

Project #2  
CS 3510 – Spring 2014  
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I. Requirements:

Develop a parser which can parse a program written in the C- language described in Appendix A of the text.

II. Design:

We built a recursive descent parser as described in class and in the book, using the scanner developed in project 1A/1B.

III. Implementation:

We made an object for each language structure (variable declarations, expressions, loops, etc.) and wrote parse methods to parse those structures using the first and follow sets of the grammar.

IV. Testing:

We wrote a Tester class that outputs the tree generated by the parser when it is given a test file. We tested using a program given in the book and with 3 test programs from the course website.

V. Summary/Conclusion:

Our project is working properly. We didn't encounter any major problems with our Parser implementation, which was extremely surprising. We did have a bit of trouble with our grammar not being up to specifications, and we were missing some tokens in our first and follow sets. This was resolved when we tried to parse structures that depended on those first/follow set tokens.

# Grammar

```
program → declaration-list
declaration-list → declaration {declaration}
declaration → int ID declaration' | void ID fun-declaration'
declaration' → var-declaration' | fun-declaration'
var-declaration → int ID [ [ NUM ] ] ;
var-declaration' → [ [ NUM ] ] ;
fun-declaration' → ( params ) compound-stmt
params → param-list | void
param-list → param { , param }
param → int ID [ [ ] ]
compound-stmt → { local-declarations statement-list }
local-declarations → {var-declaration}
statement-list → {statement}
statement → expression-stmt | compound-stmt | selection-stmt
           | iteration-stmt | return-stmt
expression-stmt → [expression] ;
selection-stmt → if ( expression ) statement [ else statement ]
iteration-stmt → while ( expression ) statement
return-stmt → return [expression] ;

expression → ( expression ) simple-expression' | NUM simple-expression'
           | ID expression'
expression' → = expression | ( args ) simple-expression'
           | [ expression ] expression'' | simple-expression'
expression'' → = expression | simple-expression'
var → [ [ expression ] ]
simple-expression' → additive-expression' [ relop additive-expression ]
relop → <= | < | > | >= | == | !=
additive-expression → term { addop term }
additive-expression' → term' { addop term }
addop → + | -
term → factor { mulop factor }
term' → { mulop factor }
mulop → * | /
factor → ( expression ) | ID varcall | NUM

varcall → var | call
call → ( args )
args → [ arg-list ]
arg-list → expression { , expression }
```

# First and Follow Sets

	First Set	Follow Set
program	INT, VOID	\$
declaration-list	INT, VOID	\$
declaration	INT, VOID	INT, VOID, \$
declaration'	(, [, ;	INT, VOID, \$
var-declaration	INT	INT, (, NUM, ID, :, {, }, IF, WHILE, RETURN, EPSILON
var-declaration'	[, ;	INT, VOID, \$
fun-declaration'	(	INT, VOID, \$
params	INT, VOID	)
param-list	INT	)
param	INT	COMMA, )
compound-stmt	{	INT, VOID, \$, (, NUM, ID, :, {, }, IF, WHILE, RETURN, ELSE, }
local-declarations	INT, EPSILON	(, NUM, ID, :, {, }, IF, WHILE, RETURN, EPSILON
statement-list	(, NUM, ID, :, {, }, IF, WHILE, RETURN, EPSILON	}
statement	(, NUM, ID, :, {, }, IF, WHILE, RETURN	(, NUM, ID, :, {, }, IF, WHILE, RETURN, ELSE, }
expression-stmt	(, NUM, ID, ;	(, NUM, ID, :, {, }, IF, WHILE, RETURN, ELSE, }
selection-stmt	IF	(, NUM, ID, :, {, }, IF, WHILE, RETURN, ELSE, }
iteration-stmt	WHILE	(, NUM, ID, :, {, }, IF, WHILE, RETURN, ELSE, }
return-stmt	RETURN	(, NUM, ID, :, {, }, IF, WHILE, RETURN, ELSE, }
expression	(, NUM, ID	;, COMMA, ), ], )
expression'	=, (, [, *, /, +, -, EPSILON	;, COMMA, ), ], )
expression"	=, *, /, +, -, EPSILON	;, COMMA, ), ], )
var	[, EPSILON	+, -, *, /, :, COMMA, ), ], )
simple-expression'	*, /, +, -, <=, <, >, >=, ==, !=, EPSILON	;, COMMA, ), ], )
relop	<=, <, >, >=, ==, !=	(, NUM, ID

# First and Follow Sets

additive-expression	(, NUM, ID	;; COMMA, ), ], )
additive-expression'	*, /, +, -, EPSILON	*, /, ;; COMMA, ), ], ), <=, <, >, >=, ==, !=
addop	+, -	(, NUM, ID
term	(, NUM, ID	+, -, *, /, ;; COMMA, ), ], ), <=, <, >, >=, ==, !=
term'	*, /, EPSILON	+, -, *, /, ;; COMMA, ), ], )
mulop	*, /	(, NUM, ID
factor	(, NUM, ID	+, -, *, /, ;; COMMA, ), ], ), <=, <, >, >=, ==, !=
varcall	EPSILON, [, (	+, -, *, /, ;; COMMA, ), ], )
call	(	+, -, *, /, ;; COMMA, ), ], )
args	(, NUM, ID, EPSILON	)
arg-list	(, NUM, ID	)

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**CMinusParser.java**

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```

package parser;

import java.io.BufferedWriter;
import java.io.FileWriter;
import java.io.IOException;
import java.util.ArrayList;
import java.util.List;

import com.sun.org.apache.xpath.internal.operations.Variable;

import scanner.Scanner;
import scanner.Token;
import scanner.Token.TokenType;
import parser.expression.*;
import parser.statement.*;

public class CMinusParser implements Parser
{
    private Scanner scanner;
    // populated after a parse
    private Program parsedProgram = null;

    /*
     * First/Follow Sets
     * The first sub-array is the first set, the following one is the follow set.
     * (Makes sense, right?)
     */
    private TokenType[][] PROGRAM = {
        { TokenType.INT, TokenType.VOID },
        { TokenType.EOF }
    };
    private TokenType[][] DECLARATION_LIST = {
        { TokenType.INT, TokenType.VOID },
        { TokenType.EOF }
    };
    private TokenType[][] DECLARATION = {
        { TokenType.INT, TokenType.VOID },
        { TokenType.INT, TokenType.VOID, TokenType.EOF }
    };
    private TokenType[][] DECLARATION_PRIME = {
        { TokenType.OPEN_PAREN, TokenType.OPEN_BRACKET, TokenType.END_STATEMENT },
        { TokenType.INT, TokenType.VOID, TokenType.EOF }
    };
    private TokenType[][] VAR_DECLARATION = {
        { TokenType.INT },
        { TokenType.INT, TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.CLOSE_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, TokenType.EPSILON }
    };
    private TokenType[][] VAR_DECLARATION_PRIME = {
        { TokenType.OPEN_BRACKET, TokenType.END_STATEMENT },
        { TokenType.INT, TokenType.VOID, TokenType.EOF }
    };
    private TokenType[][] FUN_DECLARATION_PRIME = {
        { TokenType.OPEN_PAREN },
        { TokenType.INT, TokenType.VOID, TokenType.EOF }
    };
    private TokenType[][] PARAMS = {

```

