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STARK Programming Language

By

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INTRODUCTION

STARK is a static, strongly typed imperative programming language. The word "Stark" means simple and powerful which are the main design goals. It is easy to learn and provides all the major features of a high level language.

Tools:

- *ANTLR 4*

Lexical analysis – tokenization

Parser generation – parse tree

- Java 8

Compiler is written in Java

Interpréter and Runtime environment use *JRE*

Data Structures used : Stack and Hashmap

GETTING STARTED

We will first take a look at the processing of a *STARK* program.

- The source code will be given to lexical analyzer to generate the tokens
- The generated tokens are then given to parser to build a parse tree
- The parse tree would be given semantics to generate an intermediate code
- The intermediate code is then interpreted by the runtime environment to generate an output

The source code in *STARK* will be compiled and executed in two steps :

- Compile the source code to generate the intermediate code
- Interpret the intermediate code to produce the final output

STEPS TO RUN *STARK*

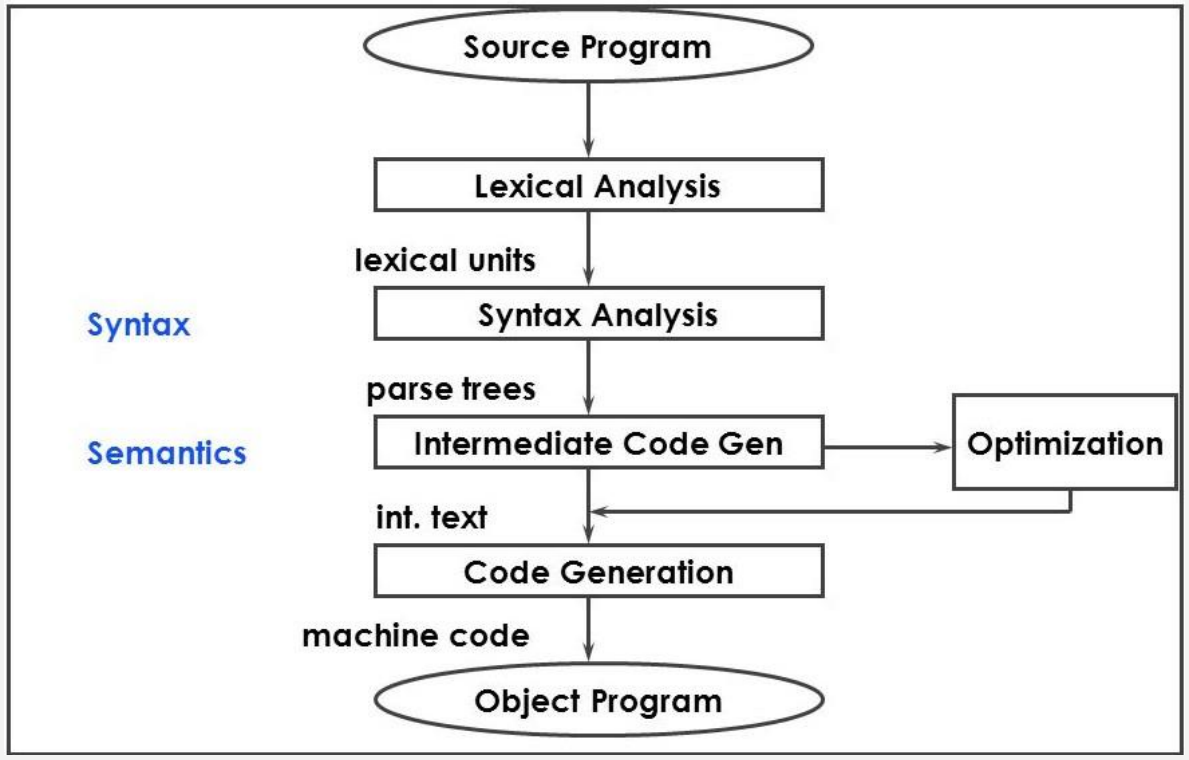
- STARK programs can be written and saved with any standard editor such as Notepad etc.
- Download STARK.jar from the git repository
- Follow the below steps to compile and execute your *STARK* programs:
- Windows Users :
  - Use Windows Command Prompt from the location of stark.jar
  - Use the command for compiling your *STARK* source code:
  - ***java -jar stark.jar -c sourcePath intermediateCodePath***
  - This will generate and display the intermediate code path with Intermediate code file name
    - ***intermediateCodePath programName.iark***
  - Use the command for executing your *STARK* intermediate code:
  - ***java -jar stark.jar -e intermediateCodePath programName.iark***

