfectly fine to not support a million features that other languages do.

One thing we did right was, to assign back-up roles, so we had 2 people for each role. Also for all the actual coding part, we had 2 people working on c++ and 2 on oCaml, so whenever somebody need to take some time-off, we could still keep the work going, rather than being stuck because the oCaml guy is not available. For most part of the project, we were trying to do the latter. It was only during the last week that we realized that is perfectly fine to not support a million features that other languages do.

8. Appendix

JSON.cpp

```
/*
* File JSON.cpp part of the SimpleJSON Library - http://mjpa.in/json
*
* Copyright (C) 2010 Mike Anchor
*
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* of this software and associated documentation files (the "Software"), to deal
* in the Software without restriction, including without limitation the rights
* to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
* copies of the Software, and to permit persons to whom the Software is
* furnished to do so, subject to the following conditions:
*
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*
* THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
OR
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* FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT
SHALL THE
* AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR
OTHER
* LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
FROM,
* OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER
DEALINGS IN
* THE SOFTWARE.
*/
```

```
#include "JSON.h"


/**
* Blocks off the public constructor
*
* @access private
*
*/
JSON::JSON()
{
}


/**
* Parses a complete JSON encoded string
* This is just a wrapper around the UNICODE Parse().
*
* @access public
*
* @param char* data The JSON text
*
* @return JSONValue* Returns a JSON Value representing the root, or NULL on error
*/
JSONValue *JSON::Parse(const char *data)
{
  size_t length = strlen(data) + 1;
  wchar_t *w_data = (wchar_t*)malloc(length * sizeof(wchar_t));
```

```
    #if defined(WIN32) && !defined(__GNUC__)
      size_t ret_value = 0;
      if (mbstowcs_s(&ret_value, w_data, length, data, length) != 0)
      {
         free(w_data);
         return NULL;
      }
    #elif defined(ANDROID)
      // mbstowcs seems to misbehave on android
      for(size_t i = 0; i<length; i++)
         w_data[i] = (wchar_t)data[i];
    #else
      if (mbstowcs(w_data, data, length) == (size_t)-1)
      {
         free(w_data);
         return NULL;
      }
    #endif

    JSONValue *value = JSON::Parse(w_data);
    free(w_data);
    return value;
  }


  /**
  * Parses a complete JSON encoded string (UNICODE input version)
  *
  * @access public
  *
```

```
* @param wchar_t* data The JSON text
*
* @return JSONValue* Returns a JSON Value representing the root, or NULL on error
*/
JSONValue *JSON::Parse(const wchar_t *data)
{
  // Skip any preceding whitespace, end of data = no JSON = fail
  if (!SkipWhitespace(&data))
    return NULL;


  // We need the start of a value here now...
  JSONValue *value = JSONValue::Parse(&data);
  if (value == NULL)
    return NULL;

  // Can be white space now and should be at the end of the string then...
  if (SkipWhitespace(&data))
  {
    delete value;
    return NULL;
  }

  // We're now at the end of the string
  return value;
}


/**
* Turns the passed in JSONValue into a JSON encode string
```

```
*
* @access public
*
* @param JSONValue* value The root value
*
* @return std::wstring Returns a JSON encoded string representation of the given value
*/
std::wstring JSON::Stringify(const JSONValue *value)
{
  if (value != NULL)
    return value->Stringify();
  else
    return L"";
}


/**
* Skips over any whitespace characters (space, tab, \r or \n) defined by the JSON spec
*
* @access protected
*
* @param wchar_t** data Pointer to a wchar_t* that contains the JSON text
*
* @return bool Returns true if there is more data, or false if the end of the text was reached
*/
bool JSON::SkipWhitespace(const wchar_t **data)
{
  while (**data != 0 && (**data == L' ' || **data == L'\t' || **data == L'\r' || **data == L'\n'))
    (*data)++;
    return **data != 0;
}


/**
* Extracts a JSON String as defined by the spec - "<some chars>"
* Any escaped characters are swapped out for their unescaped values
*
* @access protected
*
* @param wchar_t** data Pointer to a wchar_t* that contains the JSON text
* @param std::wstring& str Reference to a std::wstring to receive the extracted string
*
* @return bool Returns true on success, false on failure
*/
bool JSON::ExtractString(const wchar_t **data, std::wstring &str)
{
    str = L"";

    while (**data != 0)
    {
        // Save the char so we can change it if need be
        wchar_t next_char = **data;

        // Escaping something?
        if (next_char == L'\\')
        {
            // Move over the escape char
            (*data)++;
```

```
// Deal with the escaped char
switch (**data)
{
    case L'"': next_char = L'"'; break;
    case L'\\': next_char = L'\\'; break;
    case L'/': next_char = L'/'; break;
    case L'b': next_char = L'\b'; break;
    case L'f': next_char = L'\f'; break;
    case L'n': next_char = L'\n'; break;
    case L'r': next_char = L'\r'; break;
    case L't': next_char = L'\t'; break;
    case L'u':
    {
        // We need 5 chars (4 hex + the 'u') or its not valid
        if (!simplejson_wcsnlen(*data, 5))
            return false;

        // Deal with the chars
        next_char = 0;
        for (int i = 0; i < 4; i++)
        {
            // Do it first to move off the 'u' and leave us on the
            // final hex digit as we move on by one later on
            (*data)++;

            next_char <<= 4;

            // Parse the hex digit
            if (**data >= '0' && **data <= '9')
                next_char |= (**data - '0');
                else if (**data >= 'A' && **data <= 'F')
                    next_char |= (10 + (**data - 'A'));
                else if (**data >= 'a' && **data <= 'f')
                    next_char |= (10 + (**data - 'a'));
                else
                {
                    // Invalid hex digit = invalid JSON
                    return false;
                }
            }
            break;
        }

        // By the spec, only the above cases are allowed
        default:
            return false;
    }
}

// End of the string?
else if (next_char == L'"')
{
    (*data)++;
    str.reserve(); // Remove unused capacity
    return true;
}

// Disallowed char?
else if (next_char < L' ' && next_char != L'\t')
{
```

```
            // SPEC Violation: Allow tabs due to real world cases
            return false;
         }

         // Add the next char
         str += next_char;

         // Move on
         (*data)++;
      }

      // If we're here, the string ended incorrectly
      return false;
   }


   /**
   * Parses some text as though it is an integer
   *
   * @access protected
   *
   * @param wchar_t** data Pointer to a wchar_t* that contains the JSON text
   *
   * @return double Returns the double value of the number found
   */
   double JSON::ParseInt(const wchar_t **data)
   {
      double integer = 0;
      while (**data != 0 && **data >= '0' && **data <= '9')
         integer = integer * 10 + (*(*data)++ - '0');
      return integer;
   }


   /**
   * Parses some text as though it is a decimal
   *
   * @access protected
   *
   * @param wchar_t** data Pointer to a wchar_t* that contains the JSON text
   *
   * @return double Returns the double value of the decimal found
   */
   double JSON::ParseDecimal(const wchar_t **data)
   {
      double decimal = 0.0;
    double factor = 0.1;
      while (**data != 0 && **data >= '0' && **data <= '9')
    {
       int digit = (*(*data)++ - '0');
         decimal = decimal + digit * factor;
       factor *= 0.1;
    }
      return decimal;
   }
```

JSON.h

```
/*
```

```
* File JSON.h part of the SimpleJSON Library - http://mjpa.in/json
*
* Copyright (C) 2010 Mike Anchor
*
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* of this software and associated documentation files (the "Software"), to deal
* in the Software without restriction, including without limitation the rights
* to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
* copies of the Software, and to permit persons to whom the Software is
* furnished to do so, subject to the following conditions:
*
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* all copies or substantial portions of the Software.
*
* THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS
OR
* IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
* FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT.  IN NO EVENT
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* AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR
OTHER
* LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
FROM,
* OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER
DEALINGS IN
* THE SOFTWARE.
*/


#ifndef _JSON_H_
#define _JSON_H_
```

```
// Win32 incompatibilities
#if defined(WIN32) && !defined(__GNUC__)
  #define wcsncasecmp _wcsnicmp
  static inline bool isnan(double x) { return x != x; }
  static inline bool isinf(double x) { return !isnan(x) && isnan(x - x); }
#endif


#include <vector>
#include <string>
#include <map>


// Linux compile fix - from quaker66
#ifdef __GNUC__
  #include <cstring>
  #include <cstdlib>
#endif


// Mac compile fixes - from quaker66, Lion fix by dabrahams
#if defined(__APPLE__) && __DARWIN_C_LEVEL < 200809L || (defined(WIN32) &&
defined(__GNUC__)) || defined(ANDROID)
  #include <wctype.h>
  #include <wchar.h>

  static inline int wcsncasecmp(const wchar_t *s1, const wchar_t *s2, size_t n)
  {
    int lc1  = 0;
    int lc2  = 0;


    while (n--)
    {
      lc1 = towlower (*s1);
      lc2 = towlower (*s2);


      if (lc1 != lc2)
        return (lc1 - lc2);


      if (!lc1)
        return 0;


      ++s1;
      ++s2;
    }


    return 0;
  }
#endif


// Simple function to check a string 's' has at least 'n' characters
static inline bool simplejson_wcsnlen(const wchar_t *s, size_t n) {
  if (s == 0)
    return false;
    const wchar_t *save = s;
    while (n-- > 0)
    {
        if (*(save++) == 0) return false;
    }

    return true;
}

// Custom types
class JSONValue;
typedef std::vector<JSONValue*> JSONArray;
typedef std::map<std::wstring, JSONValue*> JSONObject;

#include "JSONValue.h"

class JSON
{
    friend class JSONValue;

    public:
        static JSONValue* Parse(const char *data);
        static JSONValue* Parse(const wchar_t *data);
        static std::wstring Stringify(const JSONValue *value);
    protected:
```

```
    static bool SkipWhitespace(const wchar_t **data);
    static bool ExtractString(const wchar_t **data, std::wstring &str);
    static double ParseInt(const wchar_t **data);
    static double ParseDecimal(const wchar_t **data);
  private:
    JSON();
};


#endif
```

JSONValue.cpp

```
/*
* File JSONValue.cpp part of the SimpleJSON Library - http://mjpa.in/json
*
* Copyright (C) 2010 Mike Anchor
*
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* of this software and associated documentation files (the "Software"), to deal
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* copies of the Software, and to permit persons to whom the Software is
* furnished to do so, subject to the following conditions:
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OTHER

* LIABILITY,  WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING
FROM,

* OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER
DEALINGS IN

* THE SOFTWARE.

*/



#include <stdio.h>

#include <string.h>

#include <stdlib.h>

#include <vector>

#include <string>

#include <sstream>

#include <iostream>

#include <math.h>



#include "JSONValue.h"



// Macros to free an array/object

#define FREE_ARRAY(x) { JSONArray::iterator iter; for (iter = x.begin(); iter != x.end(); iter++) {
delete *iter; } }

#define FREE_OBJECT(x) { JSONObject::iterator iter; for (iter = x.begin(); iter != x.end(); iter++)
{ delete (*iter).second; } }



/**
```

```
* Parses a JSON encoded value to a JSONValue object
*
* @access protected
*
* @param wchar_t** data Pointer to a wchar_t* that contains the data
*
* @return JSONValue* Returns a pointer to a JSONValue object on success, NULL on error
*/
JSONValue *JSONValue::Parse(const wchar_t **data)
{
  // Is it a string?
  if (**data == '"')
  {
    std::wstring str;
    if (!JSON::ExtractString(&(++(*data)), str))
       return NULL;
    else
       return new JSONValue(str);
  }

  // Is it a boolean?
  else if ((simplejson_wcsnlen(*data, 4) && wcsncasecmp(*data, L"true", 4) == 0) ||
(simplejson_wcsnlen(*data, 5) && wcsncasecmp(*data, L"false", 5) == 0))
  {
    bool value = wcsncasecmp(*data, L"true", 4) == 0;
    (*data) += value ? 4 : 5;
    return new JSONValue(value);
  }

  // Is it a null?
```

```
else if (simplejson_wcsnlen(*data, 4) && wcsncasecmp(*data, L"null", 4) == 0)
{
  (*data) += 4;
  return new JSONValue();
}

// Is it a number?
else if (**data == L'-' || (**data >= L'0' && **data <= L'9'))
{
  // Negative?
  bool neg = **data == L'-';
  if (neg) (*data)++;


  double number = 0.0;


  // Parse the whole part of the number - only if it wasn't 0
  if (**data == L'0')
     (*data)++;
  else if (**data >= L'1' && **data <= L'9')
     number = JSON::ParseInt(data);
  else
     return NULL;

  // Could be a decimal now...
  if (**data == '.')
  {
     (*data)++;
```

```
    // Not get any digits?
    if (!(**data >= L'0' && **data <= L'9'))
        return NULL;

    // Find the decimal and sort the decimal place out
    // Use ParseDecimal as ParseInt won't work with decimals less than 0.1
    // thanks to Javier Abadia for the report & fix
    double decimal = JSON::ParseDecimal(data);

    // Save the number
    number += decimal;
}


// Could be an exponent now...
if (**data == L'E' || **data == L'e')
{
    (*data)++;


    // Check signage of expo
    bool neg_expo = false;
    if (**data == L'-' || **data == L'+')
    {
        neg_expo = **data == L'-';
        (*data)++;
    }

    // Not get any digits?
    if (!(**data >= L'0' && **data <= L'9'))
```

```
            return NULL;

        // Sort the expo out
        double expo = JSON::ParseInt(data);
        for (double i = 0.0; i < expo; i++)
            number = neg_expo ? (number / 10.0) : (number * 10.0);
    }

    // Was it neg?
    if (neg) number *= -1;

    return new JSONValue(number);
}

// An object?
else if (**data == L'{')
{
    JSONObject object;

    (*data)++;

    while (**data != 0)
    {
        // Whitespace at the start?
        if (!JSON::SkipWhitespace(data))
        {
            FREE_OBJECT(object);
    return NULL;
}

// Special case - empty object
if (object.size() == 0 && **data == L'}')
{
    (*data)++;
    return new JSONValue(object);
}

// We want a string now...
std::wstring name;
if (!JSON::ExtractString(&(++(*data)), name))
{
    FREE_OBJECT(object);
    return NULL;
}

// More whitespace?
if (!JSON::SkipWhitespace(data))
{
    FREE_OBJECT(object);
    return NULL;
}

// Need a : now
if (*((*data)++) != L':')
{
    FREE_OBJECT(object);
    return NULL;
```

```
}

// More whitespace?
if (!JSON::SkipWhitespace(data))
{
   FREE_OBJECT(object);
   return NULL;
}

// The value is here
JSONValue *value = Parse(data);
if (value == NULL)
{
   FREE_OBJECT(object);
   return NULL;
}

// Add the name:value
if (object.find(name) != object.end())
   delete object[name];
object[name] = value;

// More whitespace?
if (!JSON::SkipWhitespace(data))
{
   FREE_OBJECT(object);
   return NULL;
}

// End of object?
```

```
        if (**data == L'}')
        {
            (*data)++;
            return new JSONValue(object);
        }

        // Want a , now
        if (**data != L',')
        {
            FREE_OBJECT(object);
            return NULL;
        }

        (*data)++;
    }

    // Only here if we ran out of data
    FREE_OBJECT(object);
    return NULL;
}

// An array?
else if (**data == L'[')
{
    JSONArray array;

    (*data)++;

    while (**data != 0)
    {
```

```
// Whitespace at the start?
if (!JSON::SkipWhitespace(data))
{
    FREE_ARRAY(array);
    return NULL;
}

// Special case - empty array
if (array.size() == 0 && **data == L']')
{
    (*data)++;
    return new JSONValue(array);
}

// Get the value
JSONValue *value = Parse(data);
if (value == NULL)
{
    FREE_ARRAY(array);
    return NULL;
}

// Add the value
array.push_back(value);

// More whitespace?
if (!JSON::SkipWhitespace(data))
{
    FREE_ARRAY(array);
    return NULL;
```

```
            }

            // End of array?
            if (**data == L']')
            {
                (*data)++;
                return new JSONValue(array);
            }

            // Want a , now
            if (**data != L',')
            {
                FREE_ARRAY(array);
                return NULL;
            }

            (*data)++;
        }

        // Only here if we ran out of data
        FREE_ARRAY(array);
        return NULL;
    }

    // Ran out of possibilites, it's bad!
    else
    {
        return NULL;
    }
}
```

```
/**
* Basic constructor for creating a JSON Value of type NULL
*
* @access public
*/
JSONValue::JSONValue(/*NULL*/)
{
   type = JSONType_Null;
}


/**
* Basic constructor for creating a JSON Value of type String
*
* @access public
*
* @param wchar_t* m_char_value The string to use as the value
*/
JSONValue::JSONValue(const wchar_t *m_char_value)
{
   type = JSONType_String;
   string_value = std::wstring(m_char_value);
}


/**
* Basic constructor for creating a JSON Value of type String
*
* @access public
```

```
*
* @param std::wstring m_string_value The string to use as the value
*/
JSONValue::JSONValue(const std::wstring &m_string_value)
{
   type = JSONType_String;
   string_value = m_string_value;
}


/**
* Basic constructor for creating a JSON Value of type Bool
*
* @access public
*
* @param bool m_bool_value The bool to use as the value
*/
JSONValue::JSONValue(bool m_bool_value)
{
   type = JSONType_Bool;
   bool_value = m_bool_value;
}


/**
* Basic constructor for creating a JSON Value of type Number
*
* @access public
*
* @param double m_number_value The number to use as the value
```

```
*/
JSONValue::JSONValue(double  m_number_value)
{
  type = JSONType_Number;
  number_value = m_number_value;
}


/**
* Basic constructor for creating a JSON Value of type Array
*
* @access public
*
* @param JSONArray m_array_value The JSONArray to use as the value
*/
JSONValue::JSONValue(const  JSONArray &m_array_value)
{
  type = JSONType_Array;
  array_value = m_array_value;
}


/**
* Basic constructor for creating a JSON Value of type Object
*
* @access public
*
* @param JSONObject m_object_value The JSONObject to use as the value
*/
JSONValue::JSONValue(const  JSONObject &m_object_value)
```

```
{
  type = JSONType_Object;
  object_value = m_object_value;
}


/**
* The destructor for the JSON Value object
* Handles deleting the objects in the array or the object value
*
* @access public
*/
JSONValue::~JSONValue()
{
  if (type == JSONType_Array)
  {
    JSONArray::iterator iter;
    for (iter = array_value.begin(); iter != array_value.end(); iter++)
       delete *iter;
  }
  else if (type == JSONType_Object)
  {
    JSONObject::iterator iter;
    for (iter = object_value.begin(); iter != object_value.end(); iter++)
    {
       delete (*iter).second;
    }
  }
}
```

```
/**
* Checks if the value is a NULL
*
* @access public
*
* @return bool Returns true if it is a NULL value, false otherwise
*/
bool JSONValue::IsNull() const
{
   return type == JSONType_Null;
}


/**
* Checks if the value is a String
*
* @access public
*
* @return bool Returns true if it is a String value, false otherwise
*/
bool JSONValue::IsString() const
{
   return type == JSONType_String;
}


/**
* Checks if the value is a Bool
*
```

```
* @access public
*
* @return bool Returns true if it is a Bool value, false otherwise
*/
bool JSONValue::IsBool() const
{
   return type == JSONType_Bool;
}


/**
* Checks if the value is a Number
*
* @access public
*
* @return bool Returns true if it is a Number value, false otherwise
*/
bool JSONValue::IsNumber() const
{
   return type == JSONType_Number;
}


/**
* Checks if the value is an Array
*
* @access public
*
* @return bool Returns true if it is an Array value, false otherwise
*/
```

```
bool JSONValue::IsArray() const
{
   return type == JSONType_Array;
}


/**
* Checks if the value is an Object
*
* @access public
*
* @return bool Returns true if it is an Object value, false otherwise
*/
bool JSONValue::IsObject() const
{
   return type == JSONType_Object;
}


/**
* Retrieves the String value of this JSONValue
* Use IsString() before using this method.
*
* @access public
*
* @return std::wstring Returns the string value
*/
const std::wstring &JSONValue::AsString() const
{
   return string_value;
}


/**
* Retrieves the Bool value of this JSONValue
* Use IsBool() before using this method.
*
* @access public
*
* @return bool Returns the bool value
*/
bool JSONValue::AsBool() const
{
  return bool_value;
}


/**
* Retrieves the Number value of this JSONValue
* Use IsNumber() before using this method.
*
* @access public
*
* @return double Returns the number value
*/
double JSONValue::AsNumber() const
{
  return number_value;
}
```

```
/**
* Retrieves the Array value of this JSONValue
* Use IsArray() before using this method.
*
* @access public
*
* @return JSONArray Returns the array value
*/
const JSONArray &JSONValue::AsArray() const
{
   return array_value;
}


/**
* Retrieves the Object value of this JSONValue
* Use IsObject() before using this method.
*
* @access public
*
* @return JSONObject Returns the object value
*/
const JSONObject &JSONValue::AsObject() const
{
   return object_value;
}


/**
* Retrieves the number of children of this JSONValue.
* This number will be 0 or the actual number of children
* if IsArray() or IsObject().
*
* @access public
*
* @return The number of children.
*/
std::size_t JSONValue::CountChildren() const
{
  switch (type)
  {
    case JSONType_Array:
       return array_value.size();
    case JSONType_Object:
       return object_value.size();
    default:
       return 0;
  }
}


/**
* Checks if this JSONValue has a child at the given index.
* Use IsArray() before using this method.
*
* @access public
*
* @return bool Returns true if the array has a value at the given index.
*/
bool JSONValue::HasChild(std::size_t index) const
```

```
{
  if (type == JSONType_Array)
  {
    return index < array_value.size();
  }
  else
  {
    return false;
  }
}


/**
* Retrieves the child of this JSONValue at the given index.
* Use IsArray() before using this method.
*
* @access public
*
* @return JSONValue* Returns JSONValue at the given index or NULL
*               if it doesn't exist.
*/
JSONValue *JSONValue::Child(std::size_t index)
{
  if (index < array_value.size())
  {
    return array_value[index];
  }
  else
  {
    return NULL;
  }
}


/**
* Checks if this JSONValue has a child at the given key.
* Use IsObject() before using this method.
*
* @access public
*
* @return bool Returns true if the object has a value at the given key.
*/
bool JSONValue::HasChild(const wchar_t* name) const
{
  if (type == JSONType_Object)
  {
    return object_value.find(name) != object_value.end();
  }
  else
  {
    return false;
  }
}


/**
* Retrieves the child of this JSONValue at the given key.
* Use IsObject() before using this method.
*
* @access public
```

```
*
* @return JSONValue* Returns JSONValue for the given key in the object
*                   or NULL if it doesn't exist.
*/
JSONValue* JSONValue::Child(const wchar_t* name)
{
  JSONObject::const_iterator it = object_value.find(name);
  if (it != object_value.end())
  {
    return it->second;
  }
  else
  {
    return NULL;
  }
}


/**
* Creates a JSON encoded string for the value with all necessary characters escaped
*
* @access public
*
* @return std::wstring Returns the JSON string
*/
std::wstring JSONValue::Stringify() const
{
  std::wstring ret_string;

  switch (type)
```

```
{
  case JSONType_Null:
     ret_string = L"null";
     break;

  case JSONType_String:
     ret_string = StringifyString(string_value);
     break;

  case JSONType_Bool:
     ret_string = bool_value ? L"true" : L"false";
     break;

  case JSONType_Number:
  {
     if (isinf(number_value) || isnan(number_value))
        ret_string = L"null";
     else
     {
        std::wstringstream ss;
        ss.precision(15);
        ss << number_value;
        ret_string = ss.str();
     }
     break;
  }

  case JSONType_Array:
  {
     ret_string = L"[";
```

```
    JSONArray::const_iterator iter = array_value.begin();
    while (iter != array_value.end())
    {
        ret_string += (*iter)->Stringify();

        // Not at the end - add a separator
        if (++iter != array_value.end())
            ret_string += L",";
    }
    ret_string += L"]";
    break;
}

case JSONType_Object:
{
    ret_string = L"{";
    JSONObject::const_iterator iter = object_value.begin();
    while (iter != object_value.end())
    {
        ret_string += StringifyString((*iter).first);
        ret_string += L":";
        ret_string += (*iter).second->Stringify();

        // Not at the end - add a separator
        if (++iter != object_value.end())
            ret_string += L",";
    }
    ret_string += L"}";
    break;
}
```

```
  }


  return ret_string;
}


/**
* Creates a JSON encoded string with all required fields escaped
* Works from http://www.ecma-internationl.org/publications/files/ECMA-ST/ECMA-262.pdf
* Section 15.12.3.
*
* @access private
*
* @param std::wstring str The string that needs to have the characters escaped
*
* @return std::wstring Returns the JSON string
*/
std::wstring JSONValue::StringifyString(const std::wstring &str)
{
  std::wstring str_out = L"\"";

  std::wstring::const_iterator iter = str.begin();
  while (iter != str.end())
  {
    wchar_t chr = *iter;


    if (chr == L'"' || chr == L'\\' || chr == L'/')
    {
       str_out += L'\\';
    str_out += chr;
}
else if (chr == L'\b')
{
    str_out += L"\\b";
}
else if (chr == L'\f')
{
    str_out += L"\\f";
}
else if (chr == L'\n')
{
    str_out += L"\\n";
}
else if (chr == L'\r')
{
    str_out += L"\\r";
}
else if (chr == L'\t')
{
    str_out += L"\\t";
}
else if (chr < L' ' || chr > 126)
{
    str_out += L"\\u";
    for (int i = 0; i < 4; i++)
    {
        int value = (chr >> 12) & 0xf;
        if (value >= 0 && value <= 9)
            str_out += (wchar_t)('0' + value);
            else if (value >= 10 && value <= 15)
                str_out += (wchar_t)('A' + (value - 10));
            chr <<= 4;
        }
    }
    else
    {
        str_out += chr;
    }

    iter++;
  }

  str_out += L"\"";
  return str_out;
}
```