```

        { TokenType.INT, TokenType.VOID },
        { TokenType.CLOSE_PAREN }
    };
    private TokenType[][] PARAM_LIST = {
        { TokenType.INT },
        { TokenType.CLOSE_PAREN }
    };
    private TokenType[][] PARAM = {
        { TokenType.INT },
        { TokenType.COMMA, TokenType.CLOSE_PAREN }
    };
    private TokenType[][] COMPOUND_STMT = {
        { TokenType.OPEN_CBRACE },
        { TokenType.INT, TokenType.VOID, TokenType.EOF, TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, TokenType.ELSE, TokenType.CLOSE_CBRACE }
    };
    private TokenType[][] LOCAL_DECLARATIONS = {
        { TokenType.INT, TokenType.EPSILON },
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.CLOSE_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, TokenType.EPSILON }
    };
    private TokenType[][] STATEMENT_LIST = {
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, TokenType.EPSILON },
        { TokenType.CLOSE_CBRACE }
    };
    private TokenType[][] STATEMENT = {
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN },
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, TokenType.ELSE, TokenType.CLOSE_CBRACE }
    };
    private TokenType[][] EXPRESSION_STMT = {
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT },
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, TokenType.ELSE, TokenType.CLOSE_CBRACE }
    };
    private TokenType[][] SELECTION_STMT = {
        { TokenType.IF },
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, TokenType.ELSE, TokenType.CLOSE_CBRACE }
    };
    private TokenType[][] ITERATION_STMT = {
        { TokenType.WHILE },
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT, TokenType.OPEN_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, TokenType.ELSE, TokenType.CLOSE_CBRACE }
    };
    private TokenType[][] RETURN_STMT = {
        { TokenType.RETURN },
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.END_STATEMENT

```

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```

EMENT, TokenType.OPEN_CBRACE, TokenType.IF, TokenType.WHILE, TokenType.RETURN, T
okenType.ELSE, TokenType.CLOSE_CBRACE }
};
private TokenType[][] EXPRESSION = {
    { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID },
    { TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, Toke
nType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
};
private TokenType[][] EXPRESSION_PRIME = {
    { TokenType.ASSIGNMENT, TokenType.OPEN_PAREN, TokenType.OPEN_BRACKET,
TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.PLUS, TokenType.MINUS, TokenType
.EPSILON },
    { TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, Toke
nType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
};
private TokenType[][] EXPRESSION_PRIME_PRIME = {
    { TokenType.ASSIGNMENT, TokenType.MULTIPLY, TokenType.DIVIDE, TokenTyp
e.PLUS, TokenType.MINUS, TokenType.EPSILON },
    { TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, Toke
nType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
};
private TokenType[][] VAR = {
    { TokenType.OPEN_BRACKET, TokenType.EPSILON },
    { TokenType.PLUS, TokenType.MINUS, TokenType.MULTIPLY, TokenType.DIVIDE
, TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, TokenType.CLO
SE_BRACKET, TokenType.CLOSE_PAREN }
};
private TokenType[][] SIMPLE_EXPRESSION_PRIME = {
    { TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.PLUS, TokenType.MINUS
, TokenType.LESS_EQUAL_THAN, TokenType.LESS_THAN, TokenType.GREATER_THAN, TokenT
ype.GREATER_EQUAL_THAN, TokenType.EQUALS, TokenType.NOT_EQUALS, TokenType.EPSILO
N },
    { TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, Toke
nType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
};
private TokenType[][] RELOP = {
    { TokenType.LESS_EQUAL_THAN, TokenType.LESS_THAN, TokenType.GREATER_THA
N, TokenType.GREATER_EQUAL_THAN, TokenType.EQUALS, TokenType.NOT_EQUALS },
    { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID }
};
private TokenType[][] ADDITIVE_EXPRESSION = {
    { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID },
    { TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, Toke
nType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
};
private TokenType[][] ADDITIVE_EXPRESSION_PRIME = {
    { TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.PLUS, TokenType.MINUS
, TokenType.LESS_EQUAL_THAN, TokenType.LESS_THAN, TokenType.GREATER_THAN, TokenT
ype.GREATER_EQUAL_THAN, TokenType.EQUALS, TokenType.NOT_EQUALS, TokenType.EPSILO
N },
    { TokenType.LESS_EQUAL_THAN, TokenType.LESS_THAN, TokenType.GREATER_THA
N, TokenType.GREATER_EQUAL_THAN, TokenType.EQUALS, TokenType.NOT_EQUALS, TokenTy
pe.MULTIPLY, TokenType.DIVIDE, TokenType.END_STATEMENT, TokenType.COMMA, TokenTy
pe.CLOSE_PAREN, TokenType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
};
private TokenType[][] ADDOP = {
    { TokenType.PLUS, TokenType.MINUS },
    { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID }
};
};

```

```

    private TokenType[][] TERM = {
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID },
        { TokenType.LESS_EQUAL_THAN, TokenType.LESS_THAN, TokenType.GREATER_THAN, TokenType.GREATER_EQUAL_THAN, TokenType.EQUALS, TokenType.NOT_EQUALS, TokenType.PLUS, TokenType.MINUS, TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, TokenType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
    };
    private TokenType[][] TERM_PRIME = {
        { TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.EPSILON },
        { TokenType.PLUS, TokenType.MINUS, TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, TokenType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
    };
    private TokenType[][] MULOP = {
        { TokenType.MULTIPLY, TokenType.DIVIDE },
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID }
    };
    private TokenType[][] FACTOR = {
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID },
        { TokenType.LESS_EQUAL_THAN, TokenType.LESS_THAN, TokenType.GREATER_THAN, TokenType.GREATER_EQUAL_THAN, TokenType.EQUALS, TokenType.NOT_EQUALS, TokenType.PLUS, TokenType.MINUS, TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, TokenType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
    };
    private TokenType[][] VARCALL = {
        { TokenType.EPSILON, TokenType.OPEN_BRACKET, TokenType.OPEN_PAREN },
        { TokenType.PLUS, TokenType.MINUS, TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, TokenType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
    };
    private TokenType[][] CALL = {
        { TokenType.OPEN_PAREN },
        { TokenType.PLUS, TokenType.MINUS, TokenType.MULTIPLY, TokenType.DIVIDE, TokenType.END_STATEMENT, TokenType.COMMA, TokenType.CLOSE_PAREN, TokenType.CLOSE_BRACKET, TokenType.CLOSE_PAREN }
    };
    private TokenType[][] ARGS = {
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID, TokenType.EPSILON },
        { TokenType.CLOSE_PAREN }
    };
    private TokenType[][] ARG_LIST = {
        { TokenType.OPEN_PAREN, TokenType.NUM, TokenType.ID },
        { TokenType.CLOSE_PAREN }
    };

    public CMinusParser(Scanner s)
    {
        scanner = s;
    }

    @Override
    public Program parse()
    {
        if (parsedProgram == null)
        {
            parsedProgram = parseProgram();
        }
    }

```



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```

    }
    return parsedProgram;
}

@Override
public void printTree(String outFile)
{
    try
    {
        BufferedWriter bw = new BufferedWriter(new FileWriter(outFile));

        if (parsedProgram != null)
        {
            parsedProgram.print(0, bw);
        }

        bw.flush();
        bw.close();
    }
    catch (IOException e)
    {
        e.printStackTrace();
    }
}

/*
 * Matches and consumes the given token.
 * @returns True if matched, false if the next token isn't the one we are looking for.
 */
private boolean matchToken(TokenType t)
{
    if (scanner.viewNextToken().getType() == t)
    {
        scanner.getNextToken();
        return true;
    }
    return false;
}

/**
 * Searches First/Follow Sets
 * @param needle
 * @param haystack
 * @return
 */
private boolean contains(TokenType needle, TokenType[] haystack)
{
    for (TokenType straw : haystack)
    {
        if (needle == straw)
            return true;
    }
    return false;
}

/**
 * Views the next token type (look ahead character)
 * @return

```

```

    */
    private TokenType nextTokenType()
    {
        return scanner.viewNextToken().getType();
    }

    /**
     * Matches (and munches) a Token or throws the passed message
     * @param tt
     * @param msg
     * @return
     */
    private Token matchOrDie(TokenType tt, String msg)
    {
        if (scanner.viewNextToken().getType() != tt)
        {
            throw new RuntimeException(msg + nextTokenType().name());
        }
        return scanner.getNextToken();
    }

    /*
     * Parse methods, BEGIN!
     */

    /**
     * Parses Program
     * @return
     */
    public Program parseProgram()
    {
        ArrayList<Declaration> declList = new ArrayList<Declaration>();

        while (contains(nextTokenType(), DECLARATION[0]))
        {
            declList.add(parseDeclaration());
        }

        if (!matchToken(TokenType.EOF))
        {
            throw new RuntimeException("parseProgram(): illegal token: " + nextTokenType().name());
        }

        return new Program(declList);
    }

    /**
     * Parses a Declaration.
     * @return
     */
    public Declaration parseDeclaration()
    {
        Declaration toReturn;
        // strip off the first two tokens
        Token typeSpecifier = scanner.getNextToken();
        Token identifier = scanner.getNextToken();

        if (typeSpecifier.getType() == TokenType.VOID || (typeSpecifier.getType()

```

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```

== TokenType.INT && nextTokenType() == TokenType.OPEN_PAREN))
{
    // declaration -> void ID fun-declaration'
    // OR decl    -> int ID fun-declaration'
    // this isn't exactly according to the grammar, but it's better coding
practice
    matchOrDie(TokenType.OPEN_PAREN, "parseDeclaration(): parsing function, open paren expected, got ");
    Params params = parseParams();
    matchOrDie(TokenType.CLOSE_PAREN, "parseDeclaration(): parsing function, close paren expected, got ");

    CompoundStatement body = parseCompoundStatement();

    toReturn = new FunctionDeclaration(typeSpecifier.getType(), (String) identifier.getData(), params, body);
}
else if (typeSpecifier.getType() == TokenType.INT)
{
    // declaration -> int ID declaration'
    // AND decl'    -> var-declaration'

    if (matchToken(TokenType.OPEN_BRACKET))
    {
        Token number = matchOrDie(TokenType.NUM, "parseDeclaration(): parsing array declaration, expected NUM, got ");

        matchOrDie(TokenType.CLOSE_BRACKET, "parseDeclaration(): parsing array declaration, expected ']', got " + nextTokenType().name());

        toReturn = new VariableDeclaration((String) identifier.getData(), (Integer) number.getData());
    }
    else if (nextTokenType() == TokenType.END_STATEMENT)
    {
        toReturn = new VariableDeclaration((String) identifier.getData());
    }
    else
    {
        throw new RuntimeException("parseDeclaration(): parsing variable, '[' or ';' expected, got " + nextTokenType().name());
    }

    matchOrDie(TokenType.END_STATEMENT, "parseDeclaration(): parsing variable declaration, ';' expected, got ");
}
else
{
    throw new RuntimeException("parseDeclaration(): type specifier expected, received " + typeSpecifier.getType().name());
}

return toReturn;
}

/**
 * Parses function parameters.

