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One Pass Assembler

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System Programming Assignment

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Chapter 1

Introduction

An assembler is a translator that translates an assembler program into a conventional machine language program. Basically, the assembler goes through the program one line at a time, and generates machine code for that instruction. Then the assembler proceeds to the next instruction. In this way, the entire machine code program is created.

In one-pass assemblers, it generates the object code in memory for immediate execution. No object program is written out, and no loader is needed. This kind of load-and-go assembler is useful in a system that is oriented toward program development and testing. Because programs are re-assembled nearly every time they are run, the efficiency of the assembly process is an important consideration. A load-and-go assembler avoids the overhead of writing the object program out and reading it back in. However, a one-pass assembler also avoids the overhead of an additional pass over the source program. Because the object program is produced in memory rather than being written out on secondary storage, the handling of forward references becomes less difficult.

1.1 Problem Statement

The one pass assembler needs to scan the program only once and create the equivalent object code. The biggest challenge is to tackle the forward referencing problem. We face this problem when either the label or variable in operand is not declared before that statement. The assembler simply generates object code instructions as it scans the source program. If an instruction operand is a symbol that has not yet been defined, the operand address is omitted when the instruction is assembled. The symbol used as an operand is entered into the symbol table (unless such an entry is already present). This entry is flagged to indicate that the symbol is undefined. The address of the operand field of the instruction that refers to the undefined symbol is added to a list of forward references associated with the symbol table entry. When the definition for a symbol is encountered, the forward reference list for that symbol is scanned (if one exists), and the proper address is inserted into any instructions previously generated.

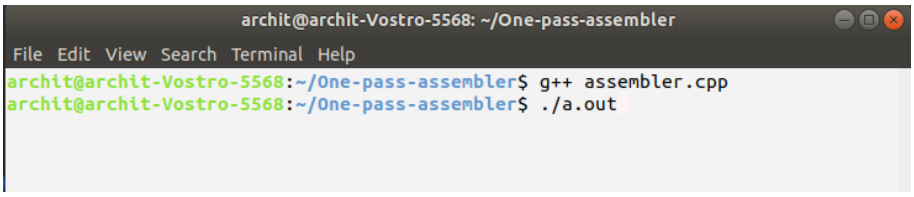
Chapter 2

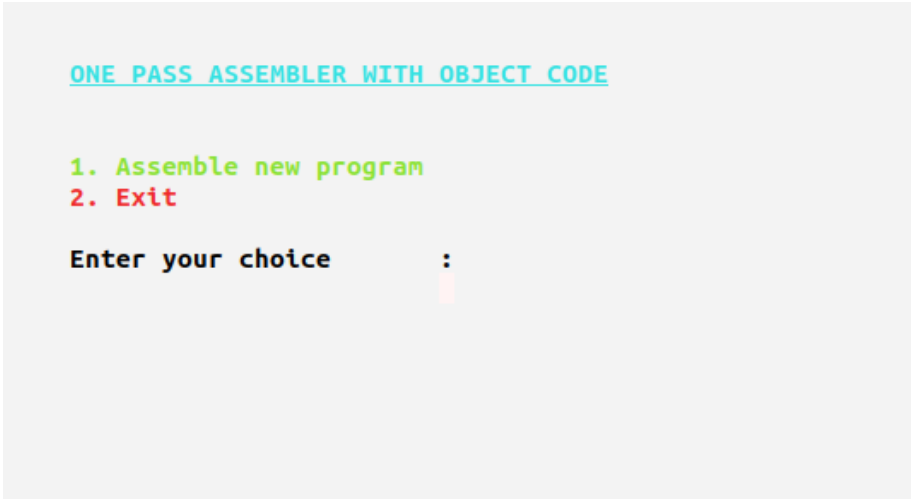
How to Compile

It is required to implement the One Pass assembler that generates object code written in C++ code.

