CS 222: Assembler Phase#1

Due on Sunday, May 18, 2014

Contents

Requirements Specification

The term project is to implement a (cross) assembler for (a subset of) SIC/XE assembler, written in C/C++, producing code for the absolute loader used in the SIC/XE programming assignments. In phase 1 of the project, it is required to implement Pass1 of the assembler. The output of this phase should be used as input for subsequent phases.

1. The pass1 is to execute by entering pass1 <source-file-name>
2. The source file for the main program for this phase is to be named "*pass1.c*".
3. You should build a parser that is capable of handling source lines that are instructions, storage declaration, comments, and assembler directives (a directive that is not implemented should be ignored possibly with a warning)
   (a) For instructions, the parser is to minimally be capable of decoding 2, 3 and 4-byte instructions as follows:
      i. 2-byte with 1 or 2 symbolic register reference (e.g., TIXR A, ADDR S,A)
      ii. RSUB (ignoring any operand or perhaps issuing a warning.)
      iii. 3-byte PC-relative with symbolic operand to include immediate, indirect, and indexed addressing.
      iv. 3-byte absolute with non-symbolic operand to include immediate, indirect, and indexed addressing.
      v. 4-byte absolute with symbolic or non-symbolic operand to include immediate, indirect, and indexed addressing.
   (b) The parser is to handle all storage directives (BYTE, WORD, RESW, and RESB).
4. The output of this phase should contain (at least):
   (a) The symbol table.
   (b) The source program in a format similar to the listing file described in your text book except that the object code is not generated as shown below. A meaningful error message is printed below the line in which the error occurred.

Design

The Design is consisting of 4 main modules (Control Unit-Parser-Validator-HashTable):

1. *ControlUnit*: This module is responsible of the following:
   (a) Reading the operations file, and storing the operations in a *HashTable*.
   (b) Reading the file line by line, and sending it to the *Parser*, then sending the parsed line (if it's not a comment..etc) to the *Validator*.
   (c) Assigning addresses to the instructions based on the response of the *Validator* concerning the instruction's size.
   (d) Writing a new formated source file with addresses of each instruction.
   (e) Writing the symbol table based on the *HashTable* created in the *Validator*.
2. *Parser*: This module is responsible of parsing an instruction line to its components(label, operation, and operand).

3. *Validator*: This module is responsible of validating an instruction line, and generally do the following:
   (a) Checking the syntax of the *operation* field (e.g. LDA from LDZ).
   (b) Assigning addresses to the instructions and labels.
   (c) Storing the symbols in a *HashTable* with their assigned addresses.
4. *HashTable*: This module is a general-purpose mapping module that can handle any type of <Key, Value> pairs. This module is used twice in this phase: In Operation Table, and Symbol Table.

Main Data Structures

The following data structures are used:

- Handmade Hashtable.
- Vector.

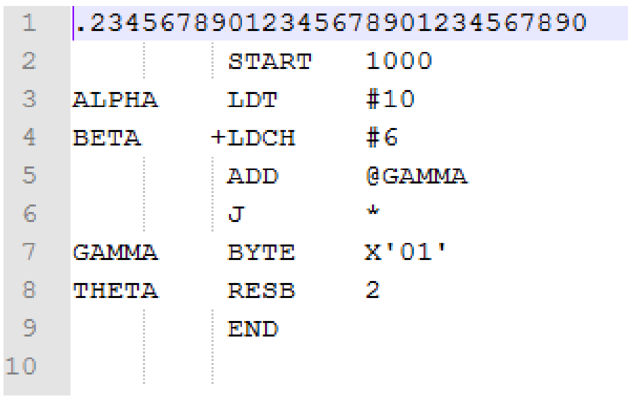
Algorithms Description

- Algorithm in *Parser*:
  1. Splitting the line by space into a vector of strings.
  2. Checking for comments and check for "RSUB."
  3. If it is neither a comment nor RSUB then,
  4. check for existance of comma ',' at the operand field.
  5. If a comma is not found then the operand field can be detected and operation field can be deteced, then checking if the statement has a label or not.
  6. Else if a comma is found, then specify its type i. Avaliable types are:
     (a) "STR,X"
     (b) "STR(space(s)),X"
     (c) "STR,(space(s))X"
     (d) "STR(space(s)),(space(s))X"
  7. For every type there's exist a method to find its operand, operation, and label if exists.
- Methods in *Validator*:
  - checkSyntax (label, operation, operand):
    1. If the instruction contains a label, then check if the label is valid using the appropriate method.
    2. If the label is correct then it will check if the operation is valid, if it is found in the operationTable then it is valid, if not then it is not valid, if the information is valid then it will get all the information and check if it is valid.
    3. If the instruction is valid then it will check its operand and index modes.
  - isValid(): This method is used by the controller to check if the instruction is valid.
  - getAddress(): This method is used to get a string containing the error(empty string if the instruction is valid).
  - checkLabelSyntax(): This method is used to check if the label name is valid.
  - checkOpernadSyntax(): To check if the operand name is valid.
  - checkDirectiveOpernadSyntax(): If the operation is a directive word this method is used to check if it's correct.

