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Internal Assessment Test 3 Answer Key– Jan. 2020									
Sub:	System Software					Sub Code:	18MCA34	Branch:	MCA
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Q1) What do you mean by macro? Explain macro definition and expansion, with suitable example [10]

Macro Definition and Expansion: The figure shows the MACRO expansion. The left block shows the MACRO definition and the right block shows the expanded macro replacing the MACRO call with its block of executable instruction.

M1 is a macro with two parameters D1 and D2. The MACRO stores the contents of register A in D1 and the contents of register B in D2. Later M1 is invoked with the parameters DATA1 and DATA2, Second time with DATA4 and DATA3. Every call of MACRO is expended with the executable statements.

Source

```
M1      MACRO    &D1, &D2
        STA      &D1
        STB      &D2
        MEND
   .
M1 DATA1, DATA2
   .
M1 DATA4, DATA3
```

Expanded source

```
   .
   .
   .
        STA      DATA1
        STB      DATA2
   .
        STA      DATA4
        STB      DATA3
   .
```

The statement M1 DATA1, DATA2 is a macro invocation statements that gives the name of the macro instruction being invoked and the arguments (M1 and M2) to be used in expanding. A macro invocation is referred as a Macro Call or Invocation.

The program with macros is supplied to the macro processor. Each macro invocation statement will be expanded into the statement s that form the body of the macro, with the arguments from the macro invocation substituted for the parameters in the macro prototype. During the expansion, the macro definition statements are deleted since they are no longer needed. The arguments and the parameters are associated with one another according to their positions. The first argument in the macro matches with the first parameter in the macro prototype and so on.

Q2) What are different Macro Processor Design options? Explain briefly [10]

1) Recursive Macro Expansion

We have seen an example of the definition of one macro instruction by another. But we have not dealt with the invocation of one macro by another.

The following example shows the invocation of one macro by another macro.

Problem of Recursive Expansion

Previous macro processor design cannot handle such kind of recursive macro invocation and expansion

The procedure EXPAND would be called recursively, thus the invocation arguments in the ARGTAB will be overwritten.

The Boolean variable EXPANDING would be set to FALSE when the "inner" macro expansion is finished, i.e., the macro process would forget that it had been in the middle of expanding an "outer" macro.

2) General-Purpose Macro Processors

Macro processors that do not dependent on any particular programming language, but can be used with a variety of different languages

Pros

- Programmers do not need to learn many macro languages.
- Although its development costs are somewhat greater than those for a language specific macro processor, this expense does not need to be repeated for each language, thus save substantial overall cost.

Cons

- Large number of details must be dealt with in a real programming language Situations in which normal macro parameter substitution should not occur, e.g., comments.
- Facilities for grouping together terms, expressions, or statements
Tokens, e.g., identifiers, constants, operators, keywords
- Syntax had better be consistent with the source programming Language

3) Macro Processing within Language Translators

The macro processors we discussed are called "Preprocessors".

- Process macro definitions
- Expand macro invocations
- Produce an expanded version of the source program, which is then used as input to an assembler or compiler

You may also combine the macro processing functions with the language translator:

- Line-by-line macro processor
- Integrated macro processor

Line-by-Line Macro Processor

Used as a sort of input routine for the assembler or compiler

- Read source program
- Process macro definitions and expand macro invocations
- Pass output lines to the assembler or compiler

Benefits

- Avoid making an extra pass over the source program.
- Data structures required by the macro processor and the language translator can be combined (e.g., OPTAB and NAMTAB)
- Utility subroutines can be used by both macro processor and the language translator.

Scanning input lines
Searching tables
Data format conversion

- It is easier to give diagnostic messages related to the source statements

Integrated Macro Processor

An integrated macro processor can potentially make use of any information about the source program that is extracted by the language translator.

Ex (blanks are not significant in FORTRAN)

DO 100 I = 1,20

a DO statement

DO 100 I = 1

An assignment statement

DO100I: variable (blanks are not significant in FORTRAN)

An integrated macro processor can support macro instructions that depend upon the context in which they occur.