BLOCK DIAGRAM FOR SOURCE CODE PROCESSING

1. Lexical Analysis:
Input : source code
Output : lexical units or tokens

2. Parser:
Input : token string
Output : parse tree

3. Bytecode:
Input : parsing tree
Output : generate intermediate code



GRAMMAR FOR *STARK*

- *STARK* supports a wide range of arithmetic and relational operators. Besides this, it also supports logical operators.
- *STARK* has two primary datatypes :
  - int – used for positive numeric integers such as 0,1,2 and so on
  - bool – used for boolean values such as 'true' and 'false'
- Identifiers are symbols used to uniquely identify a program element in the code. *STARK* identifiers are alphanumeric elements but they must begin with a character
- STARK also incorporates conditional statements like if, if-else and iterative constructs like while loop
- With STARK, user can define and use their own functions to perform certain tasks
- Each valid *STARK* statement must end in a ';'
- Comments can be added with '//' and '/*……*/' for multi line comments

```
grammar stark;

program :  statementList functionDefn;
statementList : statement  statementList |
                statement;
statement : declarationStmt ';' |
            initializationStmt ';'|
            assignmentStmt ';'|
            ifStatement |
            whileStatement |
            displayStatement ';' |
            functionCall ';';
initializationStmt: 'int' IDENTIFIER '=' expression|
                    'bool' IDENTIFIER '=' boolExpression;

declarationStmt : 'int' IDENTIFIER|
                  'bool' IDENTIFIER;
assignmentStmt : IDENTIFIER '=' boolExpression|
                 IDENTIFIER '=' expression ;

ifStatement : 'if' '(' boolExpression ')' '{' statementList '}' |
              'if' '(' boolExpression ')' '{' statementList '}' 'else' '{' statementList '}' ;

whileStatement : 'while' '(' boolExpression ')' '{' statementList '}' ;

displayStatement : 'display' expression;

relationalExpression : expression '==' expression |
                       expression '!=' expression|
                       expression '<' expression |
                       expression '<=' expression|
                       expression '>' expression |
                       expression '>=' expression|
                       expression '==' BOOLVALUES|
                       expression '!=' BOOLVALUES;
```

```
logicalExpression : relationalExpression '&&' relationalExpression |
                    relationalExpression '||' relationalExpression |
                    relationalExpression '&&' logicalExpression |
                    relationalExpression '||' logicalExpression |
                    '!'relationalExpression |
                    '!'logicalExpression;
boolExpression : relationalExpression |
                 logicalExpression |
                 BOOLVALUES;

expression : term '+' expression|
             term '-' expression|
             term;
term : factor '*' term|
       factor '/' term|
       factor '%' term|
       factor;
factor : '(' expression ')' | IDENTIFIER | NUMBER ;

functionDefn : 'func' functionName '(' parameters ')' '{' statementList  returnStatement '}'|
               'func' functionName '(' parameters ')' '{' returnStatement '}'|  ;
functionName : IDENTIFIER;
parameters : declarationStmt ',' parameters |
             declarationStmt |  ;
returnStatement : 'return' expression ';'|
                  'return' boolExpression';'|  ;
functionCall : IDENTIFIER '=' functionName '(' arguments ')'|functionName '(' arguments ')' ;
arguments : IDENTIFIER ',' arguments | NUMBER ',' arguments | NUMBER | IDENTIFIER |  ;

//Terminals
BOOLVALUES : 'true' | 'false' ;
IDENTIFIER : [a-zA-Z][a-zA-Z0-9]* ;
NUMBER :[0-9]+;
WS : [ \t\r\n]+ -> skip ;
MULTICOMMENT : '/*'.*?'*/' -> skip;
SINGLECOMMENT : '//' ~[\r\n]* -> skip;
```

DATATYPES SUPPORTED

- Stark supports **integer**(int) and **boolean**(bool) datatypes.
- Operations related to these datatypes are supported as well
  - Operations supported for int
    - Addition, Subtraction, Multiplication, Division and Modulus operator (**+ - * / %)**
    - Stark also supports relational operator like **> , <, >=, <=, ==, !=** to compare two integer values
  - Operations supported for bool
    - Logical operators like **&&** (logical AND), || (Logical OR), **!** (Logical NOT)

OPERATORS IN *STARK*: OVERVIEW

Arithmetic :