```

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```

    * @return
    */
    private Params parseParams()
    {
        List<VariableDeclaration> params = new ArrayList<VariableDeclaration>();

        if (matchToken(TokenType.VOID))
        {
            //do nothing, since there's no parameters
        }
        else if (nextTokenType() == TokenType.INT)
        {
            // grab the first param
            matchOrDie(TokenType.INT, "parseParams(): INT expected, but got " );
            Token id = matchOrDie(TokenType.ID, "parseParams(): identifier expected, got " );
            if (matchToken(TokenType.OPEN_BRACKET))
            {
                params.add(new VariableDeclaration((String) id.getData(), 0));
                matchOrDie(TokenType.CLOSE_BRACKET, "parseParams(): expected ']', but got " );
            }
            else
            {
                params.add(new VariableDeclaration((String) id.getData()));
            }

            // check for other params
            while (nextTokenType() == TokenType.COMMA)
            {
                scanner.getNextToken();

                matchOrDie(TokenType.INT, "parseParams(): INT expected, but got " );
                id = matchOrDie(TokenType.ID, "parseParams(): identifier expected, got " );
                if (matchToken(TokenType.OPEN_BRACKET))
                {
                    params.add(new VariableDeclaration((String) id.getData(), 0));
                    matchOrDie(TokenType.CLOSE_BRACKET, "parseParams(): expected ']', but got " );
                }
                else
                {
                    params.add(new VariableDeclaration((String) id.getData()));
                }
            }
        }
        else
        {
            throw new RuntimeException("parseParams(): expected 'void' or 'int', got " + nextToken
Type().name());
        }

        return new Params(params);
    }

    /**
     * Parses a CompoundStatement.
     * @return
     */
    private CompoundStatement parseCompoundStatement()
    {
        matchOrDie(TokenType.OPEN_CBACE, "parseCompoundStatement(): expected '{', got " );

```

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```

List<Declaration> decls = new ArrayList<Declaration>();
List<Statement> stmts = new ArrayList<Statement>();

while (nextTokenType() == TokenType.INT)
{
    scanner.getNextToken();
    Token id = matchOrDie(TokenType.ID, "parseCompoundStatement(): parsing variable decl
ation, expected identifier and got " );

    if (matchToken(TokenType.OPEN_BRACKET))
    {
        Token num = matchOrDie(TokenType.NUM, "parseCompoundStatement(): expected a nu
mber, but got " );
        matchOrDie(TokenType.CLOSE_BRACKET, "parseCompoundStatement(): expected ']', but
got " );
        matchOrDie(TokenType.END_STATEMENT, "parseCompoundStatement(): expected ';', but
got " );
        decls.add(new VariableDeclaration((String) id.getData(), (Integer) n
um.getData()));
    }
    else if (matchToken(TokenType.END_STATEMENT))
    {
        decls.add(new VariableDeclaration((String) id.getData()));
    }
    else
    {
        throw new RuntimeException("parseCompoundStatement(): expected '[' or ';', got " );
    }
}

while (contains(nextTokenType(), STATEMENT_LIST[0]) && nextTokenType() !=
TokenType.CLOSE_CBACE)
{
    stmts.add(parseStatement());
}

matchOrDie(TokenType.CLOSE_CBACE, "parseCompoundStatement(): expected '}', got " );
return new CompoundStatement(decls, stmts);
}

/**
 * Parses Statement
 * @return
 */
private Statement parseStatement()
{
    Statement toReturn = null;
    if(nextTokenType() == TokenType.IF)
    {
        //if ( expression ) statement [ else statement ]
        toReturn = parseSelectionStatement();
    }
    else if(nextTokenType() == TokenType.WHILE)
    {
        //while ( expression ) statement
        toReturn = parseIterationStatement();
    }
    else if(nextTokenType() == TokenType.RETURN)
    {

```

```

        //return [expression] ;
        toReturn = parseReturnStatement();
    }
    else if(nextTokenType() == TokenType.OPEN_CBRACE)
    {
        //{ local-declarations statement-list }
        toReturn = parseCompoundStatement();
    }
    else if(contains(nextTokenType(), EXPRESSION[0]))
    {
        //[expression] ;
        toReturn = parseExpressionStatement();
    }
    else
    {
        throw new RuntimeException("parseStatement(): Invalid token for statement, got " );
    }
    return toReturn;
}

/**
 * Parses an Expression Statement
 * @return
 */
private Statement parseExpressionStatement()
{
    //[expression] ;
    Expression body = null;
    if(contains(nextTokenType(), EXPRESSION[0]))
    {
        body = parseExpression();
    }
    matchOrDie(TokenType.END_STATEMENT, "parseReturnStatement(): Did not recieve ';', got" );
    Statement toReturn = new ExpressionStatement(body);
    return toReturn;
}

/**
 * Parses a SelectionStatement
 * @return
 */
private Statement parseSelectionStatement()
{
    //if ( expression ) statement [ else statement ]
    Statement else_part = null;
    matchOrDie(TokenType.IF, "parseSelectionStatement(): Did not recieve 'IF', got" );
    matchOrDie(TokenType.OPEN_PAREN, "parseSelectionStatement(): Did not recieve '(', got" );
    Expression compare = parseExpression();
    matchOrDie(TokenType.CLOSE_PAREN, "parseSelectionStatement(): Did not recieve ')' after '(', go
t");
    Statement body = parseStatement();
    if(nextTokenType() == TokenType.ELSE)
    {
        matchOrDie(TokenType.ELSE, "parseSelectionStatement(): Did not recieve 'else' after 'if', got"
);
        else_part = parseStatement();
    }
    return new SelectionStatement(compare, body, else_part);
}

```

```

/**
 * Parses Iteration Statement
 * @return
 */
private Statement parseIterationStatement()
{
    //while ( expression ) statement
    matchOrDie(TokenType.WHILE, "parseIterationStatement(): Did not receive WHILE token, got " );
    matchOrDie(TokenType.OPEN_PAREN, "parseIterationStatement(): Did not receive '(', got " );
    Expression compare = parseExpression();
    matchOrDie(TokenType.CLOSE_PAREN, "parseIterationStatement(): Did not receive ')' after '(', got
");
    Statement body = parseStatement();

    return new IterationStatement(compare, body);
}

/**
 * Parses Return Statement
 * @return
 */
private Statement parseReturnStatement()
{
    //return [expression] ;
    Expression body = null;
    matchOrDie(TokenType.RETURN, "parseReturnStatement(): Did not receive 'RETURN', got " );
    if(contains(nextTokenType(), EXPRESSION[0]))
    {
        body = parseExpression();
    }
    matchOrDie(TokenType.END_STATEMENT, "parseReturnStatement(): Did not receive ';', got " );
    return new ReturnStatement(body);
}

/**
 * Parses an additive-expression'.
 * @param lhs
 * @return
 */

/**
 * Parses Additive-Expression and Additive-Expression'
 * @param lhs
 * @return
 */
private Expression parseAdditiveExpression(Expression lhs)
{
    Expression term = null;
    if(lhs == null)
    {
        term = parseTerm(null);
    }
    else
    {
        term = parseTerm(lhs);
    }
}

