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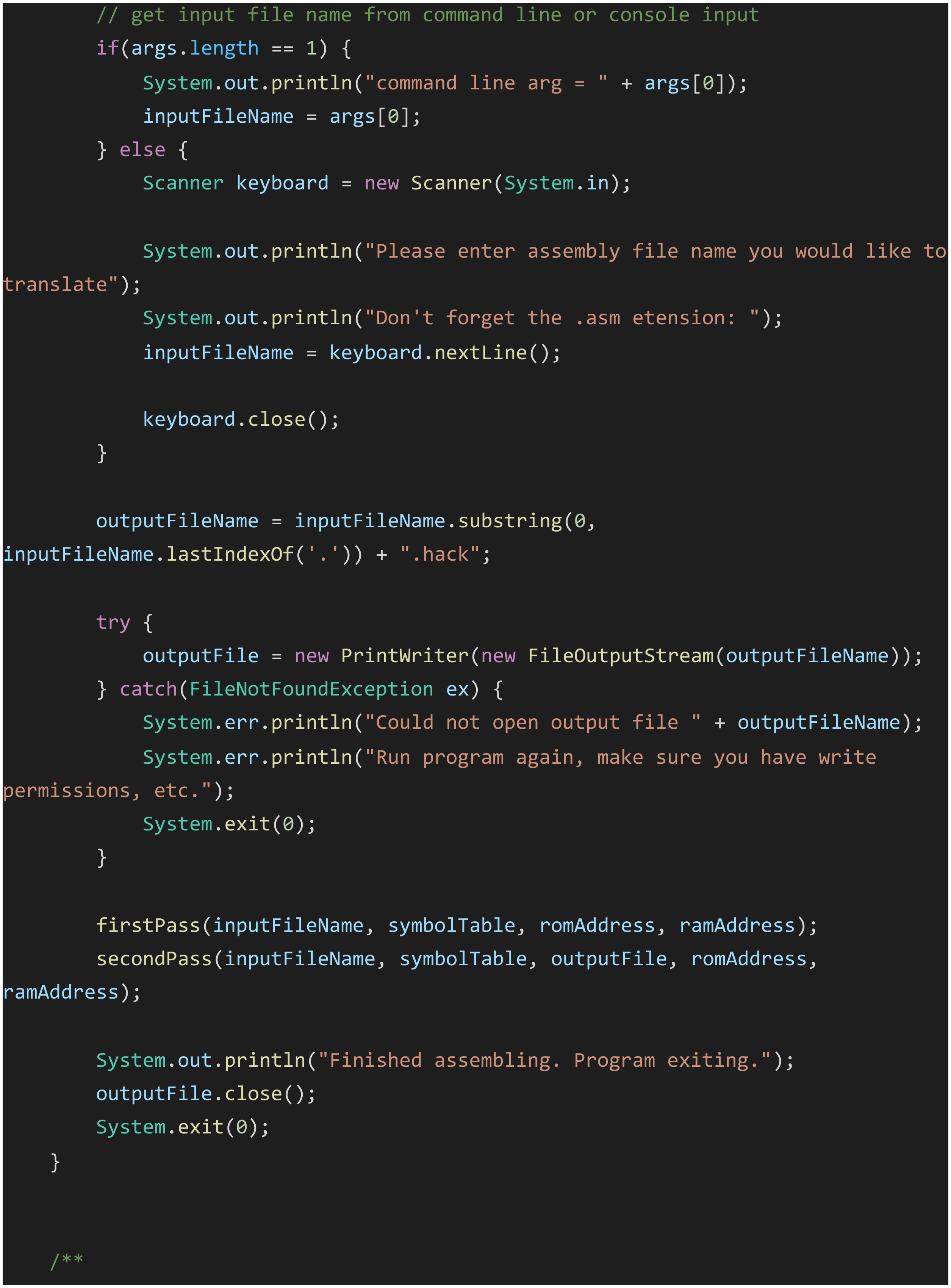
CS 220 2148

October 30, 2020

Homework 7 Assembler

Assembler.java

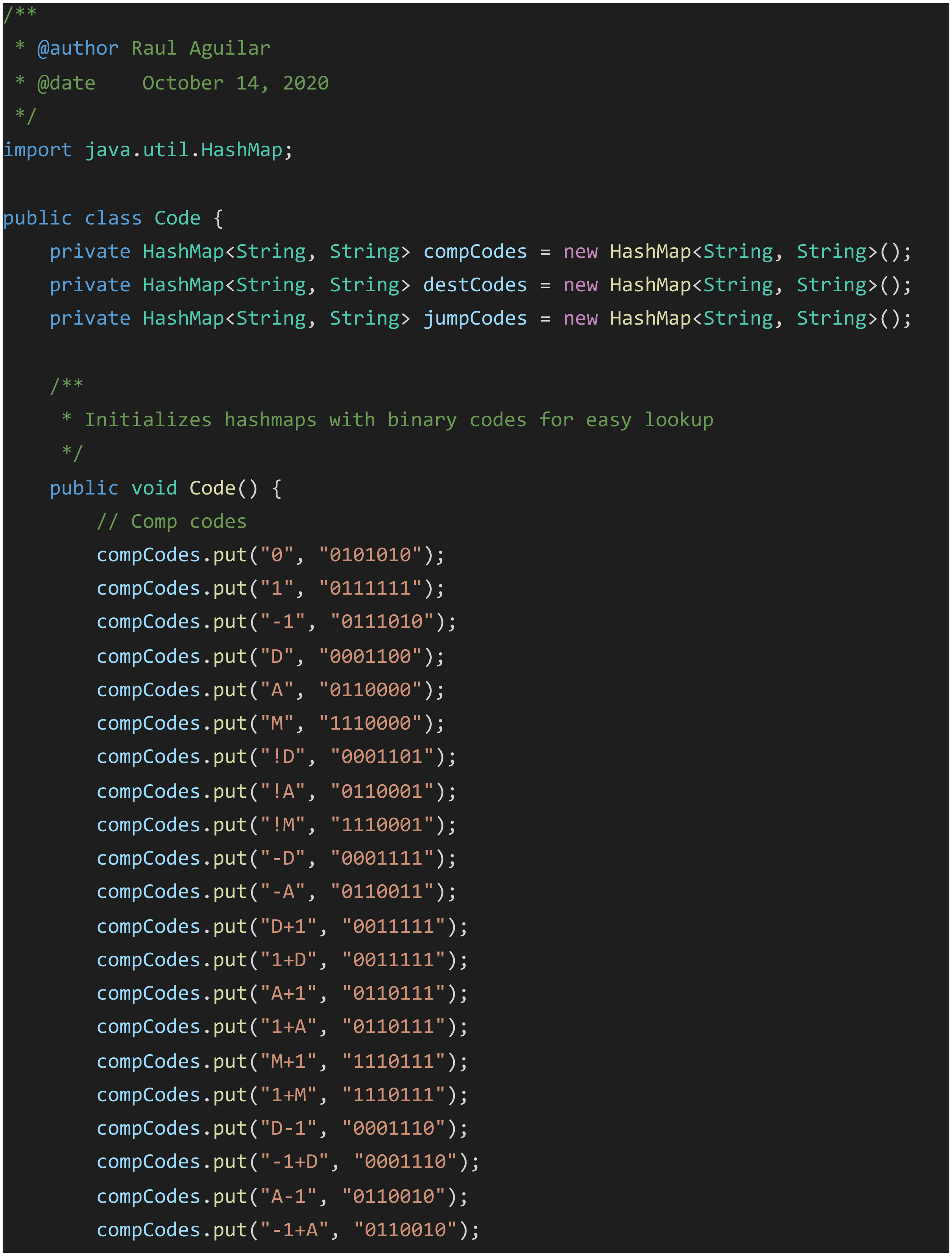
```
/**
 * @author Raul Aguilar
 * @date    October 27, 2020
 */
import java.io.FileOutputStream;
import java.io.FileNotFoundException;
import java.util.Scanner;
import java.io.PrintWriter;

public class Assembler {

    // ALGORITHM:
    // get input file name
    // create output file name and stream

    // create symbol table
    // do first pass to build symbol table (no output yet)
    // do second pass to output translated ASM to HACK code

    // print "done" message to user
    // close output file stream

    public static void main(String[] args) {
        String inputFileName, outputFileName;
        PrintWriter outputFile = null;
        SymbolTable symbolTable = new SymbolTable();

        int romAddress = 0, ramAddress = 16;
```



