CS553 Fall 2025
Final Exam Study Guide

1. Name some advantages of distributed systems over centralized systems.
2. Understand the basics of the TCP and UDP communication protocol.
3. Identify design patterns can be used to implement a concurrent server.
4. Why is threading useful on a single-core processor?
5. Identify what a thread has of its own (not shared with other threads):
6. Do more threads always mean better performance?
7. Is super-linear speedup possible?
8. What is an advantage to a connectionless oriented protocol compared to a connection-oriented protocol?
9. What is the purpose of the scheduler in a distributed system?
10. What are the advantages and disadvantages of centralized scheduling?
11. Why do we need distributed scheduling?
12. You have a cluster with 1000 compute nodes. You have a centralized scheduler that can schedule 10 tasks per second. What is the smallest granularity of task lengths that your scheduler can support in order to achieve high system utilization?
13. You have a cluster with 1000 compute nodes. You have a distributed scheduler that has 1000 schedulers, and each scheduler can process 1 task per second. What is the smallest granularity of task lengths that your scheduler can support in order to achieve high system utilization?
14. Name a distributed system framework that implements a centralized scheduler? Name the major components of this framework.
15. Name a technique that is well known to be used to implement distributed scheduling? What are the critical configuration parameters, and what do they depend on?
16. A user is in front of a browser and types in www.google.com, and hits the enter key. Think of all the protocols that are used in retrieving and rendering the Google logo and the empty search box.
17. Why are locks needed in a multi-threaded program?
18. How is replication different than caching?
19. Why do we need replication?
20. Why do we need caching?
21. Why did processors from the 1980s not have caches?
22. An alternative definition for a distributed system is that of a collection of independent computers providing the view of being a *single system*, that is, it is completely hidden from users that there even multiple computers. Give an example where this view would come in very handy.
23. Would it make sense to limit the number of threads in a server process?
24. Constructing a concurrent server by spawning a process has some advantages and disadvantages compared to multithreaded servers.

25. How does the probability of failure of an entire distributed system (assuming all components are necessary to function properly) change as the number of independent components in the system grows?
26. What components in a computer system do we know how to make resilient, and what technique is used?
27. Which types of failures is easiest to detect?
28. Data resilience through forward error correcting codes is an example what type of recovery mechanism?
29. Data resilience through replication is an example what type of recovery mechanism?
30. RAID (redundant array of inexpensive disks) is an example what type of recovery mechanism?
31. What is the technique called that allows applications to restart and recover from an intermediary point after the start of the application?
32. Describe Moore's Law.
33. Describe Amdahl's Law.
34. Today's commodity processors have 1 to 192 cores. About how many cores are expected to be in future processors by the end of the decade? How are these future processors going to look or be designed differently than today's processors? What are the big challenges they need to overcome?
35. Describe what a core and hardware thread is on a modern processor, and the difference between them? What type of workloads are hardware threads trying to improve performance for?
36. Describe what shared address space and message passing is, and the difference between them? In what environments would one be used over the other?
37. Describe what a process and a thread is, and the difference between them? Why are synchronization locks needed with threads? Why is this not the case with processes?
38. Define a cluster of computers. Define a supercomputer. What is the difference between clusters and supercomputers?
39. Define grid computing. Define cloud computing. What is the difference between grids and clouds?
40. Briefly characterize the following three cloud computing models: IaaS, PaaS, Saas
41. List and describe main characteristics of cloud computing systems.
42. Discuss key enabling technologies in cloud computing systems.
43. Discuss different ways for cloud service providers to maximize their revenue.
44. What are differences between multi-core CPU and GPU in architecture and usages?
45. Discuss the major advantages and disadvantages using virtual machines and virtual clusters in cloud computing systems?
46. Why power consumption is critical to datacenter operations?
47. If you were to build a large $1B data center, which would require $50M/year in power costs to run the data center and $50M/year in power costs to cool the data center with traditional A/C and fans. Name 2 things that the data center designer could do to significantly reduce the cost of cooling the data center? Is there any way to reduce the cost of cooling to virtually $0? Explain why or why not?
48. Compare GPU and CPU chips in terms of their strength and weakness. In particular, discuss the tradeoffs between power efficiency, programmability and performance.
49. There are three implementations of the MapReduce engine and its extensions: Google MapReduce, Apache Hadoop and Apache Spark. What is unique about each system that sets them apart?