JSONValue.h

```
/*
* File JSONValue.h part of the SimpleJSON Library - http://mjpa.in/json
*
* Copyright (C) 2010 Mike Anchor
*
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* OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN

* THE SOFTWARE.

*/



#ifndef _JSONVALUE_H_

#define _JSONVALUE_H_



#include <vector>

#include <string>



#include "JSON.h"



class JSON;
```

```
enum JSONType { JSONType_Null, JSONType_String, JSONType_Bool, JSONType_Number,
JSONType_Array, JSONType_Object };



class JSONValue

{

  friend class JSON;


  public:

    JSONValue(/*NULL*/);

    JSONValue(const wchar_t *m_char_value);

    JSONValue(const std::wstring &m_string_value);

    JSONValue(bool m_bool_value);

    JSONValue(double m_number_value);

    JSONValue(const JSONArray &m_array_value);

    JSONValue(const JSONObject &m_object_value);

    ~JSONValue();



    bool IsNull() const;

    bool IsString() const;

    bool IsBool() const;

    bool IsNumber() const;

    bool IsArray() const;

    bool IsObject() const;


    const std::wstring &AsString() const;

    bool AsBool() const;

    double AsNumber() const;

    const JSONArray &AsArray() const;

    const JSONObject &AsObject() const;
```

```
        std::size_t CountChildren() const;
        bool HasChild(std::size_t index) const;
        JSONValue *Child(std::size_t index);
        bool HasChild(const wchar_t* name) const;
        JSONValue *Child(const wchar_t* name);

        std::wstring Stringify() const;

    protected:
        static JSONValue *Parse(const wchar_t **data);

    private:
        static std::wstring StringifyString(const std::wstring &str);

        JSONType type;
        std::wstring string_value;
        bool bool_value;
        double number_value;
        JSONArray array_value;
        JSONObject object_value;
};

#endif
```

Makefile (c++)

```
CC=g++

CFLAGS=-c -Wall
LFLAGS=-lm

SOURCES=runCpluPlus.cpp JSON.cpp JSONValue.cpp
HEADERS=JSON.h JSONValue.h  cPlusPlusCompiler.h

OBJECTS=$(SOURCES:.cpp=.o)

EXECUTABLE=TestJSON

all: $(SOURCES) $(EXECUTABLE)

$(EXECUTABLE): $(OBJECTS)
  $(CC) $(LFLAGS)  $(OBJECTS) -o $@

.cpp.o:
  $(CC) $(CFLAGS)  $< -o $@

clean:
  rm -f $(OBJECTS) $(EXECUTABLE)  *~ SampleOutput.txt
```

```
full: clean all
```

SampleInput.txt

```
{ "name" : "name1",
"age" : 25123,
"BoolVal"  : True,
"scores" : [1, 2, 3, {
"foo" : "False",
"bar" : "123" } ],
"sub_object" : {
"foo" : "True",
"bar" : "123" }
}
```

