CS 5260 FALL 2021 - EXAM 1 - STUDY QUESTIONS

CHAPTER 1

(1) Describe four areas (of application) based on ever-increasing computational performance.
(2) What physical problem exists with making transistors smaller and denser, and processors increasingly faster? To what technology has this led?
(3) Give three problems with automatic translation programs.
(4) Give a diagram and an example of a tree structured global sum using 8 procs., and treat the same example using a butterfly network. What is the maximum number of receives and additions by any proc.?
(5) Define: task parallelism and data parallelism, and give a practical example with division of the work for each. Include pseudo-code illustrating both approaches.
(6) Give three instances of coordination in parallel programs.
(7) Describe two types of parallel systems with respect to memory, with a diagram of each (also see more detailed diagrams in Ch. 3 and Ch. 5).
(8) Define: (i) concurrent, (ii) parallel, (iii) distributed computing.

CHAPTER 2

(1) Give diagrams of: the classic von Neumann architecture, a shared memory system, and a distributed memory system.
(2) What is a process? List five entities of which it consists. What is a thread? How does it differ from a process? Name two resources that are shared, and two that are specific for each thread.

CHAPTER 3

(1) What is a communicator? Which communicator is defined by MPI_Init and of what does it consist?
(2) What is returned by MPI_Comm_size and by MPI_Comm_rank?
(3) What is an SMPD program? What type of construct can make our programs SMPD? Give an example scenario.
(4) What type of communication is achieved by MPI_Send and MPI_Recv? Explain the use of a message tag. What information is returned by the MPI_Status argument in MPI_Recv? Explain blocking for MPI_Send and MPI_Recv.
(5) List four steps in a general approach to write a distributed memory program (see: slide entitled “Parallelizing the trapezoidal rule”). Give a diagram showing the specific tasks for parallelizing the trapezoidal rule.
(6) Give pseudo-code for a simple MPI version of a trapezoidal rule program where the contributions from processes are received in a loop.
   Give pseudo-code for an MPI version of a trapezoidal rule program that uses collective communications for broadcast and reduce.
(7) Give pseudo-code for an MPI Get_Input function where proc. 0 does the input, and broadcasts it.
Give diagrams illustrating the communication patterns of: reduce (or single-node accumulation), all-reduce (or multi-node accumulation), single-node broadcast, single-node scatter, single-node gather, all-gather (or multi-node broadcast), multi-node scatter (or total exchange).

What does MPI Scatter do? Describe an example scenario of its use.
What does MPI Gather do? Describe an example scenario of its use.

Give pseudo-code to read and distribute (scatter) a vector.
Give pseudo-code to (gather and) print a distributed vector.

What does all-reduce do? Illustrate an implementation using a tree structures for a global sum and distribution of the result. Illustrate an implementation using a butterfly network.

What does all-gather do?

Give pseudo-code for a sequential and an MPI matrix \( \times \) vector multiplication.

Define block partitioning, cyclic partitioning, and block cyclic partitioning, with an example to illustrate each.

Give pseudo-code for an MPI program that . . . .

**Chapter 5**

What are (OpenMP) pragmas (directives)?

What are: a (thread) team, master, slaves? Give a picture showing a fork and join.

In OpenMP, what is the scope of a variable, shared scope, private scope? What is the default scope for variables declared before a parallel block?

What is a clause? Give an example (clause) for the directive `omp parallel`?

Show how to update the global result for the trapezoidal rule in the main program using `pragma omp parallel` and `pragma omp critical`, if each thread calls a `Local_Trap(a,b,n)` function.

What is a reduction? Give examples of reduction operators. Show how the global result can be updated using `omp parallel` with a reduction on `Local_Trap(a,b,n)`. What is the reduction variable?

How does a `parallel for` work?

Give a correct solution for an OpenMP program section that computes an approximation to \( \pi \) based on the series
\[
\pi = 4 \sum_{k=0}^{\infty} \frac{(-1)^k}{2k+1} = 4 \left( 1 - \frac{1}{3} + \frac{1}{5} + \ldots \right),
\]
using an `omp parallel` with a `default(none)` clause. Explain which part of the program needs special attention (so that it runs correctly in parallel). You do not need to do the input.

Explain the static, dynamic, guided and runtime schedule types.

Illustrate `schedule(static,1)`, `schedule(static,2)`, `schedule(static,4)` for 16 loop iterations and 4 threads. Illustrate schedule `schedule(guided,1)` for 40 loop iterations and two threads.

Define speedup \( S \), efficiency \( E \) using \( t \) threads.

What is a cache line or block, write-miss, read-miss? What is thread safety?

Consider matrix \( \times \) vector multiplication where the matrix is of size: (a) \( 8,000,000 \times 8 \), (b) \( 8,000 \times 8,000 \), and (c) \( 8 \times 8,000,000 \). For the three inputs, describe and explain cache related effects on performance, (i) for a sequential implementation (one thread), (ii) in parallel (multiple threads).

Give an OpenMP program that . . . .