Steps to Compile and execute the program:

1. *Use compilers of c++ 11 and above.*
2. In folder One-pass-assembler, open the terminal and run following commands:
   (a) g++ assembler.cpp
   (b) ./a.out





3. Enter you choice, source file name and file name where Object code will be stored

```
ONE PASS ASSEMBLER WITH OBJECT CODE


1. Assemble new program
2. Exit

Enter your choice       :
                        1

Source File Name  :  InputSourcePgm.txt
File name where Object Code will be stored  :  ObjectCode.txt
```

4. After entering above details. Select your choice in next window to display : Source code, OPTAB, object code

```
ONE PASS ASSEMBLER WITH OBJECT CODE


1. Display source code
2. Display OPTAB
3. Display object code
4. Return to Main

Enter your choice       :
```

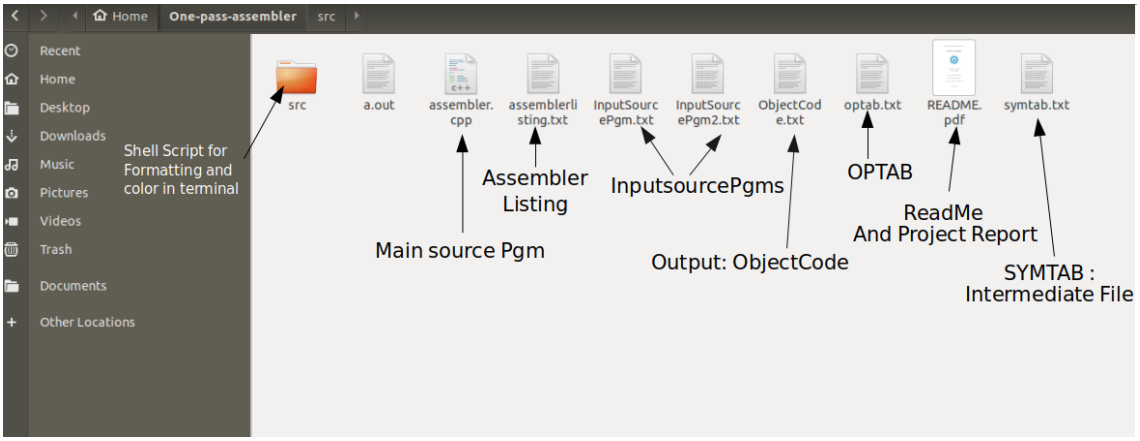
5. For Source Code:

```
================================================
COPY    START   1000
EOF     BYTE    C'EOF'
THREE   WORD    3
ZERO    WORD    0
RETADR  RESW    1
LENGTH  RESW    1
BUFFER  RESB    4096
FIRST   STL     RETADR
CLOOP   JSUB    RDREC
        LDA     LENGTH
        COMP    ZERO
        JEQ     ENDFIL
        JSUB    WRREC
        J       CLOOP
ENDFIL  LDA     EOF
        STA     BUFFER
        LDA     THREE
        STA     LENGTH
        JSUB    WRREC
        LDL     RETADR
        RSUB
.
.       SUBROUTINE TO READ RECORD INTO BUFFER
.
INPUT   BYTE    X'F1'
MAXLEN  WORD    4096
RDREC   LDX     ZERO
.
        LDA     ZERO
RLOOP   TD      INPUT
        JEQ     RLOOP
        RD      INPUT
        COMP    ZERO
        JEQ     EXIT
        STCH    BUFFER,X
        TIX     MAXLEN
        JLT     RLOOP
EXIT    STX     LENGTH
        RSUB
.
.       SUBROUTINE TO WRITE RECORD FROM BUFFER
.
OUTPUT  BYTE    X'05'
WRREC   LDX     ZERO
WLOOP   TD      OUTPUT
        JEQ     WLOOP
        LDCH    BUFFER,X
        WD      OUTPUT
        TIX     LENGTH
        JLT     WLOOP
        RSUB
        END     FIRST

================================================
```

6. Object Code :

```
ONE PASS ASSEMBLER WITH OBJECT CODE


1. Display source code
2. Display OPTAB
3. Display object code
4. Return to Main

Enter your choice       :
                        3

================================================
H^COPY  001000^00107A
T^001000^09^454F4F^000003^000000
T^00200F^15^141009^480000^00100C^281006^300000^480000^3C2012
T^00201C^02^2024
T^002024^19^001000^0C100F^001003^0C100C^480000^081009^4C0000^F1^001000
T^002013^02^203D
T^00203D^1E^041006^001006^E02039^302043^D82039^281006^300000^54900F^2C203A^382043
T^002050^02^205B
T^00205B^07^10100C^4C0000^05
T^00201F^02^2062
T^002031^02^2062
T^002062^18^041006^E02061^302065^50900F^DC2061^2C100C^382065^4C0000
E^00200F

================================================
```

