

HPC Midterm Exam - Fall 2007

Name: _____ (Please print)

Put the answers on these sheets. Use additional sheets when necessary. You can collect 100 points in total for this exam.

1. What is a PMS model? (**mark one**) (5 points)
 - (a) A model that studies the engineering of an application based on Programming (P), Modeling (M), and Software (S).
 - (b) A model that describes a machine architecture consisting of PCs (P), Monitor displays (M), and Seagate hard drives (S).
 - (c) A model that describes a machine architecture consisting of Processors (P), Memory (M), and Switches (S).
 - (d) A model that describes human-machine interaction consisting of People (P), Machines (M), and operating Systems (S).

2. What is the “diameter” defined as the maximum number of message “hops” between processors in a $N \times N$ processor mesh, with $N = \sqrt{P}$? (**mark one**) (5 points)
 - (a) P
 - (b) $2(\sqrt{P} - 1)$
 - (c) P^2
 - (d) \sqrt{P}

3. Amdahl’s law determines the speedup $S_P = P/(1 + (P - 1)f)$ of a parallel application that has a sequential fraction $0 \leq f \leq 1$. What is the speedup of a parallel application with $f = \frac{1}{3}$ and $P = 4$? (**mark one**) (5 points)
 - (a) 1
 - (b) 2
 - (c) 3
 - (d) 4

4. Indicate the RAW, WAR, and WAW dependences in the following statement sequence. (8 points)
 - A) $x = 1$
 - B) $y = 2$
 - C) $t = x + y$
 - D) $x = y$
 - E) $y = t$

5. Processors with out-of-order scheduling of instructions can reorder instructions in the execution pipeline and remove WAR dependences on register assignments by register renaming. Assume that all instructions have a uniform latency of 3 cycles, and 2 instructions are fetched simultaneously by the execution units, and 3 instructions can be in the execute phase in the pipeline regardless of the type of operation. Assuming that the processor cannot look ahead what's coming and only fetches the next pair of instructions, what is the optimal schedule of the following instruction sequence: (10 points)

- A) $r0 = r1 + 1$
- B) $r1 = 2 * r1$
- C) $r2 = r0 + r1$
- D) $r3 = r3 / 2$
- E) $r4 = r5 + 1$
- F) $r5 = r5 * 2$
- G) $r0 = r0 / 2$
- H) $r1 = 3$

6. What is a “superstep” in the bulk synchronous parallel (BSP) model? (8 points)

7. What is a critical section? How are threads synchronized/coordinated to enter and leave a critical section? (10 points)

8. What is the difference between a process and a thread? Also explain how this difference matters when your parallel algorithm must operate on shared data. (10 points)

9. What is a performance prediction graph? What measures are compared? (8 points)

10. Give an example (sketch) of a “block-and-copy” optimization. When is a “block-and-copy” useful? (8 points)

11. What are the three types of schedules in OpenMP to schedule for/do loops for work sharing?
(8 points)

12. Suppose sequential algorithm A_s runs in $t_s = 5N + 30$ units of time for data size N . The parallel version A_P runs in $10N/P + 15$ units of time.
- (a) For $N = 100$ and $P = 4$, what is the parallel speedup S_P ? (5 points)
 - (b) For $N = 100$ and $P = 4$, what is the parallel efficiency E_P ? (5 points)
 - (c) Is the parallel algorithm “cost optimal” for any N and P ? Explain why or why not. (5 points)