cPlusPlusCompiler.h

```
#include <iostream>
#include <fstream>
#include <string>
#include <vector>
#include <map>
#include <algorithm>
#include "./JSON.h"
#include <sstream>

using namespace std;

//SimpleJSON uses
```

```
void print_out(const wchar_t *output)
{
    wcout << output;
    wcout.flush();
}
string funcRemoveStr (string s) {
   int a  = 0 ;
   string p = "\\n" ;
   while ( a != -1){
      a = s.find(p) ;
      if (a == -1)
          break ;
      s = s.substr(0,a) + s.substr(a+2);
   }
   return s ;
}
string wstringToString (wstring w){
   string result = "" ;
   char x ;
    for ( int i = 0  ; w[i] != '\0' ; i ++ ){
      x = w[i] ;
      result += x ;
    }
    return result ;
}


enum dataType { NUMBER  , STRING , BOOL , JSON, LIST} ;
```

```
class CustType {

  public :

  static string data ;

  CustType (string data) {

    //this->dt = NUMBER  ;
    this->data = data ;
  }

  CustType () {

  }
  static CustType* parse (string data, string type) ;
  static string typeString ( CustType* t) ;
  static CustType* read(string filename);
  static void print(CustType* data) ;
  static void print (vector<CustType*>  :: iterator it ) ;
  static void write(CustType* data, string filename);
  static CustType* typeStruct(CustType* input);
  static CustType* typeStructList(CustType* input);
  virtual void print () {
    cout << "Printing  in CustType, Ooops! \n Somebody needs to implement this in child class\n"
;
  }
  virtual int getType(){
    cout << "getting  Type  from CustType, Ooops! \n Somebody needs to implement this in child
class" ;
  }
  virtual map<string , CustType* >::iterator getBeginIterator (){
    map<string , CustType* >::iterator it ;
    cout << "Accesing outside of Json Object "  ;
    return it ;
  }
  virtual map<string , CustType* >::iterator getEndIterator (){
    map<string , CustType* >::iterator it ;
    cout << "Accesing outside of Json Object "  ;
    return it ;
  }
  virtual vector <CustType*> :: iterator getListBegin () {
    vector <CustType*> :: iterator it ;
    cout << "Accesing outside of List Object "  ;
    return it ;
  }
  virtual vector <CustType*> :: iterator getListEnd () {
    vector <CustType*> :: iterator it ;
    cout << "Accesing outside of List Object "  ;
    return it ;
  }
  virtual CustType* getAttrList () {
    JSONObject::iterator it ;
    cout << "Accesing outside of Json Object "  ;
    return NULL ;
  }
  virtual CustType* getElementByOcaml ( CustType* key ) {
    cout << "In CustType, apparently not in JSON or LIST. Calling from some other type\n" ;
    return  NULL ;
  }
```

```
virtual CustType* getElement ( string key ) {
  cout << "In CustType, apparently not in JSON. Calling from some other type\n" ;
  return  NULL ;
}
virtual CustType* getElement ( int index ) {
  cout << "In CustType, apparently not in LIST. Calling from some other type\n" ;
  return  NULL ;
}


//Conv to String
virtual string toString () {
  return "\nInside CustType\n" ;
}


//conv to StrType
virtual CustType* makeString () {
  return CustType :: parse ("\nInside CustType\n" , "STRING") ;
}
//print json in prettyPrint format
virtual string prettyPrint(int offset){
  cout << "prettyPrint() is only valid on JSON type objects.\n" ;
}
//append to a list
virtual void add (CustType* el) {
  cout << "In CustType, apparently not in LIST. Calling from some other type\n" ;
}
virtual void addByKey (CustType* index , CustType* el){
      cout << "In CustType, apparently not in LIST or JSON. Calling from some other type\n" ;
    }



    //add item to map
    virtual void add (string  key, CustType* el) {
      cout << "In CustType, apparently not in JSON. Calling from some other type\n" ;



    }
    /*virtual void addToJson (CustType* key, CustType* el) {
      cout << "In CustType, apparently not in JSON. Calling from some other type\n" ;
    }*/
    virtual CustType* contains (CustType* t) {
      cout << "Only defined for Lists. \n" ;
      return NULL ;
    }
    virtual CustType* findIndex  (CustType* t){
      cout << "Only defined for Lists. \n" ;
      return NULL ;
    }
    virtual CustType* minus (CustType* t) {
      cout << "Only defined for Lists. \n" ;
      return NULL ;
    }
    virtual CustType* getJoType() {
            cout << "Printing in CustType, Ooops!\n Somebody needs to implement this in child
  class\n" ;
    }
    //concat items and form a list
    static CustType* concat (CustType* t1, CustType* t2) ;
```

```
//Mathematical Operators
//Add is valid for NUMBER + NUMBER and STRING + STRING (JO operator ++)
//The remaining mathematical operators are valid only for NUMBER, NUMBER
//Returns NULL pointer if arguments are of an invalid type.
static CustType* add(CustType* t1, CustType* t2);


static CustType* subtract(CustType* t1, CustType* t2);


static CustType* multiply(CustType* t1, CustType* t2);


static CustType* divide(CustType* t1, CustType* t2);


static CustType* mod(CustType* t1, CustType* t2);


//Get c++ Boolean value from BoolType
virtual bool getBoolValue() {
  cout << "In CustType, only valid for BoolType\n";
}


//Operator Overloading:
virtual CustType& operator+=(CustType& rhs)
{
  cout << "In CustType, only allowed in NUMBER and STRING\n";
```

```
    }


    virtual CustType& operator-=(CustType& rhs)
    {
      cout << "In CustType, only allowed in NUMBER\n";
    }


    virtual CustType& operator*=(CustType& rhs)
    {
      cout << "In CustType, only allowed in NUMBER\n";
    }


    virtual CustType& operator/=(CustType& rhs)
    {
      cout << "In CustType, only allowed in NUMBER\n";
    }
};


class BoolType : public CustType {
    public :


    bool da ;
    int type ;
    BoolType (bool da , int type ) : CustType (  ) {


        this -> da = da ;
        this -> type = type ;
    }
    int getType () {
       return BOOL ;
    }


    bool getBoolValue()
    {
      return da;
    }
    CustType* getJoType() {
       return ( CustType :: parse ("Bool" , "STRING")) ;
    }
    void print () {
      if(da) { cout << "true" ; }
      else { cout << "false" ; }
    }
    string toString () {
       string ret = "false";
       if ( da)
           ret = "true" ;
       return ret ;
    }
    CustType* makeString () {
       string ret = "false";
       if ( da)
           ret = "true" ;
       return CustType :: parse (this -> toString() , "STRING") ;
    }
};
```

```
class NumType : public CustType {



  public :


  double da;
  int type ;
  NumType (double da , int type) : CustType (  ) {
    this -> da = da ;
    this -> type = type ;


  }
  void print () {
    cout << da ;
  }
  int getType () {
    return NUMBER  ;
  }
  CustType* getJoType() {
    return ( CustType :: parse ("Number" , "STRING"))  ;
  }
  string toString () {
    string ret ;
    ostringstream strs;
    strs << this -> da;
    ret = strs.str() ;
    return ret ;
  }
```

```
CustType* makeString () {

   return CustType :: parse( this -> toString() , "STRING" ) ;

}
NumType& operator+=(CustType& rhs)
    {
  CustType& t1 = rhs;
  NumType& temp = dynamic_cast<NumType&>(t1);
  da+=temp.da;
  return *this;
}


NumType& operator-=(CustType& rhs)
    {
  CustType& t1 = rhs;
  NumType& temp = dynamic_cast<NumType&>(t1);
  da-=temp.da;
  return *this;
}


NumType& operator*=(CustType& rhs)
    {
  CustType& t1 = rhs;
  NumType& temp = dynamic_cast<NumType&>(t1);
  da*=temp.da;
  return *this;
}
```

```
  NumType& operator/=(CustType& rhs)
     {
    CustType& t1 = rhs;
    NumType& temp = dynamic_cast<NumType&>(t1);
    da/=temp.da;
    return *this;
  }
} ;


class StringType : public CustType {

  public :
  string da;
  int type ;
  StringType (string da , int type ) : CustType (  ) {

    this -> da = da ;
    this -> type = type ;
  }

  StringType(){


  }
  string toString () {
    return da ;
  }
  CustType* makeString () {
    return CustType :: parse(this -> toString() , "STRING" ) ;


  }
  CustType* getJoType() {
    return (CustType :: parse ("String" , "STRING")) ;
  }
  void print () {
    cout << da ;
  }
  int getType () {
    return STRING ;
  }


  StringType& operator+=(CustType& rhs)
     {
    CustType& t1 = rhs;
    StringType& temp = dynamic_cast<StringType&>(t1);
    da+=temp.da;
    return *this;
  }

} ;


class ListType : public CustType {



  int type ;
  JSONArray data ;
```

```
public :
vector <CustType*> da;
void convToListType() ;
/*(ListType (vector <CustType> da , int type) : CustType (  ) {

   this -> da = da ;
   this -> type = type ;
}*/
ListType(){

}
ListType(JSONArray data, int type) : CustType()  {
   this -> data = data ;
   this -> type = type ;
   convToListType() ;
}
ListType(vector <string> v) : CustType () {
   for (vector<string> :: iterator it = v.begin ( ); it != v.end () ; it ++ ){
      StringType* s = new StringType ( *it, STRING ) ;
      this -> da.push_back (s) ;
   }
}
int getType () {
   return LIST ;
}
CustType* getJoType() {
   return ( CustType :: parse ("List" , "STRING")) ;
}
void print () {
   /*
   for (vector<CustType*> :: iterator it = da.begin () ; it != da.end () ; ++ it) {
       (*it) -> print () ;
       if ( it != (da.end() - 1) ) {
         cout << ",";
       }
   } */
   cout << toString () ;
}
string toString () {
   string ret  = "[" ;
   for (vector<CustType*> :: iterator it = da.begin () ; it != da.end () ; ++ it) {
       if ( it != da.begin () )
           ret += "," ;
       ret += (*it) -> toString () ;


   }
   ret += "]" ;
   return ret ;


}





CustType* makeString () {


   return CustType :: parse(this -> toString() , "STRING" ) ;


}
```

```
CustType* getElementByOcaml (CustType* indexNumType) {
  NumType* indexNum = dynamic_cast<NumType *>(indexNumType);
  double doubleKey = indexNum -> da ;
  int index = (int) doubleKey ;
  if ( index >= da.size())
     return NULL ;
  return da[index] ;
}
CustType* getElement (int index) {

  if ( index >= da.size())
     return NULL ;
  return da[index] ;
}
vector<CustType*> :: iterator getListBegin(){
  return da.begin() ;
}
vector<CustType*> :: iterator getListEnd (){
  return da.end() ;
}
void addByKey (CustType* index , CustType* el){
  NumType* indexNum = dynamic_cast<NumType *>(index);
  double doubleKey = indexNum -> da ;
  int intKey = (int) doubleKey ;
  if ( intKey >= 0 ){
     da [intKey]  = el ;
  }
  else {
     cout << "index has value < 0" ;
     exit (1) ;
```

```
      }
    }
    void add ( CustType* el ) {
      da.push_back (el) ;
    }
    bool operator==(CustType *rhs)
    {
      NumType *temp1 = dynamic_cast<NumType *>(this);
      NumType *temp2 = dynamic_cast<NumType *>(rhs);


      return ((temp1->da)==(temp2->da));
    }
    //returns index of element if found, otherwise returns -1
    CustType* findIndex (CustType* c) ;
    CustType* minus (CustType* c) ;
    CustType* contains (CustType * c) ;


} ;



class JsonType : public CustType {


     //JSONObject da;
     int type;


     public :
     JSONObject data ;
    map <string , CustType* > da ;
    void convToJsonType () ;
    JsonType(JSONObject data, int type) : CustType() {
      this -> data= data;
      this -> type = type;
      //this -> da = new map <string , CustType* >  ;
      convToJsonType() ;
    }


    JsonType() {}


    void print() {/*
     JSONValue *value = new JSONValue(data);
     print_out(value->Stringify().c_str());*/
     cout <<  prettyPrint(0) ;
    }
    CustType* getJoType() {
      return ((CustType :: parse ("Json" , "STRING")) ) ;
   }
    string toString () {
      string ret = "{" ;
      for ( map<string , CustType* > :: iterator it = (this -> da).begin() ; it != (this -> da).end() ; ++ it
  ) {
          if ( it != (this -> da).begin() )
              ret += "," ;
          ret += "\"" ;
          ret += it -> first ;
          ret += "\"" ;
      ret += ":" ;
      string valStr =  (it -> second ) -> toString ();
      if ( (it -> second) -> getType () == STRING) {
          ret += "\"" ;
          ret += valStr ;
          ret += "\"" ;
      }
      else {
          ret += valStr ;
      }
  }
  ret += "}" ;
  return ret ;


}
CustType* makeString () {
  return CustType :: parse ( this -> toString () , "STRING") ;
}


string prettyPrint (int offset) {
  string ret = "" ;
  string offsetTabs = "" ;
  for ( int i = 1 ; i <= offset ; i ++) {
      offsetTabs += "\t" ;
  }
  ret += offsetTabs ;
  ret += "{\n" ;
  string insideJsonPrint = prettyPrintJsonUtility (this , offset + 1) ;
  ret += insideJsonPrint ;
  ret += offsetTabs ;
  ret += "}\n" ;
  return ret ;
}
string prettyPrintJsonUtility ( JsonType* t , int offset) {
  string ret = ""  ;
  string offsetTabs = "" ;
  for ( int i = 1 ; i <= offset ; i ++) {
      offsetTabs += "\t" ;
  }
   for ( map<string , CustType* > :: iterator it = (t -> da).begin() ; it != (t -> da).end() ; ++ it ) {
      string el = "" ;
      if ( it != (t -> da).begin() )
          el += ",\n" ;
      el += offsetTabs ;
      el += "\"" ;
      el += it -> first ;
      el += "\"" ;


      el += ":" ;
      if ( (it -> second )  -> getType() == NUMBER || (it -> second )  -> getType() == BOOL ){
          el +=  (it -> second ) -> toString ();
      }
      else if ((it -> second ) -> getType () == STRING){
          el +=  "\"" + (it -> second ) -> toString () + "\"";
```

```
        }


        else if ((it -> second ) -> getType () == JSON){
            el += "{\n" ;
            el += prettyPrintJsonUtility  ( (JsonType*)(it -> second ), offset + 1 ) ;
            el += offsetTabs ;
            el += "}" ;
        }
        else{
            el += "[\n" ;
            el += prettyPrintListUtility ( (ListType*)(it -> second) , offset + 1 ) ;
            el += offsetTabs ;
            el += "]" ;
        }
        ret += el ;
    }
     ret += "\n" ;
     return ret ;
}
 string prettyPrintListUtility(  ListType* t, int offset){
    string ret = ""   ;
    string offsetTabs = "" ;
    for ( int i = 1 ; i <= offset ; i ++) {
        offsetTabs += "\t" ;
    }
     for (vector<CustType*> :: iterator it = (t -> da).begin () ; it != (t -> da).end () ; ++ it ) {
        string el = "" ;
        if ( it != (t-> da).begin() )
            el += ",\n" ;
        el += offsetTabs ;


        if ( (*it) -> getType() == NUMBER || (*it) -> getType() == BOOL){
            el += (*it) -> toString ();
        }
        else if ( (*it) -> getType () == STRING){
            el +=  "\"" + (*it) -> toString () + "\"";
        }
        else if ((*it) -> getType  () == JSON){
            el += "{\n" ;
            el += prettyPrintJsonUtility  ((JsonType*)(*it), offset + 1 ) ;
            el += offsetTabs ;
            el += "}" ;
        }
        else{
            el += "[\n" ;
            el += prettyPrintListUtility  ((ListType*)(*it), offset + 1 ) ;
            el += offsetTabs ;
            el += "]" ;
        }
        ret += el ;
    }
    ret += "\n" ;
    return ret ;
}
int getType() {
    return JSON;
}
CustType* getAttrList () ;
```

```
   vector<string> getStringAttrList () {
     vector <string> atrrListStr;
     for ( map<string , CustType* > ::iterator iter  =  getBeginIterator()  ; iter !=  getEndIterator () ;
iter ++ ) {

         string keyString =  iter -> first  ;
         atrrListStr.push_back(keyString) ;
     }
     return atrrListStr ;
   }

   map<string , CustType* >::iterator getBeginIterator (){
     map<string , CustType* > :: iterator it  = (this -> da).begin();

     return it ;
  }

  map<string , CustType* >::iterator getEndIterator (){
     map<string , CustType* > :: iterator it = (this -> da ).end ();
     return it ;
  }
  CustType * getElementByOcaml (CustType* keyStrType) {
     StringType *keyStr = dynamic_cast<StringType *>(keyStrType);
     string key = keyStr -> toString () ;
     if ( da.find(key)  == da.end())
         return NULL  ;
     else
         return da[key]  ;
  }
  CustType * getElement (string key) {
    if ( da.find(key) == da.end())
        return NULL ;
    else
        return da[key] ;
  }
  void addToJson (CustType* key, CustType* el){
    StringType *keyStr = dynamic_cast<StringType *>(key);
    string stringKey = keyStr -> toString () ;
    da [stringKey] = el ;
  }
  void addByKey (CustType* keyStrType, CustType* el) {
    StringType *keyStr = dynamic_cast<StringType *>(keyStrType);
    string key = keyStr -> toString () ;
    da [key] = el ;
  }
  void add (string  key, CustType* el) {
    da [key] = el ;
  }
  CustType* minus (CustType* c){
    string k = c -> toString () ;
    CustType* t = new JsonType ;
    for ( map<string , CustType* > ::iterator iter  =  getBeginIterator()  ; iter !=  getEndIterator  () ;
iter ++ ) {


        if ( k != iter -> first)
            t -> add (iter -> first,iter -> second) ;


    }
```

```
      return t ;

   }

   CustType* contains (CustType* c){

      if (c ->getType() != STRING){

          cout << "\n JSON :: contains(key) expects a STRING argument\n" ;

          return this ;

      }

      string k = c -> toString() ;

      for ( map<string , CustType* > ::iterator iter  =  getBeginIterator()  ; iter !=  getEndIterator  () ;
iter ++ ) {


          if ( iter -> first == k)

              return (new BoolType(true,BOOL))  ;


      }

      return (new BoolType(false,BOOL))  ;



   }



};

/***************************************************

      CLASS DEFINITIONS  END HERE

***************************************************/



NumType* getNum(string data, int type)

{

 const char *cstr = data.c_str();

 char* pEnd;
 double num = strtod(cstr, &pEnd);
 NumType* t = new NumType(num, NUMBER);
 return t;
}


StringType* getString (string data, int type){
   /*if ( data.at(0) !='"' || data.at(data.length() - 1 ) != '"') {
      return NULL ;
   }*/
   //data.erase(0,1) ;
   //data.erase(data.length() - 1, 1) ;

   StringType* t = new StringType (data, STRING) ;


   return t ;
}


ListType* getList (string data, int type){

   std::string str = data;
    const char *cstr = str.c_str();


    JSONValue *value = JSON::Parse(cstr);
    JSONObject root;

    if (value == NULL) {
       return NULL;
    }
    else {
   if (value->IsObject() == false) {
       return NULL;
   }
   else {
       root = value->AsObject();
   }
    }


    JsonType* t = new JsonType(root, JSON);


   return (ListType *) t -> getElement ("List");
}


BoolType* getBool (string data , int type) {
   BoolType * t = new BoolType ( data == "true" ? 1 : 0 , BOOL ) ;
   return t ;
}


JsonType* getJson (string data, int type){


    std::string str = data;
    const char *cstr = str.c_str();


    JSONValue *value = JSON::Parse(cstr);
    JSONObject root;


    if (value == NULL) {
       return NULL;
    }
    else {
   if (value->IsObject() == false) {
       return NULL;
   }
   else {
       root = value->AsObject();
   }
    }



    JsonType* t = new JsonType(root, JSON);
    return t ;
}



CustType* CustType :: parse (string data, string type)  {


      data = funcRemoveStr (data) ;


      if (type == "STRING"){


          return getString ( data , STRING) ;


      }
      else if (type == "LIST"){


          data = "{ \"List\" : " + data + " }" ;
          //CustType :: dt = LIST ;
          return getList ( data , LIST ) ;
      }
      else if (type == "JSON"){
          //CustType :: dt = JSON ;
          return getJson (data, JSON) ;
      }
      else if (type == "BOOL"){
          return getBool (data, JSON) ;
      }
      else if (type == "NUMBER"){
          //CustType :: dt = NUMBER  ;
          return getNum  (data, NUMBER)  ;
      }
      else {
          return NULL  ;
      }
}


void CustType :: print ( CustType* data) {
   //cout << "I am here bitch" << endl ;
   data -> print () ;
}


void CustType :: write (CustType * data, string filename) {
 string toWrite = data -> toString();
 ofstream file(filename.c_str(), ios::app);
 if ( file.is_open() )
   {
     file << toWrite << endl;
   }
 else
   {
     cout << "Unable to open file" << endl;
   }
}


void CustType :: print (vector<CustType*>  :: iterator it ) {
   (*it) -> print () ;
}


string CustType :: typeString ( CustType* t) {


   int typeVal = t -> getType () ;
   string type = "" ;
   switch (typeVal) {
      case NUMBER :     type = "NUMBER" ;
                        break ;
      case STRING :     type = "STRING" ;
                        break ;
      case JSON :    type = "JSON" ;
                       break ;
      case LIST :    type = "LIST" ;
```

```
                    break ;
    }
    return type ;
}


void JsonType :: convToJsonType (){


    map <string , CustType* > a ;


    for ( JSONObject::iterator iter  = (this -> data).begin() ; iter !=  (this -> data).end () ; iter ++ ) {


        string key = wstringToString ( iter -> first ) ;
        if ( (iter -> second)-> IsString () ) {
            string val = wstringToString ((iter-> second)-> AsString () ) ;
            StringType* t = new StringType (val, STRING)  ;
            //cout << val ;
            a[key] = t  ;
        }
        else if ( (iter -> second)-> IsBool () ) {
            bool val = (iter-> second)-> AsBool ()  ;
            BoolType* t = new BoolType (val, BOOL) ;
            //cout << val ;
            a[key] = t ;
        }
        else if ( (iter -> second)-> IsNumber () ) {
            double val = (iter-> second)-> AsNumber ()  ;
            NumType* t = new NumType (val, NUMBER)  ;
            //cout << val ;
            a[key] = t ;
        }
        else if ( (iter -> second)-> IsObject() ){
            JSONObject val = (iter-> second)-> AsObject () ;
            JsonType* t = new JsonType ( val , JSON) ;
            a[key] =  t ;
        }
        else if ( (iter) -> second -> IsArray () ){
            JSONArray val = (iter -> second )-> AsArray () ;
            ListType* t = new ListType ( val , LIST ) ;
            a[key] = t ;
        }
        else {
            cout << "Here I am, stuck in JsonType :: convToJsonType, I think the JSON library is
screwing up, and throwing random types. " ;
        }
        //cout << endl ;


    }



    da.insert ( a.begin() , a.end () ) ;
    //return a ;
}



void ListType :: convToListType () {



    for ( vector<JSONValue*>  :: iterator iter  = data.begin () ; iter !=  data.end () ; iter ++ ) {
```

```
if ( (*iter) -> IsString () ) {
    string val = wstringToString ((*iter) -> AsString () ) ;
    StringType* t = new StringType (val, STRING) ;
    //cout << val ;
    da.push_back(t) ;
}
else if ( (*iter) -> IsBool () ) {
    bool val = (*iter) -> AsBool ()  ;
    BoolType* t = new BoolType (val, BOOL) ;
    //cout << val ;
    da.push_back(t) ;
}
else if ( (*iter) -> IsNumber () ) {
    double val = (*iter) -> AsNumber ()  ;
    NumType* t = new NumType (val, NUMBER) ;
    //cout << val ;
    da.push_back(t) ;
}
else if ( (*iter) -> IsObject() ){
    JSONObject val = (*iter) -> AsObject () ;
    JsonType* t = new JsonType ( val , JSON) ;
    da.push_back(t) ;
}
else if ( (*iter) -> IsArray () ){
    JSONArray val = (*iter) -> AsArray () ;
    ListType* t = new ListType ( val , LIST ) ;
    da.push_back(t) ;
}
else {
```

```
          cout << "Here I am, stuck in ListType :: convToListType, I think the JSON library is
screwing up, and throwing random types. " ;

      }

      //cout << endl ;


   }

}



CustType* JsonType :: getAttrList () {



   vector <string> atrrListStr;

   for ( map<string , CustType* > ::iterator iter  =  getBeginIterator() ; iter !=  getEndIterator () ;
iter ++ ) {


      string keyString =  iter -> first  ;

      atrrListStr.push_back(keyString) ;

   }

   ListType* attrList = new ListType (atrrListStr) ;

   return attrList ;

}




CustType* CustType::typeStruct(CustType *input)

{

 JsonType *inputJson = dynamic_cast<JsonType *>(input);

 CustType *returnString = new StringType("{", STRING);

 CustType *element;

 for( map<string, CustType*> :: iterator it = (inputJson->da).begin() ; it != (inputJson->da).end() ;
++ it)
```

```
 {
  int type = (it->second)->getType();
  if ( type == NUMBER )
 {
  element = new StringType(" String : Number, ", STRING);
 }
  else if ( type == STRING )
 {
  element = new StringType(" String : String, ", STRING);
 }
  else if ( type == BOOL )
 {
  element = new StringType(" String : Boolean, ", STRING);
 }
  else if ( type == JSON )
 {
  CustType *e1 = new StringType(" String : ", STRING);
  CustType *e2 = CustType::typeStruct(it->second);
  CustType *e3 = new StringType(", ", STRING);
  element = CustType::add(e1, e2);
  element = CustType::add(element, e3);
 }
  else if ( type == LIST )
 {
  //CustType *e1 = CustType::typeStructList(it->second);
  //CustType *e2 = new StringType(", ", STRING);
  //element = CustType::add(e1, e2);



  //Use next line instead of above 3 if desired behavior is to simply return "List" instead of the
types contained within the list.
```

```
     element = new StringType(" String : List, ", STRING);
   }

     returnString = CustType::add(returnString, element);
    }

 StringType *str = dynamic_cast<StringType *>(returnString);
 string data = str->da;
 str->da = data.substr(0, data.size()-2);

 StringType *s = new StringType(" }", STRING);
 CustType *toReturn = CustType::add(str, s);

 return toReturn;
}

CustType* CustType::typeStructList(CustType *input)
{
 ListType *inputList = dynamic_cast<ListType *>(input);
 CustType *returnString = new StringType("[", STRING);
 CustType *element;
 for (vector<CustType*> :: iterator it = (inputList->da).begin () ; it != (inputList->da).end () ; ++ it)
    {
     int type = (*it)->getType();
     if ( type == NUMBER )
   {
```

```
  element = new StringType(" Number,", STRING);
}
  else if ( type == STRING )
{
  element = new StringType(" String,", STRING);
}
  else if ( type == BOOL )
{
  element = new StringType("Boolean,  ", STRING);
}
  else if ( type == JSON )
{
  CustType *e0 = new StringType(" ", STRING);
  CustType *e1 = CustType::typeStruct(*it);
  CustType *e2 = new StringType(", ", STRING);
  element = CustType::add(e0, e1);
  element = CustType::add(element, e2);
}
  else if ( type == LIST )
{
  CustType *e1 = CustType::typeStructList(*it);
  CustType *e2 = new StringType(", ", STRING);
  element = CustType::add(e1, e2);
}


  returnString = CustType::add(returnString, element);
 }
 StringType *str = dynamic_cast<StringType *>(returnString);
 string data = str->da;
 str->da = data.substr(0, data.size()-2);


 StringType *s = new StringType(" ]", STRING);
 CustType *toReturn = CustType::add(str, s);


 return toReturn;
}




CustType* CustType :: concat (CustType* t1, CustType* t2){
      if ( t1 -> getType () == LIST) {
          t1 -> add ( t2 ) ;
          return t1;
      }
      CustType* t = new ListType ;
      t -> add (t1) ;
      t -> add (t2) ;
      return t ;
   }


// Mathematical Operators for NumType


CustType* CustType::add(CustType* t1, CustType* t2) {
 if( (t1->getType() == NUMBER) && (t2->getType() == NUMBER) ) {
   NumType *temp1 = dynamic_cast<NumType*>(t1);
   NumType *temp2 = dynamic_cast<NumType*>(t2);

   double num = (temp1->da) + (temp2->da);
   NumType *t = new NumType(num, NUMBER);
   return t;
}
else if( (t1->getType() == STRING) && (t2->getType() == STRING) ) {
   StringType *temp1 = dynamic_cast<StringType*>(t1);
   StringType *temp2 = dynamic_cast<StringType*>(t2);


   string str = (temp1->da) + (temp2->da);
   StringType *t = new StringType(str, STRING);
   return t;
}
else if( (t1->getType() == LIST) && (t2->getType() == LIST) ) {
   ListType *temp1 = dynamic_cast<ListType*>(t1);
   ListType *temp2 = dynamic_cast<ListType*>(t2);
   ListType* t = new ListType() ;
   for (vector<CustType*> :: iterator it = (temp1->da).begin () ; it != (temp1->da).end () ; ++ it) {
         t -> add (*it) ;
  }
  for (vector<CustType*> :: iterator it = (temp2->da).begin () ; it != (temp2->da).end () ; ++ it) {
         t -> add (*it) ;
  }

   return t;
}
```

```
 else {
    cout << "ERROR: ++ only allowed for NUMBER, NUMBER or STRING, STRING or
LIST,LIST" << endl;
    return NULL;
 }



}



CustType* CustType::subtract(CustType* t1, CustType* t2) {
   if( (t1->getType() == NUMBER) && (t2->getType() == NUMBER) ) {
      NumType *temp1 = dynamic_cast<NumType*>(t1);
      NumType *temp2 = dynamic_cast<NumType*>(t2);



      double num = (temp1->da) - (temp2->da);
      NumType *t = new NumType(num, NUMBER);
      return t;
   }
   else {
      cout << "ERROR: Subtract only allowed for NUMBER, NUMBER" << endl;
      return NULL;
   }
}



CustType* CustType::multiply(CustType* t1, CustType* t2) {
 if( (t1->getType() == NUMBER) && (t2->getType() == NUMBER) ) {
    NumType *temp1 = dynamic_cast<NumType*>(t1);
    NumType *temp2 = dynamic_cast<NumType*>(t2);
    double num = (temp1->da) * (temp2->da);
    NumType *t = new NumType(num, NUMBER);
    return t;
 }
 else {
    cout << "ERROR: Multiply only allowed for NUMBER, NUMBER" << endl;
    return NULL;
 }
}


CustType* CustType::divide(CustType* t1, CustType* t2) {
 if( (t1->getType() == NUMBER) && (t2->getType() == NUMBER) ) {
    NumType *temp1 = dynamic_cast<NumType*>(t1);
    NumType *temp2 = dynamic_cast<NumType*>(t2);

    double num = (temp1->da) / (temp2->da);
    NumType *t = new NumType(num, NUMBER);
    return t;
 }
 else {
    cout << "ERROR: Divide only allowed for NUMBER, NUMBER" << endl;
    return NULL;
 }
}


CustType* CustType::mod(CustType* t1 , CustType* t2) {
 if( (t1->getType() == NUMBER) && (t2->getType() == NUMBER) ) {
    NumType *temp1 = dynamic_cast<NumType*>(t1);
    NumType *temp2 = dynamic_cast<NumType*>(t2);


    int num1 = static_cast<int>(temp1->da);
    int num2 = static_cast<int>(temp2->da);


    int mod = num1 % num2;


    double num = static_cast<double>(mod);
    NumType *t = new NumType(num, NUMBER);
    return t;
 }
 else {
    cout << "ERROR: Mod only allowed for NUMBER, NUMBER" << endl;
    return NULL;
 }
}


//Comparison Operators for NumType



CustType* operator==(CustType &lhs, CustType &rhs)
{
   CustType *t1 = (&lhs);
     CustType *t2 = (&rhs);
     bool tempBool ;
     BoolType *toReturn ;
     if ( t1 -> getType() != t2 -> getType () ){
      //cout << "== defined on operands of same type" ;
      return (new BoolType(false, BOOL) ) ;
    }
    if (t1 -> getType() == NUMBER ){
      NumType *temp1 = dynamic_cast<NumType *>(&lhs);
      NumType *temp2 = dynamic_cast<NumType *>(&rhs);
      bool tempBool = ((temp1->da)==(temp2->da));
      toReturn = new BoolType(tempBool, BOOL);
      return toReturn ;
    }
    else if (t1 -> getType() == STRING ){
      StringType *temp3 = dynamic_cast<StringType *>(&lhs);
      StringType *temp4 = dynamic_cast<StringType *>(&rhs);
      tempBool = ((temp3->da)==(temp4->da));
        toReturn = new BoolType(tempBool, BOOL);
        return toReturn ;
     }
    else if (t1 -> getType ()  == BOOL){
      BoolType *temp5 = dynamic_cast<BoolType *>(&lhs);
      BoolType *temp6 = dynamic_cast<BoolType *>(&rhs);
      tempBool = ((temp5->da)==(temp6->da));
      //cout << "\nprinting inside c ++ " << temp5 -> getBoolValue() << temp6 -> getBoolValue()
  << tempBool << endl ;
        toReturn = new BoolType(tempBool, BOOL);
        return toReturn ;
    }
    else if (t1 -> getType () == LIST){
      ListType *temp7 = dynamic_cast<ListType *>(&lhs);
      ListType *temp8 = dynamic_cast<ListType *>(&rhs);
      if ( (temp7 -> da).size() != (temp8 -> da).size() )
          return (new BoolType(false, BOOL) ) ;
      for (vector<CustType*> :: iterator it1 = (temp7 -> da).begin () , it2 = (temp8 -> da).begin ()  ;
  it1 != (temp7 -> da).end () && it2 != (temp8 -> da).end () ; ++ it1 , ++it2) {
          //(*it1) -> print() ;
          //(*it2) -> print () ;
          BoolType* tmpResult = dynamic_cast<BoolType *> ((*(*it1)) == (*(*it2)) );
          if (tmpResult -> getBoolValue () == false)
              return (new BoolType(false, BOOL) ) ;
      }
      return (new BoolType(true, BOOL));
     }
     else if (t1 -> getType () == JSON ) {
        JsonType *temp9 = dynamic_cast<JsonType *>(&lhs);
      JsonType *temp10 = dynamic_cast<JsonType *>(&rhs);
      vector<string> attrList1 = temp9 -> getStringAttrList () ;
      vector<string> attrList2 = temp10 -> getStringAttrList () ;
      if ( attrList1.size () != attrList2.size() )
          return (new BoolType(false, BOOL) ) ;
      for ( vector<string> :: iterator it = attrList1.begin () ; it != attrList1.end () ; ++ it) {
          CustType* el2 = temp10 ->getElement(*it) ;
          if ( el2 == NULL)
              return (new BoolType(false, BOOL) ) ;
          CustType* el1 = temp9 -> getElement(*it) ;
          BoolType* tmpResult = dynamic_cast<BoolType *> ((*el1 == *el2)) ;
          if (tmpResult -> getBoolValue () == false)
              return (new BoolType(false, BOOL) ) ;
      }
      return (new BoolType(true, BOOL));
     }
```

```
    else {
      cout << "ERROR: TYPE NOT DEFINIED  FOR OBJECT" << endl;
     return NULL;
  }
}


CustType* operator!=(CustType &lhs, CustType &rhs)
{
 return (new BoolType( !( (lhs == rhs) ->getBoolValue() ), BOOL ) ); ;


}


CustType* operator<(CustType &lhs, CustType &rhs)
{
 NumType *temp1 = dynamic_cast<NumType *>(&lhs);
 NumType *temp2 = dynamic_cast<NumType *>(&rhs);
 bool tempBool = ((temp1->da)<(temp2->da));
 BoolType *toReturn = new BoolType(tempBool, BOOL);
 return toReturn;
}


CustType* operator>(CustType &lhs, CustType &rhs)
{
 NumType *temp1 = dynamic_cast<NumType *>(&lhs);
 NumType *temp2 = dynamic_cast<NumType *>(&rhs);
 bool tempBool = ((temp1->da)>(temp2->da));
 BoolType *toReturn = new BoolType(tempBool, BOOL);
 return toReturn;
}


CustType* operator<=(CustType &lhs, CustType &rhs)
{
 NumType *temp1 = dynamic_cast<NumType *>(&lhs);
 NumType *temp2 = dynamic_cast<NumType *>(&rhs);
 bool tempBool = ((temp1->da)<=(temp2->da));
 BoolType *toReturn = new BoolType(tempBool, BOOL);
 return toReturn;
}


CustType* operator>=(CustType &lhs, CustType &rhs)
{
 NumType *temp1 = dynamic_cast<NumType *>(&lhs);
 NumType *temp2 = dynamic_cast<NumType *>(&rhs);
 bool tempBool = ((temp1->da)>=(temp2->da));
 BoolType *toReturn = new BoolType(tempBool, BOOL);
 return toReturn;
}


// Logical Operators for BoolType


CustType* operator!(CustType &term)
{
 BoolType *temp = dynamic_cast<BoolType *>(&term);
 bool tempBool = !(temp->da);
 BoolType *toReturn = new BoolType(tempBool, BOOL);
 return toReturn;
}


CustType* operator&&(CustType &t1, CustType &t2)
{
 BoolType *temp1 = dynamic_cast<BoolType *>(&t1);
 BoolType *temp2 = dynamic_cast<BoolType *>(&t2);


 bool tempBool = ((temp1->da) && (temp2->da));
 BoolType *toReturn = new BoolType(tempBool, BOOL);
 return toReturn;
}


CustType* operator||(CustType &t1, CustType &t2)
{
 BoolType *temp1 = dynamic_cast<BoolType *>(&t1);
 BoolType *temp2 = dynamic_cast<BoolType *>(&t2);


 bool tempBool = ((temp1->da) || (temp2->da));
 BoolType *toReturn = new BoolType(tempBool, BOOL);
 return toReturn;
}
```

```
// Reads from text file. Returns a ListType
CustType* CustType::read(string filename)
{
 string fileText = "";
 string line;
 ifstream file (filename.c_str());
 if ( file.is_open() )
    {
     while ( getline(file, line) )
   {
     fileText+=line;


   }
     file.close();
    }
 else { cout << "Unable to open file" << endl; }
 CustType *toReturn = CustType::parse( fileText , "JSON");
 return toReturn;
}
//returns index of element if found, otherwise returns -1
CustType* ListType :: findIndex (CustType* c){
      double i = 0 ;
      for (vector<CustType*> :: iterator it = da.begin () ; it != da.end () ; ++ it) {
          if (( (*(*it)) == *c ) -> getBoolValue())
              return (new NumType(i,NUMBER)) ;
          i = i + 1 ;
      }
      i = -1 ;
      return  (new NumType(i,NUMBER)) ;
}
```

```
CustType* ListType :: minus (CustType* c){
  ListType* tmp = new ListType ;
  for (vector<CustType*> :: iterator it = da.begin () ; it != da.end () ; ++ it) {

    if (! ((*(*it)) == *c)->getBoolValue() ){
       tmp -> add ((*it)) ;


    }


  }
  return (CustType*)tmp ;
}
CustType* ListType :: contains (CustType* c){

    for (vector<CustType*> :: iterator it = da.begin () ; it != da.end () ; ++ it) {
       if (( (*(*it)) == *c ) -> getBoolValue())
          return (new BoolType(true,BOOL)) ;


    }


    return  (new BoolType(false,BOOL)) ;
}
```

runCpluPlus.cpp

```
#include <iostream>
#include "../cpp/cPlusPlusCompiler.h"
using namespace std;
```

```
CustType* Merge(CustType* a, CustType* b)

{

CustType* c = CustType::parse("{}","JSON");

CustType* g = CustType::parse("[]","LIST");

CustType* f = CustType::parse("1","NUMBER");

CustType* d = a-> getAttrList();

CustType* e = b-> getAttrList();

for (vector<CustType*> :: iterator loopVarattr = (a->getAttrList ()) -> getListBegin(); loopVarattr
!= (a->getAttrList ()) -> getListEnd();  ++loopVarattr) {

  CustType* attr = *loopVarattr;

    {

       if ((b-> getAttrList()->contains(attr))->getBoolValue())

       {

          if ((*(*((a-> getElementByOcaml(attr))->getJoType()) ==
*(CustType::parse("Json","STRING"))) && *(*((b-> getElementByOcaml(attr))->getJoType()) ==
*(CustType::parse("Json","STRING")))))->getBoolValue())

          {

             c->addByKey(attr,Merge(a-> getElementByOcaml(attr), b->
getElementByOcaml(attr)));



          }

          else

          {

             if ((*(*((a-> getElementByOcaml(attr))->getJoType()) ==
*(CustType::parse("List","STRING"))) && *(*((b-> getElementByOcaml(attr))->getJoType()) ==
*(CustType::parse("List","STRING")))))->getBoolValue())

             {

                c->addByKey(attr,CustType::add(a-> getElementByOcaml(attr),b->
getElementByOcaml(attr)));
```

```
                }
                else
                {
                    c->addByKey(attr,CustType::concat(a-> getElementByOcaml(attr),b->
getElementByOcaml(attr)));



                }
            }
        }
        else
        {
            c->addByKey(attr,a-> getElementByOcaml(attr));



        }
    }
}
for (vector<CustType*> :: iterator loopVarattr = e->getListBegin(); loopVarattr != e->getListEnd();
++loopVarattr) {
CustType* attr = *loopVarattr;
{
if ((!(*(d->contains(attr))))->getBoolValue())
{
c->addByKey(attr,b-> getElementByOcaml(attr));



}
}
}
```

```
return c;}



CustType* MergeUtil(CustType* a, CustType* b)

{

if ((*(*((a)->getJoType()) != *(CustType::parse("Json","STRING"))) || *(*((b)->getJoType()) !=
*(CustType::parse("Json","STRING"))))->getBoolValue())

{

CustType::print(CustType::parse("Both the arguments must be JSON","STRING"));

return CustType::parse("null","NULL");

} return Merge(a, b);}



int main()

{

CustType* a =
CustType::parse("{\"name\":\"harsha\",\"innerJson\":{\"sub\":\"PLT\",\"mark\":[5,6,7]}}","JSON");

CustType* b =
CustType::parse("{\"name\":\"arpit\",\"innerJson\":{\"sub\":\"OS\",\"mark\":[7,8,9]}}","JSON");

CustType* c = MergeUtil(a, b);

CustType::print(c);

}
```

test.c

```
#include <stdio.h>



int main(void) {



    int a[2][3] ;
    a[1][1] = 80;

    if(80 == *( *(a+1) + (1))) {
        printf("Address MAtches");
    } else {
        printf("Address doesn't match");
    }


    return 0;
}
```

test.s

```
    .section    __TEXT,__text,regular,pure_instructions
   .globl    _main
   .align    4, 0x90
_main:                                  ## @main
   .cfi_startproc
## BB#0:
   pushq    %rbp
Ltmp2:
   .cfi_def_cfa_offset 16
Ltmp3:
   .cfi_offset %rbp, -16
   movq    %rsp, %rbp
Ltmp4:
   .cfi_def_cfa_register %rbp
   leaq    L_.str(%rip), %rdi
```

```
    xorl    %eax, %eax
    callq    _printf
    xorl    %eax, %eax
    popq    %rbp
    retq
    .cfi_endproc


    .section    __TEXT,__cstring,cstring_literals
L_.str:                                 ## @.str
    .asciz    "Address MAtches"



.subsections_via_symbols
```