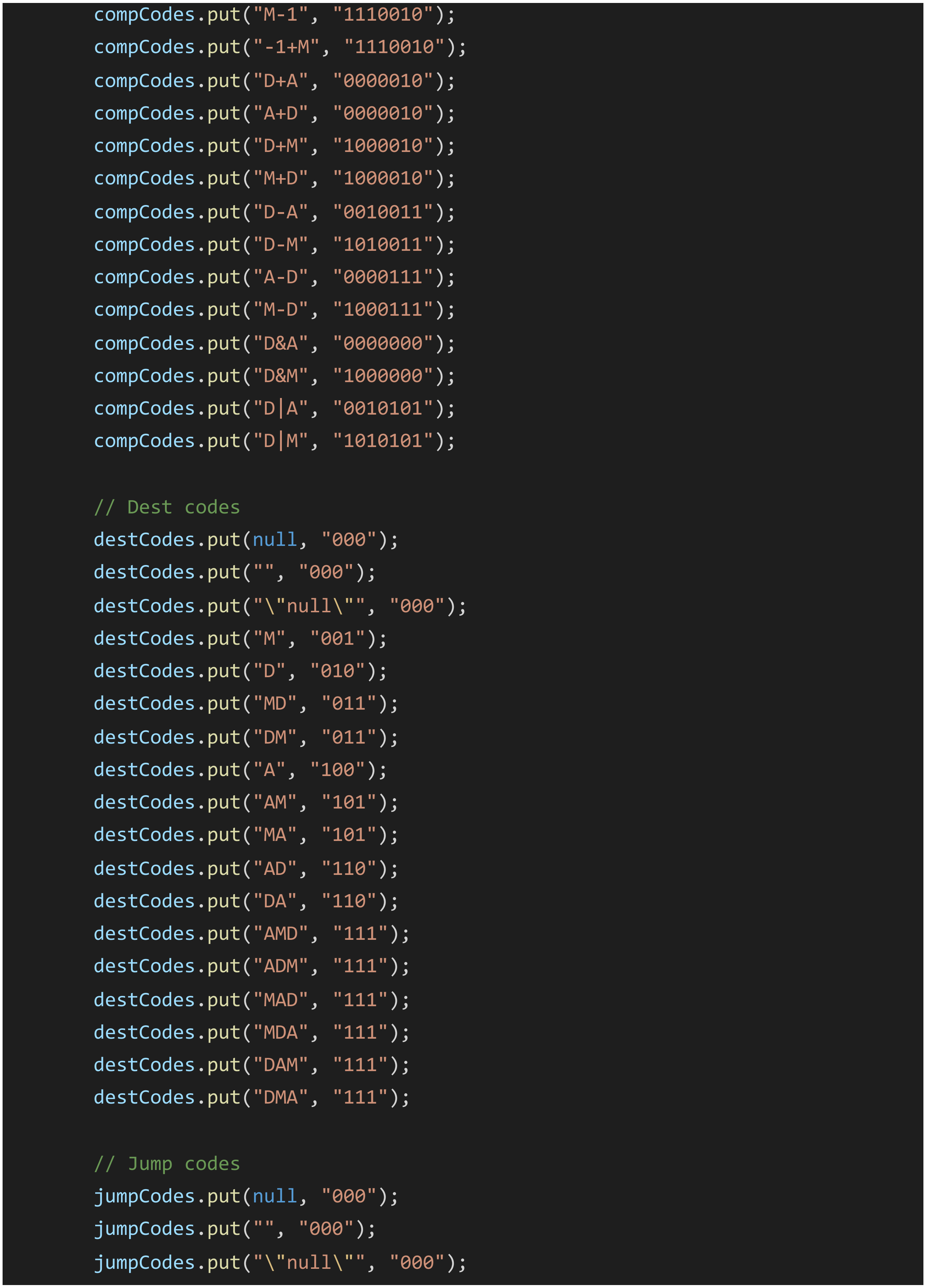
```
        // get input file name from command line or console input
        if(args.length == 1) {
            System.out.println("command line arg = " + args[0]);
            inputFileName = args[0];
        } else {
            Scanner keyboard = new Scanner(System.in);

            System.out.println("Please enter assembly file name you would like to
translate");
            System.out.println("Don't forget the .asm etension: ");
            inputFileName = keyboard.nextLine();

            keyboard.close();
        }

        outputFileName = inputFileName.substring(0,
inputFileName.lastIndexOf('.')) + ".hack";

        try {
            outputFile = new PrintWriter(new FileOutputStream(outputFileName));
        } catch(FileNotFoundException ex) {
            System.err.println("Could not open output file " + outputFileName);
            System.err.println("Run program again, make sure you have write
permissions, etc.");
            System.exit(0);
        }

        firstPass(inputFileName, symbolTable, romAddress, ramAddress);
        secondPass(inputFileName, symbolTable, outputFile, romAddress,
ramAddress);

        System.out.println("Finished assembling. Program exiting.");
        outputFile.close();
        System.exit(0);
    }


    /**
```

```
     * The first pass through the file finds and stores user-defined variables
and labels in the symbol
     * table without writing anything to the output file
     * @param inputFileName the file being read
     * @param symbolTable   the symbol table to store variables and lables
(initialzies with predefined symbols)
     * @param romAddress    the current PC rom address of the instruction
     * @param ramAddress    the current ram address to store the variable in
     * @return  symbol table filled-in with variables and labels found in file
     */
    private static SymbolTable firstPass(String inputFileName, SymbolTable
symbolTable, int romAddress, int ramAddress) {
        Parser p = new Parser();
        symbolTable.SymbolTable();
        p.Parser(inputFileName);
        while(p.hasMoreCommands()) {
            p.advance();
            if(p.getCommandType() == Command.L_COMMAND) {
                symbolTable.addEntry(p.getSymbol(), romAddress,
p.getLineNumber());
            }
            if(p.getCommandType() == Command.A_COMMAND) {
                try {
                    int decimal = Integer.parseInt(p.getSymbol());
                } catch(NumberFormatException notADecimal) {
                    if(!symbolTable.contains(p.getSymbol()) &&
Character.isLowerCase(p.getSymbol().charAt(0)) ) {
                        symbolTable.addEntry(p.getSymbol(), ramAddress,
p.getLineNumber());
                        ramAddress++;
                    }
                }

                romAddress++;
            }
            if(p.getCommandType() == Command.C_COMMAND) {
                romAddress++;
            }
        }
        return symbolTable;
    }

    /**
     * Second pass through the file converts each line to binary code, while
using the filled-in symbol
     * table from the first pass to convert symbols and labels
     * @param inputFileName the file being read
     * @param symbolTable   the predefined symbol table
     * @param outputFile    the name of the output HACK file
     * @param romAddress    the current PC rom address of the instruction
     * @param ramAddress    the current ram address for user-defined variables
     */
    private static void secondPass(String inputFileName, SymbolTable symbolTable,
PrintWriter outputFile, int romAddress, int ramAddress) {
        Parser p = new Parser();
        p.Parser(inputFileName);
        while(p.hasMoreCommands()) {
            p.advance();
            if(p.getCommandType() == Command.C_COMMAND) {
                String instruction = "111" + p.getComp() + p.getDest() +
p.getJump() + '\n';
                outputFile.write(instruction);
                romAddress++;
            }
            if(p.getCommandType() == Command.A_COMMAND) {
                try {
                    int decimal = Integer.parseInt(p.getSymbol());
                    String dec = Code.decimalToBinary(decimal) + '\n';
                    outputFile.write(dec);
                    romAddress++;
                } catch(NumberFormatException notADecimal) {
                    if(symbolTable.contains(p.getSymbol())) {
                        String dec =
Code.decimalToBinary(symbolTable.getAddress(p.getSymbol())) + '\n';
                        outputFile.write(dec);
                    } else {
                        symbolTable.addEntry(p.getSymbol(), ramAddress,
p.getLineNumber());
                        ramAddress++;
                    }
                    romAddress++;
                }
            }
        }
    }
}
```

