GX1610

OLLSCOIL NA hÉIREANN, GAILLIMH
THE NATIONAL UNIVERSITY OF IRELAND, GALWAY

SUMMER EXAMINATIONS 1999

THIRD YEAR COMPUTER SCIENCE EXAMINATION
CS405 PARALLEL PROCESSING

Professor J. Wiegold
Mr. J. Desbonnet

Time allowed: **Two** hours. Answer **three** questions.

1. In the context of memory systems explain the following terms:

   - Bandwidth
   - Cycle time
   - Access time
   - Level 1 cache
   - DRAM

   If a 32 bit wide memory system had a cycle time of 150ns calculate the bandwidth of the memory system.

   Explain how a hierarchical memory system speeds up the execution of a program. What assumptions are made regarding the behavior of a program?

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2. Explain the terms RISC and CISC.

   How are pipelines used to improve performance of a CPU?

   With the aid of a diagram explain the operation of a six stage pipeline as a program approaches a conditional branch. Assume no branch prediction. Show on this diagram the branch penalty time.

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3. The following C program is designed to run on a MPI cluster of three computers of equal speed. It integrates x^3 from 0 to 1.

   - Write a one or two sentence comment in your answer book for each of the 8 blank comment lines.
   - How is the computation partitioned among the processes? Illustrate your explanation with a graph of the function showing which element is computed by which process.
   - If one node in the cluster is much slower than the others how would it affect the performance

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of the program?

```
#include "mpi.h"
#include <math.h>

double f(double a)
{
    return (a*a*a);
}

int main(int argc, char *argv[])
{
   int  n, myid, numprocs, i, rc;
   double mybit, all, h, sum, x, a;

   /* 1: ??? */
   MPI_Init(&argc,&argv);

   /* 2: ??? */
   MPI_Comm_size(MPI_COMM_WORLD,&numprocs);

   /* 3: ??? */
   MPI_Comm_rank(MPI_COMM_WORLD,&myid);

   printf ("Found %d processes in MPI system\n",numprocs);

   n = 0;

   /* 4: ??? */
   if (myid == 0) {
      printf("Enter the number of intervals: ");
      scanf("%d",&n);
   }

   /* 5: ??? */
   MPI_Bcast(&n, 1, MPI_INT, 0, MPI_COMM_WORLD);

   h   = 1.0 / (double) n;
   sum = 0.0;
   for (i = myid + 1; i <= n; i += numprocs) {
      x = h * ((double)i - 0.5);
      sum += f(x);
   }
   mybit = h * sum;

   /* 6: ??? */
   MPI_Reduce(&mybit, &all, 1, MPI_DOUBLE, MPI_SUM, 0, MPI_COMM_WORLD);

   /* 7: ??? */
   if (myid == 0) {
      printf("Integral of f(x) = %lf\n",all);
   }

   /* 8: ??? */
   MPI_Finalize();
}
```

4. Define the terms *Speedup* and *Efficiency* of a parallel algorithm.

   Explain Amdahl's Law. Why is Amdahl's Law not perceived to be the obstacle to very large scale parallelism it was once thought to be?

   A problem takes 100 minutes to execute on a 200MHz Pentium Pro serial computer. The program was profiled and it was determined that 8% of the time was spent in code that was inherently serial. What is the best possible speedup and efficiency for a (a) 8 CPU parallel system and (b) 512 CPU parallel system? (assume that all CPUs are 200MHz Pentium Pros).

   In your opinion is attempting to solve this on a 1024 node system worth while?

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5. Explain with the aid of sketches how *buses* and *crossbars* can be used as an interconnect mechanism between CPUs and memory. List the strengths and weaknesses of both technologies.

   Sketch a diagram of a 3-D hypercube layout. Explain Gray code and show how it can be utilized to configure a hypercube network into a ring network?

   The following are the binary addresses of several nodes of a 5-D Hypercube. Which nodes are neighbours and why?

   01111, 00000, 10100, 11111, 10111
