Winter 2020

**CS351- CLOUD COMPUTING**

**FINAL EXAM**

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INSTRUCTIONS:

1. The exam on 3/28 starts at 10AM and answers are due at 12:00 Noon
2. You have two hours to complete this exam and submit the into the Blackboard dropbox. . (Few minutes delay due to technical difficulties is acceptable)
3. I will be available during the exam at Blackboard collaborate room in case you have any questions.
4. You can use notes/textbook. DO NOT USE any other material like searching on internet.
5. Please write the answers in your own words.
6. If you need to draw figures to explain a concept, use a blank white paper, draw the figure and take a picture and send it along with the exam. You can also draw the picture using any software you like if you prefer.
7. The name of the file containing the picture must contain your lastName; for example, mine would be named KanchiFigureForQuestion3a.jpeg
8. No emailing or texting a classmate is allowed during the two hour exam.
9. Answer the following questions:
10. Did you complete the course evaluation (1 point added to final exam grade) -- yes
11. Are all your grades up to date EXCEPT for Quiz 2 (same as A4), A4 and Final Exam? If not, we need to take of this today after the exam -- all but A4 is complete
12. Did you turn A4 or Project? Yes/No --- yes
13. Did you turn in extra credit homework YES/NO -- no

1. (20 points) Clearly **define the terms below and compare and contrast them** by providing one similarity and one difference.

a) High Performance Computing versus High Throughput computing

High Performance Computing (HPC) is essentially one instance of software over multiple processors, which the results are then pieced back together through a parallelized environment.

High Throughput Computing (HTC) use multiple instances separate from one another, on separate processors.

Comparison: Both HPC and HTC can be run on the same cluster computing architecture, although HTC is mainly used for computation that will normally take a long time and HPC is used when a large amount of resources must be used quickly.

b) Full virtualization versus para virtualization

Full Virtualization is a virtual machine that allows a guest OS to be run in an isolated environment, based on that guest OS being unmodified by simulation of the hardware.

Paravirtualization does not require a simulated hardware environment, due to the communication between the hypervisor on the host, and the guest OS installed in the environment.

c) Pervasive Computing versus Ubiquitous Computing

Pervasive Computing is every day devices that influence our lives such as smartphones.

Ubiquitous Computing is computing that is performed “behind the scenes” of seemingly normal tasks, such as asking for directions where it must communicate with an external source of information.

d) Grid Computing Architecture versus Cluster Computing Architecture

Grid computing is a loosely coupled network of computing devices that can be distributed across several other networks and geographical locations.

Cluster Computing is a network of computing devices that are all on the same LAN network.

They are often used for similar tasks, although grid is a more distributed version as it can be spread throughout many locations while cluster must be centralized to one location.

e) Fine Grained Multiprocessor versus Coarse grained multiprocessor

Fine Grained Multiprocessing is when commands are executed one after another across different threads.

Coarse Grained Multiprocessing is when a thread of commands will continue to execute until a thread reaches a stall, at that point it will switch to a new thread and continue.

Both of these processors will achieve the same end result, although rather than continual computation like in fine grained, coarse grained will have skipped cycles due to thread switching.

2. (10 points) How are binary translation and hyper calls helpful in full virtualization and para virtualization respectively. Explain Xen’s Para-virtualization architecture. State one advantage and disadvantage of each of these types of virtualizations.

Binary translation is used in full virtualization to combine these translations with direct execution protocols, which results in the guest OS not being aware that it is not tied with the hardware. As a consequence of this, the computation times are not the best, such as the IO that may be needed comes as a very large computational task for this sort of virtualization.

Binary translation in paravirtualization is not used, because non-virtualizable issues are solved by either paravirtualization or binary translation, so that the VMM can execute the commands it is receiving, these two are just separate ways of achieving the same goal. However a hypercall is used to communicate with the hypervisor in the virtualization layer, which allows for these commands to be read by the VMM.

Xen’s paravirtualization architecture is the most widely used hypervisor, and allows for high performance executions within the guest OS of a fully virtualized system. This is done through a hardware assisted virtualization system. This hypervisor controls the memory management, CPU state register, and IO devices, which are the main issues with computation times in a VMM.