MakeFileCPP

```
CC=g++


CFLAGS=-c -w
LFLAGS=-lm


SOURCES=testfiles/$(inputfile).cpp cpp/JSON.cpp cpp/JSONValue.cpp
HEADERS=cpp/JSON.h cpp/JSONValue.h cpp/cPlusPlusCompiler.h


OBJECTS=$(SOURCES:.cpp=.o)
```

```
EXECUTABLE=testfiles/$(inputfile).out

all: $(SOURCES) $(EXECUTABLE)

$(EXECUTABLE): $(OBJECTS)
  $(CC) $(LFLAGS) $(OBJECTS) -o $@

.cpp.o:
  $(CC) $(CFLAGS) $< -o $@

clean:
  rm -f $(OBJECTS) $(EXECUTABLE) *~
```

MakePreProc

```
CC  = gcc

CFLAGS   = -g -Wall

.PHONY: default
default: preproc

.PHONY: all
all: clean preproc
```

```
.PHONY: clean
clean:
   rm -rf *.log *.o *~ a.out* core preprocessor *.pjo


.PHONY: preproc
preproc: preprocessor.c
   $(CC) -o preprocessor preprocessor.c
```

Makefile

```
OBJS = parser.cmo scanner.cmo symboltable.cmo analyzer.cmo Str.cma jo.cmo


.PHONY: default
default: jo


.PHONY: all
all: clean jo


jo: $(OBJS)
   ocamlc -o jo $(OBJS)


scanner.ml: scanner.mll
   ocamllex scanner.mll
```

```
parser.ml parser.mli: parser.mly
	ocamlyacc parser.mly

%.cmo: %.ml
	ocamlc -c $<

%.cmi: %.mli
	ocamlc -c $<

.PHONY: clean
clean:
	rm -rf jo parser.ml parser.mli scanner.ml *.cmo *.cmi *.log *.o *~ a.out* core

# Generated by ocamldep *.ml *.mli
analyzer.cmo: symboltable.cmo ast.cmi sast.cmi
analyzer.cmx: symboltable.cmx ast.cmx sast.cmx
jo.cmo: scanner.cmo parser.cmi ast.cmi Str.cma
jo.cmx: scanner.cmx parser.cmx ast.cmi
parser.cmo: ast.cmi parser.cmi
parser.cmx: ast.cmi parser.cmi
scanner.cmo: parser.cmi
scanner.cmx: parser.cmx
parser.cmi: ast.cmi
Str.cma:
```

README.md

plt2014fall
===========

Columbia University Academic Project for Programming Language and Translators

analyzer.ml

```
open Ast
open Symboltable
(*adding testing comment *)
module StringMap = Map.Make(String)


let string_of_vtype = function
  IntType -> "number"
 | StrType -> "string"
 | BoolType -> "bool"
 | JsonType -> "json"
 | ListType -> "list"
 | NoType    -> "notype"


let vtype_of_ocaml_type = function
 "number" -> IntType
 | "string" -> StrType
 | "bool" -> BoolType
 | "json" -> JsonType
 | "list" -> ListType
 | "notype" -> NoType
 | _ -> NoType
```

```
let get_sast_type = function
   Ast.JsonType -> Sast.JsonType
   | Ast.StrType -> Sast.StrType
   | Ast.IntType -> Sast.IntType
   | Ast.BoolType -> Sast.BoolType
   | Ast.ListType -> Sast.ListType
   | Ast.NoType -> Sast.NoType


(* get variable type according to the name
* raise error if no name matching in variable list *)
let get_vtype env id =
   (* find_variable method is from the symbol table *)
   let t = find_variable id env in
   if t = "" then raise (Failure ("undefined variable: " ^ id)) else t


(* get the type of expression:
*  -> string if one of the two operands having string type
*  -> number/boolean if both of the operands having the same type *)
let get_oper_type t1 t2 =
   if t1 = "json" then "json" else
   if t1 = "list" then "list" else
   if t1 = "string" || t2 = "string" then "string" else
   if t1 = "number" && t2 = "number" then "bool" else
   if t1 = "bool" && t2 = "bool" then "bool" else
   if t1 = "number" && t2 = "bool" then raise (Failure ("cannot use number with bool type inside
expression")) else
```

```
   if t1 = "bool" && t2 = "number" then raise (Failure ("cannot use number with bool type inside
expression")) else

   raise (Failure ("type error in get_oper_type"))



(* TODO ----- NEED TO have checks for boolean op and mathermatical op

   *)


let get_bool_equal_oper_type  t1 t2 =

   if t1 = "notype" then "bool" else

   if t2 = "notype" then "bool" else

   if t1 = "json" && t2 = "json" then "bool" else

   if t1 = "list" && t2 = "list" then "bool" else

   if t1 = "string" && t2 = "string" then "bool" else

   if t1 = "number" && t2 = "number" then "bool"  else

   if t1 = "bool" && t2 = "bool"  then "bool"  else

   raise (Failure ("Cannot Compare different types"))



let get_math_oper_type t1 t2 =

   if t1 = "notype" && t2 = "notype" then "notype"  else

   if t1 = "notype" then t2 else

   if t2 = "notype" then t1 else

   if t1 = "number" && t2 = "number" then "number" else

   if t1 = "list" && t2 = "list" then "list" else

   raise (Failure ("Mathematical operator work on Number types only, ++ works on Number and
Lists"))



let get_logical_oper_type  t1 t2 =

   if t1 = "notype" then t2 else
```

```
  if t2 = "notype" then t1 else
  if t1 = "bool" && t2 = "bool" then "bool" else
  raise (Failure ("Logical operators can work on only bool types"))

let get_add_oper_type t1 t2 =
  if t1 = "notype" && t2 = "notype" then "number" else
  if t1 = "notype" then t2 else
  if t2 = "notype" then t1 else
  if t1 = "number" && t2 = "number" then "number" else
  if t1 = "string" && t2 = "string" then "string" else
  raise (Failure ("Add operator can work on numbers or strings"))


let get_comp_oper_type t1 t2 =
  if t1 = "notype" then t2 else
  if t2 = "notype" then t1 else
  if t1 = "number" && t2 = "number" then "bool" else
  raise (Failure ("comparison operators can work on only Number types types"))


let get_in_oper_type t1 t2 =
  if not(t2 = "list" || t2 = "notype") then raise (Failure ("The 'in' and 'not in' statements must be
checking in a list!"))
  else "bool"


let check_listexpr env = function
   Ast.ListItemInt(i) -> Sast.ListItemInt(i), "number"
  | Ast.ListItemStr(s) -> Sast.ListItemStr(s), "string"
```

```
(* Might have to do type checking *)

let check_func_arg lst expr arg_t = (fst expr)::lst



let match_oper e1 op e2 =

  (* snd of expr is type *)

  (*let expr_t = get_oper_type (snd e1) (snd e2) in*)

  (match op with

    Ast.Add -> let expr_t = get_add_oper_type (snd e1) (snd e2) in

            if (expr_t = "number" || expr_t ="notype") then (Sast.Binop(fst e1, Sast.Add, fst e2),
"number") else

            if expr_t = "string" then (Sast.Binop(fst e1, Sast.Add, fst e2), "string") else

          raise (Failure ("Add operator can work on number or strings"))

   | Ast.Sub -> let expr_t = get_math_oper_type (snd e1) (snd e2) in

        if (expr_t = "number" || expr_t ="notype") then (Sast.Binop(fst e1, Sast.Sub, fst e2),
"number") else

      raise (Failure ("Mathematical operator work on Number types only"))

   | Ast.Mult -> let expr_t = get_math_oper_type (snd e1) (snd e2) in

              if (expr_t = "number" || expr_t ="notype") then (Sast.Binop(fst e1, Sast.Mult, fst
e2), "number") else

        raise (Failure ("Mathematical operator work on Number types only"))

   | Ast.Div -> let expr_t = get_math_oper_type (snd e1) (snd e2) in

              if (expr_t = "number" || expr_t ="notype") then (Sast.Binop(fst e1, Sast.Div, fst
e2), "number") else

      raise (Failure ("Mathematical operator work on Number types only"))

   | Ast.Mod -> let expr_t = get_math_oper_type (snd e1) (snd e2) in

              if (expr_t = "number" || expr_t ="notype") then (Sast.Binop(fst e1, Sast.Mod, fst
e2), "number") else

      raise (Failure ("Mathematical operator work on Number types only"))

      (* equal and not equal have special case for string comparison

          we may need to add SAST and Eqs and Neqs *)

   | Ast.Equal -> let expr_t = get_bool_equal_oper_type  (snd e1) (snd e2) in
```

```
                              if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.Equal, fst
e2), "bool") else
               raise (Failure ("Cannot Compare different types"))
   | Ast.Neq -> let expr_t = get_bool_equal_oper_type  (snd e1) (snd e2) in
                              if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.Neq, fst
e2), "bool") else
               raise (Failure ("Cannot Compare different types"))
   | Ast.Less -> let expr_t = get_comp_oper_type (snd e1) (snd e2) in
                                if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.Less,
fst e2), "bool") else
               raise (Failure ("Comparison operators can work on only Number types types"))
   | Ast.Leq -> let expr_t = get_comp_oper_type (snd e1) (snd e2) in
                                if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.Leq, fst
e2), "bool") else
               raise (Failure ("Comparison operators can work on only Number types types"))
   | Ast.Greater -> let expr_t = get_comp_oper_type (snd e1) (snd e2) in
                                if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.Greater,
fst e2), "bool") else
               raise (Failure ("Comparison operators can work on only Number types types"))
   | Ast.Geq -> let expr_t = get_comp_oper_type (snd e1) (snd e2) in
                             if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.Geq, fst
e2), "bool") else
               raise (Failure ("Comparison operators can work on only Number types types"))
   | Ast.And  -> let expr_t = get_logical_oper_type  (snd e1) (snd e2) in
                             if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.And, fst
e2), "bool") else
                                 raise (Failure ("Logical operators can work on only bool types"))
   | Ast.Or -> let expr_t = get_logical_oper_type  (snd e1) (snd e2) in
                             if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.Or, fst e2),
"bool") else
                                raise (Failure ("Logical operators can work on only bool types"))
   | Ast.In  -> let expr_t = get_in_oper_type  (snd e1) (snd e2) in
```

```
                    if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.In, fst e2),
"bool") else
                        raise (Failure ("The 'in' and 'not in' statements must be checking in a
list!"))
   | Ast.NotIn -> let expr_t = get_in_oper_type (snd e1) (snd e2) in
                    if (expr_t = "bool"|| expr_t ="notype") then (Sast.Binop(fst e1, Sast.NotIn, fst
e2), "bool") else
                        raise (Failure ("The 'in' and 'not in' statements must be checking in a
list!"))
   | Ast.Concat -> (Sast.Binop(fst e1, Sast.Concat, fst e2), "list")
   | Ast.Minus -> if (snd e1) = "list" || (snd e1) = "notype" then (Sast.Binop(fst e1, Sast.Minus, fst
e2), "list") else
            if (snd e1) = "json" || (snd e1) = "notype" then (Sast.Binop(fst e1, Sast.Minus, fst e2),
"json") else
            raise (Failure ("Minus operator can work only on list or json"))
  )


let rec check_list_items env = function
    Ast.Item(e) -> Sast.Item(fst (check_list_element env e))
  | Ast.Seq(e1, sep, e2) -> Sast.Seq(fst (check_list_element env e1), Sast.Comma,
(check_list_items env e2))
  | Ast.Noitem -> Sast.Noitem
and check_list_element env = function
   Ast.LitIntElem(i) -> Sast.LitIntElem(i), "number"
  | Ast.LitStrElem(s) -> Sast.LitStrElem(s), "string"
  | Ast.LitListOfList(items) -> Sast.LitListOfList(check_list_items env items), "list"
  | Ast.LitJsonOfList(items) -> Sast.LitJsonOfList(check_json_items env items), "json"
  | Ast.LitBoolElem(i) -> Sast.LitBoolElem(i), "bool"
  | Ast.LitNullElem(s) -> Sast.LitNullElem(s), "null"



and check_json_items env = function
    Ast.JsonItem(e) -> Sast.JsonItem(check_json_keyValue env e)
  | Ast.JsonSeq(e1, sep, e2) -> Sast.JsonSeq((check_json_keyValue env e1), Sast.Comma,
(check_json_items env e2))

  | Ast.NoJsonItem  -> Sast.NoJsonItem


and check_json_keyValue env = function

  Ast.JsonValPair(e1, colon, e2) -> Sast.JsonValPair(fst (check_json_key env e1) , Sast.Colon,
fst (check_json_value env e2))


and check_json_value env = function

  Ast.LitIntJsonVal(i)  -> Sast.LitIntJsonVal(i),  "number"

  | Ast.LitStrJsonVal(s) -> Sast.LitStrJsonVal(s), "string"

  | Ast.LitJsonOfJson(items) -> Sast.LitJsonOfJson(check_json_items env items), "json"

  | Ast.LitListOfJson(items) -> Sast.LitListOfJson(check_list_items env items), "list"

  | Ast.LitBoolJsonVal(i)  -> Sast.LitBoolJsonVal(i),  "bool"

  | Ast.LitNullJsonVal(s)  -> Sast.LitNullJsonVal(s),  "null"


and check_json_key env = function

  Ast.LitStrJsonKey(i) -> Sast.LitStrJsonKey(i), "string"



(* it returns the expr and its type *)

let rec check_expr env = function

  Ast.LitInt(i)  -> Sast.LitInt(i), "number"



  | Ast.LitStr(s) -> Sast.LitStr(s), "string"


  | Ast.LitJson(items) -> Sast.LitJson(check_json_items env items), "json"


  | Ast.LitList(items) -> Sast.LitList(check_list_items env items), "list"
```

```
    | Ast.LitBool(s) -> Sast.LitBool(s), "bool"


    | Ast.LitNull(s) -> Sast.LitNull(s), "null"



    | Ast.Id(id) -> Sast.Id(id), (get_vtype env id)


    | Ast.Not(e1) ->
      let ret = check_expr env e1 in
      if (snd ret) = "bool" then Sast.Not(fst ret), "bool"
      else raise (Failure("! is applicable to bool expressions only"))


    | Ast.Binop(e1, op, e2) -> match_oper (check_expr env e1) op (check_expr env e2)
    | Ast.Call(func, el) ->
      (* find_function is from the symbol table *)
      let args = find_function func env in    (* return & arguments type list from definition *)
      ( match args with
          [] -> raise (Failure ("undefined function " ^ func))
          | hd::tl -> let new_list = try List.fold_left2 check_func_arg [] (List.map (check_expr env) el)
tl
                          with Invalid_argument "arg" -> raise(Failure("unmatched argument list"))
                    in Sast.Call(func, List.rev new_list ), "notype" )
    | Ast.ElemAccess(id, e) -> let t1 = get_vtype env id in
                                              let t2 = check_expr env e in
                                              if not ( (t1 = "notype" && (snd t2 = "string" || snd t2 = "notype"
|| snd t2 = "number")) || (t1 = "json" && (snd t2 = "string" || snd t2 = "notype")) || (t1="list" && (snd
t2 ="number" || snd t2 = "notype")) )
                                                then raise (Failure("Elements of List and Json can be
accessed via index and key respectively"))
                                              else
                                                Sast.ElemAccess (id, (fst t2)), "notype"
```

```
   | Ast.TypeStruct(id) ->    Sast.TypeStruct(id), "string"
  | Ast.AttrList(id) -> Sast.AttrList(id), "list"
  | Ast.DataType(expr) -> let (expr, expr_type) = check_expr env expr in
                        (Sast.DataType(expr , expr_type)), "string"
  | Ast.Read(str) -> Sast.Read(str), "json"
  | Ast.MakeString(expr)  -> let (expr, expr_type) = check_expr env expr in
                        (Sast.MakeString(expr  , expr_type)), "string"
  | Ast.NoExpr -> Sast.NoExpr, "notype"


and get_expr_with_type env expr =
  let e = check_expr env expr in snd e


(* convert a variable to its SAST type *)
let convert_to_sast_type x env =
  let s_expr =
  if not (x.vexpr = Ast.NoExpr) then
    fst(check_expr env x.vexpr)
  else Sast.NoExpr
  in
  {
    Sast.vtype = get_sast_type x.vtype;
    Sast.vname = x.vname;
    Sast.vexpr = s_expr;
  }


let convert_to_vdecl_type x  =
  {
    vtype  = NoType;
    vname = x;

    vexpr = NoExpr;

  }



let check_formal env formal =

  let ret = update_local formal.vname (vtype_of_ocaml_type (get_expr_with_type env
formal.vexpr)) env in

  let env = {locals = fst ret; globals = env.globals; functions = env.functions } in

  convert_to_sast_type formal env, env



let rec check_formals env formals =

  match formals with

    [] -> []

  | hd::tl -> let f, e = (check_formal env hd) in (f, e)::(check_formals e tl)



let check_local env local =

  let ret = update_local local.vname (vtype_of_ocaml_type (get_expr_with_type env
local.vexpr)) env in

  let env = {locals = fst ret; globals = env.globals; functions = env.functions } in

  convert_to_sast_type local env, env



let rec check_locals env locals =

  match locals with

    [] -> []

  | hd::tl -> let l, e = (check_local env hd) in (l, e)::(check_locals e tl)



let check_forexpr env = function
```

```
  Ast.Forid(id) -> Sast.Forid(id), get_vtype env id
  | Ast.AttrList(id) -> Sast.AttrList(id), "list"


let check_loopvar env = function
  Ast.LoopVar(id) -> let loopId = convert_to_vdecl_type id in
     let l, e = (check_local env loopId) in e, Sast.LoopVar(id)


let rec check_stmt env func = function
  Ast.Vdecl(vdecl) -> let ret = update_local vdecl.vname (vtype_of_ocaml_type
(get_expr_with_type env vdecl.vexpr)) env in
                         if (snd ret) = "exist" then let env = {locals = fst ret; globals = env.globals;
functions = env.functions } in
                                 Sast.Assign(vdecl.vname, fst (check_expr env vdecl.vexpr)), env
                            else let env = {locals = fst ret; globals = env.globals; functions =
env.functions } in
                                 Sast.Vdecl(convert_to_sast_type vdecl env), env


  | Ast.Expr(expr) -> Sast.Expr(fst (check_expr env expr)), env


  | Ast.Return(expr) -> let e = check_expr env expr in Sast.Return(fst e), env


  | Ast.Print(expr) -> let (expr, expr_type) = check_expr env expr in Sast.Print(expr , expr_type),
env


  | Ast.Block(stmt_list) -> Sast.Block(check_stmt_list env func stmt_list), env
  | Ast.If(expr, stmt1, stmt2) ->    let e = check_expr env expr in

                          if not(snd e = "bool" || snd e = "notype") then raise (Failure ("The type of the
condition in If statement must be boolean!"))

                          else Sast.If(fst e, fst (check_stmt env func stmt1), fst (check_stmt env func
stmt2)), env



  | Ast.For(expr1, expr2, stmt) -> let envNew, e1 = check_loopvar env expr1 in let e2 =
check_forexpr envNew expr2 in

                      if not ( snd e2 = "list" || snd e2 = "notype") then raise (Failure("The type of the
expression in a For statement must be list!"))

                      else (Sast.For( e1, fst e2, fst (check_stmt envNew func stmt))), envNew



  | Ast.Write(expr, str) -> let (expr, expr_type) = check_expr env expr in (Sast.Write(expr , str)),
env



  | Ast.ElemAssign(id, expr1, expr2) -> let t1 = get_vtype env id in

                                    let t2 = check_expr env expr1 in

                                              if not ( (t1 = "notype" && (snd t2 = "string" || snd t2 = "notype"
|| snd t2 = "number")) ||

                                               (t1 = "json" && (snd t2 = "string" || snd t2 = "notype")) ||
(t1="list" && (snd t2 ="number" || snd t2 = "notype")) )

                                                 then raise (Failure("Elements of List and Json can be
accessed via index and key respectively!"))

                                              else

                                                 Sast.ElemAssign (id, (fst t2), fst (check_expr env expr2)),
env




and check_stmt_list env func = function

    [] -> []
```

```
   | hd::tl -> let s,e = (check_stmt env func hd) in s::(check_stmt_list e func tl)





(* this function will return the updated formals and body as per the abstract syntax tree, the
return type, name and locals *)

let check_function env func =

   match List.hd (List.rev func.body) with

   Return(_) ->

        let env = {locals = StringMap.empty; globals = env.globals; functions = env.functions } in

        (*  ret is new env *)

      let ret = add_function func.fname func.return func.formals env in

      if StringMap.is_empty ret then raise (Failure ("function " ^ func.fname ^ " is already
defined"))

      (* update the env with functions from ret *)

      else let env = {locals = env.locals; globals = env.globals; functions = ret } in

      (* check the formal arguments, returns formal list appended with their env *)

      let f = check_formals env func.formals in

      (* get the list of formals from f *)

      let formals = List.map (fun formal -> fst formal) f in

      (* get the final env from the last formal *)

      let env =

          (    match f with

              [] -> env

              | _ ->     snd (List.hd (List.rev f)) ) in

      (* get the stmt list from body *)

      let body = check_stmt_list env func func.body in

                    { Sast.return = get_sast_type func.return;

                      Sast.fname = func.fname;

                      Sast.formals = formals;

                      Sast.body = body
              }, env



  | _ ->
    if not (func.fname = "main") then raise (Failure ("Return statement is missing for function
"'^func.fname^"'"))
  else
  let env = {locals = StringMap.empty; globals = env.globals; functions = env.functions } in
      (*  ret is new env *)
    let ret = add_function func.fname func.return func.formals env in
    if StringMap.is_empty ret then raise (Failure ("function " ^ func.fname ^ " is already
defined"))
    (* update the env with functions from ret *)
    else let env = {locals = env.locals; globals = env.globals; functions = ret } in
    (* check the formal arguments, returns formal list appended with their env *)
    let f = check_formals env func.formals in
    (* get the list of formals from f *)
    let formals = List.map (fun formal -> fst formal) f in
    (* get the final env from the last formal *)
    let env =
       (    match f with
          [] -> env
          | _ ->     snd (List.hd (List.rev f)) ) in
    (* get the stmt list from body *)
    let body = check_stmt_list env func func.body in
              { Sast.return = get_sast_type func.return;
                Sast.fname = func.fname;
                Sast.formals = formals;
                Sast.body = body
              }, env
```

```
let check_main_function funcs =
  List.fold_left (fun s e -> s || (e.fname="main")) false funcs



let rec check_functions env funcs =
  match funcs with
    [] -> []
  | hd::tl -> let f, e = (check_function env hd) in f::(check_functions e tl)



(* returns the global and its env *)
let check_global env global =
   let ret = update_global global.vname (vtype_of_ocaml_type (get_expr_with_type env
global.vexpr)) env in
  (* update the env with globals from ret *)
  let env = {locals = env.locals; globals = ret; functions = env.functions } in
  convert_to_sast_type global env, env



let rec check_globals env globals =
  match globals with
    [] -> []
  | hd::tl -> let g, e = (check_global env hd) in (g, e)::(check_globals e tl)



let check_program (globals, funcs) =
  (* create the default environment *)
  if not (check_main_function funcs) then raise (Failure ("main function is not defined in the
program"))
else
```

```
  let env = {    locals = StringMap.empty;
            globals = StringMap.empty;
            functions = StringMap.empty }
  in
  (* return the list of each global appended with its environments, the last global has the final
env *)
  let g = check_globals env globals in
  (* make a list of globals *)
  let globals = List.map (fun global -> fst global) g in
  match g with
  (* no globals *)
      [] -> (globals, (check_functions env (List.rev funcs)))
    (* get the envirnment from the last global *)
    | _ -> let e = snd (List.hd (List.rev g)) in (globals, (check_functions e (List.rev funcs)))
```