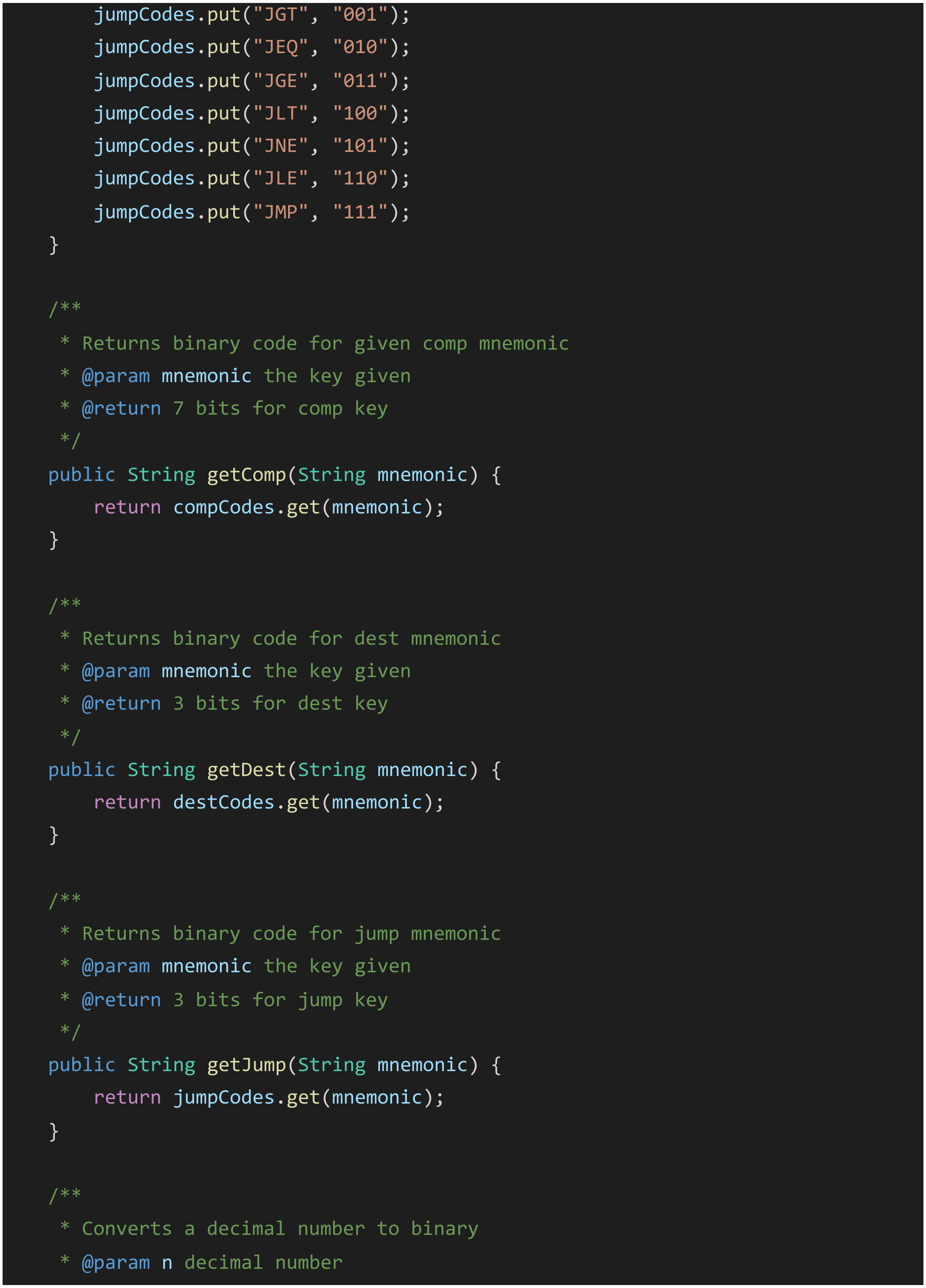
Code.java



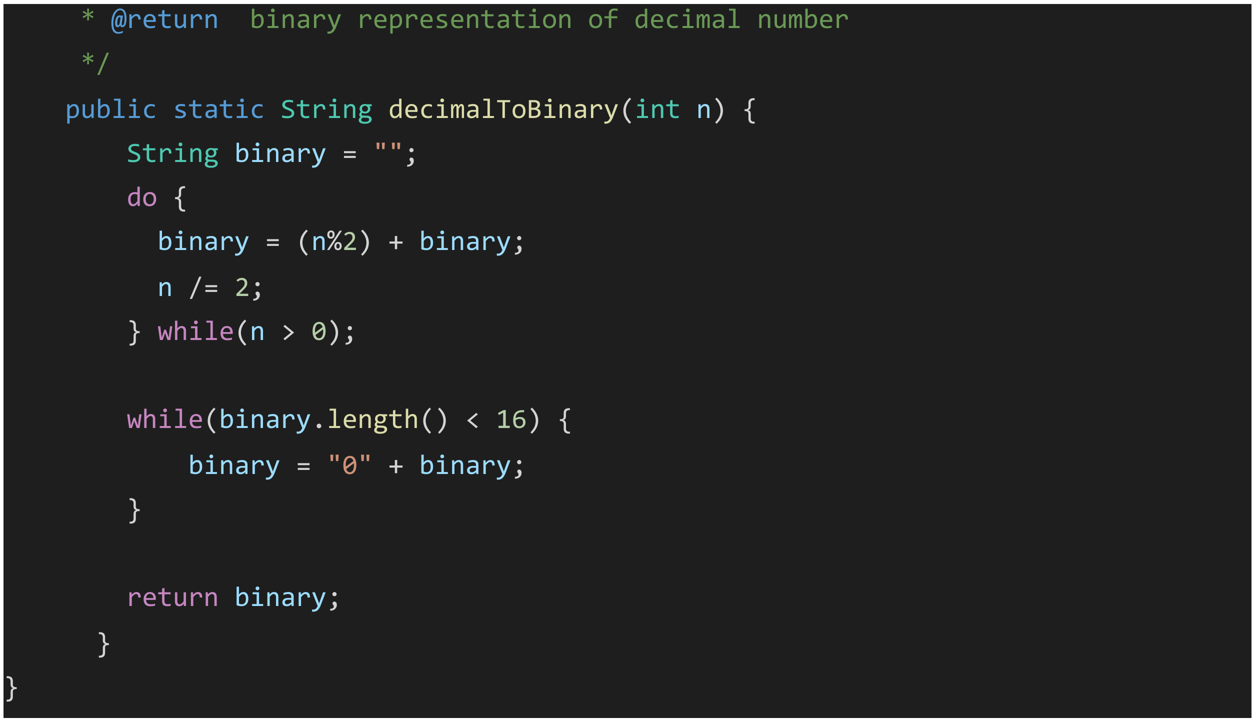
```java
/**
 * @author Raul Aguilar
 * @date    October 14, 2020
 */
import java.util.HashMap;

public class Code {
    private HashMap<String, String> compCodes = new HashMap<String, String>();
    private HashMap<String, String> destCodes = new HashMap<String, String>();
    private HashMap<String, String> jumpCodes = new HashMap<String, String>();

    /**
     * Initializes hashmaps with binary codes for easy lookup
     */
    public void Code() {
        // Comp codes
        compCodes.put("0", "0101010");
        compCodes.put("1", "0111111");
        compCodes.put("-1", "0111010");
        compCodes.put("D", "0001100");
        compCodes.put("A", "0110000");
        compCodes.put("M", "1110000");
        compCodes.put("!D", "0001101");
        compCodes.put("!A", "0110001");
        compCodes.put("!M", "1110001");
        compCodes.put("-D", "0001111");
        compCodes.put("-A", "0110011");
        compCodes.put("D+1", "0011111");
        compCodes.put("1+D", "0011111");
        compCodes.put("A+1", "0110111");
        compCodes.put("1+A", "0110111");
        compCodes.put("M+1", "1110111");
        compCodes.put("1+M", "1110111");
        compCodes.put("D-1", "0001110");
        compCodes.put("-1+D", "0001110");
        compCodes.put("A-1", "0110010");
        compCodes.put("-1+A", "0110010");
```



```
        compCodes.put("M-1", "1110010");
        compCodes.put("-1+M", "1110010");
        compCodes.put("D+A", "0000010");
        compCodes.put("A+D", "0000010");
        compCodes.put("D+M", "1000010");
        compCodes.put("M+D", "1000010");
        compCodes.put("D-A", "0010011");
        compCodes.put("D-M", "1010011");
        compCodes.put("A-D", "0000111");
        compCodes.put("M-D", "1000111");
        compCodes.put("D&A", "0000000");
        compCodes.put("D&M", "1000000");
        compCodes.put("D|A", "0010101");
        compCodes.put("D|M", "1010101");

        // Dest codes
        destCodes.put(null, "000");
        destCodes.put("", "000");
        destCodes.put("\"null\"", "000");
        destCodes.put("M", "001");
        destCodes.put("D", "010");
        destCodes.put("MD", "011");
        destCodes.put("DM", "011");
        destCodes.put("A", "100");
        destCodes.put("AM", "101");
        destCodes.put("MA", "101");
        destCodes.put("AD", "110");
        destCodes.put("DA", "110");
        destCodes.put("AMD", "111");
        destCodes.put("ADM", "111");
        destCodes.put("MAD", "111");
        destCodes.put("MDA", "111");
        destCodes.put("DAM", "111");
        destCodes.put("DMA", "111");

        // Jump codes
        jumpCodes.put(null, "000");
        jumpCodes.put("", "000");
        jumpCodes.put("\"null\"", "000");
```

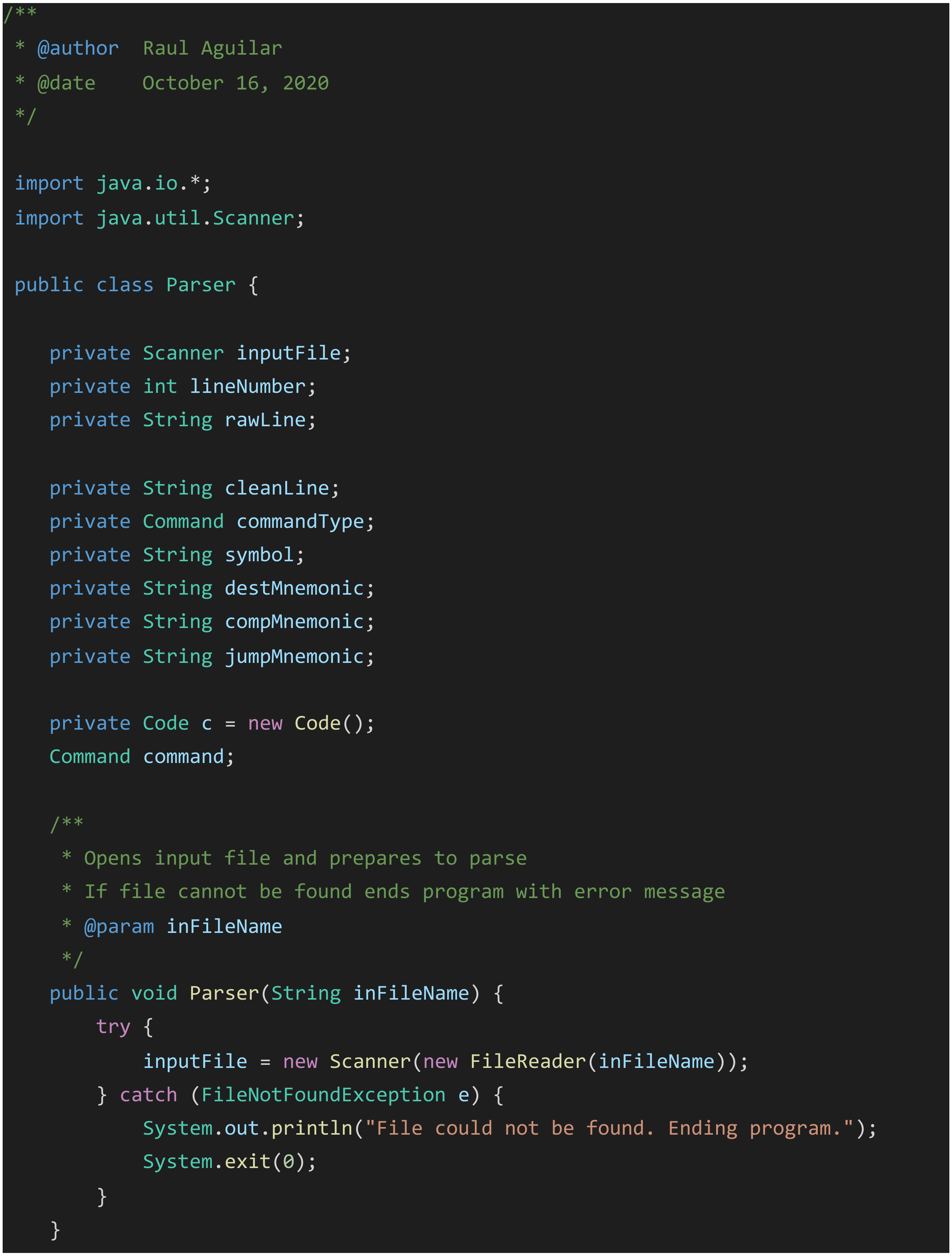


```
        jumpCodes.put("JGT", "001");
        jumpCodes.put("JEQ", "010");
        jumpCodes.put("JGE", "011");
        jumpCodes.put("JLT", "100");
        jumpCodes.put("JNE", "101");
        jumpCodes.put("JLE", "110");
        jumpCodes.put("JMP", "111");
    }

    /**
     * Returns binary code for given comp mnemonic
     * @param mnemonic the key given
     * @return 7 bits for comp key
     */
    public String getComp(String mnemonic) {
        return compCodes.get(mnemonic);
    }

    /**
     * Returns binary code for dest mnemonic
     * @param mnemonic the key given
     * @return 3 bits for dest key
     */
    public String getDest(String mnemonic) {
        return destCodes.get(mnemonic);
    }

    /**
     * Returns binary code for jump mnemonic
     * @param mnemonic the key given
     * @return 3 bits for jump key
     */
    public String getJump(String mnemonic) {
        return jumpCodes.get(mnemonic);
    }

    /**
     * Converts a decimal number to binary
     * @param n decimal number
```