Q3) Discuss with a suitable example, the usage of various data structures in handling an assembly language program involving macros [10]

The data structures required are:

DEFTAB (Definition Table)

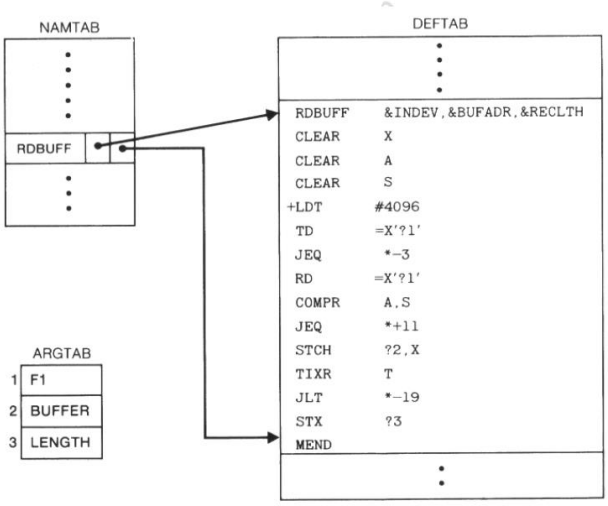
- Stores the macro definition including macro prototype and macro body
- Comment lines are omitted.
- References to the macro instruction parameters are converted to a positional notation for efficiency in substituting arguments.

NAMTAB (Name Table)

- Stores macro names
- Serves as an index to DEFTAB
- Pointers to the beginning and the end of the macro definition (DEFTAB)

ARGTAB (Argument Table)

- Stores the arguments according to their positions in the argument list.
- As the macro is expanded the arguments from the Argument table are substituted for the corresponding parameters in the macro body.
- The figure below shows the different data structures described and their relationship.



In fig 4.4(a) definition of RDBUFF is stored in DEFTAB, with an entry in NAMTAB having the pointers to the beginning and the end of the definition. The arguments referred by the instructions are denoted by their positional notations. For example, TD =X'?1'

The above instruction is to test the availability of the device whose number is given by the parameter &INDEV. In the instruction this is replaced by its positional value? 1.

Figure 4.4(b) shows the ARTAB as it would appear during expansion of the RDBUFF statement as given below: CLOOP RDBUFF F1, BUFFER, LENGTH For the invocation of the macro RDBUFF, the first parameter is F1 (input device code), second is BUFFER (indicating the address where the characters read are stored), and the third is LENGTH (which indicates total length of the record to be read). When the ?n notation is encountered in a line fro DEFTAB, a simple indexing operation supplies the proper argument from ARGTAB.

The algorithm of the Macro processor is given below. This has the procedure DEFINE to make the entry of macro name in the NAMTAB, Macro Prototype in DEFTAB. EXPAND is called to set up the argument values in ARGTAB and expand a Macro Invocation statement. Procedure GETLINE is called to get the next line to be processed either from the DEFTAB or from the file itself.

When a macro definition is encountered it is entered in the DEFTAB. The normal approach is to continue entering till MEND is encountered. If there is a program having a Macro defined within another Macro.

While defining in the DEFTAB the very first MEND is taken as the end of the Macro definition. This does not complete the definition as there is another outer Macro which completes the definition of Macro as a whole. Therefore the DEFINE procedure keeps a counter variable LEVEL. Every time a Macro directive is encountered this counter is incremented by 1. The moment the innermost Macro ends indicated by the directive MEND it starts decreasing the value of the counter variable by one. The last MEND should make the counter value set to zero. So when LEVEL becomes zero, the MEND corresponds to the original MACRO directive.