Operator	Name	Operand	Function
+	Addition	a + b	Adds two numbers
-	Subtraction	a – b	Subtracts two numbers
/	Division	a / b	Divides two numbers
*	Multiplication	a * b	Multiplies two numbers
%	Modulus	a % b	Returns the remainder when a is divided by b

OPERATORS IN *STARK*: OVERVIEW

Relational and Logical :

Operator	Name	Operand	Returns True If
<	Less than	a < b	a is less than b
>	Greater than	a > b	a is greater than b
<=	Less than or equal to	a <= b	a is less than or equal to b
>=	Greater than or equal to	a >= b	a is greater than or equal to b
==	Is equal	a == b	a is equal to b
!=	Not equal to	a != b	a is not equal to b
&&	Logical AND	a && b	Both a and b are true
||	Logical OR	a || b	Either a or b is true

Besides this, we also support '!' which is the logical NOT operator. For eg: !a will compliment the value stored in a.

IDENTIFIERS

Identifiers are a sequence of one or more characters. Consecutive characters in the identifiers are optional and could comprise of **alphanumeric characters** but should **begin with an alphabet.**

- IDENTIFIER : [a-zA-Z][a-zA-Z0-9]*
- Eg : a, sum, num2

VARIABLES

- Variables are used to store data values of a certain type- **int or bool values**
- The stored value of variables can change during program execution.
- Stark supports variable **declarations , initialization and assignments operations**
- Variables should be declared or initialized before they can be used. Else Stark gives **compiler error**
  - Sample usage
    - int a; a=10;
    - int a=10;
    - bool b = true;
    - bool b;

EXPRESSIONS

- Stark supports the following types of expression
    - **Numeric expressions**
    - **Relational expressions**
    - **Logical expressions**

    Relational and logical expressions together form boolean expressions i.e. they return a boolean value based on the operation
- Numeric expressions handle **precedence** in the following order
    - ***, /, %**
    - **+, -**

    They are **left associative** as well.

STATEMENTS

- Stark statements could be any of the following :-
    - Declaration statement
    - Assignment statement
    - Initialization statement
    - If Statement (Also **Nested IF**)
    - If – Else Statement (Also **Nested IF-ELSE**)
    - While Statement (Also **Nested WHILE**)
    - Display Statement
    - **Function call**
- **Single line and multi-line comments** are also supported

DECLARATION STATEMENT

- Declaration should be in the following format :
  - **Datatype <varName>;**

  Example –

  int count;

  bool isZero;

INITIALIZATION STATEMENT

- To initialize a variable , the following format has to be followed
  - **dataType variableName = Value ;**
- Example –

```
int count = 0;
bool isZero = false;
```

ASSIGNMENT STATEMENT

- Assignment statement helps assign a value to a variable. It can be used in the following format
    - **variableName = Value ;**
- Example –

```
count = 0;
isZero = false;
```

DISPLAY STATEMENT

- Value of an expression or a variable can be displayed using the display statement
  - **display expression**;

- Example –

  display sum;

  display a+b;

IF STATEMENT

- Stark supports if condition in the following format

if(condition) {

Statement list;

}

Example : if(count>10) {

count = count – 1;

}

- Nested If is supported.
- Example – if(count>10) {

count = count -1;

if(count>5) {

display count;

}

}

IF ELSE STATEMENT

- If else can be used in the following format.

```
if(condition) {
    statementlist;
} else {
 statementlist;
}
```

Example

```
if(count>10) {
    count = count – 1;
} else {
    display count;
}
```

Nested if-else is also supported.

WHILE STATEMENT

- While statement can be used in the following format.

```
while(condition) {
    statementlist;
}
```

Example

```
while(a>5) {
    display a;
    a = a-1;
}
```

Nested while is also supported.

FUNCTION CALL

- Function call can be used in the following format

  identifier = functionName(arguments) *arguments are optional

  or

  functionName(arguments) *arguments are optional

- Functions may or may not return a value. Function returning a value should be assigned to a variable of appropriate data type
- Example:
  - int sum; sum=add(a,b);
  - add(a,b);
  - add(5,10);
- Arguments can be of same or different data types

FUNCTION DEFINITION

- Function definition can be used in the following format
  - func functionName(parameters) { statementList; returnStatement }

    or

    func functionName(parameters) { returnStatement } *parameters are optional
- Example:
  - func add(int a,int b){

    int c = a+b;

    return c;