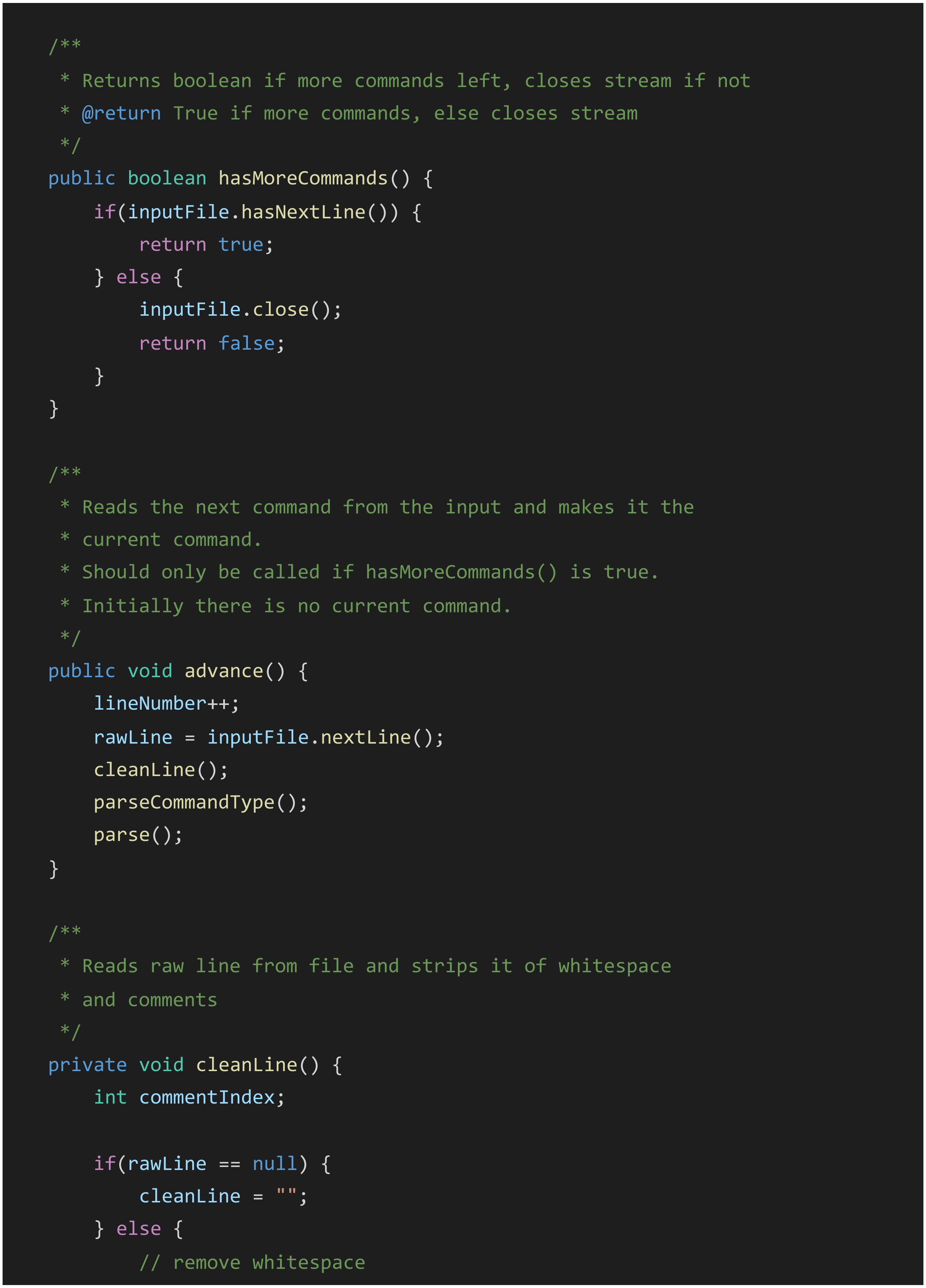


```
   * @return  binary representation of decimal number
   */
  public static String decimalToBinary(int n) {
    String binary = "";
    do {
     binary = (n%2) + binary;
     n /= 2;
    } while(n > 0);

    while(binary.length() < 16) {
      binary = "0" + binary;
    }

    return binary;
   }
}
```