```

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CMinusParser.java

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```

        while (contains(nextTokenType(), ADDOP[0]))
        {
            if (nextTokenType() == TokenType.PLUS || nextTokenType() == TokenType.MIN
US)
            {
                term = new BinaryExpression(term, scanner.getNextToken().getType(),
parseTerm(null));
            }
            else
            {
                throw new RuntimeException("parseTerm(): '*' or '/' expected, but got " );
            }
        }

        return term;
    }

```

```

/**
 * Parses term and term'.
 * @param term
 * @return
 */
private Expression parseTerm(Expression term)
{
    if(term == null)
    {
        term = parseFactor();
    }

    while (contains(nextTokenType(), MULOP[0]))
    {
        if (nextTokenType() == TokenType.MULTIPLY || nextTokenType() == TokenType
.DIVIDE)
        {
            term = new BinaryExpression(term, scanner.getNextToken().getType(),
parseFactor());
        }
        else
        {
            throw new RuntimeException("parseTerm(): '*' or '/' expected, but got " );
        }
    }

    return term;
}

```

```

/**
 * Parses a Factor.
 * @return
 */
private Expression parseFactor()
{
    Expression toReturn;

    if (matchToken(TokenType.OPEN_PAREN))

```



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CMinusParser.java

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```

    {
        // factor -> ( expression )
        toReturn = parseExpression();

        matchOrDie(TokenType.CLOSE_PAREN, "parseFactor(): No ')' found, got " );
    }
    else if (nextTokenType() == TokenType.NUM)
    {
        // factor -> NUM
        toReturn = new NumberExpression((Integer)(scanner.getNextToken().getDat
a())));
    }
    else if (nextTokenType() == TokenType.ID)
    {
        // factor -> ID varcall
        Token id = scanner.getNextToken();

        if (matchToken(TokenType.OPEN_PAREN))
        {
            // varcall -> call -> ( args )
            List<Expression> args = parseArgs();

            toReturn = new CallExpression((String) id.getData(), args);

            matchOrDie(TokenType.CLOSE_PAREN, "parseFactor(): No ')' found after args in function
call, got " );
        }
        else if (matchToken(TokenType.OPEN_BRACKET))
        {
            // varcall -> var -> [ expression ]
            Expression xpr = parseExpression();
            toReturn = new VariableExpression((String) id.getData(), xpr);

            matchOrDie(TokenType.CLOSE_BRACKET, "parseFactor(): No ']' found after '[', got " );
        }
        else if (contains(nextTokenType(), VARCALL[1]))
        {
            // next token is in $varcall
            // varcall -> var -> EPSILON
            toReturn = new VariableExpression((String) id.getData());
        }
        else
        {
            throw new RuntimeException("parseFactor(): Illegal token after ID!" );
        }
    }
    else
    {
        throw new RuntimeException("parseFactor(): Illegal token for factor, got " + nextTokenT
ype().name());
    }

    return toReturn;
}

```

```

/**
 * Parses Expression, Expression', and Expression''
 * @return

```

```

    */

    private Expression parseExpression()
    {
        Expression toReturn = null;

        if(matchToken(TokenType.OPEN_PAREN))
        {
            //Expression -> ( expression ) simple-expression'
            Expression compare = parseExpression();
            matchOrDie(TokenType.CLOSE_PAREN, "parseExpression(): No ')' found after '(', got " );
            toReturn = parseSimpleExpression(compare);
        }
        else if(nextTokenType() == TokenType.ID)
        {
            Token ID = scanner.getNextToken();

            //Expression -> ID expression'
            if(matchToken(TokenType.ASSIGNMENT))
            {
                //expression' -> = expression
                VariableExpression var = new VariableExpression((String)ID.getData()
);
                toReturn = new AssignExpression(var, parseExpression());
            }
            else if(matchToken(TokenType.OPEN_PAREN))
            {
                //expression' -> ( args ) simple-expression'
                List<Expression> args = parseArgs();
                Expression func = new CallExpression((String)ID.getData(), args);
                matchOrDie(TokenType.CLOSE_PAREN, "parseExpression(): No ')' found after '(', got " )
;
                toReturn = parseSimpleExpression(func);
            }
            else if(matchToken(TokenType.OPEN_BRACKET))
            {
                //expression' -> [ expression ] expression''

                Expression internalExpr = parseExpression();

                matchOrDie(TokenType.CLOSE_BRACKET, "parseExpression(): No ']' found after '[',
got " );
                Expression varExpression = new VariableExpression((String)ID.getDa
ata(), internalExpr);

                if(matchToken(TokenType.ASSIGNMENT))
                {
                    //expression'' -> = expression
                    toReturn = new AssignExpression((VariableExpression) varExpres
sion, parseExpression());
                }
                else if(contains(nextTokenType(), SIMPLE_EXPRESSION_PRIME[0]))
                {
                    //expression'' -> simple-expression'
                    toReturn = parseSimpleExpression(varExpression);
                }
                else if(contains(nextTokenType(), SIMPLE_EXPRESSION_PRIME[1]))
                {
                    // expression'' -> simple-expression' -> epsilon

```

```

        toReturn = varExpression;
    }
    else
    {
        throw new RuntimeException("parseExpression(): Illegal token following ]!" );
    }
}
else if(contains(nextTokenType(), SIMPLE_EXPRESSION_PRIME[0]) || contains(nextTokenType(), SIMPLE_EXPRESSION_PRIME[1]))
{
    //expression' -> simple-expression'
    Expression temp = new VariableExpression((String) ID.getData());
    toReturn = parseSimpleExpression(temp);
}
else
{
    throw new RuntimeException("parseExpression(): Illegal token following " + ID.getType().name() + ":" + ID.getData() + ", got " + nextTokenType());
}
}
else if(nextTokenType() == TokenType.NUM)
{
    //Expression -> NUM simple-expression'
    Token num = scanner.getNextToken();
    Expression Num = new NumberExpression((Integer)num.getData());
    toReturn = parseSimpleExpression(Num);
}
else
{
    throw new RuntimeException("parseExpression(): Illegal token for Expression, got " + nextTokenType());
}
return toReturn;
}

/**
 * Parses Simple-Expression'
 * @param lhs
 * @return
 */

private Expression parseSimpleExpression(Expression lhs) {
    Expression toReturn = null;
    Expression left = parseAdditiveExpression(lhs);

    if(contains(nextTokenType(), RELOP[0]))
    {
        //match Relop
        TokenType opp = scanner.getNextToken().getType();

        Expression right = parseAdditiveExpression(null);
        toReturn = new BinaryExpression(left, opp, right);
    }
    else
    {
        toReturn = left;
    }

    return toReturn;
}

```

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CMinusParser.java

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```

    }

    /**
     * Parses Args and Arg-list
     * @return
     */

    private List<Expression> parseArgs()
    {
        List<Expression> args = new ArrayList<Expression>();

        while (nextTokenType() != TokenType.CLOSE_PAREN)
        {
            args.add(parseExpression());

            if (nextTokenType() != TokenType.CLOSE_PAREN)
            {
                matchOrDie(TokenType.COMMA, "parseArgs(): We didn't match the comma?? Instead we fo
und a " );
            }
        }

        return args;
    }
}

```

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**Declaration.java**

Page 1/1

```
package parser;

import java.io.BufferedWriter;
import java.io.IOException;

public abstract class Declaration
{
    public abstract void print(int indent, BufferedWriter out) throws IOException
    ;
}
```

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**FunctionDeclaration.java**

Page 1/1

```

package parser;

import java.io.BufferedWriter;
import java.io.IOException;

import parser.statement.CompoundStatement;
import scanner.Token.TokenType;

public class FunctionDeclaration extends Declaration
{
    private TokenType returnType;
    private Params parameters;
    private String name;
    private CompoundStatement body;

    public FunctionDeclaration(TokenType returnType, String functionName, Params
params, CompoundStatement body)
    {
        this.returnType = returnType;
        parameters = params;
        name = functionName;
        this.body = body;
    }

    public String getName()
    {
        return name;
    }

    public Params getParams()
    {
        return parameters;
    }

    public CompoundStatement getBody()
    {
        return body;
    }

    @Override
    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<FunctionDeclaration>\n");

        out.write(prefix + "\t<Name>" + name + "</Name>\n");
        out.write(prefix + "\t<ReturnType>" + returnType.name() + "</ReturnType>\n");

        parameters.print(indent + 1, out);

        body.print(indent + 1, out);
        out.write(prefix + "</FunctionDeclaration>\n");
    }
}

```

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Params.java

Page 1/1

```
package parser;

import java.io.BufferedWriter;
import java.io.IOException;
import java.util.List;

public class Params
{
    List<VariableDeclaration> paramList;

    public Params(List<VariableDeclaration> list)
    {
        paramList = list;
    }

    public List<VariableDeclaration> getParameters()
    {
        return paramList;
    }

    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<Params>\n");

        for (VariableDeclaration varDec : paramList)
        {
            varDec.print(indent + 1, out);
        }

        out.write(prefix + "</Params>\n");
    }
}
```

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**Parser.java**

Page 1/1

```
package parser;

public interface Parser
{
    public void printTree(String outFile);
    public Program parse();
}
```



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**Program.java**

Page 1/1

```
package parser;

import java.io.BufferedWriter;
import java.io.IOException;
import java.util.ArrayList;
import java.util.List;

public class Program
{
    private List<Declaration> declarations;

    public Program(List<Declaration> decls)
    {
        declarations = decls;
    }

    public List<Declaration> getProgram()
    {
        return declarations;
    }

    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<Program>\n");

        for (Declaration decl : declarations)
            decl.print(indent + 1, out);

        out.write(prefix + "</Program>\n");
    }
}
```

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Tester.java

Page 1/1

```

package parser;

import java.io.BufferedWriter;
import java.io.BufferedReader;
import java.io.FileReader;
import java.io.FileWriter;
import java.io.IOException;

import scanner.CMinusScanner;
import scanner.Scanner;
import scanner.Token;
import scanner.Token.TokenType;

