Department of Computer Science and Automation Indian Institute of Science E0 255 Compiler Design Test #2 Answer all questions $24^{th}March2006$ Max marks 90 10.00 AM - 11.30 AM

- 1. Consider the following loop nest.
 - (a) Construct the dependence graph for this nest including the direction vectors also.
 - (b) Convert as many of the three loops as possible into parallel loops (doall) using loop-reversal and loop-interchange transformations. Justify your arguments based on dependence.

15+5 marks

2. Write the dependence equations for the following and apply the GCD test.

do I = 1, N do J = 1, M do k = 1, L S1: A(K*24 - I*3 - J*6 - 15) = ...S2: ... = A(I*42 + K - 8 - 12*J)end do end do end do

10 marks

3. Consider the following loop:

do I = 1, 100 do J = 1, 100 S1: A(I,J) = ... S2: ... = A(J,I) end do end do

Compute the dependences (and direction vectors) between S1 and S2. You may simply unroll the loop for this purpose. Provide justification for your answer using the definitions of dependence and direction vector.

10 marks

4. Find the best schedule for the machine instructions computing the expression (X*Y*2 + V*W*3). Assume that loads take three cycles, immediate loads take one cycle, floating addition takes one cycle, and floating multiplication takes two cycles. There is only one floating point instruction unit and one load-store unit. All instructions are pipelined but the machine can issue atmost one instruction per cycle. Construct the dependence DAG and assume highest priority for a node with the longest path from the root to the node. The instruction sequence is given below:

LF R1, X LF R2, Y MULF R3, R1, R2 LIF R4, #2 MULF R5, R3, R4 LF R6, V LF R7, W MULF R8, R6, R7 LIF R9, #3 MULF R10, R8, R9 ADDF R11, R5, R10

15 marks

5. Apply the dynamic programming based algorithm and generate optimal code for the assignment expression tree shown below. Note that the indexing operator requires the index in a register. Assume the format of the indexing instructions as []b, R which means load b[R] into R, R being a register, with R being the index (left operand of [] in the tree) and b being the base address (right operand of [] in the tree). The cost of such an instruction may be taken as two. All other instructions are as discussed in class. Show the important steps clearly and assume 3 registers.

18 marks



Figure 1: Figure for question 5

6. Show the quads that should be generated for the following program. Show the memory layout for an object and any supporting structures needed at run time.

```
class A{
   public int y = 6; public int z;
   public int f (int x){
      z = x + y; return z;
   }
};
int main(){
   A s; int y;
   y = s.f(4);
}
```

 $17 \mathrm{\ marks}$