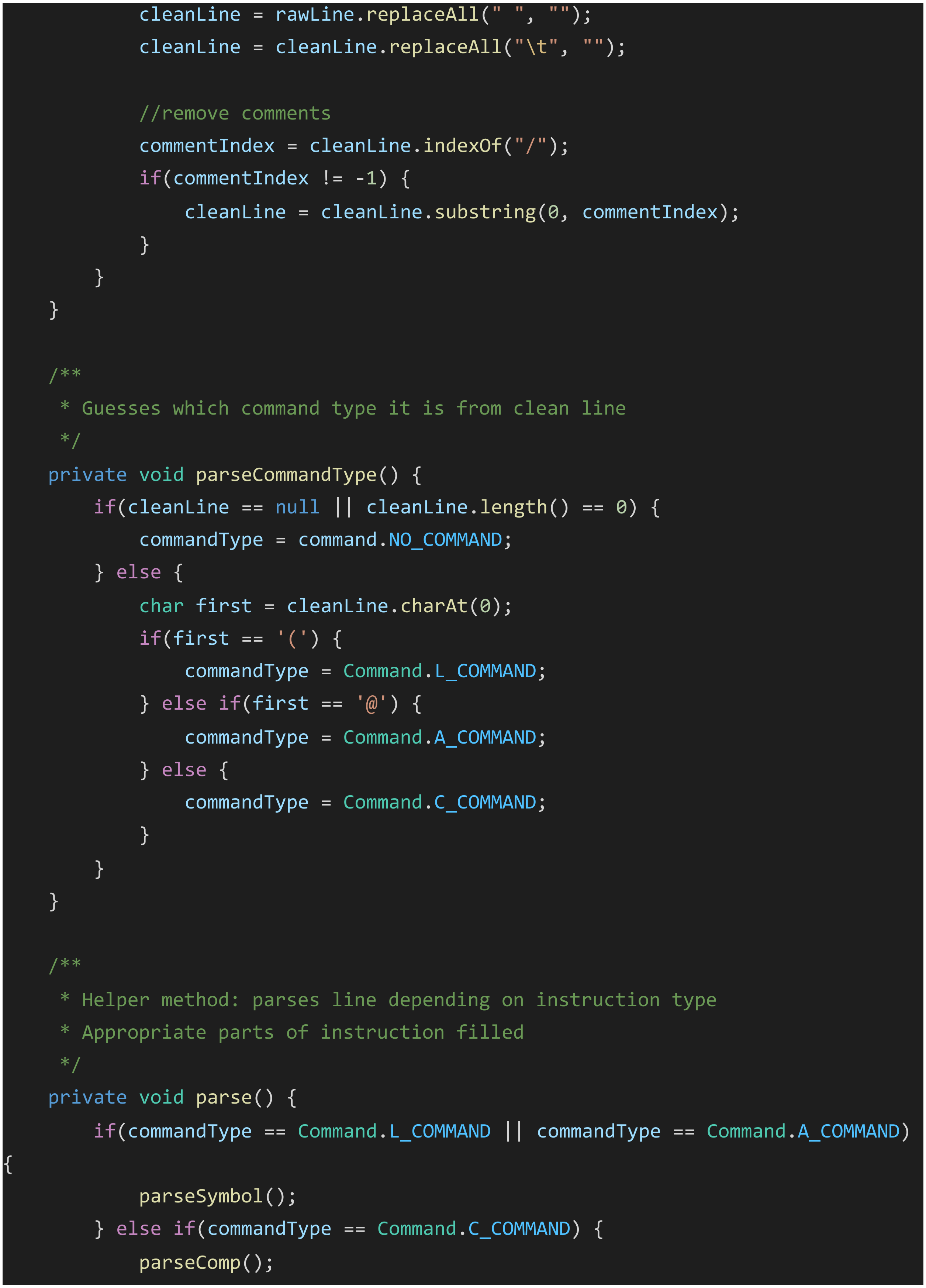
Parser.java



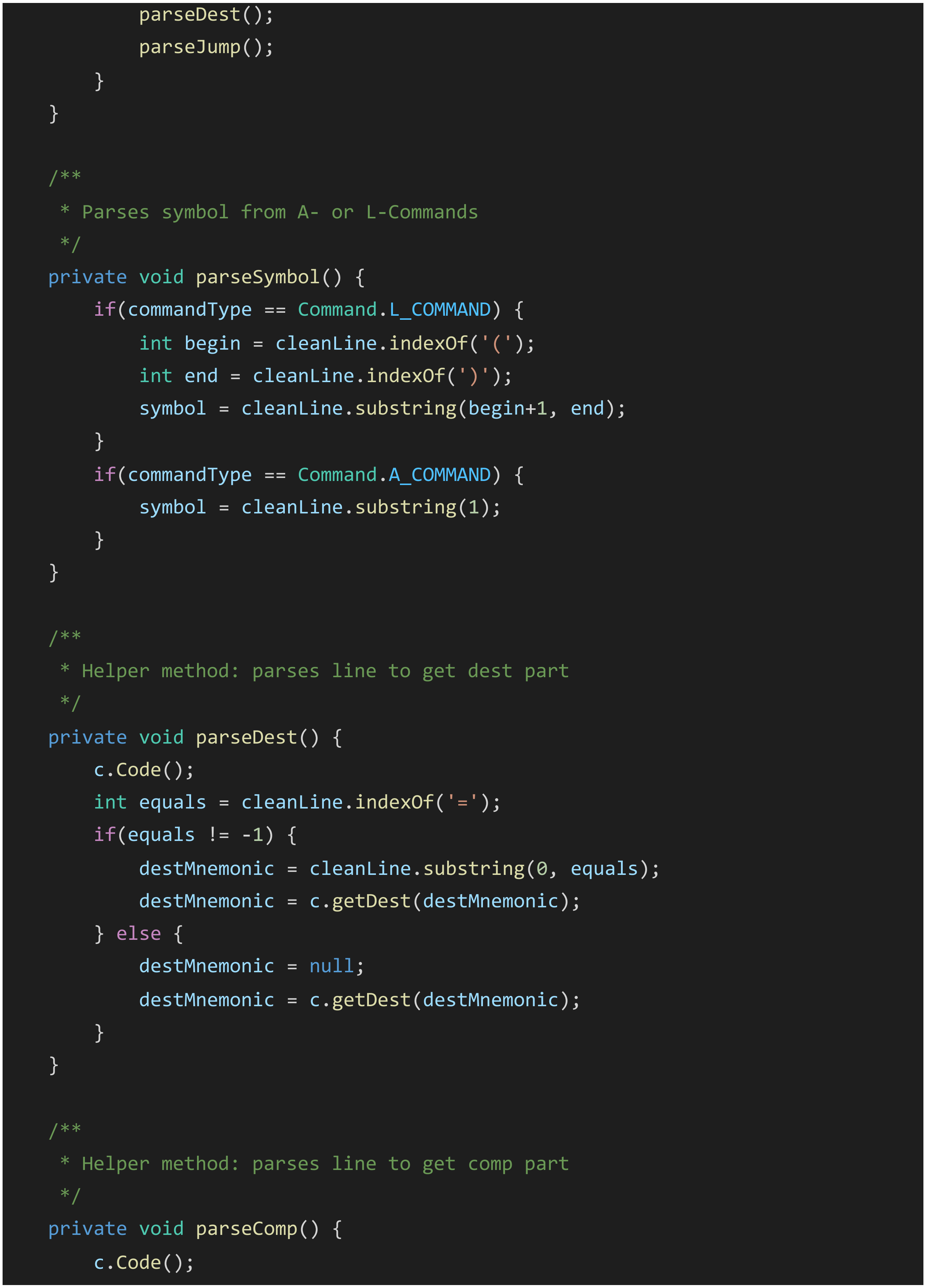
```java
/**
 * @author  Raul Aguilar
 * @date    October 16, 2020
 */

 import java.io.*;
 import java.util.Scanner;

 public class Parser {

    private Scanner inputFile;
    private int lineNumber;
    private String rawLine;

    private String cleanLine;
    private Command commandType;
    private String symbol;
    private String destMnemonic;
    private String compMnemonic;
    private String jumpMnemonic;

    private Code c = new Code();
    Command command;

    /**
     * Opens input file and prepares to parse
     * If file cannot be found ends program with error message
     * @param inFileName
     */
    public void Parser(String inFileName) {
        try {
            inputFile = new Scanner(new FileReader(inFileName));
        } catch (FileNotFoundException e) {
            System.out.println("File could not be found. Ending program.");
            System.exit(0);
        }
    }
```



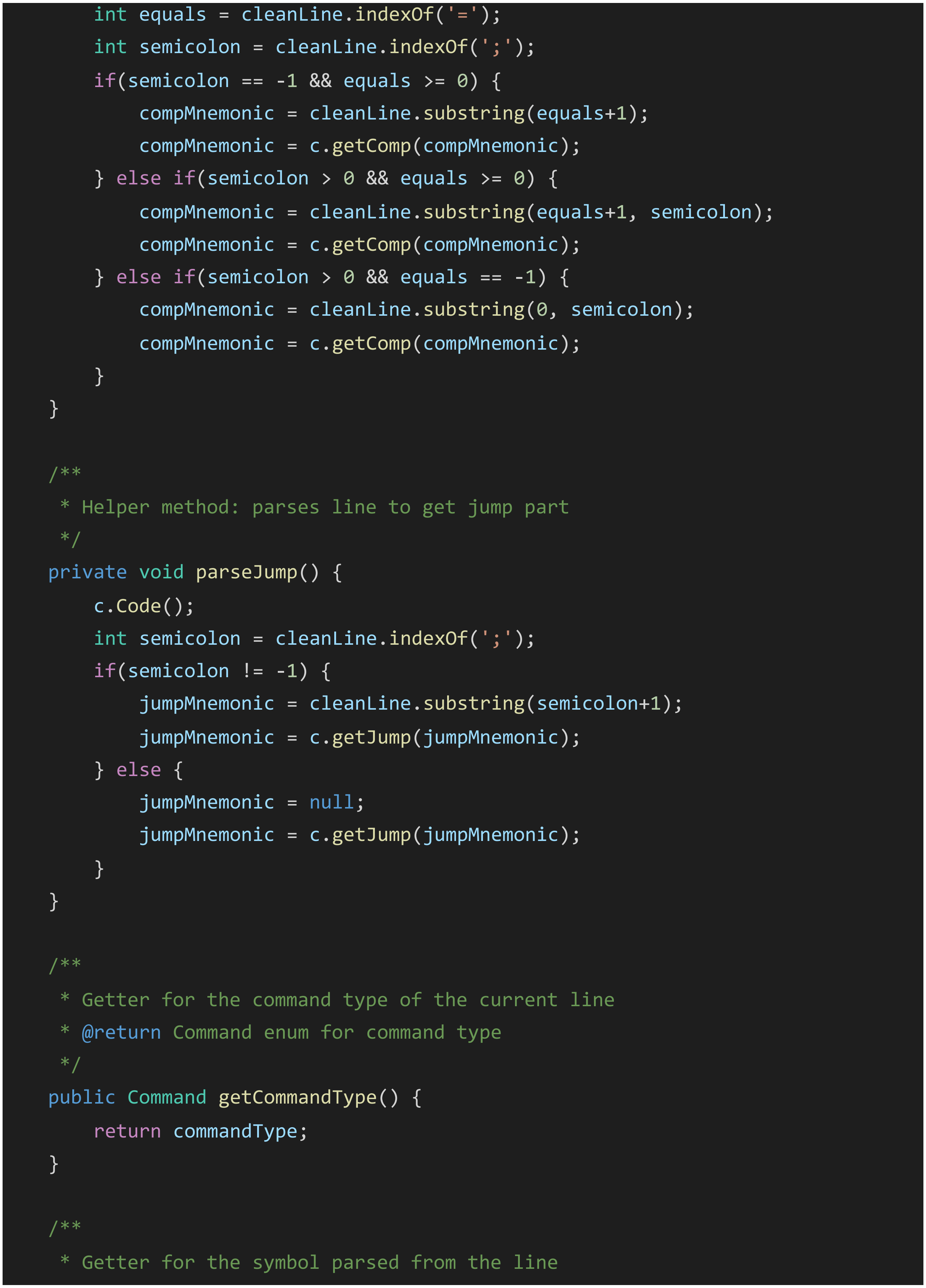
```
/**
 * Returns boolean if more commands left, closes stream if not
 * @return True if more commands, else closes stream
 */
public boolean hasMoreCommands() {
    if(inputFile.hasNextLine()) {
        return true;
    } else {
        inputFile.close();
        return false;
    }
}

/**
 * Reads the next command from the input and makes it the
 * current command.
 * Should only be called if hasMoreCommands() is true.
 * Initially there is no current command.
 */
public void advance() {
    lineNumber++;
    rawLine = inputFile.nextLine();
    cleanLine();
    parseCommandType();
    parse();
}

/**
 * Reads raw line from file and strips it of whitespace
 * and comments
 */
private void cleanLine() {
    int commentIndex;

    if(rawLine == null) {
        cleanLine = "";
    } else {
        // remove whitespace
```