7. .zip file view



Chapter 3

Design & Data Structures

3.1 Design

The Design is consisting of 5 main modules(Control Unit-Parser-Address Convertors-OpTab-SymTab)

1. Control Unit:
   (a) Reading and storing the InputSourceFile and sending it to parser and store tokens in vector.
   (b) Assigning Address using LOCCTR.
   (c) Storing Symbol Table, Records and Opcode in map (Hash).
   (d) Write the symbol table and object code in file.
2. Parser:
   This Module is reponsible of parsing an instruction line into tokens(Labels, Opcode, Operands).
3. Address Convertors:
   They are responsible for converting hecToDec, hexToBin and decToHex addresses.
4. OpTab:
   It store opcodes in map
5. SymTab:
   It store symbols in map and while execution symbols are stored in this table and whenever required search the symbols and also used to validate the program.

3.2 Data Structure

In this assembler various Data Structure used like Map, List and Vector to implement OPTAB, SYMTAB, Records, LOCCTR
Following Data Structure are implemented as given below:

OPTAB

1. OPTAB implemented as map$< string, string >$
2. In this key and value is stored as string.

SYMTAB

1. SYMTAB implemented as map$map < string, pair < int, list < int >>>$
2. In this key is stored as string.
3. In pair$< int, list < int >>$ LOCCTR(address) value of symbol and address of undefined symbol is added into list of forward references associated with symbol table entry.

Records

1. Records implemented as map$< int, pair < int, vector < string >>>$
2. In this it stores text record entries of object code.
3. In key it store record number and in vector$< string >$ it stores object codes.

LOCCTR

1. LOOCTR is implemented as integer and containing Decimal value of Locations(Hexadecimal).

Chapter 4

Algorithm

One-pass assemblers that produce object programs follow a slightly different procedure. Forward references are entered into lists as before. Now, however, when the definition of a symbol is encountered, instructions that made forward references to that symbol may no longer be available in memory for modification. In general, they will already have been written out as part of a Text record in the object program. In this case the assembler must generate another Text record with the correct operand address. When the program is loaded, this address will be inserted into the instruction by the action of the loader

Algorithm to implement this assembler is as follows:

```
begin
  read first input line {from intermediate file}
  if OPCODE = 'START' then
     begin
        write listing line
        read next input line
     end {if START}
  write Header record to object program
  initialize first Text record
```

cont'd

```
while opcode != 'End' do
begin
        if there is no conmment line then
        begin
                if there is a symbol in the LABEL field then
                begin
                        search SYMTAB for LABEL
                        if found then
                        begin
                                if <symbol value> as null
                                set <symbol value> as LOCCTR and search
                                        the linked list with corresponding
                                        operand
                                PTR addresses and generate operand
                                        addresses as corresponding symbol
                                        values
                                set symbol value as LOCCTR in symbol table
                                        and delete  the linked list
                        end
                        else
                                insert (LABEL,LOCCTR) into symtab

                end
                search OPTAB for OPCODE
                if found then
                begin
                        search SYMTAB for OPERAND addresses
                        if found then
                                if symbol value not equal to null then
                                        store symbol value as OPERAND address
                                else
                                        insert at the end of the linked list
                                        with a node with address as LOCCTR
                        else
                                insert (symbol name,null)
                        LOCCTR+=3
                end
                else if OPCODE='WORD' then
                        add 3 to LOCCTR and convert comment to object code
                else if OPCODE='RESW' then
                        add 3 #[OPERAND] to LOCCTR
                else if OPCODE='RESB' then
                        add #[OPERAND] to LOCCTR
                else if OPCODE='Byte' then
                begin
                        find the length of constant in bytes
                        add length to LOCCTR
                        convert constant to object code
                end
                if object code will not fit into current text record then
                begin
                        write text record to object program initialize new Text record
                end
                add object code to Text record
        end
        write listing line
        read next input line
end
write last Text recordto object program
write End record to object program
write last listing line
```

Chapter 5

References

Leland L. Beck, D. Manjula, System software: An introduction to systems programming, Pearson education, 3 rd ed, 2007.