/**
 * @author Mitch Birti
 * @author Seth Yost
 * @version 1.0
 * File: Tester.java
 * Created: Feb 2014
 * Â©Copyright the authors. All rights reserved.
 *
 * Description: Tests CMinusScanner.java
 */

public class Tester
{
    public static void main(String[] args)
    {
        try
        {
            // set up the scanner and the output file
            String baseName = "TestFile";
            Scanner s = new CMinusScanner(new BufferedReader(new FileReader("tests/"
+ baseName + ".cm")));

            Parser parser = new CMinusParser(s);

            parser.parse();
            parser.printTree("tests/" + baseName + ".xml");
        }
        catch (Exception e)
        {
            e.printStackTrace();
        }
    }
}

```

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**VariableDeclaration.java**

Page 1/2

```

package parser;

import java.io.BufferedWriter;
import java.io.IOException;

public class VariableDeclaration extends Declaration
{
    private String id;
    // -1 indicates this isn't an array
    private int arraySize;

    /**
     * Makes a variable of type int.
     * @param id
     */
    public VariableDeclaration(String id)
    {
        this.id = id;
        arraySize = -1;
    }

    /**
     * Makes an array of type int.
     * @param id
     * @param size
     */
    public VariableDeclaration(String id, int size)
    {
        this.id = id;
        arraySize = size;
    }

    public String getId()
    {
        return id;
    }

    /**
     * Gets the size of this variable array.
     * -1 indicates it is not an array.
     * @return
     */
    public int arraySize()
    {
        return arraySize;
    }

    @Override
    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<VariableDeclaration>\n");

        out.write(prefix + "\t<Name>" + id + "</Name>\n");
        out.write(prefix + "\t<Type>" + "INT" + "</Type>\n");
    }
}

```

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**VariableDeclaration.java**

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```
    if (arraySize != -1)
        out.write(prefix + "\t<Size>" + arraySize + "</Size>\n");

    out.write(prefix + "</VariableDeclaration>\n");
}
```

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**AssignExpression.java**

Page 1/1

```
package parser.expression;

import java.io.BufferedWriter;
import java.io.IOException;

public class AssignExpression extends Expression
{
    private VariableExpression variable;
    private Expression rightSide;

    public AssignExpression(VariableExpression var, Expression rhs)
    {
        variable = var;
        rightSide = rhs;
    }

    public VariableExpression getVariableExpr()
    {
        return variable;
    }

    public Expression getRightSide()
    {
        return rightSide;
    }

    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<AssignExpression>\n");

        out.write(prefix + "\t<Variable>\n");
        variable.print(indent + 2, out);
        out.write(prefix + "\t</Variable>\n");

        out.write(prefix + "\t<Value>\n");
        rightSide.print(indent + 2, out);
        out.write(prefix + "\t</Value>\n");

        out.write(prefix + "</AssignExpression>\n");
    }
}
```

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**BinaryExpression.java**

Page 1/1

```

package parser.expression;

import java.io.BufferedWriter;
import java.io.IOException;

import scanner.Token.TokenType;

public class BinaryExpression extends Expression
{
    private Expression leftSide;
    private Expression rightSide;
    private TokenType operand;

    public BinaryExpression(Expression lhs, TokenType op, Expression rhs)
    {
        leftSide = lhs;
        operand = op;
        rightSide = rhs;
    }

    public Expression getLeftSide()
    {
        return leftSide;
    }

    public Expression getRightSide()
    {
        return rightSide;
    }

    public TokenType getOperand()
    {
        return operand;
    }

    @Override
    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<BinaryExpression>\n");

        out.write(prefix + "\t<Operand>" + operand.name() + "</Operand>\n");

        out.write(prefix + "\t<LeftSide>\n");
        leftSide.print(indent + 2, out);
        out.write(prefix + "\t</LeftSide>\n");

        out.write(prefix + "\t<RightSide>\n");
        rightSide.print(indent + 2, out);
        out.write(prefix + "\t</RightSide>\n");

        out.write(prefix + "</BinaryExpression>\n");
    }
}

```

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**CallExpression.java**

Page 1/1

```

package parser.expression;

import java.io.BufferedWriter;
import java.io.IOException;
import java.util.List;

public class CallExpression extends Expression
{
    String functionName;
    List<Expression> arguments;

    public CallExpression(String funcName, List<Expression> args)
    {
        functionName = funcName;
        arguments = args;
    }

    public String getFunctionName()
    {
        return functionName;
    }

    public List<Expression> getArgs()
    {
        return arguments;
    }

    @Override
    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<CallExpression>\n");

        out.write(prefix + "\t<FunctionName>" + functionName + "</FunctionName>\n");

        out.write(prefix + "\t<Arguments>\n");

        for (Expression arg : arguments)
            arg.print(indent + 2, out);

        out.write(prefix + "\t</Arguments>\n");
        out.write(prefix + "</CallExpression>\n");
    }
}

```

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**Expression.java**

Page 1/1

```
package parser.expression;

import java.io.BufferedWriter;
import java.io.IOException;

public abstract class Expression
{
    public abstract void print(int indent, BufferedWriter out) throws IOException
    ;
}
```



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**NumberExpression.java**

Page 1/1

```
package parser.expression;

import java.io.BufferedWriter;
import java.io.IOException;

public class NumberExpression extends Expression
{
    private int value;

    public NumberExpression(int val)
    {
        value = val;
    }

    public int getValue()
    {
        return value;
    }

    @Override
    public void print(int index, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < index; i++)
            prefix += "\t";

        out.write(prefix + "<NumberExpression>" + value + "</NumberExpression>\n");
    }
}
```

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**VariableExpression.java**

Page 1/1

```

package parser.expression;

import java.io.BufferedWriter;
import java.io.IOException;

public class VariableExpression extends Expression
{
    private String identifier;
    private Expression index;

    public VariableExpression(String id)
    {
        identifier = id;
        index = null;
    }

    public VariableExpression(String id, Expression index)
    {
        identifier = id;
        this.index = index;
    }

    public String getIdentifier()
    {
        return identifier;
    }

    /**
     * Gets the index expression for this array.
     * If null, this isn't an array variable.
     * @return
     */
    public Expression getIndex()
    {
        return index;
    }

    @Override
    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<VariableExpression>\n");

        out.write(prefix + "\t<Identifier>" + identifier + "</Identifier>\n");
        if (index != null)
        {
            out.write(prefix + "\t<Index>\n");
            index.print(indent + 2, out);
            out.write(prefix + "\t</Index>\n");
        }

        out.write(prefix + "</VariableExpression>\n");
    }
}

```

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**CompoundStatement.java**

Page 1/1

```

package parser.statement;

import parser.*;

import java.io.BufferedWriter;
import java.io.IOException;
import java.util.List;

public class CompoundStatement extends Statement
{
    private List<Declaration> locals;
    private List<Statement> body;

    public CompoundStatement(List<Declaration> locals, List<Statement> body)
    {
        this.locals = locals;
        this.body = body;
    }

    public List<Declaration> getLocals()
    {
        return locals;
    }

    public List<Statement> getBody()
    {
        return body;
    }

    // to keep Statement happy in the meantime
    @Override
    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<CompoundStatement>\n");
        out.write(prefix + "\t<Declarations>\n");
        for (Declaration decl : locals)
        {
            decl.print(indent+2, out);
        }
        out.write(prefix + "\t</Declarations>\n");
        out.write(prefix + "\t<Statments>\n");
        for (Statement temp : body)
        {
            temp.print(indent+2, out);
        }
        out.write(prefix + "\t</Statments>\n");
        out.write(prefix + "</CompoundStatement>\n");
    }
}

```

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**ExpressionStatement.java**

Page 1/1

```
package parser.statement;

import java.io.BufferedWriter;
import java.io.IOException;

import parser.expression.*;

public class ExpressionStatement extends Statement{

    private Expression data;

    public ExpressionStatement(Expression data)
    {
        this.data = data;
    }

    public Expression getData()
    {
        return data;
    }

    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for(int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<ExpressionStatement>\n");
        data.print(indent+1, out);
        out.write(prefix + "</ExpressionStatement>\n");
    }
}
```

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**IterationStatement.java**

Page 1/1

```
package parser.statement;

import java.io.BufferedWriter;
import java.io.IOException;

import parser.expression.*;

public class IterationStatement extends Statement{

    private Expression compare;
    private Statement body;

    public IterationStatement(Expression compare, Statement body)
    {
        this.compare = compare;
        this.body = body;
    }

    public Expression getCompare()
    {
        return compare;
    }

    public Statement getBody()
    {
        return body;
    }

    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for(int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<IterationStatement>\n");
        out.write(prefix + "\t<Expression>\n");
        compare.print(indent+2, out);
        out.write(prefix + "\t</Expression>\n");
        out.write(prefix + "\t<Then>\n");
        body.print(indent+2, out);
        out.write(prefix + "\t</Then>\n");
        out.write(prefix + "</IterationStatement>\n");
    }
}
```

