Review Notes for Midterm Exam

The midterm exam will be derived from these questions, with the approximate points shown. The midterm exam will be worth approximately 100 points. *Most* of the important material is summarized here. Both the points on each question below and the total number of points for the exam are approximate and may change.

Short Answer Questions: You should be able to answer the following short answer questions:

1. [8] Describe the four sources of performance degradation for HPC and give an example of each.

2. [8] Describe the HPC system stack, starting with device technologies and ending with the application layer.

3. [5] Name and describe the five types of memory models that can be used in an MIMD system, slide 25, Lecture 2

4. [5] Briefly describe what the Berkeley NOW project is and four of the things it is noted for accomplishing.

5. [5] Briefly describe what the NASA Beowulf project is and four of the things it is noted for accomplishing.

6. [5] Describe at least five of the types of parallelism found in clusters.

7. [10] In a line or two define, “benchmark.” In a paragraph, name and briefly describe several purposes, properties, and/or common mistakes of benchmarking. What three parallel benchmark suites did we study in class?

8. [5] By whom and when was the HPL benchmark introduced? Expand HPL. In a few lines explain what the HPL benchmark does.

9. [5] Suppose that my application runs in 1 hour on one processor and that 10% of my application cannot be parallelized. According to Amdahl’s Law, what is the maximum speedup that I can gain by running the application on a parallel computer, no matter how many processors I run it on?

10. [4] What is the purpose of a Condor ClassAd? Name three of the entries in a Condor ClassAd.

11. [4] Describe the four steps of Condor matchmaking.

12. [6] Describe three ways that starvation can occur in the context of capacity computing. (Partial answer – expand this for full credit: insufficient work, inadequate parallelism, poor load distribution)

13. [10] What is meant by the CSP programming model? Describe at least eight characteristics of this in a paragraph or so. Also describe at least three performance issues for CSP.

14. [5] What is a program? What is a process? Briefly explain how new processes are created in Unix.

15. [8] What is a socket? Describe at least three feature of sockets communication. Give four problems with sockets programming.

16. [4] True or false: You can write a program using MPI that will run across all of the cores of your multicore computer in parallel. Also, if this is possible, indicate if you think this is a good way to write the program. You must justify your answer to receive credit.

17. [2] In MPI, when does a blocking recv message return?

18. [2] In MPI, when does a non-blocking recv message return?

19. [2] What is an MPI communicator? What is MPI_COMM_WORLD?

20. [1] In MPI, what is a process rank?

21. [1] True or false: In MPI you set the number of processes when you write the source code.

22. [4] Give a short piece of pseudocode that illustrates the master/slave programming model.

23. [2] Explain if the following MPI code segment is correct or not, and why:
    Process 0 executes:

```
MPI_Recv(&yourdata, 1, MPI_FLOAT, 1, tag, MPI_COMM_WORLD, &status);
MPI_Send(&mydata, 1, MPI_FLOAT, 1, tag, MPI_COMM_WORLD);
```

    Process 1 executes:

```
MPI_Recv(&yourdata, 1, MPI_FLOAT, 0, tag,MPI_COMM_WORLD, &status);
MPI_Send(&mydata, 1, MPI_FLOAT, 0, tag, MPI_COMM_WORLD);
```

24. [4] Suppose that process 0 has variable A, and process 1 also has a variable A. Write MPI-like pseudocode to exchange these values between the processes.

25. [3 pts each] Explain the purpose of each of the library calls listed.

    - MPI_Init
    - MPI_Finalize

- MPI_Comm_rank
- MPI_Comm_size
- MPI_Send
- MPI_Recv
- MPI_Barrier
- MPI_Bcast
- MPI_Scatter
- MPI_Gather
- MPI_Reduce

26. [6] What is an MPI derived datatype and when would you use one? Give an example.

27. [8] Describe five of the major elements of an SMP node.

28. [5] Name the five levels of the memory hierarchy. What are the (very approximate) access times for each of them?

29. [6] We mentioned three ways to transfer data between memory and a device. Name and briefly describe these.

30. [10] Give the approximate range of data rates for the PCI bus, the PCI Express bus, and the PCI-X bus. Expand the acronyms DDR. QDR. How is the bus throughput changed if the bus is 16 bits versus 32 bits or 64 bits? How many bits per second of throughput is 4GB/s?

31. [8] The OSI (Open Systems Interconnect) defines a reference model for networking. Give the seven layers of the OSI model from the application layer down to the physical layer and briefly describe the purpose of each layer.

32. [2] What is the theoretical throughput of Gigabit Ethernet? Of 10 Gigabit Ethernet?

33. [4] Briefly describe what InfiniBand is.

34. [3] Define race condition and give an example of one.

35. [6] Names three items that may be in the private state of a thread. Describe three ways that a thread is different from a process.

36. [5] Give an example of a section of code that uses a mutex lock. What are some disadvantages of programming with mutex locks?

37. [4] What is a spurious wakeup? Give an example code that compensates for a spurious wakeup (hint – see slide 20 Lecture 11).

38. [6] Give an example of code that has good spatial locality and one that has bad spatial locality. What difference does this make in the performance of the code?

39. [4] Name and describe four factors that you have to consider in the performance of shared memory programs.

40. [6] Describe how a write-through cache works. Describe how a write-back cache works.

41. [2] Explain how environmental variable in OpenMP affect the execution of the program.

42. [6] Name and describe the three main scoping clauses in OpenMP.

43. [4] How does OpenMP use a for statement to create parallelism?

44. [4] What is the purpose of the critical directive in OpenMP? What is the effect if you access shared variables outside a critical directive?

Term and acronyms: You should be able to expand each of the following acronyms, and define each of these terms and acronyms in a line or two. [2 points each]

- Supercomputer
- Top 500 list
- Flynn's Taxonomy (all four acronyms and an example of each)
- MPP
- SMP
- Parallel Vector Processor
- Commodity cluster
- Constellation
- Multicore
- Moore's Law
- benchmark
- Latency
- Peak performance
- Sustained performance
- Ops
- Ips
- Flops
- Mflops
- Gflops
- Tflops
- Pflops
- Strict scaling
- Weak scaling
- Capability computing
- Capacity computing
- Cooperative computing

- Memory wall
- Latency
- Cycle time
- Throughput
- Granularity
- CSP
- SPMD
- ILP
- Pipelining
- MIMD
- PGAS
- System Area Network
- UC-Berkeley NOW Project
- Gigabit Ethernet
- Myrinet
- InfiniBand
- Scheduler
- MPI
- MPICH
- OpenMPI
- NFS
- PVFS
- Condor
- Global barrier
- CSP
- Reduction
- TCP
- IP
- Hyper-transport-based SMP
- MCM
- Cache hit
- Cache miss
- Miss penalty
- Average memory access time
- CPI
- Motherboard
- Cache
- NIC
- Primary storage
- Secondary storage
- Tertiary storage
- Off-line storage
- SRAM
- DRAM

- SDRAM
- PCI bus
- Diameter of a network
- Latency in a network
- Race condition
- Critical section
- Spinlock
- Mutex lock
- Temporal locality in cache
- Spatial locality in cache
- OpenMP

Formulas and calculations: You should be able to provide the formulas and perform calculations using the following. Be sure that you can do all the assigned homework exercises. [10-15 points each]

- Amdahl's Law, slide 56, Lecture 1
- Amdahl's Law with Overhead, slide 57, Lecture 1
- Speedup and efficiency, slide 5, Lecture 5
- Overhead
- Using Amdahl's Law to calculate speedup, slide 13, Lecture 9
- Time to do a memory access given cache hit rate, CPI, slide 8, Lecture 11