Full Virtualization is significantly slower due to the use of binary translation into instructions that the VMM can understand, though it creates a fully simulated and separate environment.

Paravirtualization is very good with overall system utilization, although a major hindrance of this system is that it must modify the guest OS in order to communicate with the hypervisor. Xen however gives a little bit of both, in that it acts as a fully virtualized system with better hypervised system calls.

3) (15 points) Explain why hardware assistance is needed to virtualize CPU, memory and I/O devices. What kinds of hardware assistance is available for virtualizing CPU, memory and I/O devices and how do they help with virtualization? Include shadow page table in your discussion.

Hardware assistance is essentially needed because all virtualization is complicated, (page 147). There are many system calls that each have to deal with such as sending the IO to either the host or guest OS, the memory management, or allocation of resources. CPU assistance is found using CPU acceleration, also known as VT-x. It essentially adds another ring to the system’s structure, and places the hypervisor in the new ring that has Root privileges. VT-d assists the process of IO and memory by remapping the DMA transfers, as well as the interrupts generated by the devices involved.

I was unable to find any information on what a “shadow page table” looks like in the books available…

4. (15 points) Explain how each of these hardware is virtualized. In case state if you can provide more virtual hardware than physical hardware. Why or why not?

a) CPU

A CPU is virtualized by essentially partitioning threads of the CPU and allocating those resources towards the virtualization processes. This allows for multiple machines to be ran on a single piece of hardware, as I can run multiple virtual machines on a single processor due to multithreading and other aspects of modern CPU’s

b) RAM

RAM is virtualized by using a memory management unit and translation lookaside buffer. This creates a 2 stage memory mapping process from virtual memory to physical memory.

c) Disk

The disk is simply a partition of the available resources. The virtual machine will ask for a certain place to put its data on the drive, and will keep it completely separate from the rest of the storage. The amount of space given to the virtual machine is determined by the user.

5. (20 points) Define the term live migration and provide activities that take place in each step of the VM migration including Pre-migration, Reservation, Iterative pre-copy, Stop and Copy, Commitment, and Activation.

State three reasons why VMs need to be migrated?

Which of the steps in the live migration takes least amount of time?

Live migration is the ability to switch between the virtual machine and the physical machine without stopping the processes of either machines.

Pre-copy is when the hypervisor copies the memory page to the destination while the VMM is still processing.

Reservation is when a container is initialized on the host machine.

Iterative pre-copy enables shadow paging and copies dirty pages.

Stop and copy suspends the VMM, generates ARP to redirect to a new VMM host and then synchronizes the states of each VMM to make sure no data was lost.

Commitment is when the original VMM host is freed from the VMM.

Activation is when the new host of the VMM is able to operate and connect to devices, and resumes operation as usual.

VM’s need to be migrated so that their data can be used on multiple machines, it allows for ease of use across many different pieces of hardware, and it is very useful for bug testing on different platforms with different specs.

Stop and copy takes the longest due to the amount of files that must be copied and moved.

6. (15 points) Assume that 25 percent of the program in a SIMD (Single Instruction Multiple Data) parallel system execution is attributed to the execution of MPI (Message Passing Interface) commands which are issued sequentially.

Given that the total execution time of the program on a 4-server cluster is T minutes,

what is the speedup factor of executing the same program on a 256-server cluster, compared with using the four-server cluster? Use Amdhal’s Law. Assume that the program execution is deadlock free and ignore all other runtime execution overheads in the calculation.

S(P) = 1 / ( (1 – 25) + (25 / 256) )

= 1.332

The total speedup for this situation would be about a third faster than with the 4 server cluster.

7) (5 points) Define the term System Availability. What percentage of time is a server available if it is likely to go down every 100 seconds and it takes 20 seconds to come back alive?

System availability is the percentage of time that the system is available to access, ideally this number should be very close to 100% of the time.

Availability = 100 / (100 + 20)

= .8333333

Therefore this system has a system availability of 83% of the time, which is not very reliable.