Q4) Discuss all the machine Independent macro features.[10]

The design of macro processor doesn‟t depend on the architecture of the machine. We will be studying some extended feature for this macro processor.
These features are:

- Concatenation of Macro Parameters
- Generation of unique labels
- Conditional Macro Expansion
- Keyword Macro Parameters

Most macro processor allows parameters to be concatenated with other character strings. Suppose that a program contains a series of variables named by the symbols XA1, XA2, XA3,…, another series of variables named XB1, XB2, XB3,…, etc. If similar processing is to be performed on each series of labels, the programmer might put this as a macro instruction. The parameter to such a macro instruction could specify the series of variables to be operated on (A, B, etc.). The macro processor would use this parameter to construct the symbols required in the macro expansion (XA1, Xb1, etc.).
Suppose that the parameter to such a macro instruction is named &ID. The body of the macro definition might contain a statement like
LDA X&ID1

Generation of Unique Labels

It is not possible to use labels for the instructions in the macro definition, since every expansion of macro would include the label repeatedly which is not allowed by the assembler.
This in turn forces us to use relative addressing in the jump instructions. Instead we can use the technique of generating unique labels for every macro invocation and expansion.
During macro expansion each $ will be replaced with $XX, where xx is a two-character alphanumeric counter of the number of macro instructions expansion. For example, XX = AA, AB, AC…

Conditional Macro Expansion

- Macro-time conditional statements - IF-ELSE-ENDIF
- Macro-time variables
- Macro-time looping statement

 Macro processor function

Macro processor function

%NITEMS: THE NUMBER OF MEMBERS IN AN ARGUMENT LIST

Q5 Explain recursive descent parsing. Write recursive descent parse for READ statement. [10]

A top-down method which is known as recursive descent is made up of procedures for each non-terminal symbol in the grammar.

When a procedure is called, it attempts to find a substring of the input, beginning with the current token that can be interpreted as the non-terminal with which the procedure is associated.

In the process of doing this, it may call other procedures or even call itself recursively, to search for other non-terminals. If a procedure finds the non-terminal that is its goal, it returns an indication of success to its caller. It also advances the current-token pointer past the substring it has just recognized.

If the procedure is unable to find a substring that can be interpreted as the desired non-terminal it returns and indication of failure or invokes an error diagnosis and recovery routine.

The procedure is only slightly more complicated when there are several alternatives defined by the grammar for a non-terminal. In that case, the procedure must decide which of the alternatives to try. For the recursive descent technique, it must be possible to decide which alternative to use by examining the next input token. There are other top-down methods that remove this requirement; however, they are not as efficient as recursive descent.

Example: consider following rule of grammar.

<read> := READ(<id-list>)

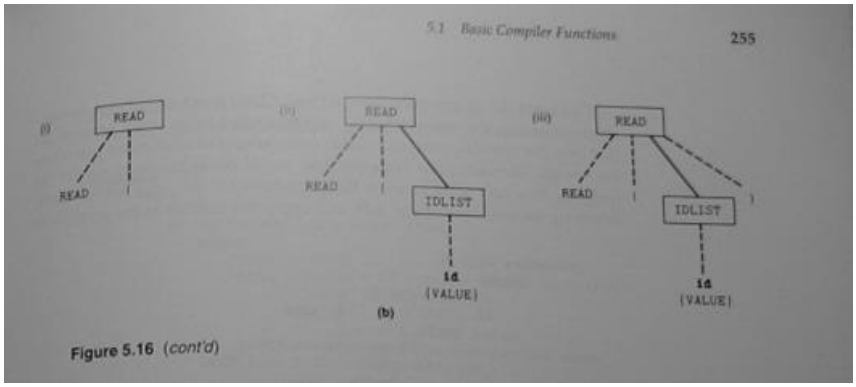


Figure 5.16 (cont'd)

```
procedure READ
        begin
            FOUND := FALSE
            if TOKEN = 8 (READ) then
               begin
                  advance to next token
                  if TOKEN = 20 ( ( ) then
                     begin
                        advance to next token
                        if IDLIST returns success then
                           if TOKEN = 21 ( ) ) then
                              begin
                                 FOUND := TRUE
                                 advance to next token
                              end (if ) )
                     end (if ( )
               end (if READ)
            if FOUND = TRUE then
               return success
            else
               return failure
        end (READ)

procedure IDLIST
        begin
            FOUND := FALSE
            if TOKEN = 22 (id) then
               begin
                  FOUND := TRUE
                  advance to next token
                  while (TOKEN = 14 (,)) and (FOUND = TRUE) do
                     begin
                        advance to next token
                        if TOKEN = 22 (id) then
                           advance to next token
                        else
                           FOUND := FALSE
                     end (while)
               end (if id)
            if FOUND = TRUE then
               return success
            else
               return failure
        end (IDLIST)
```

(a)

Figure 5.16 Recursive-descent parse of a READ statement.