ast.mli

```
type op = Add | Sub | Mult | Div | Equal | Neq | Less | Leq | Greater | Geq | And | Or | Concat |
Minus | Mod | In | NotIn


type data_type =  StrType | IntType | BoolType | JsonType | ListType | NoType


type sep = Comma


type colon = Colon


type list_expr =
 ListItemInt of float
 | ListItemStr of string


type list_element =
 LitIntElem of float
 | LitStrElem of string
   | LitListOfList of items
   | LitJsonOfList of json_items
   | LitBoolElem of string
   | LitNullElem of string
and items =
    Item of list_element
 | Seq of list_element * sep * items
 | Noitem
and json_key_type =
   LitStrJsonKey of string
and json_item_value =
 LitIntJsonVal of float
 | LitStrJsonVal of string
   | LitJsonOfJson of json_items
   | LitListOfJson of items
   | LitBoolJsonVal of string
   | LitNullJsonVal of string
and json_item =
   JsonValPair of json_key_type * colon * json_item_value
and json_items =
    JsonItem of json_item
 | JsonSeq of json_item * sep * json_items
 | NoJsonItem
```

```
type expr =
    LitInt of float
 | LitStr of string
 | LitJson of json_items
 | LitList of items
   | LitBool of string
   | LitNull of string
 | Id of string
 | Not of expr
 | Binop of expr * op * expr
   | Call of string * expr list
   | ElemAccess of string * expr
   | TypeStruct of string
   | AttrList of string
 | DataType of expr
   | Read of string
 | MakeString of expr
 | NoExpr

type var_decl = {
 vtype : data_type;
 vname : string;
 vexpr : expr;
}


type for_expr =
    Forid of string
    | AttrList of string


type loop_var =
    LoopVar of string


type stmt =
    Block of stmt list
 | Vdecl of var_decl
 | Expr of expr
 | Return of expr
 | Print of expr
 | If of expr * stmt * stmt
 | For of loop_var * for_expr * stmt
   | Write of expr * string
 | ElemAssign of string * expr * expr


type func_decl = {
    return : data_type;
    fname : string;
    formals : var_decl list;
    body : stmt list;
 }


type program = var_decl list * func_decl list
```

cleanall.sh

```
make -f MakePreProc clean
make -f Makefile  clean
rm -rf testfiles/*.error
rm -rf testfiles/*.o
rm -rf testfiles/*.cpp
rm -rf testfiles/*.pjo
rm -rf cpp/*.o
rm -rf testfiles/*.out
rm -rf testfiles/*.output
```

jo.ml

```
open Sast


let rec string_of_items = function
    Item(e) ->  string_of_elements e


 | Seq(e, sep, i2) ->  string_of_elements e ^ ","
                   ^ (string_of_items i2)
 | Noitem -> ""
and string_of_elements = function
   LitIntElem(l)  ->  string_of_float l ^ "0" (* ocaml prints 5 to 5. *)
 | LitStrElem(l) -> Str.global_replace  (Str.regexp "\"")  "\\\"" l
   | LitListOfList(l) -> "[" ^ string_of_items l ^ "]"
   | LitJsonOfList(l) -> "{" ^ json_items l ^ "}"
   | LitBoolElem(l) ->  l
 | LitNullElem(l) -> l
```

```
and json_items = function
    JsonItem(e) -> json_key_value e
 | JsonSeq(e, sep, i2) -> json_key_value e ^ ","
                   ^ (json_items i2)
 | NoJsonItem -> ""
and json_key_value = function
   JsonValPair(e1, colon, e2) -> json_key e1 ^ ":" ^ json_value e2
and json_key = function
   LitStrJsonKey(l) -> Str.global_replace (Str.regexp "\"") "\\\"" l
and json_value = function
   LitIntJsonVal(l) -> string_of_float l ^ "0" (* ocaml prints 5 to 5. *)
   | LitStrJsonVal(l) -> Str.global_replace (Str.regexp "\"") "\\\"" l
   | LitJsonOfJson(l) -> "{" ^ json_items l ^ "}"
   | LitListOfJson(l) -> "[" ^ string_of_items l ^ "]"
   | LitBoolJsonVal(l) -> l
   | LitNullJsonVal(l) -> l


let get_for_id e = match e with
    Forid(id) -> id
    | AttrList(id) -> "("^id ^ "-> getAttrList())"


let string_of_loop_var_t = function
 LoopVar(l) -> l


let rec string_of_expr e = match e with
    LitInt(l) -> "CustType::parse(\"" ^ string_of_float l ^ "0" ^ "\",\"NUMBER\")" (* ocaml prints 5 to
5. *)
 | LitStr(l) -> "CustType::parse(" ^ l ^ ",\"STRING\")"
 | LitJson(l) -> "CustType::parse(\"{" ^ json_items l ^ "}\",\"JSON\")"
 | LitList(l) -> "CustType::parse(\"[" ^ string_of_items l ^ "]\",\"LIST\")"
 | LitBool(l) -> "CustType::parse(\"" ^ l ^ "\",\"BOOL\")"
 | LitNull(l) -> "CustType::parse(\"" ^ l ^ "\",\"NULL\")"
 | Id(s) -> s
 | Not(e1) -> "!(*(" ^ string_of_expr e1 ^ "))"
 | Binop(e1, o, e2) ->

   ( match o with
     Add -> "CustType::add("^string_of_expr e1 ^ "," ^ string_of_expr e2 ^")"
     | Sub -> "CustType::subtract("^string_of_expr e1 ^ "," ^ string_of_expr e2 ^")"
     | Mult -> "CustType::multiply("^string_of_expr e1 ^ "," ^ string_of_expr e2 ^")"
     | Div -> "CustType::divide("^string_of_expr e1 ^ "," ^ string_of_expr e2 ^")"
     | Mod -> "CustType::mod("^string_of_expr e1 ^ "," ^ string_of_expr e2 ^")"
     | Or -> "*("^string_of_expr e1 ^ ") " ^ "||" ^ " *(" ^ string_of_expr e2 ^")"
     | And -> "*("^string_of_expr e1 ^ ") " ^ "&&" ^ " *(" ^ string_of_expr e2 ^")"
     | Geq -> "*("^string_of_expr e1 ^ ") " ^ ">=" ^ " *(" ^ string_of_expr e2 ^")"
     | Leq -> "*("^string_of_expr e1 ^ ") " ^ "<=" ^ " *(" ^ string_of_expr e2 ^")"
     | Greater -> "*("^string_of_expr e1 ^ ") " ^ ">" ^ " *(" ^ string_of_expr e2 ^")"
     | Less -> "*("^string_of_expr e1 ^ ") " ^ "<" ^ " *(" ^ string_of_expr e2 ^")"
     | Equal -> "*("^string_of_expr e1 ^ ") " ^ "==" ^ " *(" ^ string_of_expr e2 ^")"
     | Neq -> "*("^string_of_expr e1 ^ ") " ^ "!=" ^ " *(" ^ string_of_expr e2 ^")"
     | Concat -> "CustType::concat(" ^ string_of_expr e1 ^ "," ^ string_of_expr e2 ^ ")"
     | Minus -> string_of_expr e1 ^ "->minus(" ^ string_of_expr e2 ^ ")"
     | In -> string_of_expr e2 ^ "->contains("^ string_of_expr e1^")"
     | NotIn -> "!(*("^string_of_expr e2 ^ "->contains("^ string_of_expr e1^")))"
    )
 (*| Assign(v, e) -> v ^ " = " ^ string_of_expr e ^ ";"*)
 | Call(f, el) ->
   f ^ "(" ^ String.concat ", " (List.map string_of_expr el) ^ ")"
  | ElemAccess(id, e) ->  id ^ "-> getElementByOcaml("^string_of_expr e ^ ")"
  | TypeStruct(id) -> "CustType::typeStruct(" ^ id ^ ")"
  | AttrList(id) -> id ^ "-> getAttrList()"
 | DataType(expr, expr_type) -> "(" ^ string_of_expr expr ^ ")->getJoType()"
 | Read(str) -> "CustType::read(" ^ str ^ ")"
 | MakeString(expr, expr_type) -> "(" ^ string_of_expr expr ^ ")->makeString()"
 | NoExpr -> ""


let string_of_vtype = function
  IntType -> "CustType*"
 | StrType -> "CustType*"
 | BoolType ->"CustType*"
 | ListType -> "CustType*"
 | JsonType -> "CustType*"
 | NoType -> "CustType*"


let string_of_vdecl vdecl =
   string_of_vtype vdecl.vtype ^ " " ^ vdecl.vname ^ " = " ^ string_of_expr vdecl.vexpr ^ ";\n"



let rec string_of_stmt = function
   Vdecl(vdecl) -> string_of_vdecl vdecl
   | Expr(expr) -> if compare (string_of_expr expr) "" = 0 then "\n" else string_of_expr expr ^ ";"


   | Return(expr) -> (*if fname = "main" then "return 0 " else*) " return " ^ string_of_expr expr ^
";"
```

```
    | Print(expr, expr_type) -> "CustType::print(" ^ string_of_expr expr ^ ");\n"

    | Block(stmts) -> "{\n" ^ String.concat "" (List.map string_of_stmt stmts) ^ "\n}"

  | For(e1, e2, s1) -> "for (vector<CustType*> :: iterator loopVar" ^ string_of_loop_var_t e1 ^ " = 
" ^ get_for_id e2 ^ "->getListBegin(); loopVar" ^ string_of_loop_var_t e1 ^ " != " ^ get_for_id e2 ^
     "->getListEnd();  " ^ "++loopVar" ^ string_of_loop_var_t e1 ^ ") {\n CustType* "^
string_of_loop_var_t e1 ^ " = *loopVar" ^ string_of_loop_var_t e1 ^ ";\n"
   ^ string_of_stmt s1 ^ "\n}\n"

  | If(e, s, Block([])) -> "if ((" ^ string_of_expr e ^ ")->getBoolValue())\n" ^ string_of_stmt s

  | If(e, s1, s2) ->  "if ((" ^ string_of_expr e ^ ")->getBoolValue())\n" ^ string_of_stmt s1 ^
"else\n" ^ string_of_stmt s2

    | Write(expr, str) -> "CustType::write(" ^ string_of_expr expr ^ "," ^ str ^ ");\n"

  | Assign(v, e) -> v ^ " = " ^ string_of_expr e  ^ ";\n"

  | ElemAssign(id, expr1, expr2) -> id ^ "->addByKey("^string_of_expr  expr1 ^
","^string_of_expr  expr2 ^ ");\n"

let string_of_formaldecl vdecl = string_of_vtype vdecl.vtype  ^ " " ^ vdecl.vname
let string_of_fdecl fdecl = (if fdecl.fname = "main" then
"int " ^ fdecl.fname ^ "("
else
 string_of_vtype fdecl.return ^ " " ^ fdecl.fname ^ "(" )
^   String.concat ", " (List.map string_of_formaldecl fdecl.formals) ^ ")\n{\n" ^
 String.concat "" (List.map string_of_stmt fdecl.body ) ^
    "}\n"
let string_of_program (vars, funcs) =
   "\n#include <iostream>\n#include \"../cpp/cPlusPlusCompiler.h\"\nusing namespace std;\n\n" ^
   String.concat "\n" (List.map string_of_vdecl vars) ^ "\n" ^
 String.concat "\n" (List.map string_of_fdecl funcs) ^ "\n"


let _ =
 (* first argument is the filename *)
 let fname = Sys.argv.(1) in
    (* check the extension *)
    let index = (if String.contains fname '.' then String.rindex fname '.' else 0 ) in
    let suffix = String.sub fname index 4 in
    if not (suffix = ".pjo") then raise (Failure ("Invalid  type of source file."))
    else
     let input = open_in fname in
     let lexbuf = Lexing.from_channel input in
     let program = Parser.program Scanner.token lexbuf in
     (* added the type check *)
     let program_t = Analyzer.check_program program in
     let output = string_of_program program_t in
     print_endline output
```

parser.mly

```
%{ open Ast %}


%token LPAREN RPAREN LBRACE RBRACE LBRACK RBRACK COMMA SEMI
%token PLUS MINUS  TIMES DIVIDE ASSIGN ACCESS COMPLUS COMMINUS  COLON
%token EQ NEQ LT GT LEQ GEQ NOT MOD
%token RETURN IF ELSE HASH NULL
%token AND OR FOR IN NOTIN
%token FUNC END DECL
%token NOTIN READ PRINT TYPE TYPESTRUCT JOIN MAKESTRING  ATTRLIST WRITE
%token <float> NUM_LIT
%token <string> STRING_LIT
%token <string> JSON_LIT
%token <string> LIST_LIT
%token <string> BOOL_LIT
%token <string> ID
%token EOF


%nonassoc NOELSE
%nonassoc ELSE


%right ASSIGN


%left AND OR
%left EQ NEQ
%left LT GT LEQ GEQ MOD
%left PLUS MINUS
```

```
%left TIMES DIVIDE
%left COMPLUS COMMINUS
%right NOT NOTIN IN


%start program
%type <Ast.program> program


%%


program:
   { [] , [] }
   | program vdecl { ($2 :: fst $1) , snd $1 }
   | program fdecl { fst $1, ($2 :: snd $1) }


fdecl:
   FUNC ID LPAREN formals_opt RPAREN LBRACE stmt_list RBRACE
     {{
      return = Ast.StrType;
      fname = $2;
      formals = $4;
      body = List.rev $7 }}


formals_opt:
   { [] }
   | formal_list   { List.rev $1 }
```

```
formal_list:
    formal                    { [$1] }
    | formal_list COMMA formal { $3 :: $1 }


formal:
    ID      { { vtype = NoType;   vname = $1; vexpr = NoExpr; } }


vdecl:
    ID ASSIGN expr SEMI { { vtype = StrType ;   vname = $1; vexpr = $3 } }


stmt_list:
    { [] }
    | stmt_list stmt { $2 :: $1 }


rev_stmt_list:
    stmt_list          { List.rev $1 }


/* using SEMI ';' to separate stmts */
stmt:
    vdecl                                            {Vdecl($1)}
    | expr SEMI                                        { Expr($1) }
    | RETURN expr_opt SEMI                                 { Return($2) }
    | PRINT LPAREN expr RPAREN SEMI                      { Print($3) }
   | FOR loop_var IN for_expr stmt                     { For($2, $4, $5 ) }
    | IF LPAREN expr RPAREN stmt ELSE stmt               { If($3, $5, $7) }
    | IF LPAREN expr RPAREN stmt %prec NOELSE           { If($3, $5, Block([])) }
    | LBRACE rev_stmt_list RBRACE                    { Block($2) }
   | WRITE LPAREN expr COMMA STRING_LIT RPAREN SEMI    { Write($3, $5) }
    | ID LBRACK expr RBRACK ASSIGN expr SEMI           { ElemAssign($1, $3, $6) }


for_expr:
    ID                          { Forid($1) }
    | ID ACCESS ATTRLIST LPAREN RPAREN      { AttrList($1) }


loop_var:
    ID                          { LoopVar($1) }


expr_opt:
    { NoExpr }
 | expr        { $1 }


expr:
    | NUM_LIT                              { LitInt($1) }
    | STRING_LIT                             { LitStr($1) }
    | HASH LBRACE json_items RBRACE HASH    { LitJson($3) }
    | LBRACK list_items RBRACK             { LitList($2) }
    | BOOL_LIT                     { LitBool($1) }
    | NULL                        { LitNull("null") }
    | ID                         { Id($1)  }
    | NOT LPAREN expr  RPAREN      { Not($3) }
    | NOT expr                    { Not($2) }
    | expr COMPLUS    expr         { Binop($1, Concat,  $3) }
    | expr COMMINUS     expr        { Binop($1, Minus,   $3) }
    | expr PLUS   expr            { Binop($1, Add,      $3) }
    | expr MINUS   expr            { Binop($1, Sub,      $3) }
    | expr TIMES  expr            { Binop($1, Mult,     $3) }
    | expr DIVIDE expr            { Binop($1, Div,      $3) }
    | expr EQ     expr            { Binop($1, Equal,    $3) }
    | expr NEQ    expr            { Binop($1, Neq,      $3) }
    | expr LT     expr            { Binop($1, Less,   $3) }
    | expr LEQ    expr            { Binop($1, Leq,   $3) }
    | expr GT     expr            { Binop($1, Greater,   $3) }
    | expr GEQ    expr            { Binop($1, Geq,   $3) }
    | expr MOD    expr            { Binop($1, Mod,   $3) }
    | expr AND expr               { Binop($1, And,      $3) }
    | expr OR expr                { Binop($1, Or,       $3) }
    | expr IN expr                { Binop($1,In,  $3) }
    | expr NOTIN expr             { Binop($1,NotIn,  $3) }
    | ID LPAREN actuals_opt RPAREN { Call($1,   $3) }
    | ID LBRACK expr RBRACK       { ElemAccess($1, $3) }
    | ID ACCESS TYPESTRUCT LPAREN   RPAREN  { TypeStruct($1) }
    | ID ACCESS ATTRLIST  LPAREN RPAREN     { AttrList($1) }
    | TYPE LPAREN expr RPAREN              { DataType($3) }
    | READ LPAREN STRING_LIT  RPAREN       { Read($3) }
    | MAKESTRING  LPAREN expr RPAREN       { MakeString($3)  }



list_items:
    { Noitem }
    | list_element                 { Item($1) }
    | list_element COMMA list_items       { Seq($1, Comma, $3) }
```

```
list_element:
    NUM_LIT                       { LitIntElem($1) }
    | STRING_LIT                  { LitStrElem($1) }
    | LBRACK list_items RBRACK   { LitListOfList($2) }
    | LBRACE json_items RBRACE   { LitJsonOfList($2) }
   | BOOL_LIT                    { LitBoolElem($1) }
   | NULL                        { LitNullElem("null")  }


json_items:
{ NoJsonItem }
| json_item                     { JsonItem($1)}
| json_item COMMA json_items   { JsonSeq($1, Comma, $3) }


json_item:
    json_item_key COLON json_item_value { JsonValPair($1,Colon,$3)  }


json_item_value:
    NUM_LIT                       { LitIntJsonVal($1)  }
    | STRING_LIT                  { LitStrJsonVal($1)  }
    | LBRACE json_items RBRACE   { LitJsonOfJson($2) }
    | LBRACK list_items RBRACK   { LitListOfJson($2) }
   | BOOL_LIT                    { LitBoolJsonVal($1)  }
   | NULL                        { LitNullJsonVal("null")  }


json_item_key:
```

```
STRING_LIT                  { LitStrJsonKey($1) }


actuals_opt:
   { [] }
   | actuals_list  { List.rev $1 }


actuals_list:
   expr                     { [$1] }
   | actuals_list COMMA expr { $3 :: $1 }
```