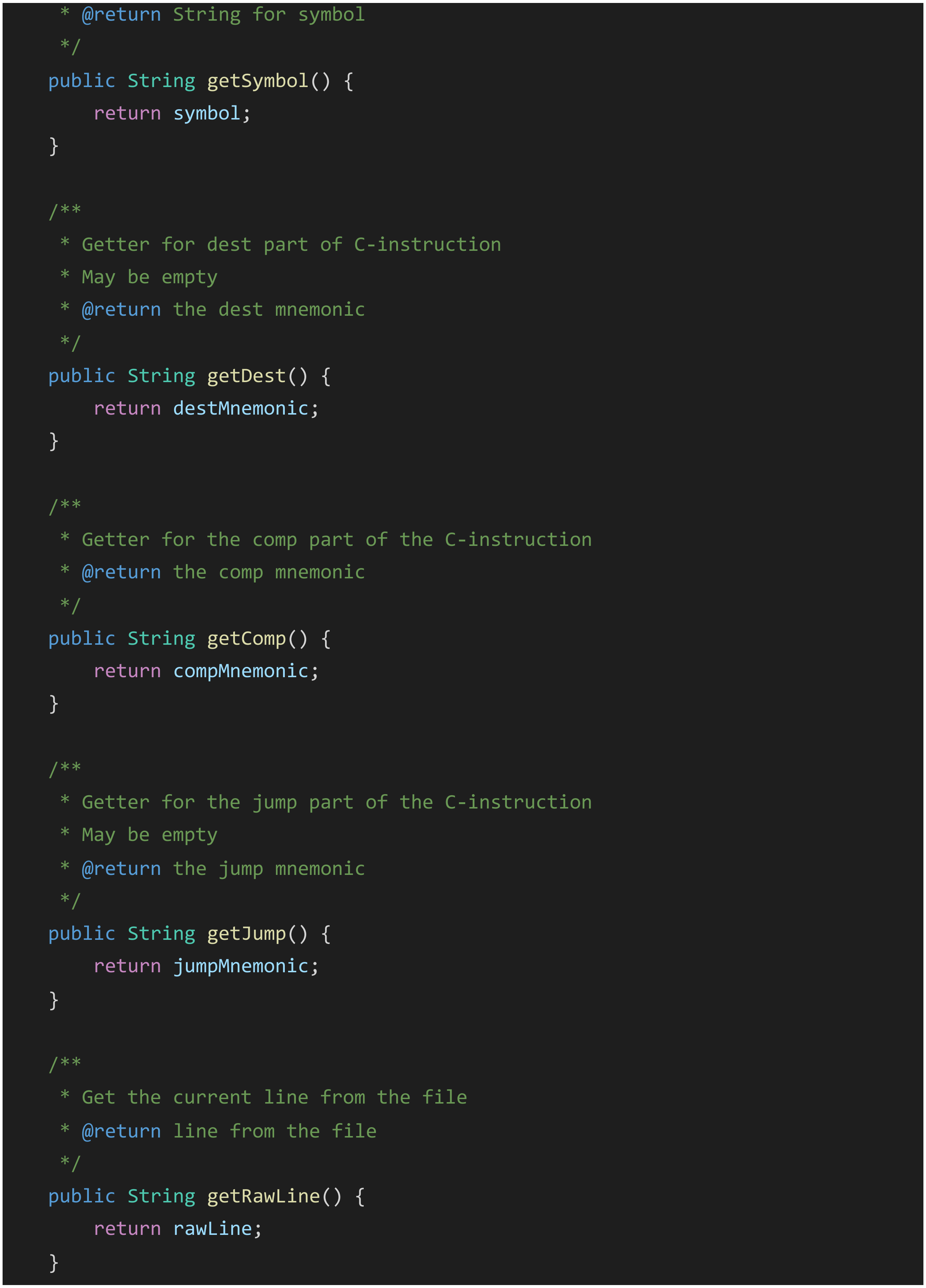
```
            cleanLine = rawLine.replaceAll(" ", "");
            cleanLine = cleanLine.replaceAll("\t", "");

            //remove comments
            commentIndex = cleanLine.indexOf("/");
            if(commentIndex != -1) {
                cleanLine = cleanLine.substring(0, commentIndex);
            }
        }
    }

    /**
     * Guesses which command type it is from clean line
     */
    private void parseCommandType() {
        if(cleanLine == null || cleanLine.length() == 0) {
            commandType = command.NO_COMMAND;
        } else {
            char first = cleanLine.charAt(0);
            if(first == '(') {
                commandType = Command.L_COMMAND;
            } else if(first == '@') {
                commandType = Command.A_COMMAND;
            } else {
                commandType = Command.C_COMMAND;
            }
        }
    }

    /**
     * Helper method: parses line depending on instruction type
     * Appropriate parts of instruction filled
     */
    private void parse() {
        if(commandType == Command.L_COMMAND || commandType == Command.A_COMMAND)
{
            parseSymbol();
        } else if(commandType == Command.C_COMMAND) {
            parseComp();
```



```java
            parseDest();
            parseJump();
        }
    }

    /**
     * Parses symbol from A- or L-Commands
     */
    private void parseSymbol() {
        if(commandType == Command.L_COMMAND) {
            int begin = cleanLine.indexOf('(');
            int end = cleanLine.indexOf(')');
            symbol = cleanLine.substring(begin+1, end);
        }
        if(commandType == Command.A_COMMAND) {
            symbol = cleanLine.substring(1);
        }
    }

    /**
     * Helper method: parses line to get dest part
     */
    private void parseDest() {
        c.Code();
        int equals = cleanLine.indexOf('=');
        if(equals != -1) {
            destMnemonic = cleanLine.substring(0, equals);
            destMnemonic = c.getDest(destMnemonic);
        } else {
            destMnemonic = null;
            destMnemonic = c.getDest(destMnemonic);
        }
    }

    /**
     * Helper method: parses line to get comp part
     */
    private void parseComp() {
        c.Code();
```



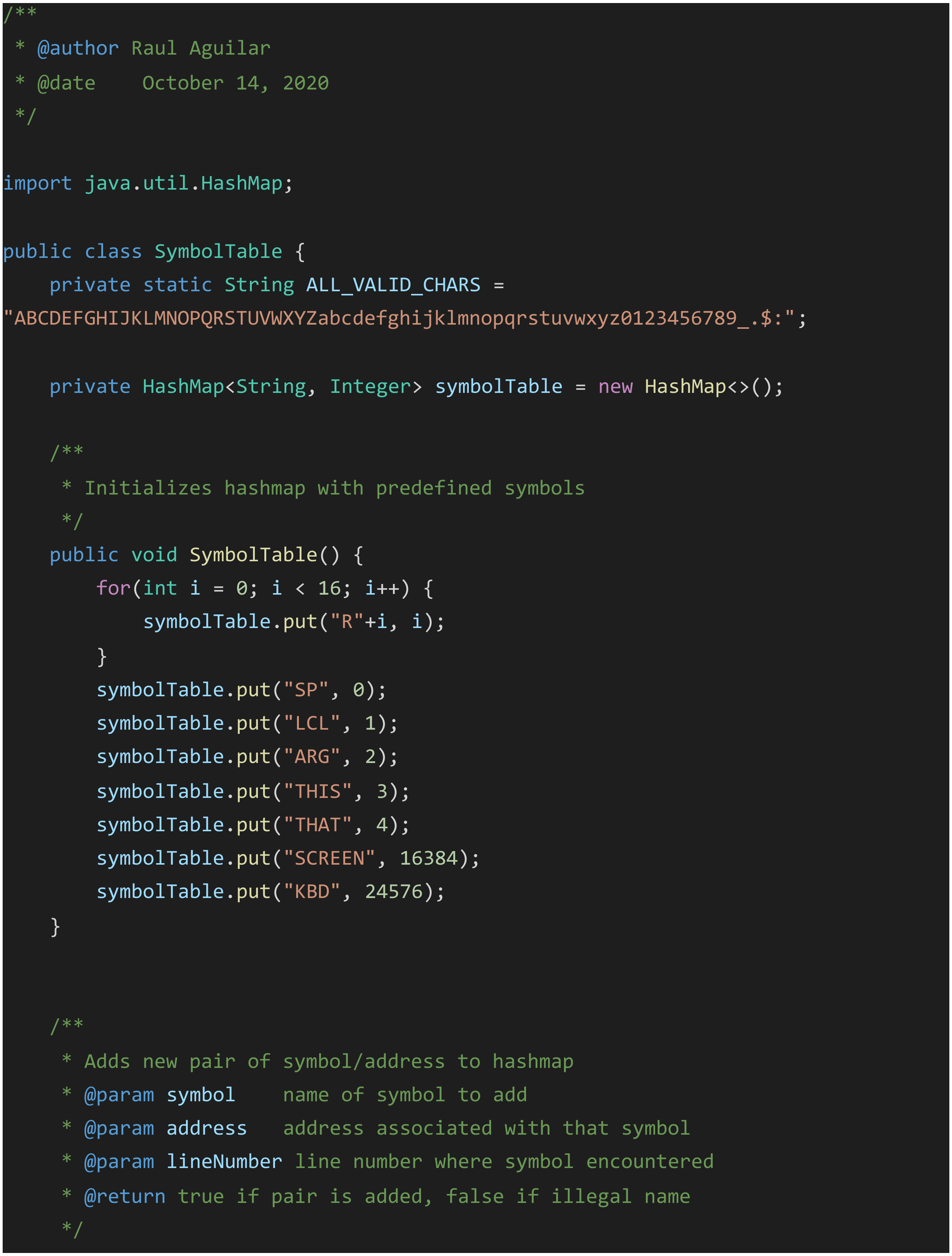
```java
        int equals = cleanLine.indexOf('=');
        int semicolon = cleanLine.indexOf(';');
        if(semicolon == -1 && equals >= 0) {
            compMnemonic = cleanLine.substring(equals+1);
            compMnemonic = c.getComp(compMnemonic);
        } else if(semicolon > 0 && equals >= 0) {
            compMnemonic = cleanLine.substring(equals+1, semicolon);
            compMnemonic = c.getComp(compMnemonic);
        } else if(semicolon > 0 && equals == -1) {
            compMnemonic = cleanLine.substring(0, semicolon);
            compMnemonic = c.getComp(compMnemonic);
        }
    }

    /**
     * Helper method: parses line to get jump part
     */
    private void parseJump() {
        c.Code();
        int semicolon = cleanLine.indexOf(';');
        if(semicolon != -1) {
            jumpMnemonic = cleanLine.substring(semicolon+1);
            jumpMnemonic = c.getJump(jumpMnemonic);
        } else {
            jumpMnemonic = null;
            jumpMnemonic = c.getJump(jumpMnemonic);
        }
    }

    /**
     * Getter for the command type of the current line
     * @return Command enum for command type
     */
    public Command getCommandType() {
        return commandType;
    }

    /**
     * Getter for the symbol parsed from the line
```