Q6) Explain machine Dependent compiler Features [10]

1) Intermediate form of the Program

There are many possible ways of representing a program in an intermediate form for code analysis and optimization.
One of the methods is representing the executable instructions of the program with a sequence of quadruples.
Each quadruple is of the form
Operation, op1, op2, result
Operation – function to be performed by the object code
Op1 and op2 operands for this operation
Result – where the resulting value is to be placed
Example :
SUM := SUM + VALUE
Could be represented with the quadruples
+, SUM, VALUE, i1
:= , i1, , SUM
These quadruples would be created by intermediate code generation routines.
Many types of analysis and manipulation can be performed on the quadruples for code-optimization purpose.
After optimization, the modified quadruples are translated into machine code.
Quadruples appear in the order which the corresponding object code instruction are to be executed.
This greatly simplifies the task of analyzing the code for the purpose of optimization. It also means that the translation into machine instruction will be relatively easy.

2) Machine Dependent Code optimization
There are several different possibilities for performing machine dependent code optimization.
1) Assignment and use of registers

General purpose register are used for various purpose like storing values or intermediate result or for addressing (base register, index register).
Registers are also used as instruction operands. Machine instructions that use registers as operands are usually faster than the corresponding instruction that refer to location in memory. Therefore it is preferable to store value or intermediate results in registers.
There are rarely as many registers available as we would like to use. The problem then becomes one of selecting which register value to replace when it is necessary to assign a register for some other purpose.
One approach is to scan the program and the value that is not needed for longest time will be replaced. If the register that is being reassigned contains the value of some variable already stored in memory, the can value can be simply discarded. Otherwise this value must be saved using temporary variable
Second approach is to divide the program into basic blocks. A basic block is a sequence of quadruples with one entry point, which is at the beginning of the block, one exit point, which is at the end of the block and no jumps within the block. When control passes from one block to another all the values are stored in temporary variables.
2) Rearranging quadruples before machine code is generated. Note that the value of the intermediate result i1 is calculated first and stored in temporary variable T1. Then the value of i2 is calculated. The third quadruple in this series calls for subtracting the value of i2 from i1. Since i2 had just been computed, its value is available registers A; however, this does no good, since the first operand for a – operation must be in register. It is necessary to store the value of i1 from T1 into register A before performing the subtraction.
With a little analysis, an optimizing compiler could recognize this situation and rearrange the quadruples so the second operand of the subtraction is computed first. The resulting machine code requires two fewer instructions and uses only one temporary variable instead of two.

3) Taking advantage of specific characteristics and instructions of the target machine

For example there may be special loop-control instructions or addressing modes that can be used to create more efficient object code.
On some computers there are high level machines instructions that can perform complicated functions such as calling procedures and manipulating data structures in single operations.
Use of such feature can greatly improve the efficiency of the object program.
CPU is made of several functional units. On such system machine instruction order can affect speed of execution.
Consecutive instructions that require different functional unit can be executed at the same time.

Q7) Explain Machine independent code optimization and structured variable [10]

1) Structured variables

Arrays, records, strings, and sets are example of structured variables. We are primarily concerned with the allocation of storage for such variables and with generation of code to reference them.
General array declaration:
ARRAY [l…u] OF INTEGER
Then we must allocate u-l+1 words of storage for the array
Eg : A : ARRAY[1…10] OF INTEGER

Multidimensional array declaration
ARRAY[l1..u1,l2...u2] OF INTEGER
The number of words allocated is given by
(u1-l1+1)*(u2-l2+1)

All the array elements that have the same value of the first subscript are stored in contiguous locations; this is called row-major order.
All elements that have the same value of the second subscript are stored together; this is called column-major order.
Compilers for most of high level languages store arrays using row-major order.
If an array reference involves only constant subscripts, the relative address calculation can be performed during compilation.
Relative address of the referenced array element A[s] is given by
W*(s-l)
The relative address of B[s1,s2] is given by
W * [(s1-l1) * (u2-l2+1) + (s2-l2)]