parser.output

```
0  $accept : %entry% $end


  1  program :
  2         | program vdecl
  3         | program fdecl


  4  fdecl : FUNC ID LPAREN formals_opt RPAREN LBRACE vdecl_opt stmt_list RBRACE


  5  formals_opt :
  6             | formal_list


  7  formal_list : formal
  8             | formal_list COMMA formal
```

```
 9  formal : ID

10  vdecl_opt :
11          | vdecl_list

12  vdecl_list : vdecl
13           | vdecl_list vdecl

14  vdecl : DECL ID ASSIGN expr SEMI

15  stmt_list :
16          | stmt_list stmt

17  rev_stmt_list : stmt_list

18  stmt : expr SEMI
19      | RETURN expr_opt SEMI
20      | PRINT expr SEMI
21      | IF LPAREN expr RPAREN stmt ELSE stmt
22      | IF LPAREN expr RPAREN stmt
23      | LBRACE rev_stmt_list RBRACE

24  expr_opt :
        | expr

list_expr : NUM_LIT
         | STRING_LIT

expr : NUM_LIT
    | STRING_LIT
    | LBRACE json_items RBRACE
    | LBRACK list_items RBRACK
    | BOOL_LIT
    | ID
    | expr PLUS expr
    | expr MINUS  expr
    | expr TIMES expr
    | expr DIVIDE expr
    | expr EQ expr
    | expr NEQ expr
    | ID ASSIGN expr
    | ID LPAREN actuals_opt RPAREN
    | MAINFUNC
    | ID LBRACK list_expr RBRACK

list_items :
          | list_element
          | list_element COMMA list_items

list_element : NUM_LIT
```

```
 48              | STRING_LIT
 49              | LBRACK list_items RBRACK


 50  json_items :
 51            | json_item
 52            | json_item COMMA json_items


 53  json_item : STRING_LIT  COLON json_item_value


 54  json_item_value : NUM_LIT
 55                  | STRING_LIT


 56  actuals_opt :
 57             | actuals_list


 58  actuals_list : expr
 59              | actuals_list COMMA expr


 60  %entry% : '\001' program


state 0
   $accept : . %entry% $end  (0)


   '\001'  shift 1
```

```
  .  error


  %entry%  goto 2



state 1
  %entry% : '\001' . program  (60)
  program : .  (1)


  .  reduce 1


  program  goto 3



state 2
  $accept : %entry% . $end  (0)


  $end  accept



state 3
  program : program . vdecl  (2)
  program : program . fdecl  (3)
  %entry% : '\001' program .  (60)
  FUNC  shift 4
  DECL  shift 5
  $end  reduce 60


  vdecl  goto 6
  fdecl  goto 7



state 4
  fdecl : FUNC . ID LPAREN formals_opt RPAREN LBRACE vdecl_opt stmt_list RBRACE  (4)


  ID  shift 8
  .  error



state 5
  vdecl : DECL . ID ASSIGN expr SEMI  (14)


  ID  shift 9
  .  error



state 6
  program : program vdecl .  (2)


  .  reduce 2
```

```
state 7
  program : program fdecl .  (3)

  .  reduce 3


state 8
  fdecl : FUNC ID . LPAREN formals_opt RPAREN LBRACE vdecl_opt stmt_list RBRACE  (4)

  LPAREN  shift 10
  .  error


state 9
  vdecl : DECL ID . ASSIGN expr SEMI  (14)

  ASSIGN  shift 11
  .  error


state 10
  fdecl : FUNC ID LPAREN . formals_opt RPAREN LBRACE vdecl_opt stmt_list RBRACE  (4)
  formals_opt : .  (5)
```

```
	ID  shift 12
	RPAREN  reduce 5

	formals_opt  goto 13
	formal_list  goto 14
	formal  goto 15


state 11
	vdecl : DECL ID ASSIGN . expr SEMI  (14)

	LBRACE  shift 16
	LBRACK  shift 17
	MAINFUNC  shift 18
	NUM_LIT  shift 19
	STRING_LIT  shift 20
	BOOL_LIT  shift 21
	ID  shift 22
	.  error

	expr  goto 23


state 12
	formal : ID .  (9)
```

```
  .  reduce 9


state 13
  fdecl : FUNC ID LPAREN formals_opt . RPAREN LBRACE vdecl_opt stmt_list RBRACE  (4)

  RPAREN  shift 24
  .  error


state 14
  formals_opt : formal_list .  (6)
  formal_list : formal_list . COMMA formal  (8)

  COMMA  shift 25
  RPAREN  reduce 6


state 15
  formal_list : formal .  (7)

  .  reduce 7


state 16
  expr : LBRACE . json_items RBRACE  (30)
```

```
   json_items : .  (50)

   STRING_LIT   shift 26
   RBRACE  reduce 50

   json_items  goto 27
   json_item  goto 28


state 17
   expr : LBRACK . list_items RBRACK  (31)
   list_items : .  (44)

   LBRACK  shift 29
   NUM_LIT   shift 30
   STRING_LIT   shift 31
   RBRACK  reduce 44

   list_items  goto 32
   list_element  goto 33


state 18
   expr : MAINFUNC  .  (42)

   .  reduce 42
```

```
state 19
  expr : NUM_LIT  .  (28)


  .  reduce 28



state 20
  expr : STRING_LIT  .  (29)


  .  reduce 29



state 21
  expr : BOOL_LIT .  (32)


  .  reduce 32



state 22
  expr : ID .  (33)
  expr : ID . ASSIGN expr  (40)
  expr : ID . LPAREN actuals_opt RPAREN  (41)
  expr : ID . LBRACK list_expr RBRACK  (43)
  LPAREN  shift 34
  LBRACK  shift 35
  ASSIGN   shift 36
  RPAREN  reduce 33
  COMMA   reduce 33
  SEMI  reduce 33
  PLUS  reduce 33
  MINUS   reduce 33
  TIMES  reduce 33
  DIVIDE  reduce 33
  EQ  reduce 33
  NEQ  reduce 33


state 23
  vdecl : DECL ID ASSIGN expr . SEMI  (14)
  expr : expr . PLUS expr  (34)
  expr : expr . MINUS expr  (35)
  expr : expr . TIMES expr  (36)
  expr : expr . DIVIDE expr  (37)
  expr : expr . EQ expr  (38)
  expr : expr . NEQ expr  (39)


  SEMI  shift 37
  PLUS  shift 38
  MINUS   shift 39
  TIMES  shift 40
  DIVIDE  shift 41
  EQ  shift 42
  NEQ  shift 43
  .  error


state 24
  fdecl : FUNC ID LPAREN formals_opt RPAREN . LBRACE vdecl_opt stmt_list RBRACE  (4)

  LBRACE  shift 44
  .  error


state 25
  formal_list : formal_list COMMA . formal  (8)

  ID  shift 12
  .  error

  formal  goto 45


state 26
  json_item : STRING_LIT . COLON json_item_value  (53)

  COLON  shift 46
  .  error
```

```
state 27
   expr : LBRACE json_items . RBRACE  (30)


   RBRACE  shift 47
   .  error



state 28
   json_items : json_item .  (51)
   json_items : json_item . COMMA json_items  (52)


   COMMA   shift 48
   RBRACE  reduce 51



state 29
   list_element : LBRACK . list_items RBRACK  (49)
   list_items : .  (44)


   LBRACK  shift 29
   NUM_LIT   shift 30
   STRING_LIT   shift 31
   RBRACK  reduce 44
```

```
  list_items  goto 49
  list_element  goto 33


state 30
  list_element : NUM_LIT  .  (47)

  .  reduce 47


state 31
  list_element : STRING_LIT  .  (48)

  .  reduce 48


state 32
  expr : LBRACK list_items . RBRACK  (31)

  RBRACK  shift 50
  .  error


state 33
  list_items : list_element .  (45)
  list_items : list_element . COMMA list_items  (46)
  COMMA  shift 51
  RBRACK  reduce 45


state 34
  expr : ID LPAREN . actuals_opt RPAREN  (41)
  actuals_opt : .  (56)


  LBRACE  shift 16
  LBRACK  shift 17
  MAINFUNC  shift 18
  NUM_LIT  shift 19
  STRING_LIT  shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  RPAREN  reduce 56


  expr  goto 52
  actuals_opt  goto 53
  actuals_list  goto 54


state 35
  expr : ID LBRACK . list_expr RBRACK  (43)
```

```
	NUM_LIT  shift 55
	STRING_LIT  shift 56
	.  error

	list_expr  goto 57


state 36
	expr : ID ASSIGN . expr  (40)

	LBRACE  shift 16
	LBRACK  shift 17
	MAINFUNC  shift 18
	NUM_LIT  shift 19
	STRING_LIT  shift 20
	BOOL_LIT  shift 21
	ID  shift 22
	.  error

	expr  goto 58


state 37
	vdecl : DECL ID ASSIGN expr SEMI .  (14)

	.  reduce 14
```

```
state 38
  expr : expr PLUS . expr  (34)


  LBRACE  shift 16
  LBRACK  shift 17
  MAINFUNC   shift 18
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  .  error


  expr  goto 59



state 39
  expr : expr MINUS  . expr  (35)


  LBRACE  shift 16
  LBRACK  shift 17
  MAINFUNC   shift 18
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  .  error


  expr  goto 60


state 40
  expr : expr TIMES . expr  (36)


  LBRACE  shift 16
  LBRACK  shift 17
  MAINFUNC   shift 18
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  .  error


  expr  goto 61



state 41
  expr : expr DIVIDE . expr  (37)


  LBRACE  shift 16
  LBRACK  shift 17
  MAINFUNC   shift 18
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  .  error


  expr  goto 62



state 42
  expr : expr EQ . expr  (38)


  LBRACE  shift 16
  LBRACK  shift 17
  MAINFUNC   shift 18
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  .  error


  expr  goto 63



state 43
  expr : expr NEQ . expr  (39)
```

```
   LBRACE  shift 16
   LBRACK  shift 17
   MAINFUNC   shift 18
   NUM_LIT   shift 19
   STRING_LIT   shift 20
   BOOL_LIT  shift 21
   ID  shift 22
   .  error


   expr  goto 64



state 44
   fdecl : FUNC ID LPAREN formals_opt RPAREN LBRACE . vdecl_opt stmt_list RBRACE  (4)
   vdecl_opt : .  (10)


   DECL  shift 5
   LBRACE  reduce 10
   RBRACE  reduce 10
   LBRACK  reduce 10
   RETURN  reduce 10
   IF  reduce 10
   MAINFUNC   reduce 10
   PRINT  reduce 10
   NUM_LIT   reduce 10
   STRING_LIT   reduce 10
```

```
  BOOL_LIT  reduce 10
  ID  reduce 10


  vdecl  goto 65
  vdecl_opt  goto 66
  vdecl_list  goto 67



state 45
  formal_list : formal_list COMMA formal .  (8)


  .  reduce 8



state 46
  json_item : STRING_LIT  COLON . json_item_value  (53)


  NUM_LIT   shift 68
  STRING_LIT   shift 69
  .  error


  json_item_value  goto 70



state 47
  expr : LBRACE json_items RBRACE .  (30)
  .  reduce 30



state 48
  json_items : json_item COMMA  . json_items  (52)
  json_items : .  (50)


  STRING_LIT   shift 26
  RBRACE  reduce 50


  json_items  goto 71
  json_item  goto 28



state 49
  list_element : LBRACK list_items . RBRACK  (49)


  RBRACK  shift 72
  .  error



state 50
  expr : LBRACK list_items RBRACK .  (31)
  .  reduce 31



state 51
  list_items : list_element COMMA . list_items  (46)
  list_items : .  (44)


  LBRACK  shift 29
  NUM_LIT   shift 30
  STRING_LIT   shift 31
  RBRACK  reduce 44


  list_items  goto 73
  list_element  goto 33



state 52
  expr : expr . PLUS expr  (34)
  expr : expr . MINUS  expr  (35)
  expr : expr . TIMES  expr  (36)
  expr : expr . DIVIDE  expr  (37)
  expr : expr . EQ expr  (38)
  expr : expr . NEQ expr  (39)
  actuals_list : expr .  (58)


  PLUS  shift 38
  MINUS   shift 39
  TIMES  shift 40
  DIVIDE  shift 41
  EQ  shift 42
  NEQ  shift 43
  RPAREN  reduce 58
  COMMA  reduce 58


state 53
  expr : ID LPAREN actuals_opt . RPAREN  (41)

  RPAREN  shift 74
  .  error


state 54
  actuals_opt : actuals_list .  (57)
  actuals_list : actuals_list . COMMA expr  (59)

  COMMA  shift 75
  RPAREN  reduce 57


state 55
  list_expr : NUM_LIT  .  (26)

  .  reduce 26
```

```
state 56
   list_expr : STRING_LIT  .  (27)


   .  reduce 27



state 57
   expr : ID LBRACK list_expr . RBRACK  (43)


   RBRACK  shift 76
   .  error



state 58
   expr : expr . PLUS expr  (34)
   expr : expr . MINUS  expr  (35)
   expr : expr . TIMES  expr  (36)
   expr : expr . DIVIDE  expr  (37)
   expr : expr . EQ expr  (38)
   expr : expr . NEQ expr  (39)
   expr : ID ASSIGN expr .  (40)


   PLUS  shift 38
   MINUS   shift 39
   TIMES  shift 40
```

```
  DIVIDE  shift 41
  EQ  shift 42
  NEQ  shift 43
  RPAREN  reduce 40
  COMMA  reduce 40
  SEMI  reduce 40



state 59
  expr : expr . PLUS expr  (34)
  expr : expr PLUS expr .  (34)
  expr : expr . MINUS expr  (35)
  expr : expr . TIMES expr  (36)
  expr : expr . DIVIDE expr  (37)
  expr : expr . EQ expr  (38)
  expr : expr . NEQ expr  (39)


  TIMES  shift 40
  DIVIDE  shift 41
  RPAREN  reduce 34
  COMMA  reduce 34
  SEMI  reduce 34
  PLUS  reduce 34
  MINUS  reduce 34
  EQ  reduce 34
  NEQ  reduce 34
```

```
state 60
   expr : expr . PLUS expr  (34)
   expr : expr . MINUS  expr  (35)
   expr : expr MINUS  expr .  (35)
   expr : expr . TIMES  expr  (36)
   expr : expr . DIVIDE  expr  (37)
   expr : expr . EQ expr  (38)
   expr : expr . NEQ expr  (39)


   TIMES  shift 40
   DIVIDE  shift 41
   RPAREN  reduce 35
   COMMA  reduce 35
   SEMI  reduce 35
   PLUS  reduce 35
   MINUS  reduce 35
   EQ  reduce 35
   NEQ  reduce 35



state 61
   expr : expr . PLUS expr  (34)
   expr : expr . MINUS  expr  (35)
   expr : expr . TIMES  expr  (36)
   expr : expr TIMES  expr .  (36)
   expr : expr . DIVIDE  expr  (37)
   expr : expr . EQ expr  (38)
   expr : expr . NEQ expr  (39)
   .  reduce 36



state 62
   expr : expr . PLUS expr  (34)
   expr : expr . MINUS  expr  (35)
   expr : expr . TIMES  expr  (36)
   expr : expr . DIVIDE  expr  (37)
   expr : expr DIVIDE  expr .  (37)
   expr : expr . EQ expr  (38)
   expr : expr . NEQ expr  (39)

   .  reduce 37



state 63
   expr : expr . PLUS expr  (34)
   expr : expr . MINUS  expr  (35)
   expr : expr . TIMES  expr  (36)
   expr : expr . DIVIDE  expr  (37)
   expr : expr . EQ expr  (38)
   expr : expr EQ expr .  (38)
   expr : expr . NEQ expr  (39)

   PLUS   shift 38
   MINUS   shift 39
```

```
    TIMES  shift 40
    DIVIDE  shift 41
    RPAREN  reduce 38
    COMMA  reduce 38
    SEMI  reduce 38
    EQ  reduce 38
    NEQ  reduce 38



state 64
    expr : expr . PLUS expr  (34)
    expr : expr . MINUS expr  (35)
    expr : expr . TIMES expr  (36)
    expr : expr . DIVIDE expr  (37)
    expr : expr . EQ expr  (38)
    expr : expr . NEQ expr  (39)
    expr : expr NEQ expr .  (39)


    PLUS  shift 38
    MINUS  shift 39
    TIMES  shift 40
    DIVIDE  shift 41
    RPAREN  reduce 39
    COMMA  reduce 39
    SEMI  reduce 39
    EQ  reduce 39
    NEQ  reduce 39
```

```
state 65
   vdecl_list : vdecl .  (12)

   .  reduce 12


state 66
   fdecl : FUNC ID LPAREN formals_opt RPAREN LBRACE vdecl_opt . stmt_list RBRACE  (4)
   stmt_list : .  (15)

   .  reduce 15

   stmt_list  goto 77


state 67
   vdecl_opt : vdecl_list .  (11)
   vdecl_list : vdecl_list . vdecl  (13)

   DECL  shift 5
   LBRACE  reduce 11
   RBRACE  reduce 11
   LBRACK  reduce 11
   RETURN  reduce 11
```

```
  IF  reduce 11
  MAINFUNC  reduce 11
  PRINT  reduce 11
  NUM_LIT  reduce 11
  STRING_LIT  reduce 11
  BOOL_LIT  reduce 11
  ID  reduce 11


  vdecl  goto 78



state 68
  json_item_value : NUM_LIT .  (54)


  .  reduce 54



state 69
  json_item_value : STRING_LIT .  (55)


  .  reduce 55



state 70
  json_item : STRING_LIT COLON json_item_value .  (53)
```

```
    .  reduce 53


state 71
    json_items : json_item COMMA json_items .  (52)

    .  reduce 52


state 72
    list_element : LBRACK list_items RBRACK .  (49)

    .  reduce 49


state 73
    list_items : list_element COMMA list_items .  (46)

    .  reduce 46


state 74
    expr : ID LPAREN actuals_opt RPAREN .  (41)

    .  reduce 41
```

```
state 75
   actuals_list : actuals_list COMMA . expr  (59)


   LBRACE  shift 16
   LBRACK  shift 17
   MAINFUNC   shift 18
   NUM_LIT   shift 19
   STRING_LIT   shift 20
   BOOL_LIT  shift 21
   ID  shift 22
   .  error


   expr  goto 79



state 76
   expr : ID LBRACK list_expr RBRACK .  (43)


   .  reduce 43



state 77
   fdecl : FUNC ID LPAREN formals_opt RPAREN LBRACE vdecl_opt stmt_list . RBRACE  (4)
   stmt_list : stmt_list . stmt  (16)
```

```
  LBRACE  shift 80
  RBRACE  shift 81
  LBRACK  shift 17
  RETURN  shift 82
  IF  shift 83
  MAINFUNC   shift 18
  PRINT  shift 84
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  .  error


  expr  goto 85
  stmt  goto 86



state 78
  vdecl_list : vdecl_list vdecl .  (13)


  .  reduce 13



state 79
  expr : expr . PLUS expr  (34)
  expr : expr . MINUS  expr  (35)
  expr : expr . TIMES expr  (36)
  expr : expr . DIVIDE expr  (37)
  expr : expr . EQ expr  (38)
  expr : expr . NEQ expr  (39)
  actuals_list : actuals_list COMMA expr .  (59)


  PLUS  shift 38
  MINUS  shift 39
  TIMES  shift 40
  DIVIDE  shift 41
  EQ  shift 42
  NEQ  shift 43
  RPAREN  reduce 59
  COMMA  reduce 59



80: reduce/reduce conflict (reduce 15, reduce 50) on RBRACE
80: shift/reduce conflict (shift 26, reduce 15) on STRING_LIT
state 80
  stmt : LBRACE . rev_stmt_list RBRACE  (23)
  expr : LBRACE . json_items RBRACE  (30)
  stmt_list : .  (15)
  json_items : .  (50)


  STRING_LIT  shift 26
  LBRACE  reduce 15
  RBRACE  reduce 15
  LBRACK  reduce 15
```

```
    RETURN  reduce 15
    IF  reduce 15
    MAINFUNC   reduce 15
    PRINT  reduce 15
    NUM_LIT   reduce 15
    BOOL_LIT  reduce 15
    ID  reduce 15


    stmt_list  goto 87
    rev_stmt_list  goto 88
    json_items  goto 27
    json_item  goto 28



  state 81
    fdecl : FUNC ID LPAREN formals_opt RPAREN LBRACE vdecl_opt stmt_list RBRACE .  (4)


    .  reduce 4



  state 82
    stmt : RETURN . expr_opt SEMI  (19)
    expr_opt : .  (24)


    LBRACE  shift 16
    LBRACK  shift 17
    MAINFUNC   shift 18
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  SEMI  reduce 24


  expr  goto 89
  expr_opt  goto 90



state 83
  stmt : IF . LPAREN expr RPAREN stmt ELSE stmt  (21)
  stmt : IF . LPAREN expr RPAREN stmt  (22)


  LPAREN  shift 91
  .  error



state 84
  stmt : PRINT . expr SEMI  (20)


  LBRACE  shift 16
  LBRACK  shift 17
  MAINFUNC   shift 18
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
```

```
    ID  shift 22
    .  error


    expr  goto 92



state 85
    stmt : expr . SEMI  (18)
    expr : expr . PLUS expr  (34)
    expr : expr . MINUS  expr  (35)
    expr : expr . TIMES  expr  (36)
    expr : expr . DIVIDE  expr  (37)
    expr : expr . EQ expr  (38)
    expr : expr . NEQ expr  (39)


    SEMI  shift 93
    PLUS  shift 38
    MINUS   shift 39
    TIMES  shift 40
    DIVIDE  shift 41
    EQ  shift 42
    NEQ  shift 43
    .  error



state 86
    stmt_list : stmt_list stmt .  (16)
```

```
   .  reduce 16


state 87
   stmt_list : stmt_list . stmt  (16)
   rev_stmt_list : stmt_list .  (17)

   LBRACE  shift 80
   LBRACK  shift 17
   RETURN  shift 82
   IF  shift 83
   MAINFUNC  shift 18
   PRINT  shift 84
   NUM_LIT  shift 19
   STRING_LIT  shift 20
   BOOL_LIT  shift 21
   ID  shift 22
   RBRACE  reduce 17

   expr  goto 85
   stmt  goto 86


state 88
   stmt : LBRACE rev_stmt_list . RBRACE  (23)
```

```
  RBRACE  shift 94
  .  error


state 89
  expr_opt : expr .  (25)
  expr : expr . PLUS expr  (34)
  expr : expr . MINUS  expr  (35)
  expr : expr . TIMES  expr  (36)
  expr : expr . DIVIDE  expr  (37)
  expr : expr . EQ expr  (38)
  expr : expr . NEQ expr  (39)

  PLUS  shift 38
  MINUS   shift 39
  TIMES  shift 40
  DIVIDE  shift 41
  EQ  shift 42
  NEQ  shift 43
  SEMI  reduce 25


state 90
  stmt : RETURN expr_opt . SEMI  (19)

  SEMI  shift 95
  .  error


state 91
  stmt : IF LPAREN . expr RPAREN stmt ELSE stmt  (21)
  stmt : IF LPAREN . expr RPAREN stmt  (22)

  LBRACE  shift 16
  LBRACK  shift 17
  MAINFUNC   shift 18
  NUM_LIT   shift 19
  STRING_LIT   shift 20
  BOOL_LIT  shift 21
  ID  shift 22
  .  error

  expr  goto 96


state 92
  stmt : PRINT expr . SEMI  (20)
  expr : expr . PLUS expr  (34)
  expr : expr . MINUS  expr  (35)
  expr : expr . TIMES  expr  (36)
  expr : expr . DIVIDE  expr  (37)
  expr : expr . EQ expr  (38)
  expr : expr . NEQ expr  (39)
```

```
    SEMI  shift 97
    PLUS  shift 38
    MINUS  shift 39
    TIMES  shift 40
    DIVIDE  shift 41
    EQ  shift 42
    NEQ  shift 43
    .  error


state 93
    stmt : expr SEMI .  (18)


    .  reduce 18


state 94
    stmt : LBRACE rev_stmt_list RBRACE .  (23)


    .  reduce 23


state 95
    stmt : RETURN expr_opt SEMI .  (19)
```

```
   .  reduce 19



state 96
   stmt : IF LPAREN expr . RPAREN stmt ELSE stmt  (21)
   stmt : IF LPAREN expr . RPAREN stmt  (22)
   expr : expr . PLUS expr  (34)
   expr : expr . MINUS  expr  (35)
   expr : expr . TIMES  expr  (36)
   expr : expr . DIVIDE  expr  (37)
   expr : expr . EQ expr  (38)
   expr : expr . NEQ expr  (39)


   RPAREN  shift 98
   PLUS  shift 38
   MINUS   shift 39
   TIMES   shift 40
   DIVIDE   shift 41
   EQ  shift 42
   NEQ  shift 43
   .  error



state 97
   stmt : PRINT expr SEMI .  (20)


   .  reduce 20
```

```
state 98
   stmt : IF LPAREN expr RPAREN . stmt ELSE stmt  (21)
   stmt : IF LPAREN expr RPAREN . stmt  (22)


   LBRACE  shift 80
   LBRACK  shift 17
   RETURN  shift 82
   IF  shift 83
   MAINFUNC   shift 18
   PRINT  shift 84
   NUM_LIT   shift 19
   STRING_LIT   shift 20
   BOOL_LIT  shift 21
   ID  shift 22
   .  error


   expr  goto 85
   stmt  goto 99



state 99
   stmt : IF LPAREN expr RPAREN stmt . ELSE stmt  (21)
   stmt : IF LPAREN expr RPAREN stmt .  (22)


   ELSE  shift 100
```

```
    LBRACE  reduce 22
    RBRACE  reduce 22
    LBRACK  reduce 22
    RETURN  reduce 22
    IF  reduce 22
    MAINFUNC   reduce 22
    PRINT  reduce 22
    NUM_LIT   reduce 22
    STRING_LIT   reduce 22
    BOOL_LIT  reduce 22
    ID  reduce 22



state 100
    stmt : IF LPAREN expr RPAREN stmt ELSE . stmt  (21)


    LBRACE  shift 80
    LBRACK  shift 17
    RETURN  shift 82
    IF  shift 83
    MAINFUNC   shift 18
    PRINT  shift 84
    NUM_LIT   shift 19
    STRING_LIT   shift 20
    BOOL_LIT  shift 21
    ID  shift 22
    .  error
```

```
  expr  goto 85
  stmt  goto 101


state 101
  stmt : IF LPAREN expr RPAREN stmt ELSE stmt .  (21)


  .  reduce 21


State 80 contains 1 shift/reduce conflict, 1 reduce/reduce conflict.


55 terminals, 23 nonterminals
61 grammar rules, 102 states
```

preprocessor.c

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <assert.h>
#include <ctype.h>  /* For isspace(). */
#include <stddef.h>  /* For size_t. */