    }
- All the variables in the functions are **locally scoped**
- Parameters can be of same or different data types

RETURN STATEMENT

- Return statement can be used in the following format to return value from a function
  - **return expression**

  Example –

  return count;

  return a+b;

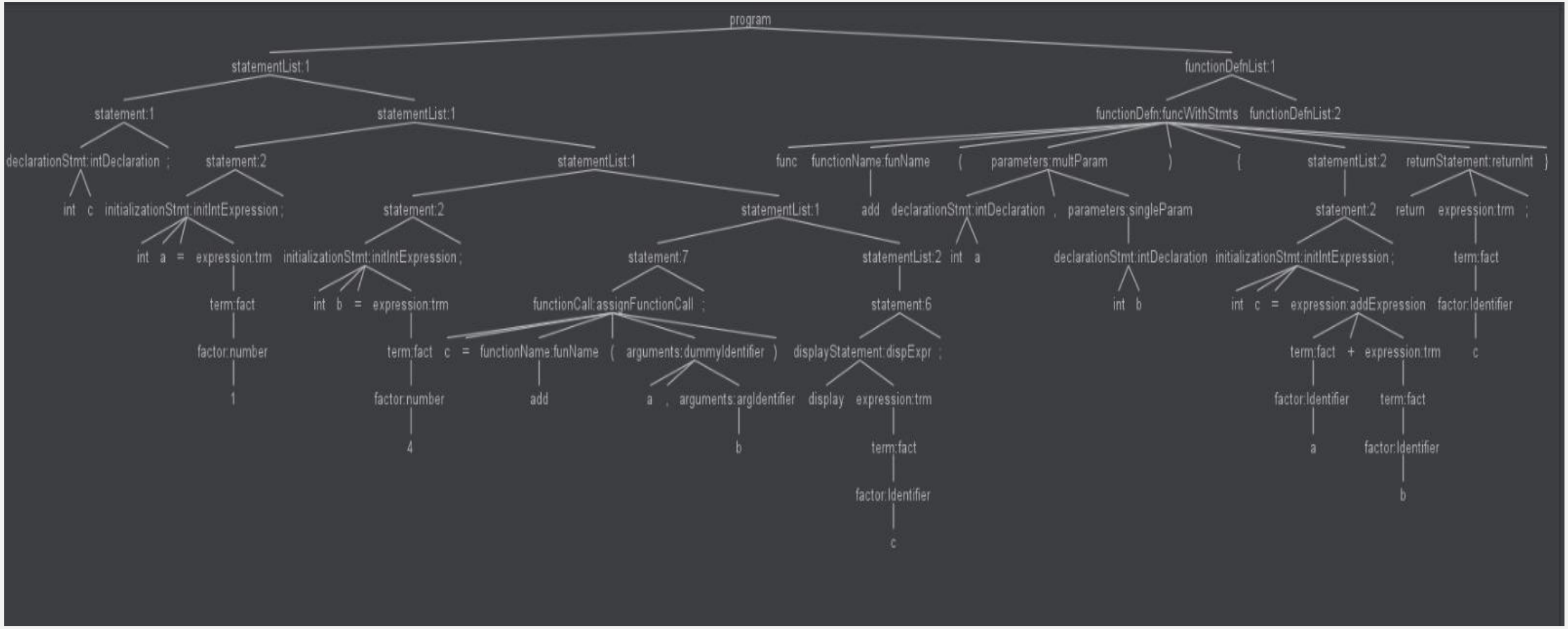
SAMPLE PROGRAM WITH INTERMEDIATE CODE

```
int c;
int a = 1;
int b = 4;
c=add(a,b);
display c;

func add(int a,int b){
int c = a+b;
return c;
}
```

```
DECINT c
DECINT a
PUSH 1
STORE a
DECINT b
PUSH 4
STORE b
LOAD b
LOAD a
CALL add 1 2
END CALL add 1
STORE c
LOAD c
DISPLAY c
HALT
BEGIN FUNC add
DECINT a
DECINT b
DECINT c
LOAD a
LOAD b
ADD
STORE c
LOAD c
RET c
END FUNC add
```

SAMPLE PARSE TREE



FUTURE IMPROVEMENTS

The popularity of a programming language depends to some extent, on its designer's willingness to extend its features. On this note, we would like to improve the following for *STARK* in future :

- Support more data types and unary operators
- Support additional looping constructs
- Support data structures like array and stack
- Support recursion for user-defined functions

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Thank You!