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**ReturnStatement.java**

Page 1/1

```
package parser.statement;

import java.io.BufferedWriter;
import java.io.IOException;

import parser.expression.*;

public class ReturnStatement extends Statement{

    private Expression body;

    public ReturnStatement(Expression body)
    {
        this.body = body;
    }

    public Expression getBody()
    {
        return body;
    }

    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for(int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<ReturnStatement>");
        if (body != null)
        {
            out.write("\n" + prefix + "\t<Expression>\n");
            body.print(indent+2, out);
            out.write(prefix + "\t</Expression>\n" + prefix);
        }
        out.write("</ReturnStatement>\n");
    }
}
```

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**SelectionStatement.java**

Page 1/2

```

package parser.statement;

import java.io.BufferedWriter;
import java.io.IOException;

import parser.statement.*;
import parser.expression.*;

public class SelectionStatement extends Statement{

    private Expression compare;
    private Statement body;
    private Statement else_part;

    public SelectionStatement(Expression compare, Statement body, Statement else_
part)
    {
        this.compare = compare;
        this.body = body;
        this.else_part = else_part;
    }

    public Expression getCompare() {
        return compare;
    }

    public Statement getBody() {
        return body;
    }

    public Statement getElse_part() {
        return else_part;
    }

    public void print(int indent, BufferedWriter out) throws IOException
    {
        String prefix = "";
        for (int i = 0; i < indent; i++)
            prefix += "\t";

        out.write(prefix + "<SelectionStatement>\n");

        out.write(prefix + "\t<Expression>\n");
        compare.print(indent+2, out);
        out.write(prefix + "\t</Expression>\n");

        out.write(prefix + "\t<Then>\n");
        body.print(indent+2, out);
        out.write(prefix + "\t</Then>\n");

        if(else_part != null)
        {
            out.write(prefix + "\t<Else>\n");
            else_part.print(indent+2, out);
            out.write(prefix + "\t</Else>\n");
        }

        out.write(prefix + "</SelectionStatement>\n");
    }
}

```

```
}
```



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**Statement.java**

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```
package parser.statement;

import java.io.BufferedWriter;
import java.io.IOException;

public abstract class Statement
{
    public abstract void print(int indent, BufferedWriter out) throws IOException
    ;
}
```

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ben.cm

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```
void test(void){
    int a;
    int b;
    a = 0;
    b = 1;
    a = b = 0;
    if(a > b){
        b = b - 1;
    }
    else{
        b = 2;
        while( b == 2){
            b = 2;
            if(b == 2){
                b = b + 1;
            }
            else{
                b = 1;
                while(b == 1){
                    b = b + 2;
                }
            }
        }
    }
    if(a == b){
        while (a == b){
            while(a == b){
                a = b - 1;
            }
        }
    }
    b = 3;
    return;
}
```

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ben.xml

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```

<Program>
  <FunctionDeclaration>
    <Name>test</Name>
    <ReturnType>VOID</ReturnType>
    <Params>
    </Params>
    <CompoundStatement>
      <Declarations>
        <VariableDeclaration>
          <Name>a</Name>
          <Type>INT</Type>
        </VariableDeclaration>
        <VariableDeclaration>
          <Name>b</Name>
          <Type>INT</Type>
        </VariableDeclaration>
      </Declarations>
      <Statments>
        <ExpressionStatement>
          <AssignExpression>
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              <VariableExpression>
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              </VariableExpression>
            </Variable>
            <Value>
              <NumberExpression>0</NumberExpression>
            </Value>
          </AssignExpression>
        </ExpressionStatement>
        <ExpressionStatement>
          <AssignExpression>
            <Variable>
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                <Identifier>b</Identifier>
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            </Variable>
            <Value>
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                <Variable>
                  <VariableExpression>
                    <Identifier>b</Identifier>
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                </Value>
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    </CompoundStatement>
  </FunctionDeclaration>
</Program>

```

```

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            <RightSide>
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                    <Identifier>b</Identifier>
                </VariableExpression>
            </RightSide>
        </BinaryExpression>
    </Expression>
    <Then>
        <CompoundStatement>
            <Declarations>
            </Declarations>
            <Statments>
                <ExpressionStatement>
                    <AssignExpression>
                        <Variable>
                            <VariableExpression>
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                            </VariableExpression>
                        </Variable>
                        <Value>
                            <BinaryExpression>
                                <Operand>MINUS</Operand>
                                <LeftSide>
                                    <VariableExpression>
                                        <Identifier>b</Identifier>
                                    </VariableExpression>
                                </LeftSide>
                                <RightSide>
                                    <NumberExpression>1</NumberExpression>
                                </RightSide>
                            </BinaryExpression>
                        </Value>
                    </AssignExpression>
                </ExpressionStatement>
            </Statments>
        </CompoundStatement>
    </Then>
    <Else>
        <CompoundStatement>
            <Declarations>
            </Declarations>
            <Statments>
                <ExpressionStatement>
                    <AssignExpression>
                        <Variable>
                            <VariableExpression>

```

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**ben.xml**

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```

        <Identifier>b</Identifier>
      </VariableExpression>
    </Variable>
    <Value>
      <NumberExpression>2</NumberExpression>
    </Value>
  </AssignExpression>
</ExpressionStatement>
<IterationStatement>
  <Expression>
    <BinaryExpression>
      <Operand>EQUALS</Operand>
      <LeftSide>
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          <Identifier>b</Identifier>
        </VariableExpression>
      </LeftSide>
      <RightSide>
        <NumberExpression>2</NumberExpression>
      </RightSide>
    </BinaryExpression>
  </Expression>
  <Then>
    <CompoundStatement>
      <Declarations>
      </Declarations>
      <Statments>
        <ExpressionStatement>
          <AssignExpression>
            <Variable>
              <VariableExpression>
                <Identifier>b</Identifier>
              </VariableExpression>
            </Variable>
            <Value>
              <NumberExpression>2</NumberExpressi
on>
            </Value>
          </AssignExpression>
        </ExpressionStatement>
        <SelectionStatement>
          <Expression>
            <BinaryExpression>
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              <LeftSide>
                <VariableExpression>
                  <Identifier>b</Identifier>
                </VariableExpression>
              </LeftSide>
              <RightSide>
                <NumberExpression>2</NumberExpre
ssion>
              </RightSide>
            </BinaryExpression>
          </Expression>
          <Then>
            <CompoundStatement>
              <Declarations>
              </Declarations>

```

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ben.xml

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ifier&gt;

nd&gt;

on&gt;

/Identifier&gt;

ion&gt;

&gt;1&lt;/NumberExpression&gt;

ifier&gt;

mberExpression&gt;

d&gt;

```

    <Statments>
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            <VariableExpression>
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ifier>

            </VariableExpression>
          </Variable>
          <Value>
            <BinaryExpression>
              <Operand>PLUS</Opera
nd>

              <LeftSide>
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on>

                <Identifier>b<
/Identifier>

                </VariableExpress
ion>

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              <RightSide>
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              </RightSide>
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    </Statments>
  </CompoundStatement>
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    </Declarations>
    <Statments>
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ifier>

            </VariableExpression>
          </Variable>
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mberExpression>

            </Value>
          </AssignExpression>
        </ExpressionStatement>
      <IterationStatement>
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          <BinaryExpression>
            <Operand>EQUALS</Operan
d>

            <LeftSide>
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                <Identifier>b</Id

```

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ben.xml

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```

        </Statements>
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</Else>
</SelectionStatement>
</Statements>
</CompoundStatement>
</Then>
</IterationStatement>
</Statements>
</CompoundStatement>
</Else>
</SelectionStatement>
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            </LeftSide>
            <RightSide>
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                    <Identifier>b</Identifier>
                </VariableExpression>
            </RightSide>
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    </Expression>
</Then>
    <CompoundStatement>
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        </Declarations>
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                            <VariableExpression>
                                <Identifier>a</Identifier>
                            </VariableExpression>
                        </LeftSide>
                        <RightSide>
                            <VariableExpression>
                                <Identifier>b</Identifier>
                            </VariableExpression>
                        </RightSide>
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            </Then>
                <CompoundStatement>
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                    </Declarations>
                    <Statements>
                        <IterationStatement>
                            <Expression>
                                <BinaryExpression>
                                    <Operand>EQUALS</Operand>
                                    <LeftSide>

```



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ben.xml

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```

        <VariableExpression>
            <Identifier>a</Identifier>
        </VariableExpression>
    </LeftSide>
    <RightSide>
        <VariableExpression>
            <Identifier>b</Identifier>
        </VariableExpression>
    </RightSide>
</BinaryExpression>
</Expression>
<Then>
    <CompoundStatement>
        <Declarations>
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                <AssignExpression>
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                        <VariableExpression>
                            <Identifier>a</Ident
ifier>

                                </VariableExpression>
                        </Variable>
                        <Value>
                            <BinaryExpression>
                                <Operand>MINUS</Oper

and>

                                <LeftSide>
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on>

                                    <Identifier>b<

/Identifier>

                                    </VariableExpress

ion>

                                </LeftSide>
                                <RightSide>
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>1</NumberExpression>

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</IterationStatement>
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</CompoundStatement>
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</Statments>
</CompoundStatement>
</Then>
</SelectionStatement>
<ExpressionStatement>
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        <Variable>