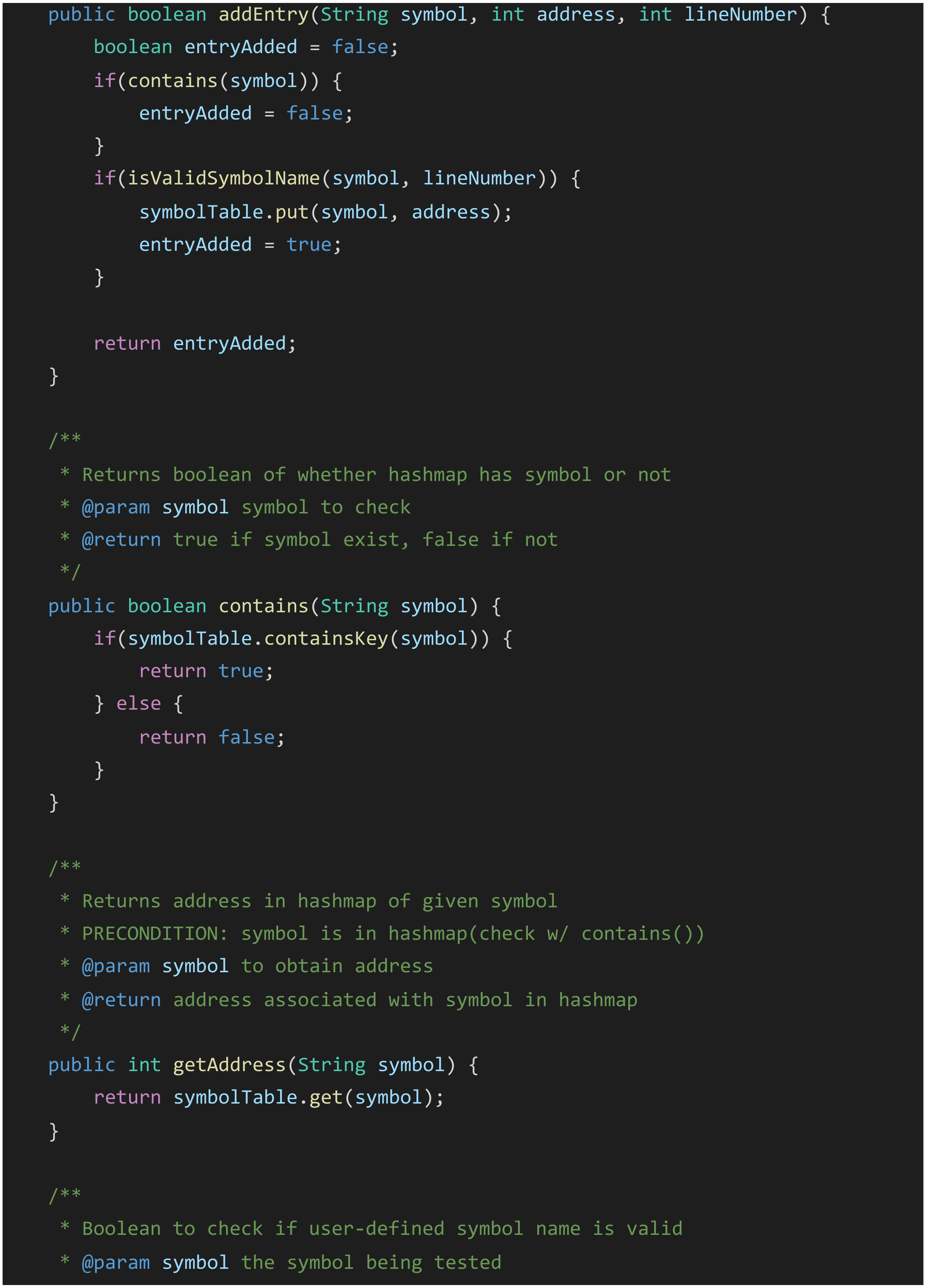
```
     * @return String for symbol
     */
    public String getSymbol() {
        return symbol;
    }

    /**
     * Getter for dest part of C-instruction
     * May be empty
     * @return the dest mnemonic
     */
    public String getDest() {
        return destMnemonic;
    }

    /**
     * Getter for the comp part of the C-instruction
     * @return the comp mnemonic
     */
    public String getComp() {
        return compMnemonic;
    }

    /**
     * Getter for the jump part of the C-instruction
     * May be empty
     * @return the jump mnemonic
     */
    public String getJump() {
        return jumpMnemonic;
    }

    /**
     * Get the current line from the file
     * @return line from the file
     */
    public String getRawLine() {
        return rawLine;
    }
```

```java
    /**
     * Get the clean version of the raw line
     * @return cleaned up line
     */
    public String getCleanLine() {
        return cleanLine;
    }

    /**
     * Get the line number of the symbol encountered
     * @return current line number
     */
    public int getLineNumber() {
        return lineNumber;
    }
}
```

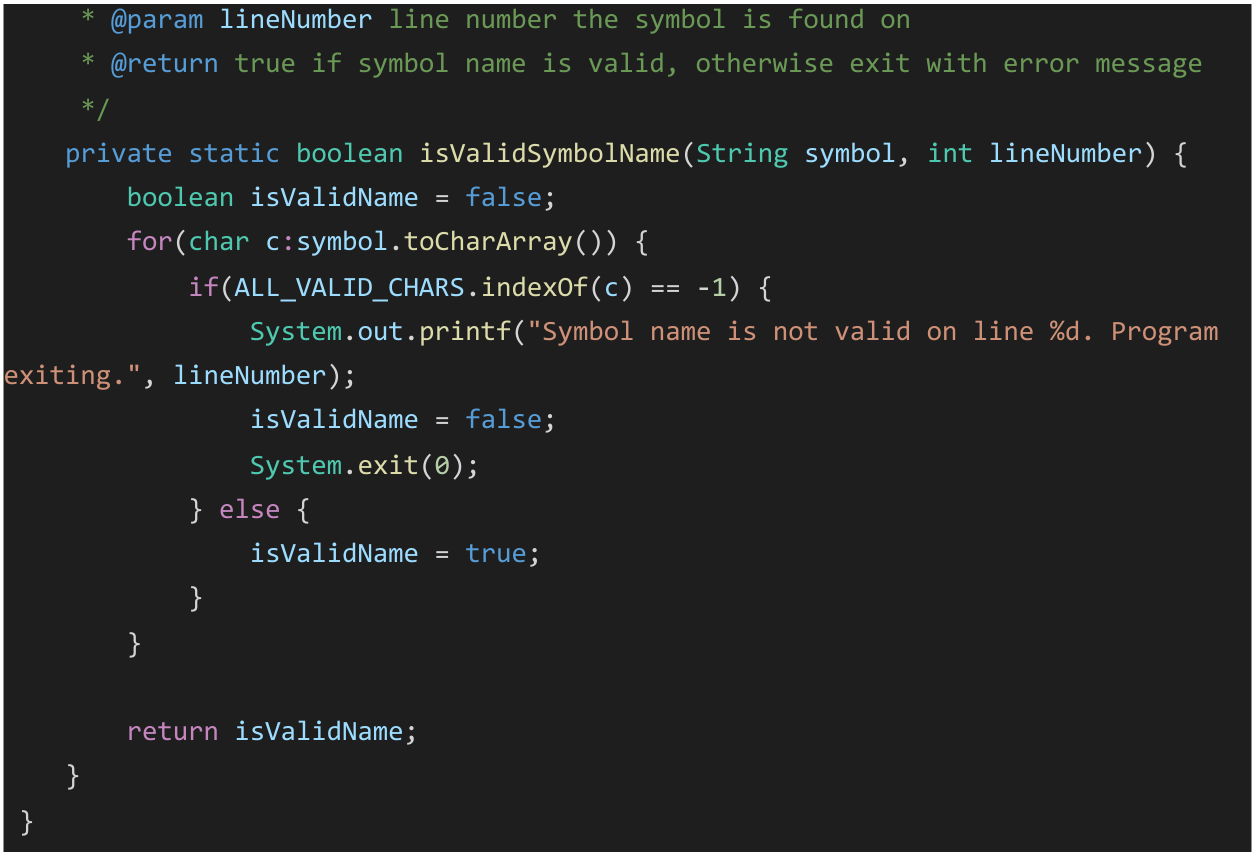
SymbolTable.java



```java
/**
 * @author Raul Aguilar
 * @date    October 14, 2020
 */

import java.util.HashMap;

public class SymbolTable {
    private static String ALL_VALID_CHARS =
"ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789_.$:";

    private HashMap<String, Integer> symbolTable = new HashMap<>();

    /**
     * Initializes hashmap with predefined symbols
     */
    public void SymbolTable() {
        for(int i = 0; i < 16; i++) {
            symbolTable.put("R"+i, i);
        }
        symbolTable.put("SP", 0);
        symbolTable.put("LCL", 1);
        symbolTable.put("ARG", 2);
        symbolTable.put("THIS", 3);
        symbolTable.put("THAT", 4);
        symbolTable.put("SCREEN", 16384);
        symbolTable.put("KBD", 24576);
    }


    /**
     * Adds new pair of symbol/address to hashmap
     * @param symbol     name of symbol to add
     * @param address    address associated with that symbol
     * @param lineNumber line number where symbol encountered
     * @return true if pair is added, false if illegal name
     */
```