#define MAX_BUFFER  4096
```

```
static void die(const char *message)
{
    perror(message);
    exit(1);
}


const char *getFileExtension(const char *fileName) {
    const char *dot = strrchr(fileName, '.');
    if(!dot || dot == fileName) return "";
    return dot + 1;
}


void remove_whitespace(char *str) {
    char *p;
    size_t len = strlen(str);


    for(p = str; *p; p ++, len --) {
       while(isspace(*p)) memmove(p, p+1, len--);
    }
}


int is_empty(const char *s) {
 while (*s != '\0') {
    if (!isspace(*s))
     return 0;
    s++;
 }
 return 1;
}



int main(int argc, char const *argv[])
{
    if (argc != 3) {
       fprintf(stderr, "%s\n", "usage: ./preprocessor <jo program file> <pjo program file>");
       exit(1);
    }
    char *fileName = (char *) argv[1];
    char *outputFileName = (char *) argv[2];


    // check input file extension
    if (strcmp("jo", getFileExtension(fileName)) != 0)
    {
       die("file extension must be jo");
    }


    // check output file extension
    if (strcmp("pjo", getFileExtension(outputFileName)) != 0)
    {
       die("output file extension must be pjo");
    }
```

```
FILE *input;
if ((input = fopen(fileName, "r")) == NULL) {
   die("fopen() failed");
}


FILE *output;
if ((output = fopen(outputFileName, "w")) == NULL) {
   die("fopen() failed");
}


char buffer[MAX_BUFFER];


while (fgets(buffer, sizeof(buffer), input) != NULL) {


   size_t len = strlen(buffer) - 1;
   if (buffer[len] == '\n') {
       buffer[len] = '\0';
   }
   if (strstr(buffer, "*/") != NULL) {
       fprintf(output, "%s\n", buffer);
   }
   else if (strstr(buffer, "/*") != NULL) {
       fprintf(output, "%s\n", buffer);
   }
   else if (strstr(buffer, "func ") != NULL) {
       fprintf(output, "%s {\n", buffer);
   }
```

```
        else if (strstr(buffer, "int ") != NULL) {
            fprintf(output, "%s;\n", buffer);
        }
/*      else if (strstr(buffer, "path ") != NULL) {
            fprintf(output, "%s;\n", buffer);
        }
        else if (strstr(buffer, "dict ") != NULL) {
            fprintf(output, "%s;\n", buffer);
        } */
        else if (strstr(buffer, "list ") != NULL) {
            fprintf(output, "%s;\n", buffer);
        }
        else if (strstr(buffer, "string ") != NULL) {
            fprintf(output, "%s;\n", buffer);
        }
        else if (strstr(buffer, "bool ") != NULL) {
            fprintf(output, "%s;\n", buffer);
        }
        else if (strstr(buffer, "for ") != NULL) {
            fprintf(output, "%s {\n", buffer);
        }
        else if ((strstr(buffer, "if (") != NULL || strstr(buffer, "if(") != NULL) && (strstr(buffer, ")") !=
NULL)) {
            fprintf(output, "%s {\n", buffer);
        }
        else if ((strstr(buffer, "if (") != NULL || strstr(buffer, "if(") != NULL) && (strstr(buffer, ")") ==
NULL)) {
            fprintf(output, "%s\n", buffer);
        }
        /*else if (strstr(buffer, ")") != NULL) {
            fprintf(output, "%s {\n", buffer);
}*/
else if (strstr(buffer, "else") != NULL) {
    int i;
    int counter = 0;
    for (i = 0; i < strlen(buffer); ++i)
    {
        if (buffer[i] == ' ') {
            fprintf(output, "%c", buffer[i]);
            counter++;
        }
    }
    fprintf(output, "} %s {\n", buffer + counter);
}
else if (strstr(buffer, "end") != NULL) {
    int i;
    for (i = 0; i < strlen(buffer); i++){
        if (buffer[i] == 'e') {
            buffer[i] = '}';
        } else if (buffer[i] == 'n') {
            buffer[i] = '\n';
        } else if (buffer[i] == 'd') {
            buffer[i] = '\0';
        } else {


        }
    }
    fprintf(output, "%s", buffer);
}
else {
```

```
            if (is_empty(buffer)) {
                remove_whitespace(buffer);
                fprintf(output, "\n");
            } else {
                fprintf(output, "%s;\n", buffer);
            }
        }
    }
    fclose(input);
    fclose(output);
    return 0;
}
```

runCommands.sh

```
!/bin/bash
ocamllex scanner.mll
ocamlyacc parser.mly
ocamlc -c ast.mli
ocamlc -c parser.mli
ocamlc -c scanner.ml
ocamlc -c parser.ml
ocamlc -c sast.mli
ocamlc -c symboltable.ml
ocamlc -c analyzer.ml
#load Str.cma
ocamlc -c jo.ml
ocamlc -o jo parser.cmo scanner.cmo symboltable.cmo analyzer.cmo Str.cma jo.cmo
```

runjo.sh

```
#!/bin/sh


if [ ! -f "./preprocessor" ]; then
make -f MakePreProc >> make.log
fi


if [ ! -f "./jo" ]; then
make -f Makefile  >> make.log
fi


# jo exectutable
JO="./jo"


# preprocessor executable
PRE="./preprocessor"
TEST_BASE="testfiles"


# Compare <outfile> <reffile> <difffile>
# Compares the outfile with reffile.  Differences, if any, written to difffile
Compare() {
difference=$(diff -b $1 $2)
echo $difference
if [ "$difference" != "" ]; then
echo $difference > $3
fi
```

```
}


function compileAndRun() {
basename=`echo $1 | sed 's/.*\\///
s/.jo//'`
echo "Running file $basename"
reffile=`echo $1 | sed 's/.jo$//'`
prepfile=$TEST_BASE/$basename'.pjo'
#echo $prepfile
basedir="`echo $1 | sed 's/\/[^\/]*$//'`/"


#Remove all Old Generated File
rm -rf ${reffile}.fdlp
rm -rf ${reffile}.cpp
rm -rf ${reffile}.out
rm -rf ${reffile}.o
rm -rf ${reffile}.output


# gets the path of the test output file
testoutput=`echo ${basedir}test_outputs/$basename.c.out`


echo "Preprocessing '$1'"
$PRE $1 $prepfile && echo "Preprocessor for $1 succeeded"


echo "Compiling '$prepfile'"
if [ ! -f $prepfile ]; then
```

```
echo "$prepfile does not exist"
return
fi
# converting from JO to C++
$JO $prepfile > "${reffile}.cpp" && echo "Ocaml to C++ of $1 succeeded"


if [ ! -s ${reffile}.cpp ] ; then
echo "Error in Compilation of ${reffile}"
return
fi ;



# compliling the C++ file
if [ -f "${reffile}.cpp" ]; then
   make inputfile=$basename -f MakeFileCPP
else
   echo "Compiling $1 failed"
   return
fi


# running the binary
if [ -f "${reffile}.out" ]; then
   eval ${reffile}.out
   echo
fi


}
```

```
files=$TEST_BASE/*.jo


if [ -f $1 ]; then
compileAndRun $1
else
echo "$1 doesnt exist"
fi
```

sast.mli

```
type op_t = Add | Sub | Mult | Div | Equal | Neq | Less | Leq | Greater | Geq | And | Or | Concat |
Minus | Mod | In | NotIn


type data_type_t = StrType | IntType | BoolType | JsonType | ListType | NoType


type sep_t = Comma


type colon_t = Colon


type list_expr_t =
 ListItemInt of float
 | ListItemStr of string


type list_element_t =
 LitIntElem of float
 | LitStrElem of string
   | LitListOfList of items_t
   | LitJsonOfList of json_items_t
   | LitNullElem of string
   | LitBoolElem of string
and items_t =
    Item of list_element_t
 | Seq of list_element_t * sep_t * items_t
 | Noitem
and json_key_type_t =
   LitStrJsonKey of string
and json_item_value_t =
 LitIntJsonVal  of float
 | LitStrJsonVal of string
   | LitJsonOfJson of json_items_t
   | LitListOfJson of items_t
   | LitBoolJsonVal  of string
   | LitNullJsonVal  of string
and json_item_t =
   JsonValPair  of json_key_type_t  * colon_t * json_item_value_t
and json_items_t =
    JsonItem of json_item_t
 | JsonSeq of json_item_t * sep_t * json_items_t
 | NoJsonItem


type expr_t =
    LitInt  of float
 | LitStr of string
   | LitJson of json_items_t
 | LitList of items_t
```

```
   | LitBool of string
   | LitNull of string
 | Id of string
 | Not of expr_t
 | Binop of expr_t * op_t * expr_t
 | Call of string * expr_t list
   | ElemAccess of string * expr_t
   | TypeStruct of string
   | AttrList of string
 | DataType of expr_t * string
   | Read of string
 | MakeString of expr_t * string
 | NoExpr


type var_decl_t = {
 vtype : data_type_t;
 vname : string;
 vexpr : expr_t;
}


type for_expr_t =
    Forid of string
    | AttrList of string


type loop_var_t =
    LoopVar of string
```

```
type stmt_t =
    Expr of expr_t
 | Block of stmt_t list
 | Vdecl of var_decl_t
 | Return of expr_t
   | Print of expr_t * string
 | For of loop_var_t * for_expr_t * stmt_t
 | If of expr_t * stmt_t * stmt_t
   | Write of expr_t * string
 | Assign of string * expr_t
 | ElemAssign of string * expr_t * expr_t


type func_decl_t = {
    return : data_type_t;
    fname : string;
    formals : var_decl_t list;
    body : stmt_t list;
 }


type program_t = var_decl_t list * func_decl_t list
```

scanner.mll

```
{ open Parser }


let letter = ['a' - 'z' 'A' - 'Z']
let digit = ['0' - '9']
let quote = '"'
```

```
rule token = parse
  [' ' '\r' '\n' '\t']    { token lexbuf }
  | "/*"           { comment lexbuf }
  | '('          { LPAREN }
  | ')'          { RPAREN }
  | '{'          { LBRACE }
  | ','           { COMMA }
  | '}'          { RBRACE }
  | '['          { LBRACK }
  | ']'          { RBRACK }
  | '.'          { ACCESS }
  | "++"           { PLUS }
  | "--"           { MINUS  }
  | "**"           { TIMES }
  | "//"           { DIVIDE }
  | '='           { ASSIGN }
  | ';'          { SEMI }
  | "=="           { EQ }
  | "!="           { NEQ }
  | '<'           { LT }
  | "<="           { LEQ }
  | '>'           { GT }
  | ">="           { GEQ }
  | "&&"           { AND }
  | "||"           { OR }
  | '!'          { NOT }
  | '-'           { COMMINUS  }
  | '+'            { COMPLUS }
  | ':'          { COLON }
  | '#'          { HASH }
  | "%%"           { MOD }
    | "func"      { FUNC }
    | "if"         { IF }
  | "else"      { ELSE }
  | "for"          { FOR }
  | "in"          { IN }
  | "end"          { END }
  | "not in"      { NOTIN }
  | "read"      { READ }
  | "write"      { WRITE }
  | "print"      { PRINT }
  | "type"      { TYPE }
  | "typeStruct"  { TYPESTRUCT }
  | "attrList"    { ATTRLIST }
  | "makeString"    { MAKESTRING }
  | "return"      { RETURN }
  | "null"       { NULL }
  | eof          { EOF }          (* do as microC *)
  | ('-'? digit+) | ('-'? digit* '.' digit+) as lit                   { NUM_LIT(float_of_string  lit) }
  | quote [^'""]*  quote as lit    { STRING_LIT(lit)  }
  | "true" | "false" as lit { BOOL_LIT (lit) }
  | letter | (letter | digit | '_')* as id       { ID(id) }
  | _ as char       { raise (Failure("illegal character " ^ Char.escaped char)) }


and comment = parse
  "*/"          { token lexbuf }
  | _              { comment lexbuf }
```

symboltable.ml

```
open Ast


module StringMap = Map.Make(String)


type env = {
    locals:         string StringMap.t;
   globals:        string StringMap.t;
   functions:      string list StringMap.t;
}


let string_of_vtype = function
   IntType -> "number"
 | StrType -> "string"
 | BoolType -> "bool"
 | JsonType -> "json"
 | ListType -> "list"
 | NoType -> "notype"


let find_variable name env =
   try StringMap.find name env.locals
   with Not_found -> try StringMap.find name env.globals
   with Not_found -> ""


let find_function name env =
   try StringMap.find name env.functions
   with Not_found -> []


let add_local name v_type env =
   if StringMap.mem name env.locals then StringMap.empty
   else StringMap.add name (string_of_vtype v_type) env.locals


let update_local name v_type env =
   if StringMap.mem name env.locals then StringMap.add name (string_of_vtype v_type)
env.locals, "exist"
   else StringMap.add name (string_of_vtype v_type) env.locals, "added"


let add_global name v_type env =
   if StringMap.mem name env.globals then StringMap.empty
   else StringMap.add name (string_of_vtype v_type) env.globals


let update_global name v_type env =
   StringMap.add name (string_of_vtype v_type) env.globals


(* from the ast *)
let get_arg_type = function
   v -> string_of_vtype v.vtype


let add_function name return_type formals env =
   if StringMap.mem name env.functions then StringMap.empty
   else let f = List.map get_arg_type formals in
```

```
   StringMap.add  name (string_of_vtype (return_type)::f) env.functions
```

test.sh

```
#!/bin/sh


if [ ! -f "./preprocessor" ]; then
make -f MakePreProc >> make.log
fi


if [ ! -f "./jo" ]; then
make -f Makefile  >> make.log
fi


# jo exectutable
JO="./jo"


# preprocessor executable
PRE="./preprocessor"
TEST_BASE="testfiles"


# Compare <outfile> <reffile> <difffile>
# Compares the outfile with reffile.  Differences, if any, written to difffile
Compare() {
difference=$(diff -b $1 $2)
echo $difference
if [ "$difference" != "" ]; then
```

```
echo $difference > $3
fi
}


function compileAndRun() {
basename=`echo $1 | sed 's/.*\///
s/.jo//'`
echo "Running file $basename"
reffile=`echo $1 | sed 's/.jo$//'`
prepfile=$TEST_BASE/$basename'.pjo'
#echo $prepfile
basedir="`echo $1 | sed 's/\/[^\/]*$//'`/"


#Remove all Old Generated File
rm -rf ${reffile}.fdlp
rm -rf ${reffile}.cpp
rm -rf ${reffile}.out
rm -rf ${reffile}.o
rm -rf ${reffile}.output


# gets the path of the test output file
testoutput=`echo ${basedir}test_outputs/$basename.c.out`


echo "Preprocessing '$1'"
$PRE $1 $prepfile && echo "Preprocessor for $1 succeeded"
```

```
echo "Compiling '$prepfile'"
if [ ! -f $prepfile ]; then
echo "$prepfile does not exist"
return
fi
# converting from JO to C++
$JO $prepfile > "${reffile}.cpp" && echo "Ocaml to C++ of $1 succeeded"


if [ ! -s ${reffile}.cpp ] ; then
echo "Error in Compilation of ${reffile}"
return
fi ;




# compliling the C++ file
if [ -f "${reffile}.cpp" ]; then


   make inputfile=$basename -f MakeFileCPP


else
   echo "Compiling $1 failed"
   return
fi


# running the binary
if [ -f "${reffile}.out" ]; then
eval ${reffile}.out >> ${reffile}.output
```

```
Compare ${reffile}.output ${reffile}.exp ${reffile}.error


rm -rf ${reffile}.o


echo "ran $1 successfully"
else
echo "C++ to binary of ${reffile}.cpp failed"
fi


}


files=$TEST_BASE/*.jo


if [ -f $1 ]; then
  compileAndRun $1
else
  echo "$1 doesnt exist"
fi
```

testall.sh

```
#!/bin/sh


if [ ! -f "./preprocessor" ]; then
   make -f MakePreProc >> make.log
fi
```

```
if [ ! -f "./jo" ]; then
  make -f Makefile  >> make.log
fi


# jo exectutable
JO="./jo"


# preprocessor executable
PRE="./preprocessor"
TEST_BASE="testfiles"


# Compare <outfile> <reffile> <difffile>
# Compares the outfile with reffile.  Differences, if any, written to difffile
Compare() {
   difference=$(diff -b $1 $2)
   echo $difference
   if [ "$difference" != "" ]; then
      echo $difference > $3
   fi
}


function compileAndRun() {
   basename=`echo $1 | sed 's/.*\\///
                           s/.jo//'`
    echo "Running file $basename"
```

```
reffile=`echo $1 | sed 's/.jo$//'`
 prepfile=$TEST_BASE/$basename'.pjo'
 #echo $prepfile
 basedir="`echo $1 | sed 's/\/[^\/]*$//'`/"


 # gets the path of the test output file
testoutput=`echo ${basedir}test_outputs/$basename.c.out`



 echo "Preprocessing '$1'"
$PRE $1 $prepfile && echo "Preprocessor for $1 succeeded"



echo "Compiling '$prepfile'"
if [ ! -f $prepfile ]; then
   echo "$prepfile does not exist"
   return
fi
# converting from JO to C++
 $JO $prepfile > "${reffile}.cpp" && echo "Ocaml to C++ of $1 succeeded"



if [ ! -s ${reffile}.cpp ] ; then
   echo "Error in Compilation of ${reffile}"
   return
fi ;



 # compliling the C++ file
 if [ -f "${reffile}.cpp" ]; then
```

```
        make inputfile=$basename -f MakeFileCPP
    else
      echo "Compiling $1 failed"
      return
    fi


    # running the binary
    if [ -f "${reffile}.out" ]; then
       eval ${reffile}.out >> ${reffile}.output
       Compare ${reffile}.output ${reffile}.exp ${reffile}.error


       rm -rf ${reffile}.fdlp
       rm -rf ${reffile}.pjo
       rm -rf ${reffile}.cpp
       rm -rf ${reffile}.out
       rm -rf ${reffile}.o
       rm -rf ${reffile}.output
       echo "ran $1 successfully"
    else
       echo "C++ to binary of ${reffile}.cpp failed"
    fi


}


files=$TEST_BASE/*.jo
```

```
for file in $files
do
  compileAndRun $file
done
```

testreadinput.txt

```
{"name":"harsha", "courses":["PLT","OS"]}
```

dataproc3.jo

```
func main()
  input = read("testfiles/yelpPlaces.json")
  dataList = input["data"]

  c = "{ String : String,  String : List,  String : String,  String : String,  String : Number,  String :
Number,  String : String,  String : List,  String : Boolean,  String : String,  String : Number,  String
: List,  String : Number,  String : String,  String : String,  String : String }"

  allMatched = true

  for jsonEl in dataList
    if (c != jsonEl.typeStruct())
      print("not matched")
      allMatched = false
    end
  end
  if (allMatched)
    print ("\n\n\n\n\nAll Json elements from file have the correct structure!!!\n\n\n\n")
  end



  print ("Adding a Json that has a different one\n\n\n\n")
  print ("Changing a list inside that had just a single string to become just that string, without the
list\n\n\n\n")



  d = #{"business_id": "Iu-oeVzv8ZgP18NIB0UMqg",  "full_address": "3320 S Hill StSouth East
LALos Angeles, CA 90007", "schools": ["University of Southern California"], "open": true,
"categories": ["Medical Centers", "Health and Medical"], "photo_url": "http://s3-
media1.ak.yelpcdn.com/bphoto/SdUWxREuWuPvvot6faxfXg/ms.jpg", "city": "Los Angeles",
"review_count": 2, "name": "Southern California Medical Group", "neighborhoods": "South East
LA", "url": "http://www.yelp.com/biz/southern-california-medical-group-los-angeles", "longitude":
-118.274281, "state": "CA", "stars": 3.5, "latitude": 34.019710000000003, "type": "business"}#



  if (d.typeStruct() == c)
    print ("Matched the wrong one too\n")
  else
    print ("Found the wrong one!!\n")
  end



end
```

dataproc2.jo

```
func main()
  input = read("testfiles/yelpPlaces.json")
  datalist = input["data"]


  c = #{"business_id": "lu-oeVzv8ZgP18NIB0UMqg",  "full_address": "3320 S Hill StSouth East
LALos Angeles, CA 90007", "schools": ["University of Southern California"], "open": true,
"categories": ["Medical Centers", "Health and Medical"], "photo_url": "http://s3-
media1.ak.yelpcdn.com/bphoto/SdUWxREuWuPvvot6faxfXg/ms.jpg", "city": "Los Angeles",
"review_count": 2, "name": "Southern California Medical Group", "neighborhoods": ["South East
LA"], "url": "http://www.yelp.com/biz/southern-california-medical-group-los-angeles", "longitude":
-118.274281, "state": "CA", "stars": 3.5, "latitude": 34.019710000000003, "type": "business"}#


  d = #{"business_id": "lu-oeVzv8ZgP18NIB0UMqg",  "full_address": "3320 S Hill StSouth East
LALos Angeles, CA 90007", "schools": ["University of Southern California"], "open": true,
"categories": ["Medical Centers"], "photo_url": "http://s3-
media1.ak.yelpcdn.com/bphoto/SdUWxREuWuPvvot6faxfXg/ms.jpg", "city": "Los Angeles",
"review_count": 2, "name": "Southern California Medical Group", "neighborhoods": ["South East
LA"], "url": "http://www.yelp.com/biz/southern-california-medical-group-los-angeles", "longitude":
-118.274281, "state": "CA", "stars": 3.5, "latitude": 34.019710000000003, "type": "business"}#


  if(c in datalist)
    print("found\n")
  end


  if(d in datalist)
    print("found Second")
  else
    print("Second not found")
  end


end
```

dataproc.jo

```
func processYelp(category, data)
  for entry in data
    categoryList = entry["categories"]
    if (category in categoryList)
       write (entry, "testfiles/processed.txt")
    end
  end
  return null
end


func main()
  input = read("testfiles/yelpPlaces.json")
  datalist = input["data"]
  processYelp("Pubs", datalist)
end
```

TypeFunction.jo