```

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**ben.xml**

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```
        <VariableExpression>
          <Identifier>b</Identifier>
        </VariableExpression>
      </Variable>
    <Value>
      <NumberExpression>3</NumberExpression>
    </Value>
  </AssignExpression>
</ExpressionStatement>
<ReturnStatement></ReturnStatement>
</Statments>
</CompoundStatement>
</FunctionDeclaration>
</Program>
```

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test5.cm

Page 1/1

```
int a;

int addThem(int d, int e) {
    int f;
    f = d + e;

    return f;
}

int main (void) {

    int b;
    int c;
    int g;
    int h;
    int i;

    b = 5;

    if (b == 5) {
        a = 3;
    }
    else {
        a = 4;
    }

    g = 0;
    i = 1;
    while (i <= 8) {
        g = g + i;
        i = i+1;
    }
    h = g / 3;
    g = h * 4;

    c = addThem(a, b);
    putchar (c+g);
    putchar (10);

    return 0;
}
```

```

<Program>
  <VariableDeclaration>
    <Name>a</Name>
    <Type>INT</Type>
  </VariableDeclaration>
  <FunctionDeclaration>
    <Name>addThem</Name>
    <ReturnType>INT</ReturnType>
    <Params>
      <VariableDeclaration>
        <Name>d</Name>
        <Type>INT</Type>
      </VariableDeclaration>
      <VariableDeclaration>
        <Name>e</Name>
        <Type>INT</Type>
      </VariableDeclaration>
    </Params>
    <CompoundStatement>
      <Declarations>
        <VariableDeclaration>
          <Name>f</Name>
          <Type>INT</Type>
        </VariableDeclaration>
      </Declarations>
      <Statments>
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            <Variable>
              <VariableExpression>
                <Identifier>f</Identifier>
              </VariableExpression>
            </Variable>
            <Value>
              <BinaryExpression>
                <Operand>PLUS</Operand>
                <LeftSide>
                  <VariableExpression>
                    <Identifier>d</Identifier>
                  </VariableExpression>
                </LeftSide>
                <RightSide>
                  <VariableExpression>
                    <Identifier>e</Identifier>
                  </VariableExpression>
                </RightSide>
              </BinaryExpression>
            </Value>
          </AssignExpression>
        </ExpressionStatement>
        <ReturnStatement>
          <Expression>
            <VariableExpression>
              <Identifier>f</Identifier>
            </VariableExpression>
          </Expression>
        </ReturnStatement>
      </Statments>
    </CompoundStatement>
  </FunctionDeclaration>
</Program>

```

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test5.xml

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```

</FunctionDeclaration>
<FunctionDeclaration>
  <Name>main</Name>
  <ReturnType>INT</ReturnType>
  <Params>
  </Params>
  <CompoundStatement>
    <Declarations>
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        <Type>INT</Type>
      </VariableDeclaration>
      <VariableDeclaration>
        <Name>c</Name>
        <Type>INT</Type>
      </VariableDeclaration>
      <VariableDeclaration>
        <Name>g</Name>
        <Type>INT</Type>
      </VariableDeclaration>
      <VariableDeclaration>
        <Name>h</Name>
        <Type>INT</Type>
      </VariableDeclaration>
      <VariableDeclaration>
        <Name>i</Name>
        <Type>INT</Type>
      </VariableDeclaration>
    </Declarations>
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      <SelectionStatement>
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            <Declarations>

```

```

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                    </Variable>
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                    </Value>
                </AssignExpression>
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    </CompoundStatement>
</Then>
<Else>
    <CompoundStatement>
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        </Declarations>
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                    </Variable>
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        </Statments>
    </CompoundStatement>
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```

```

    </Value>
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      <RightSide>
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      </Declarations>
      <Statments>
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              </VariableExpression>
            </Variable>
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                    <Identifier>g</Identifier>
                  </VariableExpression>
                </LeftSide>
                <RightSide>
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                    <Identifier>i</Identifier>
                  </VariableExpression>
                </RightSide>
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        <ExpressionStatement>
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              </VariableExpression>
            </Variable>
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              <BinaryExpression>
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```

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test5.xml

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```

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    </AssignExpression>
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        </Variable>
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</ExpressionStatement>
<ExpressionStatement>
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```



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test5.xml

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```

    <Variable>
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        <Identifier>c</Identifier>
      </VariableExpression>
    </Variable>
    <Value>
      <CallExpression>
        <FunctionName>addThem</FunctionName>
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          <VariableExpression>
            <Identifier>a</Identifier>
          </VariableExpression>
          <VariableExpression>
            <Identifier>b</Identifier>
          </VariableExpression>
        </Arguments>
      </CallExpression>
    </Value>
  </AssignExpression>
</ExpressionStatement>
<ExpressionStatement>
  <CallExpression>
    <FunctionName>putchar</FunctionName>
    <Arguments>
      <BinaryExpression>
        <Operand>PLUS</Operand>
        <LeftSide>
          <VariableExpression>
            <Identifier>c</Identifier>
          </VariableExpression>
        </LeftSide>
        <RightSide>
          <VariableExpression>
            <Identifier>g</Identifier>
          </VariableExpression>
        </RightSide>
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  </CallExpression>
</ExpressionStatement>
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  <CallExpression>
    <FunctionName>putchar</FunctionName>
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    </Arguments>
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<ReturnStatement>
  <Expression>
    <NumberExpression>0</NumberExpression>
  </Expression>
</ReturnStatement>
</Statments>
</CompoundStatement>
</FunctionDeclaration>
</Program>

```

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testcode.cm

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```
int a;

int addThem(int d, int e) {
    int f;
    f = d + e;

    return f;
}

void putDigit(int s) {
    putchar(48+s);
}

void printInt(int r) {
    int t;
    int found;

    found = 0;

    if (r >= 10000) {
        /* print -1) */
        putchar(45);
        putDigit(1);
        return;
    }
    else {
        if (r >= 1000) {
            t = r / 1000;
            putDigit(t);
            r = r - t * 1000;
            found=1;
        }

        if (r >= 100) {
            t = r / 100;
            putDigit(t);
            r = r - t * 100;
            found=1;
        }
        else if (found == 1) {
            putDigit(0);
        }

        if (r >= 10) {
            t = r / 10;
            putDigit(t);
            r = r - t * 10;
        }
        else if (found == 1) {
            putDigit(0);
        }

        putDigit(r);
    }
}

int main (void) {
```

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testcode.cm

Page 2/3

```
int b;
int c;
int g;
int h;
int i;

b = c = 5;

if (b == 5) {
    a = 3;
}
else {
    a = 4;
}

g = 0;
i = 1;
while (i <= 8) {
    g = g + i;
    i = i+1;
}
h = g / 3;
g = h * 4;

c = addThem(a, b);
putchar (56);
putchar (61);
putchar (c+g);
putchar (10);

i = 0;
while (i < 10) {
    putchar(48+i);
    i = i+1;
}
putchar(10);
putchar(67);
putchar(83);
printInt(3510);
putchar(10);

b = 0;
c = 1;
g = 1;
h = 0;
i = 0;

if (b == 0) {
    if (c==0) {
        i = 1;
    }
    else if (g == 0) {
        i = 2;
    }
    else if (h == 0) {
        i = 10;
    }
    else {
        i = 3;
    }
}
```

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testcode.cm

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```
    }  
  }  
  else {  
    i = 0;  
  }  
  
  if (i == 10) {  
    putchar(99);  
    putDigit(0);  
    putDigit(0);  
    putchar(108);  
  }  
  else {  
    putchar(98);  
    putchar(97);  
    putchar(100);  
    putchar(61);  
    printInt(i);  
  }  
  putchar(10);  
  
  return 0;  
}
```

```

<Program>
  <VariableDeclaration>
    <Name>a</Name>
    <Type>INT</Type>
  </VariableDeclaration>
  <FunctionDeclaration>
    <Name>addThem</Name>
    <ReturnType>INT</ReturnType>
    <Params>
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        <Name>d</Name>
        <Type>INT</Type>
      </VariableDeclaration>
      <VariableDeclaration>
        <Name>e</Name>
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      </VariableDeclaration>
    </Params>
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      <Declarations>
        <VariableDeclaration>
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      </Declarations>
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                </RightSide>
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        </ExpressionStatement>
        <ReturnStatement>
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          </Expression>
        </ReturnStatement>
      </Statments>
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```

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```



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```

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on&gt;

Name&gt;

pression&gt;

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```

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              <AssignExpression>
                <Variable>
                  <VariableExpression>
                    <Identifier>i</Ident
ifier>
                    </VariableExpression>
                  </Variable>
                <Value>
                  <NumberExpression>10</N
umberExpression>
                  </Value>
                </AssignExpression>
              </ExpressionStatement>
            </Statments>
          </CompoundStatement>
        </Then>
      <Else>
        <CompoundStatement>
          <Declarations>
          </Declarations>
          <Statments>
            <ExpressionStatement>
              <AssignExpression>
                <Variable>
                  <VariableExpression>
                    <Identifier>i</Ident
ifier>
                    </VariableExpression>

```



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testcode.xml

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mberExpression&gt;

