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Semester End Examination
Masters of Computer Applications
MCAC 401: Compiler Design
Unique Paper Code: 223401402
Semester IV
May-2023
Year of admission: 2021

Time: 3 hours **Maximum Marks: 70**

Instructions:

1. **Parts of a question should be answered together.**
2. **Attempt all questions.**

1. a. Consider the code snippet of merge sort. Draw the activation tree to sort the array `arr`. Also show the contents of the activation record for the first function call. **5 marks**

```
void merge(int arr[], int l, int m, int r)
{
      int n1 = m - l + 1;
      int n2 = r - m;
      int L[n1], R[n2];

      /* Merges two subarrays of arr[].
       First subarray is arr[l..m]
        Second subarray is arr[m+1..r] */
      .........
}

void mergeSort(int arr[], int l, int r)
{
     if(l>=r)
     {
       return;
     }
     int m = (l+r-1)/2;
     mergeSort(arr,l,m);
     mergeSort(arr,m+1,r);
     merge(arr,l,m,r);
}


void printArray(int A[], int size)
{
      //print the sorted array
}
```

```
int main()
{
        int arr[] = {12, 11, 13, 5};
        int arr_size = sizeof(arr) / sizeof(arr[0]);
        mergeSort(arr, 0, arr_size - 1);
        printArray(arr, arr_size);
        return 0;
}
```

b. Consider the following Syntax Directed Translation (SDT): **5 marks**

$N \rightarrow L \quad \{N.dval = L.dval\}$
$L \rightarrow L_1\ B \quad \{L.dval = L_1.dval * 2 + B.dval\}$
$L \rightarrow B \quad \{L.dval = B.dval\}$
$B \rightarrow 0 \quad \{B.dval = 0\}$
$B \rightarrow 1 \quad \{B.dval = 1\}$

Draw the annotated parse tree for a bit string "011000101" (showing all dependencies) to evaluate the final value of `N.dval`. Also, identify the synthesized and inherited attributes (if any).

2. a. Consider the following grammar with a set of non-terminals as {S, V} and a set of terminals as {(, ',', c,)}. S is the start symbol. **4 marks**

$S \rightarrow (V) \mid c$
$V \rightarrow V,S \mid S$

Construct the parse tree for the sentence $(c,c),(c,(c,c))$. Also, construct the rightmost derivation of the sentence and determine the handle in each step.

b. Consider the following context-free grammar with the set of non-terminals as $\{S, A, B, C\}$, compute the $FIRST()$ and $FOLLOW()$ of each non-terminal: **6 marks**

$S \rightarrow A\ C B \mid C\ b\ B \mid B\ a$
$A \rightarrow da \mid BC$
$B \rightarrow g \mid \in$
$C \rightarrow h \mid \in$

3. a. Why does shift/shift conflict not arise in LR parsing algorithms? **3 marks**
b. Briefly explain the phases involved in the front end of the compiler. **3 marks**
c. What is a viable prefix? Consider the following grammar. List three viable prefixes for the input string 000111. **4 marks**

$S \rightarrow 0\ S\ 1 \mid 0\ 1$

4. a. Write atleast two benefits of using indirect triples over triples in intermediate code generation? Explain with the help of an example. **4 marks**

b. Translate the following statement into a three-address code: **6 marks**

$if(x < 10 \;||\; x > 20 \;||\; x! = y)\{x = 0;\}$

5. a. Write a syntax-directed definition that generates the correct three-address code for `do-while` statements and `for`-statements in C++ programming. **5 marks**

   b. What is the calling and return sequence when procedure A calls procedure B? Describe using the control stack. **5 marks**

6. a. Show that the following grammar: **5 marks**

$$S \rightarrow A\,a \mid b\,A\,c \mid B\,c \mid b\,B\,a$$
$$A \rightarrow d$$
$$B \rightarrow d$$

is LR (1), but not LALR (1).

   b. Consider a hypothetical machine with three general-purpose registers and an accumulator register. The machine supports load, store, move, arithmetic, and logical operations with two operands. All the arithmetic and logical instructions require both operands to be in registers. **5 marks**

Generate the machine code for the following quadruples representing intermediate code. Determine the cost of each machine instruction. Clearly, state the assumptions, if any.

Operation	Operand1	Operand2	Result
-	p	q	t1
*	r	s	t2
*	t	u	t3
/	t1	t2	t4
+	t4	t3	t5
=	t5		a

7. a. Write type expressions for a two-dimensional array of integers whose rows are indexed from 0 to 9 and whose columns are indexed from -10 to 10. **2 marks**

   b. Consider the following syntax to define a function prototype in the C++ programming language: **8 marks**

```
returnType functionName( parameter list );
```

Write the lexical analyzer generator program and the parser program for the above syntax. Clearly state the assumptions, if any.