```
/* Type Function simple types */


func main ()


  a = true
  b = "asdfasdf"
  c = false
  d = 345534

  e = []

  f = #{}#


  print(type(a))

  print(type(b))

  print(type(c))

  print(type(d))

  print(type(e))

  print(type(f))



end
```

TypeFunction.exp

```
BoolStringBoolNumberListJson
```

TestTypeStruct2.jo

```
/* Nested Json TypeStruct test */



func main ()



  a = #{ "glossary": { "title": "example glossary","GlossDiv": {"title": "S","GlossList":
{"GlossEntry": { "ID": "SGML","SortAs": "SGML", "GlossTerm": "Standard Generalized Markup
Language",   "Acronym": "SGML",   "Abbrev": "ISO 8879:1986", "GlossSee": "markup" }  }  } }
}#


    b = a.typeStruct()

    print (b)
```

```
end
```

TestTypeStruct2.exp

```
{ String : { String : { String : { String : { String : String,  String : String,  String : String,  String : String,  String : String,  String : String } },  String : String },  String : String } }
```

TestTypeStruct.jo

```
/* Test How TypeStruct function work */



func main ()



  a = #{"name":"harsha", "number":12223, "list":[], "json":{"name":"harsha"}, "boolean":true}#
  b = a.typeStruct()
  print (b)

end
```

TestTypeStruct.exp

```
{ String : Boolean,  String : { String : String },  String : List,  String : String,  String : Number }
```

TestStringConcat.jo

```
/* Test String Concatenation */



func main ()
  a = "hi"
  b = "bye"
  print(a ++ b)
end
```

TestStringConcat.exp

```
hibye
```

TestNotOperator.jo

```
func main ()
  a = true
  b = false
  if( !(a==b))
    print (a)
  end
  if(!a)
    print(b)
  end
  if(!a ==b)
    print(a)
  end
end
```

TestNotOperator.exp

```
truetrue
```

TestNestedIfCondition.jo

```
/* Test If Condition */
```

```
func main ()


  if ( 5 == 5 )
    print ("true")

    if(true)
       print("Iinside 1st nested loop")

       if("hi" == "hi")
          print("Inside 2nd Nested If")
       end

    end
  else
     print ("false")
  end

end
```

TestNestedIfcondition.exp

```
trueIinside 1st nested loopInside 2nd Nested If
```

TestNestedForCondition.jo

```
/* Test Nested For Condition */
```

```
func main ()
  a = #{"a":[1,2,3], "b":[4,5,6], "c":[7,8,9]}#
  d = a.attrList()

  for i in d
    c = a[i]
    for j in c
       print (j)
    end
  end
end
```

TestNestedForCondition.exp

```
123456789
```

TestIfIn.jo

```
func main ()
  a = "hi"
  b = "bye"
  c = ["bbye","hello","bye"]
  if(a in c)
    print(a)
  end
  if(b in c)
    print(b)
  else
    print("Not found")
  end
  if(1==2)
    print("equal")
  end
  if(1!=2)
    print("not equal")
  else
    print("equal")
  end
end
```

TestIfIn.exp

```
byenot equal
```

TestIfCondition.jo

```
/* Test If Condition */


func main ()


  if ( 5 == 5 )
    print ("true")
  else
     print ("false")
  end

end
```

TestIfCondition.exp

```
true
```

TestForCondition.jo

```
/* Test For Condition */


func main ()
  a = [2,3,4]

  for i in a
    print (i)
  end


end
```

TestForCondition.exp

```
234
```

TestAttrList.jo

```
/* Test How AttrList function work */


func main ()
  a = #{"name":"harsha", "courses":["PLT", "OS"]}#
  b = a.attrList()
  print (b)
end
```

TestAttrList.exp

```
[courses,name]
```

ScopeCheck2.jo

```
/* Check variable Scope */


func checkScope(x)
  x = "Inside Check Scope"
  print (x)
  return null
end


func main ()
  x = "Inside Main Function"
  print (x)
  checkScope(x)
end
```

ScopeCheck2.exp

```
Inside Main FunctionInside Check Scope
```

ScopeCheck.jo

```
/* Check variable Scope */
```

```
x = "Global Declaration"


func main ()
  print (x)
  x = "Inside Main Function"
  print (x)
end
```

ScopeCheck.exp

```
Global DeclarationInside Main Function
```

ReadFunction.jo

```
/* Test Read function */


func main ()
  a = read ("testfiles/testreadinput.txt")
  print (a)
end
```

ReadFunction.exp

```
{
   "courses":[
   "PLT",
   "OS"
   ],
    "name":"harsha"
}
```

PrintHelloWorld.jo

```
/* Declare a Global Variable and print in Main function */


a = "Hello World"


func main ()
   print (a)
end
```

PrintHelloWorld.exp

```
Hello World
```

PrettyPrintJson.jo

```
/* Test Json Pretty Print */


a = #{"name":"harsha","courses":[1,"PLT",true]}#


func main ()
   print (a)
end
```

PrettyPrintJson.exp

```
{
   "courses":[
     1,
     "PLT",
     true
   ],
   "name":"harsha"
}
```

NotInOperator

```
/* Not In Operator */

func main ()

   a = [2243,1232,3454]
   b = 1232 not in a

   c = [["a","b"], 45, "ccc"]

   print(b)
   print("ccc" not in c)
   print("ab" not in c)
   print(["a","c"] not in c)
end
```

NotInOperator.exp

```
falsefalsetruetrue
```

NegativeWrongFunctionCall.jo

```
/* Invalid Function Call */


func testMeth ()
  print ("testMethod")
  return null
end


func main ()
  invalidFun()
end
```

NegativeWrongDeclaration.jo

```
/* Wrong declaration */


func main ()
  a = "highlight
  b = treu

  print(b)
end
```

NegativeWriteFunction.jo

```
/* Test Write function */
func main ()
```

```
a = "Text to write into file"
write (a, /Users/harsha/testfilewriting.txt)
end
```

NegativeVariableUse2.jo

```
/* Variable not declared */


func testMeth (a)
  c = b
  print (c)
  return null
end


func main ()
  a = "highlight"
  testMeth(a)
end
```

NegativeVariableUse.jo

```
/* Variable not declared */


func testMeth ()
  print ("testMethod")
  return null
end
```

```
func main ()
  print (a)
  a = "highlight"
end
```

NegativeStringConcatTest.jo

```
/* String Concatenation with number */


func main ()
  a = "hi"
  b = 121
  print(a ++ b)
end
```

NegativeReadDeclaration.jo

```
/* Test Read function */


func main ()
  b = 23324
  a = read (b)
  print (a)
end
```

NegativeOpTestCase.jo

```
/* Mathematical Operator on List */
```

```
func main ()
a = [5]
b = 6


print (a == b)


end
```

NegativeMathOpTestcases.jo

```
/* Mathematical Operator on List */


func main ()
   a = [5]
   b = 6
   print (a ++ b)
end
```

NegativeInvalidList.jo

```
/* Invalid List Declaration */


func main ()
   a = ["name",asdfdf]
   print (a)
end
```

NegativeInvalidJson.jo

```
/* Invalid Json Declaration */


func main ()
  a = #{"name":asdfdf}#
end
```

NegativeFunctionNoReturn.jo

```
/* Function call with different arguments */


func testMeth (a,b)
  print (a)
  return null
end


func main ()
  a = "highlight"
  testMeth(a)
end
```

NegativeFunctionCall.jo

```
/* Function call with different arguments */


func testMeth (a)
  print (a)
end
```

```
func main ()
  a = "highlight"
  testMeth(a)
end
```

NegativeForusage.jo

```
/* Test If Condition */


func main ()
  a = "Hello"

  for i in a
    print (i)
  end


end
```

NegativeElementAccess.jo

```
a = #{"a":"b"}#


func main()
  print(a[true])
end
```

NegationOperator3.jo

```
/* Negation Operator List minus Json, Number */


func main ()
  list1 =  ["able",  "barista", {"carrie":"Its a name"}]
  list2 = [1121, 2323]

  json1 =  #{"carrie":"Its a name"}#
  num = 2323

  print (list1 - json1)
  print (list2 - num)
end
```

AllTypeCreation.jo

```
/* Creation of all Types */

func main ()
     a = "Hello World all variable types created"
     b = 10
     c = #{"name":"harsha"}#
     d = [4,6,7]
     e = true
     f = null
     print (a)
end
```

AllTypeCreation.exp

```
Hello World all variable types created
```

CommentInsideFunction.jo

```
/* Testing Comment Inside a Function */

a = 45
b = 81

func findGCD(a,b)
    if(b == 0)
        return a
     end
     /*
     This is a GCD Program
     */
    return findGCD(b, a%%b)
end

func main ()
    print( findGCD(a,b) )
end
```

CommentInsideFunction.exp

```
9
```

ComparisonOperator.jo

```
/* Comparison equal and not equal */

func main ()
    a = 5
    b = 6
    c = "f"
    d = "l"

    if(a==b)
      print ("hi")
    end

    if (c!=d)
      print ("hello")
    end

end
```

ComparisonOperator.exp

```
hello
```

ComparisonOperator2.jo

```
/* Comparison Operator with booleans */

func main ()
```

```
    a = true
    b = false

    if(a && b)
      print ("hi")
    end

    if (a || b)
      print ("hello")
    end

    if (a || b && true)
      print ("hello1")
    end

end
```

ComparisonOperator2.exp

```
hellohello1
```

ComparisonOperator3.jo

```
/* Comparison Operator with Not */

func main ()
    a = true
    b = false

    c = 5
    d = 6
    if(!b)
      print ("hi")
    end

    if (a && !b)
      print ("hello")
    end

    if (!(c==d))
      print ("hello1")
    end

end
```

ComparisonOperator3.exp

```
hihellohello1
```

ConcatenationOperator1.jo

```
/* Concatenation on Numbers and String */

func main ()
    a = 59
    b = 600
    c = "Hello"
    d = "world"
    e = a+b
    f = c+d
    print (b + a)
    print (c + d)
    print (f + e)
end
```

ConcatenationOperator1.exp

```
[600,59][Hello,world][Hello,world,[59,600]]
```

ConcatenationOperator2.jo

```
/* Concatenation of Json */

func main ()
    a = #{"name":"harsha", "innerJson":{"sub":"PLT","mark":[5,6,7]}}#
    b = #{"name":"arpit"}#

    print (a + b)
    print (a + 5)
    print (a + "json")
end
```

ConcatenationOperator2.exp

```
[{"innerJson":{"mark":[5,6,7],"sub":"PLT"},"name":"harsha"},{"name":"arpit"}][{"innerJson":{"mark":[5,6
,7],"sub":"PLT"},"name":"harsha"},5][{"innerJson":{"mark":[5,6,7],"sub":"PLT"},"name":"harsha"},json]
```

ConcatenationOperator3.jo

```
/* Concatenation of List */

func main ()
```

```
    a = [[1,2,"a"]]
    b = ["hi","hello"]
    c = 5
    d = "hey"

    print (a + b)
    print (a + c +d)
end
```

ConcatenationOperator3.exp

```
[[1,2,a],[hi,hello]][[1,2,a],[hi,hello],5,hey]
```

CustomFunction1.jo

```
/* Testing Function call from Main and printing inside callee */

a = "Hello World"

func test(b)
    print (b)
    return 0
end

func main ()
    print (a)
    test(a)
end
```

CustomFunction1.exp

```
Hello WorldHello World
```

CustomFunction2.jo

```
/* Testing Variable declaration inside function and printing */

func createVarAndPrint()
    a = "This is a String"
    print (a)
    return 0
end

func main ()
    createVarAndPrint()
end
```

CustomFunction2.exp

```
This is a String
```

CustomFunction3.jo

```
/* Testing Function Return and print */

func returnAValue(a)
    return a ++ 100
end

func callAnotherMethod(a)
    b = returnAValue(a ++ 10)
    print (b)
    return 0
end

func main ()
    callAnotherMethod(10)
end
```

CustomFunction3.exp

```
120
```

dataproc.jo

```
func processYelp(category, data)
    for entry in data
       categoryList = entry["categories"]
       if (category in categoryList)
           write (entry, "testfiles/processed.txt")
       end
    end
    return null
end

func main()
    input = read("testfiles/yelpPlaces.json")
    datalist = input["data"]
    processYelp("Pubs", datalist)
end
```

dataproc2.jo

```
func main()

    input = read("testfiles/yelpPlaces.json")


    datalist = input["data"]


    c = #{"business_id": "Iu-oeVzv8ZgP18NIB0UMqg", "full_address": 
"3320 S Hill StSouth East LALos Angeles, CA 90007", "schools": 
["University of Southern California"], "open": true, "categories": 
["Medical Centers", "Health and Medical"], "photo_url": "http://s3-
media1.ak.yelpcdn.com/bphoto/SdUWxREuWuPvvot6faxfXg/ms.jpg", "city": 
"Los Angeles", "review_count": 2, "name": "Southern California Medical 
Group", "neighborhoods": ["South East LA"], "url": 
"http://www.yelp.com/biz/southern-california-medical-group-los-
angeles", "longitude": -118.274281, "state": "CA", "stars": 3.5, 
"latitude": 34.019710000000003, "type": "business"}#


    d = #{"business_id": "Iu-oeVzv8ZgP18NIB0UMqg", "full_address": 
"3320 S Hill StSouth East LALos Angeles, CA 90007", "schools": 
["University of Southern California"], "open": true, "categories": 
["Medical Centers"], "photo_url": "http://s3-
media1.ak.yelpcdn.com/bphoto/SdUWxREuWuPvvot6faxfXg/ms.jpg", "city": 
"Los Angeles", "review_count": 2, "name": "Southern California Medical 
Group", "neighborhoods": ["South East LA"], "url": 
"http://www.yelp.com/biz/southern-california-medical-group-los-
angeles", "longitude": -118.274281, "state": "CA", "stars": 3.5, 
"latitude": 34.019710000000003, "type": "business"}#



    if(c in datalist)
       print("found\n")
    end


    if(d in datalist)
       print("found Second")
    else
       print("Second not found")
    end
```

```
end
```

dataproc3.jo

```
func main()
    input = read("testfiles/yelpPlaces.json")
    dataList = input["data"]

    c = "{ String : String,  String : List,  String : String,  String
: String,  String : Number,  String : Number,  String : String,
String : List,  String : Boolean,  String : String,  String : Number,
String : List,  String : Number,  String : String,  String : String,
String : String }"

    allMatched = true

    for jsonEl in dataList
       if (c != jsonEl.typeStruct())
           print("not matched")
           allMatched = false
       end
    end

    if (allMatched)
       print ("\n\n\n\n\nAll Json elements from file have the correct
structure!!!\n\n\n\n")
    end

    print ("Adding a Json that has a different one\n\n\n\n")
    print ("Changing a list inside that had just a single string to
become just that string, without the list\n\n\n\n")


    d = #{"business_id": "Iu-oeVzv8ZgP18NIB0UMqg", "full_address":
"3320 S Hill StSouth East LALos Angeles, CA 90007", "schools":
["University of Southern California"], "open": true, "categories":
["Medical Centers", "Health and Medical"], "photo_url": "http://s3-
media1.ak.yelpcdn.com/bphoto/SdUWxREuWuPvvot6faxfXg/ms.jpg", "city":
"Los Angeles", "review_count": 2, "name": "Southern California Medical
Group", "neighborhoods": "South East LA", "url":
"http://www.yelp.com/biz/southern-california-medical-group-los-
angeles", "longitude": -118.274281, "state": "CA", "stars": 3.5,
"latitude": 34.019710000000003, "type": "business"}#


    if (d.typeStruct() == c)

       print ("Matched the wrong one too\n")

    else

       print ("Found the wrong one!!\n")

    end


end
```

DynamicTyping.jo

```
/* Change type of variable at run-time */


func test(l)

    print(l - "d")

    return null

end


func main()
```

```
    e = ["a","c", "d"]
    test(e)
    e = 5
    print(e)
end
```

DynamicTyping.exp

```
[a,c]5
```

ElementAccess.jo

```
/* Element Access in Json */

func main ()
    b = #{"name":"harsha", "innerJson":{"sub":"PLT","mark":[5,6,7]}}#
    d = b["innerJson"]
    print (d)
end
```

ElementAccess.exp

```
{
  "mark":[
  5,
  6,
  7
  ],
  "sub":"PLT"
```

}

ElementAccess2.jo

```
/* Element Access in List */

func main ()
    a = [1,"2",[4,["qw",3,4],"name"], {"name":"harsha",
"innerJson":{"sub":"PLT","mark":[5,6,7]}, "number":2324} ]
    print (a[3])
end
```

ElementAccess2.exp

```
{
  "innerJson":{
    "mark":[
    5,
    6,
    7
    ],
    "sub":"PLT"
  },
  "name":"harsha",
  "number":2324
}
```

ElementAssign.jo

```
/* Element Assignment in a Json */

a = #{"a":"b"}#

func main()
    a["c"] = ["d"]
    a["school"] = #{"names":["Columbia","Caltech"]}#
    print(a["c"])
    print(a)
end
```

ElementAssign.exp

```
[d]{
  "a":"b",
  "c":[
  "d"
  ],
  "school":{
    "names":[
    "Columbia",
    "Caltech"
    ]
  }
}
```

ElementAssign2.jo

```
/* Element Assignment in a List */



func main()

    a = [1,2,3,4]

    a[0] = "High"
    a[1] = "School"
    a[2] = #{"name":"Veer"}#

    print(a[0])
    print(a)
end
```

ElementAssign2.exp

```
High[High,School,{"name":"Veer"},4]
```

FileWriteFunction.jo

```
/* Test Write function */

func main ()
a = "Text to write into file"
write (a, "/Users/harsha/testfilewriting.txt")
end
```

ForStatement.jo

```
/* Declare a Global Variable and print in Main function */

a = [1, 2 ,3 ]

func main ()
    for b in a
       print (b)
    end
end
```

ForStatement.exp

```
123
```

GCD.jo

```
/* Test GCD function */

a = 45
b = 81

func findGCD(a,b)
    if(b == 0)
        return a
     end
    return findGCD(b, a%%b)
end

func main ()
    print( findGCD(a,b) )
end
```

GCD.exp

9

InOperator.jo

```
/* In Operator */

func main ()

    a = [2243,1232,3454]
    b = 1232 in a

    c = [["a","b"], 45, "ccc"]

    print(b)
    print("ccc" in c)
    print("ab" in c)
    print(["a","b"] in c)
end
```

InOperator.exp

```
Truetruefalsetrue
```

MakeStringFunction.jo

```
/* Use makeString and Concatente Strings */

func main ()
```

```
    a = 2243
    b = ["abc","bac"]
    c = #{"name":"harsha"}#

    print(makeString(a))
    print(makeString(b))
    print(makeString(c))
end
```

MakeStringFunction.exp

```
2243[abc,bac]{"name":"harsha"}
```

MakeStringFunction2.jo

```
/* MakeString Function of Number, List and Json */

func main ()

    a = 2243
    b = ["abc","bac"]
    c = #{"name":"harsha"}#

    d = makeString(a) ++ makeString(b)

    print(d)

    print(makeString(d) ++ makeString(c))
```

```
end
```

MakeStringFunction2.exp

```
2243[abc,bac]2243[abc,bac]{"name":"harsha"}
```

MathematicalOperator.jo

```
/* Mathematical Operator */

func main ()
    a = 5
    b = 6
    print (a ++ b)
    print (b -- a)
    print (a ** b)
    print (a // 5)
    print (a > b)
    print (a >= b)
    print (a < b)
    print (a <= b)
    print (b %% a)
end
```

MathematicalOperator.exp

```
111301falsefalsetruetrue1
```

MathematicalOperator2.jo

```
/* Mathematical Operator */
```

```
func main ()
    print (5 ++ 6 ** 3 ** 2 // 3 -- 2)
    print (9 %% 3 ** 2)
end
```

MathematicalOperator2.exp

```
153
```

Merge.jo

```
func Merge (a,b)
    c = #{ }#
    d = a.attrList()
    e = b.attrList()
    for attr in d
       if ( attr in e)
           if (type(a[attr]) == "Json" && type(b[attr]) == "Json")

               c[attr] = Merge(a[attr],b[attr])
           else
               if (type(a[attr]) == "List" && type(b[attr]) == "List")
                   c[attr] = a[attr] ++ b[attr]
               else
                   c[attr] = a[attr] + b[attr]
               end
           end
       else
           c[attr] = a[attr]
       end
    end
    for attr in e
```

```
        if ( attr not in d  )
            c[attr] = b[attr]
        end
    end
    return c
end

func MergeUtil (a,b)
    if ( type(a) != "Json" || type(b) != "Json")
        print("Both the arguments must be JSON")
        return null
    end
    return Merge(a,b)
end

func main ()

a  = #{"name":"harsha", "innerJson":{"sub":"PLT","mark":[5,6,7]}}#
b  = #{"name":"arpit", "innerJson":{"sub":"OS","mark":[7,8,9]}}#
c = MergeUtil (a,b)
print (c)
end
```

Merge.exp

```
{
  "innerJson":{
    "mark":[
    5,
    6,
    7,
    7,
    8,
    9
    ],
    "sub":[
    "PLT",
    "OS"
    ]
  },
  "name":[
  "harsha",
  "arpit"
  ]
}
```

NegationOperator1.jo

```
/* Negation Operator Json minus string */

func main ()
    json = #{"name": {"first":"chase", "last":"larson"}, "marks":
[2,3]}#
    print (json - "name")
end
```

```
NegationOperator1.exp
{
  "marks":[
  2,
  3
  ]
}
```

NegationOperator2.jo

```
/* Negation Operator List minus List, String */

func main ()
    list1 =  ["able", "barista", "carrie"]
    list2 =  ["barista", "carrie"]
    str = "barista"
    print (list1 - list2)
    print (list2 - str)
end
```

NegationOperator2.exp

```
[able,barista,carrie][carrie]
```

NegationOperator3.exp

```
[able,barista][1121]
```