```

        </Variable>
        <Value>
            <NumberExpression>3</Nu
mberExpression>
        </Value>
    </AssignExpression>
</ExpressionStatement>
</Statments>
</CompoundStatement>
</Else>
</SelectionStatement>
</Else>
</SelectionStatement>
</Else>
</SelectionStatement>
</Statments>
</CompoundStatement>
</Then>
<Else>
    <CompoundStatement>
        <Declarations>
        </Declarations>
        <Statments>
            <ExpressionStatement>
                <AssignExpression>
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                        <VariableExpression>
                            <Identifier>i</Identifier>
                        </VariableExpression>
                    </Variable>
                    <Value>
                        <NumberExpression>0</NumberExpression>
                    </Value>
                </AssignExpression>
            </ExpressionStatement>
        </Statments>
    </CompoundStatement>
</Else>
</SelectionStatement>
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        <BinaryExpression>
            <Operand>EQUALS</Operand>
            <LeftSide>
                <VariableExpression>
                    <Identifier>i</Identifier>
                </VariableExpression>
            </LeftSide>
            <RightSide>
                <NumberExpression>10</NumberExpression>
            </RightSide>
        </BinaryExpression>
    </Expression>
    <Then>
        <CompoundStatement>
            <Declarations>
            </Declarations>
            <Statments>
                <ExpressionStatement>

```

```

        <CallExpression>
          <FunctionName>putchar</FunctionName>
          <Arguments>
            <NumberExpression>99</NumberExpression>
          </Arguments>
        </CallExpression>
      </ExpressionStatement>
    </ExpressionStatement>
    <CallExpression>
      <FunctionName>putDigit</FunctionName>
      <Arguments>
        <NumberExpression>0</NumberExpression>
      </Arguments>
    </CallExpression>
  </ExpressionStatement>
</ExpressionStatement>
<CallExpression>
  <FunctionName>putDigit</FunctionName>
  <Arguments>
    <NumberExpression>0</NumberExpression>
  </Arguments>
</CallExpression>
</ExpressionStatement>
<ExpressionStatement>
  <CallExpression>
    <FunctionName>putchar</FunctionName>
    <Arguments>
      <NumberExpression>108</NumberExpression>
    </Arguments>
  </CallExpression>
</ExpressionStatement>
</Statments>
</CompoundStatement>
</Then>
<Else>
  <CompoundStatement>
    <Declarations>
    </Declarations>
    <Statments>
      <ExpressionStatement>
        <CallExpression>
          <FunctionName>putchar</FunctionName>
          <Arguments>
            <NumberExpression>98</NumberExpression>
          </Arguments>
        </CallExpression>
      </ExpressionStatement>
      <ExpressionStatement>
        <CallExpression>
          <FunctionName>putchar</FunctionName>
          <Arguments>
            <NumberExpression>97</NumberExpression>
          </Arguments>
        </CallExpression>
      </ExpressionStatement>
    </ExpressionStatement>
    <CallExpression>
      <FunctionName>putchar</FunctionName>
      <Arguments>

```

```

        <NumberExpression>100</NumberExpression>
    </Arguments>
</CallExpression>
</ExpressionStatement>
<ExpressionStatement>
    <CallExpression>
        <FunctionName>putchar</FunctionName>
        <Arguments>
            <NumberExpression>61</NumberExpression>
        </Arguments>
    </CallExpression>
</ExpressionStatement>
<ExpressionStatement>
    <CallExpression>
        <FunctionName>printInt</FunctionName>
        <Arguments>
            <VariableExpression>
                <Identifier>i</Identifier>
            </VariableExpression>
        </Arguments>
    </CallExpression>
</ExpressionStatement>
</Statments>
</CompoundStatement>
</Else>
</SelectionStatement>
<ExpressionStatement>
    <CallExpression>
        <FunctionName>putchar</FunctionName>
        <Arguments>
            <NumberExpression>10</NumberExpression>
        </Arguments>
    </CallExpression>
</ExpressionStatement>
<ReturnStatement>
    <Expression>
        <NumberExpression>0</NumberExpression>
    </Expression>
</ReturnStatement>
</Statments>
</CompoundStatement>
</FunctionDeclaration>
</Program>

```

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**TestFile.cm**

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```
int fact( int x )
/* recursive factorial function */
{ if (x > 1)
    return x * fact(x-1);
else
    return 1;
}

void main (void)
{
    int x;
    x = read();
    if(x > 0) write (fact(x));
}
```

```

<Program>
  <FunctionDeclaration>
    <Name>fact</Name>
    <ReturnType>INT</ReturnType>
    <Params>
      <VariableDeclaration>
        <Name>x</Name>
        <Type>INT</Type>
      </VariableDeclaration>
    </Params>
    <CompoundStatement>
      <Declarations>
      </Declarations>
      <Statments>
        <SelectionStatement>
          <Expression>
            <BinaryExpression>
              <Operand>GREATER_THAN</Operand>
              <LeftSide>
                <VariableExpression>
                  <Identifier>x</Identifier>
                </VariableExpression>
              </LeftSide>
              <RightSide>
                <NumberExpression>1</NumberExpression>
              </RightSide>
            </BinaryExpression>
          </Expression>
          <Then>
            <ReturnStatement>
              <Expression>
                <BinaryExpression>
                  <Operand>MULTIPLY</Operand>
                  <LeftSide>
                    <VariableExpression>
                      <Identifier>x</Identifier>
                    </VariableExpression>
                  </LeftSide>
                  <RightSide>
                    <CallExpression>
                      <FunctionName>fact</FunctionName>
                      <Arguments>
                        <BinaryExpression>
                          <Operand>MINUS</Operand>
                          <LeftSide>
                            <VariableExpression>
                              <Identifier>x</Identifier>
                            </VariableExpression>
                          </LeftSide>
                          <RightSide>
                            <NumberExpression>1</NumberExpression>
                          </RightSide>
                        </BinaryExpression>
                      </Arguments>
                    </CallExpression>
                  </RightSide>
                </BinaryExpression>
              </Expression>
            </ReturnStatement>
          </Then>
        </SelectionStatement>
      </Statments>
    </CompoundStatement>
  </FunctionDeclaration>
</Program>

```

```

        </Then>
        <Else>
            <ReturnStatement>
                <Expression>
                    <NumberExpression>1</NumberExpression>
                </Expression>
            </ReturnStatement>
        </Else>
    </SelectionStatement>
</Statements>
</CompoundStatement>
</FunctionDeclaration>
<FunctionDeclaration>
    <Name>main</Name>
    <ReturnType>VOID</ReturnType>
    <Params>
    </Params>
    <CompoundStatement>
        <Declarations>
            <VariableDeclaration>
                <Name>x</Name>
                <Type>INT</Type>
            </VariableDeclaration>
        </Declarations>
        <Statements>
            <ExpressionStatement>
                <AssignExpression>
                    <Variable>
                        <VariableExpression>
                            <Identifier>x</Identifier>
                        </VariableExpression>
                    </Variable>
                    <Value>
                        <CallExpression>
                            <FunctionName>read</FunctionName>
                            <Arguments>
                            </Arguments>
                        </CallExpression>
                    </Value>
                </AssignExpression>
            </ExpressionStatement>
            <SelectionStatement>
                <Expression>
                    <BinaryExpression>
                        <Operand>GREATER_THAN</Operand>
                        <LeftSide>
                            <VariableExpression>
                                <Identifier>x</Identifier>
                            </VariableExpression>
                        </LeftSide>
                        <RightSide>
                            <NumberExpression>0</NumberExpression>
                        </RightSide>
                    </BinaryExpression>
                </Expression>
            <Then>
                <ExpressionStatement>
                    <CallExpression>
                        <FunctionName>write</FunctionName>

```

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**TestFile.xml**

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```
<Arguments>
  <CallExpression>
    <FunctionName>fact</FunctionName>
    <Arguments>
      <VariableExpression>
        <Identifier>x</Identifier>
      </VariableExpression>
    </Arguments>
  </CallExpression>
</Arguments>
</CallExpression>
</ExpressionStatement>
</Then>
</SelectionStatement>
</Statments>
</CompoundStatement>
</FunctionDeclaration>
</Program>
```

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**print.sh**

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```
a2ps -R -s1 --media=letter --columns=1 --rows=1 --chars-per-line=80 --major=rows
--border=no --tabsize=3 src/parser/* src/parser/expression/* src/parser/stateme
nt/* tests/* print.sh -o - | ps2pdf - Program.pdf
pdfunite write-ups/Project2WriteUp.pdf Grammar-MkII.pdf First-Follow-MkII.pdf Pr
ogram.pdf Printout.pdf
```