Assumptions

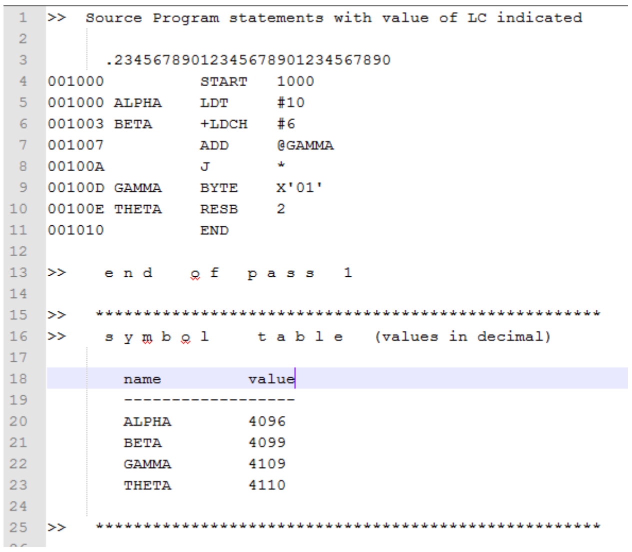
- Assumptions in *Parser*:
  1. No operation other than RSUB takes no operand else it works with standard format of SIC/XE.
  2. Free format is allowed when leaving any number of spaces between the label and operation or between opearation and operand.
  3. Free format will be allowed when entering two registers separated by comma at oprand field and all kinds of this case are handeled.
  4. A comment-line always starts (possible after some blank spaces) with ”.”
  5. If at any stage the splitted words were too much, then this line is invalid from *Parser*'s point of view.
- Assumptions in *Validator*:
  1. the label name can't start with a number, it must contain characters , it must not contain any valid characters like(@ ,# , + , * ....etc) ,and it can't be the name of instruction.
  2. Invalid index modes indexing can't be used with immediate or indirect addressing.
  3. The address next to the directive word(START) must be valid hexadecimal digit.
  4. The address can't be greater than (1048576) integer.
  5. In case of the directive *BYTE*:
     - If the operand start with (X) then it is a hexadecimal number and the number of the digit must be even number.
     - If the operand start with (C) then it is a string.
  6. If the instruction needs two register then the operand must be two valid registers.
  7. User can't define the label more than once.
  8. If the instruction is invalid then the address of this instruction will be the same as the previous instruction.
  9. If the user didn't specify the start of the program then it will be zero.

Sample Runs



```
.23456789012345678901234567890
          START   1000
ALPHA     LDT     #10
BETA     +LDCH    #6
          ADD     @GAMMA
          J       *
GAMMA     BYTE    X'01'
THETA     RESB    2
          END
```

Figure 1: Test 1

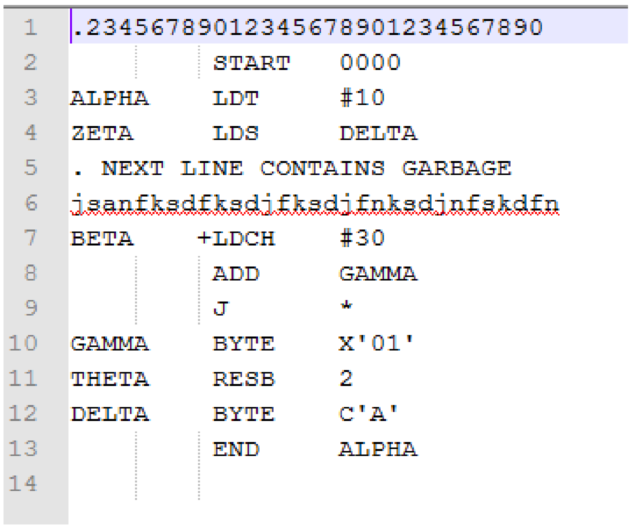


```
>>  Source Program statements with value of LC indicated

      .23456789012345678901234567890
001000          START   1000
001000 ALPHA    LDT     #10
001003 BETA     +LDCH   #6
001007          ADD     @GAMMA
00100A          J       *
00100D GAMMA    BYTE    X'01'
00100E THETA    RESB    2
001010          END

>>    e n d    o f   p a s s   1

>>   *****************************************************
>>    s y m b o l     t a b l e   (values in decimal)

        name         value
        -----------------
        ALPHA        4096
        BETA         4099
        GAMMA        4109
        THETA        4110

>>   *****************************************************
```