50. Briefly characterize the following branches of distributed systems: HPC, HTC, MTC, P2P, Grid, Cluster, Cloud, Supercomputing
51. Assume that when a node fails, it takes 10s to diagnose the fault and another 30s for the workload to be switched over: A. What is the availability of the cluster if planned downtime is ignored? B. What is the availability of the cluster if the cluster is taken down 1 hour per week for maintenance, but one node at a time?
52. Throughput can be used to measure processors, memory, disk, and networks. What are the basic units of measurement for each of these?
53. Name two network technologies you would use in building a large scale computing system? One network should be used to optimize cost, while the other should be used to optimize performance. Give cost/performance details for each network type.
54. Name two network topologies you would use in building a large scale computing system? One of these network topologies is destined to be used in most future supercomputers due to some desirable properties at large scale. What are these properties?
55. What is live migration of virtual machines? Describe the steps needed to complete for live migration to occur. What type of workloads are not suitable for live migration?
56. Name an open source cloud IaaS middleware system. What are common components across other IaaS middleware systems?
57. What is the difference between a NOSQL and SQL database? Give some examples of each.
58. What is an elastic block device (EBS) in Amazon's infrastructure? Why is it a useful system?
59. What does it mean for a system to be scalable?
60. Under what conditions would live migration not work? Assume the VM is running off a network disk.
61. What is 1 advantage of full virtualization compared to para-virtualization?
62. Why do we not have processors running at 1THz today (as would have been predicted in 2000 based on prior growth patterns)?
63. What is an advantage of a modular data center shipping container resource over traditional racks with machines?
64. What technique is used to secure data in a storage system with the least performance penalty?
65. What technique is used to secure data in a computer system?
66. What is the local loopback network interface?
67. Describe the difference between strong scaling and weak scaling experiments.
68. Why does Cloud Computing claim to offer infinite capacity? Why is it not the case for Supercomputing?
69. Assume you have virtual machines with 1-core, 10MB caches, 10GB memory, 100GB disk, and a 10Gb/sec network. Assume the 100GB disk resides on a network volume. Estimate the downtime the VM would have as it migrated from one physical machine to another. The downtime should measure from when the application on node 1 stops until it is running again on node 2. Measure downtime in milliseconds, and round to the nearest millisecond.
70. Assume that you have a private cloud that has 100 physical nodes which has a decentralized storage system to manage its VM images. Assume the storage system can sustain up to 10GB/sec I/O rates, and assume the 100 nodes running VMs are equipped with 10Gb/sec network interfaces. Assume that a

single user wants to launch 100 VMs on the 100 physical machines. Assume that the cloud scheduler can initiate 10 VM launch requests per second. Assuming image sizes of 1GB each and that the OS takes 10 seconds to boot, estimate how long (in milliseconds; round to nearest millisecond) it would take for a single user to launch 100 VMs on the 100 nodes?