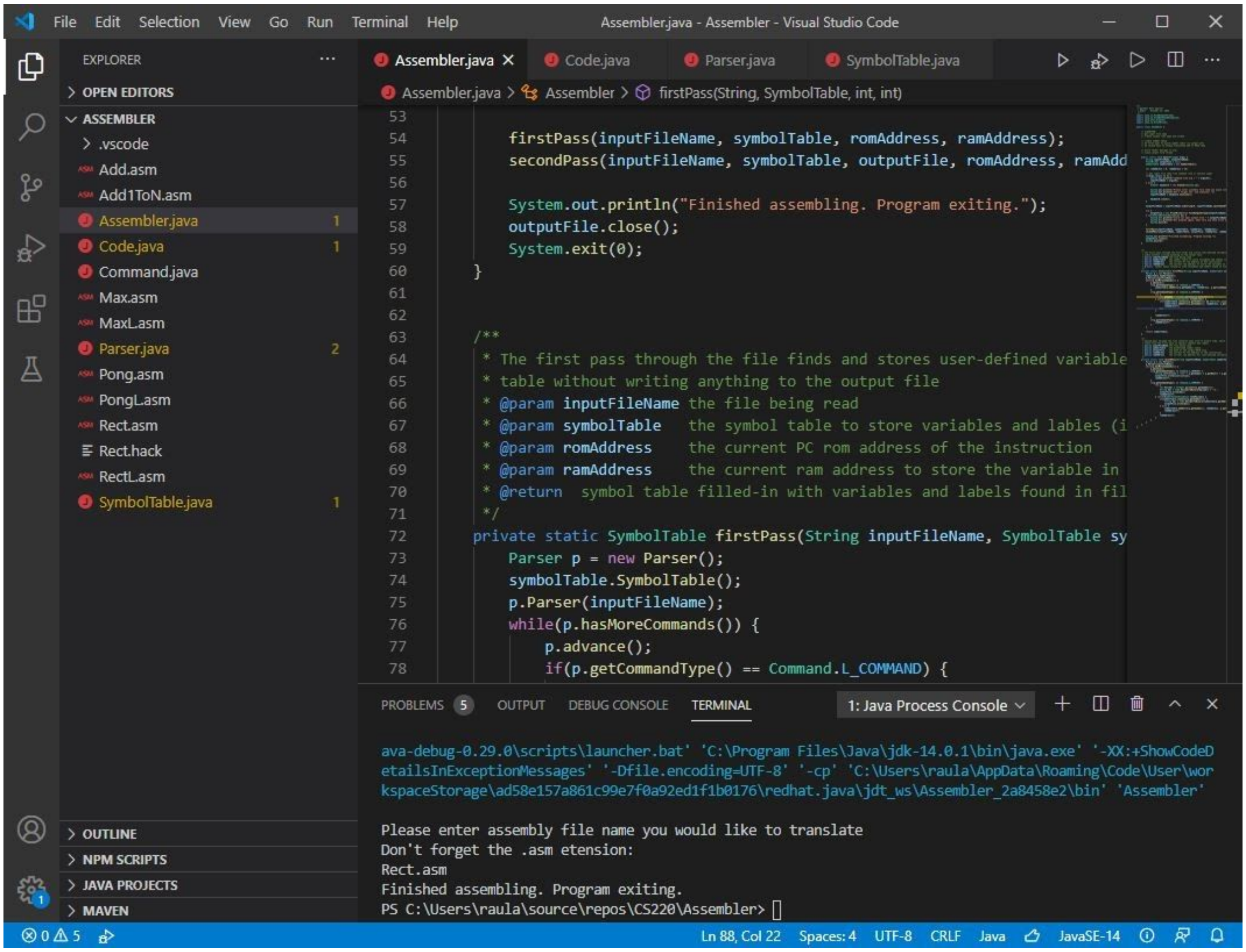


```java
    public boolean addEntry(String symbol, int address, int lineNumber) {
        boolean entryAdded = false;
        if(contains(symbol)) {
            entryAdded = false;
        }
        if(isValidSymbolName(symbol, lineNumber)) {
            symbolTable.put(symbol, address);
            entryAdded = true;
        }

        return entryAdded;
    }

    /**
     * Returns boolean of whether hashmap has symbol or not
     * @param symbol symbol to check
     * @return true if symbol exist, false if not
     */
    public boolean contains(String symbol) {
        if(symbolTable.containsKey(symbol)) {
            return true;
        } else {
            return false;
        }
    }

    /**
     * Returns address in hashmap of given symbol
     * PRECONDITION: symbol is in hashmap(check w/ contains())
     * @param symbol to obtain address
     * @return address associated with symbol in hashmap
     */
    public int getAddress(String symbol) {
        return symbolTable.get(symbol);
    }

    /**
     * Boolean to check if user-defined symbol name is valid
     * @param symbol the symbol being tested
```



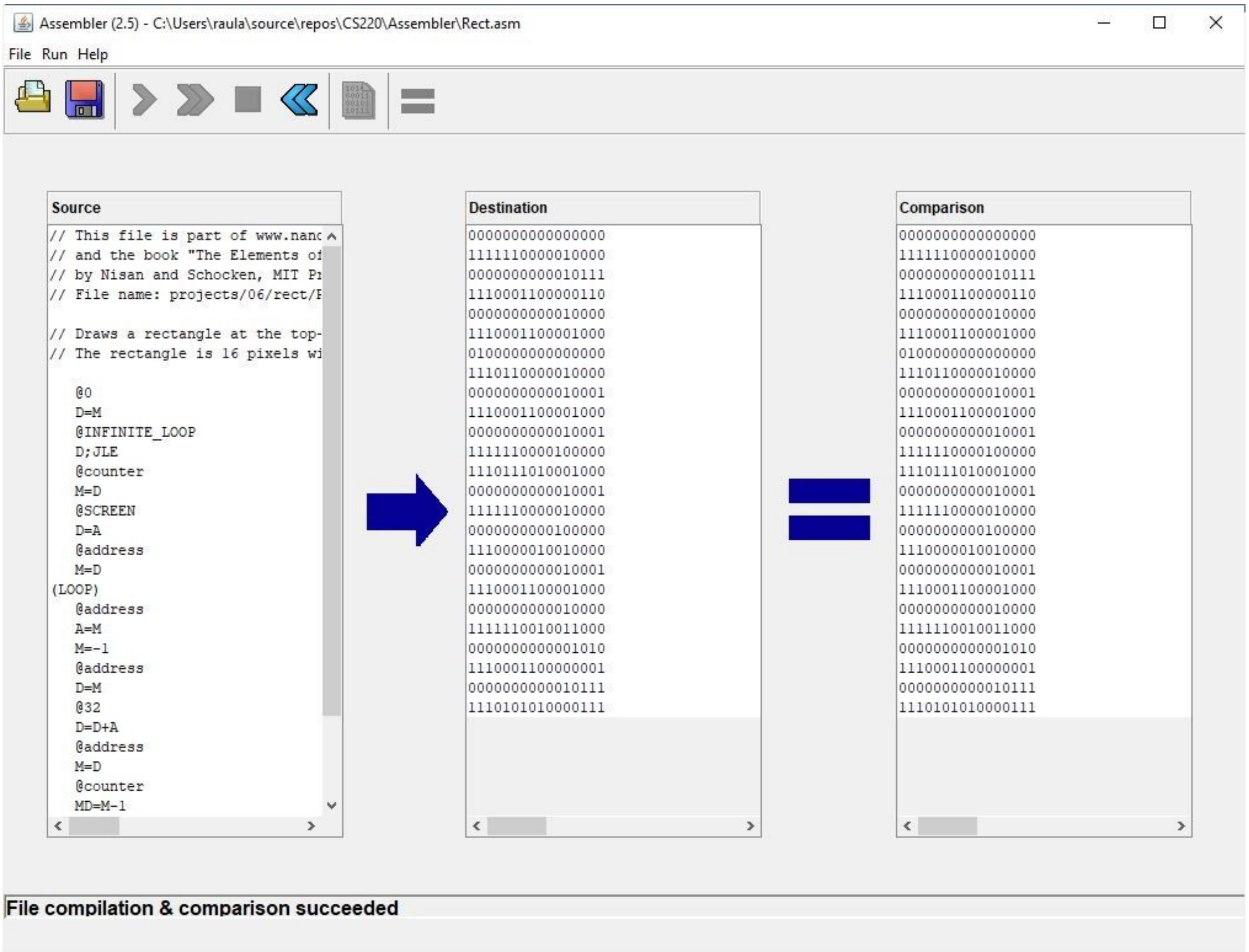
```java
     * @param lineNumber line number the symbol is found on
     * @return true if symbol name is valid, otherwise exit with error message
     */
    private static boolean isValidSymbolName(String symbol, int lineNumber) {
        boolean isValidName = false;
        for(char c:symbol.toCharArray()) {
            if(ALL_VALID_CHARS.indexOf(c) == -1) {
                System.out.printf("Symbol name is not valid on line %d. Program exiting.", lineNumber);
                isValidName = false;
                System.exit(0);
            } else {
                isValidName = true;
            }
        }

        return isValidName;
    }
 }
```

Rect.asm



```java

        firstPass(inputFileName, symbolTable, romAddress, ramAddress);
        secondPass(inputFileName, symbolTable, outputFile, romAddress, ramAdd

        System.out.println("Finished assembling. Program exiting.");
        outputFile.close();
        System.exit(0);
    }


    /**
     * The first pass through the file finds and stores user-defined variable
     * table without writing anything to the output file
     * @param inputFileName the file being read
     * @param symbolTable   the symbol table to store variables and lables (i
     * @param romAddress    the current PC rom address of the instruction
     * @param ramAddress    the current ram address to store the variable in
     * @return  symbol table filled-in with variables and labels found in fil
     */
    private static SymbolTable firstPass(String inputFileName, SymbolTable sy
        Parser p = new Parser();
        symbolTable.SymbolTable();
        p.Parser(inputFileName);
        while(p.hasMoreCommands()) {
            p.advance();
            if(p.getCommandType() == Command.L_COMMAND) {
```

```
ava-debug-0.29.0\scripts\launcher.bat' 'C:\Program Files\Java\jdk-14.0.1\bin\java.exe' '-XX:+ShowCodeD
etailsInExceptionMessages' '-Dfile.encoding=UTF-8' '-cp' 'C:\Users\raula\AppData\Roaming\Code\User\wor
kspaceStorage\ad58e157a861c99e7f0a92ed1f1b0176\redhat.java\jdt_ws\Assembler_2a8458e2\bin' 'Assembler'

Please enter assembly file name you would like to translate
Don't forget the .asm etension:
Rect.asm
Finished assembling. Program exiting.
PS C:\Users\raula\source\repos\CS220\Assembler> 
```


Assembler (2.5) - C:\Users\raula\source\repos\CS220\Assembler\Rect.asm
File
Run
Help
Source
Destination
Comparison

```
// This file is part of www.nanc
// and the book "The Elements of
// by Nisan and Schocken, MIT Pr
// File name: projects/06/rect/F

// Draws a rectangle at the top-
// The rectangle is 16 pixels wi

   @0
   D=M
   @INFINITE_LOOP
   D;JLE
   @counter
   M=D
   @SCREEN
   D=A
   @address
   M=D
(LOOP)
   @address
   A=M
   M=-1
   @address
   D=M
   @32
   D=D+A
   @address
   M=D
   @counter
   MD=M-1
```

```
0000000000000000
1111110000010000
0000000000010111
1110001100000110
0000000000010000
1110001100001000
0100000000000000
1110110000010000
0000000000010001
1110001100001000
0000000000010001
1111110000100000
1110111010001000
0000000000010001
1111110000010000
0000000000100000
1110000010010000
0000000000010001
1110001100001000
0000000000010000
1111110010011000
0000000000001010
1110001100000001
0000000000010111
1110101010000111
```

```
0000000000000000
1111110000010000
0000000000010111
1110001100000110
0000000000010000
1110001100001000
0100000000000000
1110110000010000
0000000000010001
1110001100001000
0000000000010001
1111110000100000
1110111010001000
0000000000010001
1111110000010000
0000000000100000
1110000010010000
0000000000010001
1110001100001000
0000000000010000
1111110010011000
0000000000001010
1110001100000001
0000000000010111
1110101010000111
```

File compilation & comparison succeeded