Figure 2: LISAFILE Test 1

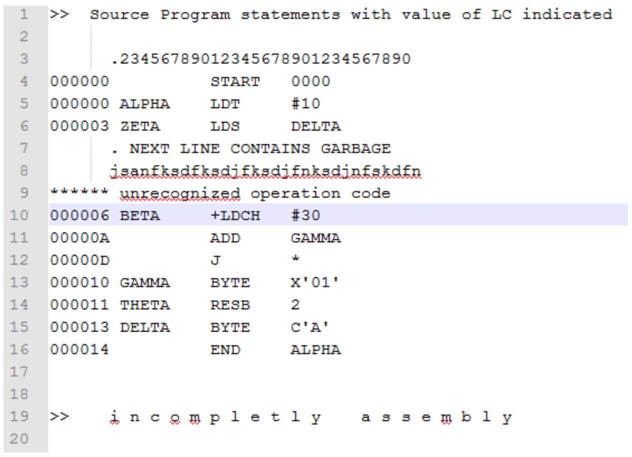
Work Division

- Mostafa Hamdy: He was responisble of implementing the *Validator* module.
- Waleed Adel: He was responsible of implementing the *Parser* module.
- Diaa Ibrahim: He was responsible of implementing the Control Unit Module.
- Abdallah Mahmoud: He was responsible of writting the operations table, and reading it.
- Mahmoud A.Gawad: He waas responsible of implementing the *Hashtable* module, and writing this report.



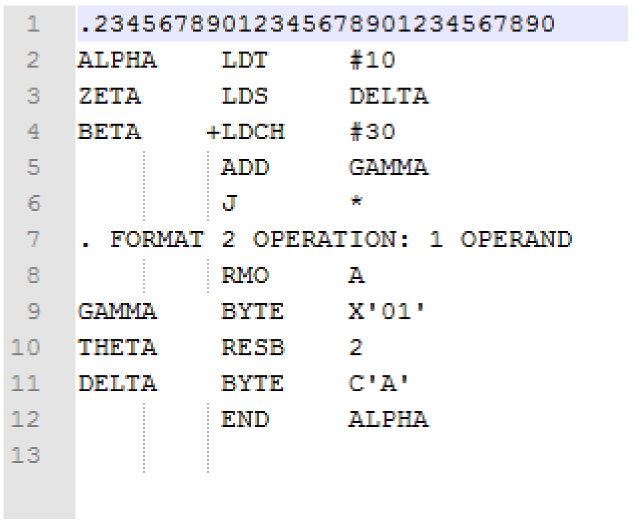
```
.234567890123456789012345678900
        START   0000
ALPHA   LDT     #10
ZETA    LDS     DELTA
. NEXT LINE CONTAINS GARBAGE
jsanfksdfksdjfksdjfnksdjnfskdfn
BETA   +LDCH    #30
        ADD     GAMMA
        J       *
GAMMA   BYTE    X'01'
THETA   RESB    2
DELTA   BYTE    C'A'
        END     ALPHA
```

Figure 3: Test 2



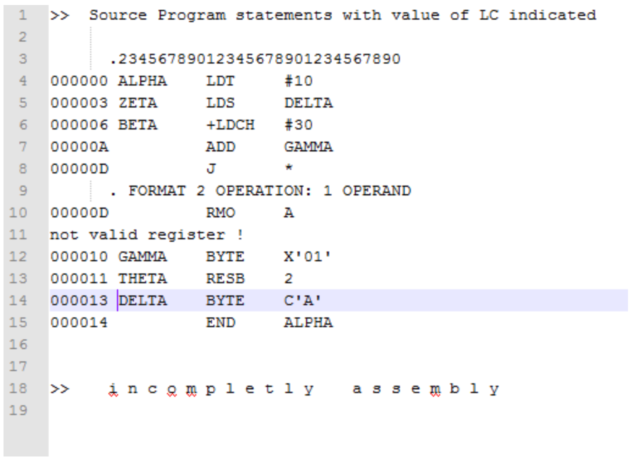
```
>>  Source Program statements with value of LC indicated

  .234567890123456789012345678900
000000          START   0000
000000 ALPHA    LDT     #10
000003 ZETA     LDS     DELTA
  . NEXT LINE CONTAINS GARBAGE
  jsanfksdfksdjfksdjfnksdjnfskdfn
****** unrecognized operation code
000006 BETA     +LDCH   #30
00000A          ADD     GAMMA
00000D          J       *
000010 GAMMA    BYTE    X'01'
000011 THETA    RESB    2
000013 DELTA    BYTE    C'A'
000014          END     ALPHA


>>   i n c o m p l e t l y   a s s e m b l y
```

Figure 4: LISAFILE Test 2



```
.234567890123456789012345678900
ALPHA   LDT     #10
ZETA    LDS     DELTA
BETA   +LDCH    #30
        ADD     GAMMA
        J       *
. FORMAT 2 OPERATION: 1 OPERAND
        RMO     A
GAMMA   BYTE    X'01'
THETA   RESB    2
DELTA   BYTE    C'A'
        END     ALPHA
```

Figure 5: Test 3



```
>>  Source Program statements with value of LC indicated

      .23456789012345678901234567890
000000 ALPHA    LDT     #10
000003 ZETA     LDS     DELTA
000006 BETA     +LDCH   #30
00000A          ADD     GAMMA
00000D          J       *
      . FORMAT 2 OPERATION: 1 OPERAND
00000D          RMO     A
not valid register !
000010 GAMMA    BYTE    X'01'
000011 THETA    RESB    2
000013 DELTA    BYTE    C'A'
000014          END     ALPHA


>>   i n c o m p l e t l y   a s s e m b l y
```

Figure 6: LISAFILE Test 3