71. If you have a system with 99.999% availability, how much downtime a year can you have (round to nearest second)?
72. Assume you have a cluster with 30 nodes. You have 1 network card per node with 1Gb/sec Ethernet Full Duplex, and have access to 6-port switches (also 1Gb/sec Ethernet Full Duplex) in order to build a Fat Tree network architecture. Draw a picture of the Fat Tree topology for your 30-node cluster (clearly show the switches, cables, and nodes). How many switches in total do you need? What is the bi-section bandwidth of your network? What is the bi-section bandwidth of your network in Gb/sec (round to nearest Gb/sec)? Assuming each switch incurs a 100-microsecond forwarding delay, and networking stack requires 40-microseconds to process network messages (e.g. TCP/IP) on each side (e.g. sender and receiver), what is the best-case and worst-case latency you can expect from this network topology?
73. A MapReduce Job consists of many tasks that are distributed among TaskTrackers for execution. Sometimes, even when the machines and the tasks are identical, a few of the tasks will take much longer to complete than the others. But, a map or reduce stage cannot complete until its constituent tasks all complete. Describe a technique used by both Google's MapReduce and Hadoop MapReduce to mitigate this problem. Explain why it is safe and effective.
74. While using the Amazon AWS or a similar cloud services, imagine running an application that could have access to a Hadoop Distributed File System (HDFS), an Elastic Block Service (EBS), Simple Storage Service (S3), and DynamoDB. Which of the four storage options would you expect to be the easiest for a traditional enterprise application to be modified to use, and why? Which would give the best throughput for large datasets (e.g. 1 petabyte)? How about for small object access (e.g. 1KB)
75. In HW4, you had to generate hashes using a NONCE, organize the hashes, and ultimately sort them before storing them on disk. Write the pseudo code of your program implemented in your homework (make sure your psuedo code utilize multi-core architectures).
76. Assuming you have a sorted dataset (as the one you generated in HW4), write the pseudo code to implement an efficient search routine. Discuss the time complexity of your search. Assuming you have a 16TB file, how much data will you have to read in order to find the specific hash you are searching for? Estimate the amount of time the search will take in milliseconds. Assume a spinning hard drive (HDD) that runs at 7200 RPM to compute the minimum latency of the HDD. Assume a SATA interface that allows a sustained read/write speed of 250MB/sec.
77. What was the bottleneck in your HW4 implementation? Was it the processor core counts, processor speed frequency, memory capacity, memory speed, disk capacity, or disk speed? If the bottleneck lies in multiple places, discuss all of them, and how you were able to determine where the bottleneck came from. What tools did you use to identify these bottlenecks? If you were a hardware designer, how would you design the hardware differently so that this bottleneck could be overcome.
78. What is the difference between in-memory sort and external sort? What do you believe was the bottleneck in your implementation of external sort?
79. What are two most important properties of hashing algorithms.
80. What are two most important properties of cryptographic hashing algorithms.
81. What is the difference between hashing algorithms cryptographic hashing algorithms.

82. Write the pseudo code to a simple hashing algorithm.
83. Write the pseudo code to a simple hash table implementation.
84. Describe what OpenMP is, and what it could be used for.
85. Describe what MPI is, and what it could be used for.
86. How is the namespace of a POSIX file system organized?
87. Describe the binning process of computer processors, and how a small core count CPU can be nearly identical to a large core count CPU.
88. Describe what the program SSH does in Linux. What is SSH Public Key Authentication?
89. Describe the work stealing load balancing technique in distributed scheduling.
90. Describe how a mechanical hard drive works. How are bandwidth and latency fundamentally fixed by the hardware and technology used? For example, discuss the lowest possible latency achievable in a traditional hard drive at a given RPM of the platter.
91. Libraries that generate random numbers typically require a SEED value to be passed in the initialization phase of the library. Can you explain why? What are good possible values for the SEED? Explain your answer.
92. Explain what data locality is, and how it has helped MapReduce Hadoop to scale well on real world problems.
93. What limitations does Hadoop have that Spark has addressed? Discuss the workload patterns, and at a high level, how Spark has managed to address this shortcoming of Hadoop.
94. Describe what a time-series database is? How is this database different than a NoSQL database? How about how is it different than a relational database? Name 2 examples of time-series databases.
95. If a manufacturer claims that their HDD can deliver sub-millisecond latency on average, can this be true? Justify your answer?
96. Explain why flash memory SSD can deliver better performance for some applications than HDD.
97. What types of workloads benefit the most from SSD storage?
98. If a manufacturer claims they have built a storage system that can deliver 1 Terabit/second of persistent storage per node, would you believe them? Justify your answer to why this is possible, or not. Make sure to use specific examples of types of hardware and expected performance.
99. Name the top 10 commands you used in Linux when you implemented and evaluated your programming assignments in this class. Describe each command at a high level what it does. If there were alternatives to these commands, outline what these other commands were.
100. Explain what a blockchain is. Why is a blockchain system considered a distributed application? What are some of the largest challenges of operating blockchain systems (such as Bitcoin) at global scale?