Dynamic arrays could be declared as
INTEGER, ALLOCABLE, ARRAY(: , :) :: MATRIX
The allocation can be accomplished by a statement like
ALLOCATE(MATRIX (ROWS, COLUMNS))

In dynamic arrays values of row and columns are not known at compilation time, the compiler cannot directly generate code. Instead, compiler creates descriptor (often called as dope vector) for the array. This descriptor includes space for storing the lower and upper bounds for each array subscript. When the storage is allocated value of these bounds are computed and stored in the descriptor.

Machine Independent code optimization

1) Elimination of common sub expressions.
One important source code optimization is the elimination of common sub expressions. These sub expressions that appear at more than one point in the program and that compute the same value.
Common sub expressions are usually detected through the analysis of an intermediate form of the program
Example:
1) := #1 I

2)

3)

4)

5) * #2 J i3

6)

7)

8)

9)

10)

11)

12) * #2 J i10 .

We see that quadruples 5 and 12 are same except for the name of the intermediate result produced. Operand J does not change value between 5 and 12. It is not possible to reach quadruples 12 without passing through 5. This means we can delete quadruple 12 and replace any reference to its result (i10) with reference to i3, the result of quadruple 5. This modification eliminates the duplicate calculation of 2*J, which we identified previously as a common sub expression in the source statement

2) Removal of loop variants.

These are the sub expressions within a loop whose values do not change from one iteration of the loop to the next. Thus their values can be computed once before loop is entered, rather than being recalculated for each iteration. Because most programs spend most of their running time in the execution of loops, the time saving from this sort of optimization can be highly significant.

Example

Loop-invariant computation is the term 2*j. the result of this computation depends only on the operand J, which does not change in value during the execution of the loop. Thus it can be moved to the point immediately before the loop is entered.

3) Substitution of more efficient operation for less efficient one.

Consider following example:

DO 10 I = 1,20

TABLE(I) = 2**I

This DO loop creates a table that contains the first 20 powers of 2. On closer examination, we can see that there is a more efficient way to perform the computation. For each iteration of the loop, the value of I increased by 1. Therefore, the value of 2**I for the current iteration can be found by multiplying the value for the previous iteration by 2. Clearly this method of computing 2**I is much more efficient than performing a series of multiplications or using a logarithmic technique. Such a transformation is called reduction in strength of an operation.

There are number of other possibilities for machine-impendent code optimization. For example, computations whose operand values are known at compilation time can be performed by the compiler. This optimization is known as folding.

Other optimization include converting a loop into straight line code(loop unrolling) and margining of the bodies of loop (loop jamming))

Q8) Explain following compiler design options i) Division into passes ii) Interpreters

Q9) Explain p code compiler and Compiler-Compiler with neat diagram [10]

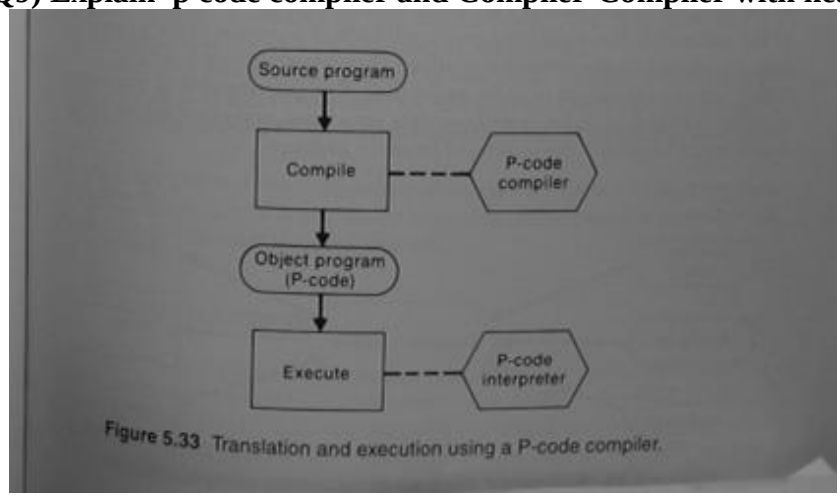


Figure 5.33 Translation and execution using a P-code compiler.

P-code compilers (also called byte code compilers) are very similar in concept to interpreters.

In both cases, the source program is analyzed and converted into an intermediate form, which is then executed interpretively.

With a P-code compiler, however, this intermediate form is the machine language for a hypothetical computer, often called pseudo-machine or P-machine.

The source program is compiled, with the resulting object program being in P-code.

This P-code program is then read and executed under the control of a P-code interpreter

The main advantage of this approach is portability of software. It is not necessary for the compiler to generate different code for different computers, because the p-code object programs can be executed on any machine that has a p-code interpreter.

Even the compiler itself can be transported if it is written in the language that it compiles. To accomplish this, the source version of the compiler is compiled into p-code; this p-code can then be interpreted on another computer.

In this way a p-code compiler can be used without modification on a wide variety of system if a p-code interpreter is written for each different machine.

The design of a P-machine and the associated P-code is often related to the requirements of the language being compiled.

The interpretive execution of a p-code program may be much slower than the execution of the equivalent machine code.

P-code object program is often much smaller than a corresponding machine-code program would be. This particularly useful n machines with severely limited memory size

Many p-code compilers designed for a single user running on dedicated microcomputer system.

If execution speed is important some P-code compilers support the use of machine language subroutines.

By rewriting a small number of commonly used routines in machine language, rather than P-code, it is often possible to achieve substantial improvements in performance. But this approach scarifies some of the portability associated with the use of P-code compiler

Compiler-compiler

 A compiler-compiler is a software tool that can be used to help in the task of compiler construction.

 Such tools are often called compiler generators or translator-writing systems.

 The process of using a typical compiler-compiler is illustrated below.

 The user provides a description of the language to be translated. This description may consist of a set of lexical rules for defining tokens and a grammar for the source language.

 Some compiler-compilers use this information to generate a scanner and a parser directly.

 Others create tables for use by standard table driven scanning and parsing routines that are supplied by the compiler-compiler.

 In addition to the description of the source language, the user provides a set of semantic or code-generation routines.

 Compiler-compilers frequently provide special languages, notations, data structures and other similar facilities that can be used in the writing of semantic routines.

 The main advantage of using a compiler-compiler is of course ease of compiler construction and testing.

 The amount of work required from the user varies considerably form one compiler-compiler to another depending upon the degree of flexibility provided.

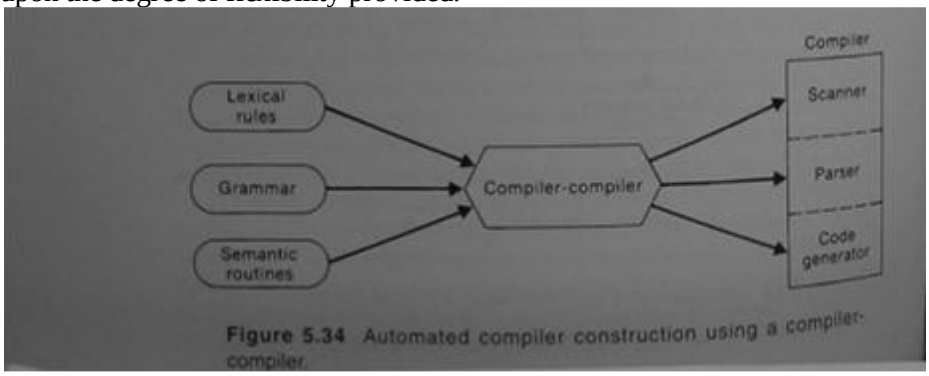


Figure 5.34 Automated compiler construction using a compiler-compiler.

Q 10) Write a finite automata to recognize an identifier wit following rules:
i)An identifier should start with an alphabet
ii) subsequent characters can be alphanumeric

iii)An identifier may or may not have an under score in between other characters, but not in the beginning or at the end. [10]