Colin Kirby
EEL4798

HW #1

1 - Draw a table to explain the difference among data-intensive scalable computing, cloud computing, HPC, AIoT (Artificial Intelligence of Things) in the following aspects: System Architectures, Application, and Programming Model.

Aspect	DISC	Cloud Computing	HPC	AIoT
System Architecture	Distributed systems consisting of multiple autonomous computers, each with their own private memory that focus on parallel data processing.	Virtualized resources across distributed data centers. May be built from physical or virtualized resources however.	Centralized supercomputers, however moving to geographically distributed desktops, or clusters.	Edge computing with IoT devices with integrated AI.
Application	Big Data Analytics, batch processing (e.g. MapReduce, Hadoop)	Scalable web services, storage, serverless functions, scalable applications.	Science & Engineering, Business, Internet and web services. Like scientific simulations, weather forecasting.	Autonomous vehicles, smart cities, healthcare monitoring.
Programming Model	MapReduce, Spark, Distributed Processing.	API for virtualized services (apps that are containerized like Docker), Serverless computing.	MPI, OpenMP, CUDA	AI Frameworks with IoT protocols (like TensorFlow).

Colin Kirby
EEL4798

2 - Explain the differences among the three NAND flash memory technologies: SLC, MLC, and QLC. Discuss their applications.

Technology	Description	Applications
SLC	Stores 1 bit per cell. High endurance, fast R/W speeds, and high reliability. Most expensive out of the 3.	Industrial applications, High Performance SSDs.
MLC	Stores 2 bits per cell. Moderate endurance and performance, lower cost than SLC.	Consumer SSDs, laptops, general storage.
QLC	Stores 4 bits per cell. Lower endurance and performance, but highest density and cost efficiency.	Large scale data storage, Archival systems.

Colin Kirby
EEL4798

3 - SPEC ratios are shown for the Pentium and the Pentium Pro (Pentium+) processors

Clock	Pentium	Pentium+	Pentium	Pentium+
Rate	SPECint	SPECint	SPECfp	SPECfp
100 MHz	3.2	N/A	2.6	N/A
150 MHz	4.3	6.0	3.0	5.1
200 MHz	5.5	8.0	3.8	6.8

3.1 - SPECint shows Pentium+ is 1.4 to 1.45 times faster than Pentium. How about SPECfp results?

At 150 MHz, Pentium+ has a value of 5.1, and Pentium has a value of 3.0. Pentium+ is 1.7 times faster than Pentium.

At 200 MHz, Pentium+ has a value of 6.8, and Pentium has a value of 3.8. Pentium+ is 1.79 times faster than Pentium.

Thus, Pentium+ shows a greater improvement in SPECfp, as we have seen a roughly 1.75 avg improvement in comparison to SPECint which was only a roughly 1.4 average improvement.

3.2 - Clock rate of the Pentium doubles from 100 MHz to 200 MHz, are both the SPECint and SPECfp performance doubled correspondingly?

With SPECint, Pentium performance increases from 3.2 to 5.5, meaning there was a 1.72x improvement.

With SPECfp, Pentium performance increases from 2.6 to 3.8, meaning there was a 1.46x improvement.

Thus, doubling the clock rate does not double SPECint or SPECfp performance due to other bottlenecks.

Colin Kirby
EEL4798

4 - We are using Amdahl's Law and Gustafson's Law to calculate overall speedup and scaled speedup. Given a 10% serial section of a program, calculate both speedups for a 64-processor machine.

Serial Section : 10% or 0.1

Parallel Section : 90% or 0.9

# of processors : 64

Amdahl's Law :

$$Speedup = \frac{1}{S + \frac{P}{N}} = \frac{1}{0.1 + \frac{0.9}{64}} = \frac{1}{0.1 + 0.014} = \frac{1}{0.114} \cong 8.77$$

Gustafson's Law :

$$Scaled\ Speedup = S + P * N = 0.1 + 0.9 * 64 = 0.1 + 57.6 = 57.7$$

Colin Kirby
EEL4798

5 - Textbook (A Quantitative Approach to Computer Architecture, 5th edition) Page 63: Exercise 1.4

a. Assuming the maximum load for each component, and a power supply efficiency of 80%, what wattage must the server's power supply deliver to a system with an Intel Pentium 4 chip, 2 GB 240-pin Kingston DRAM, and one 7200 rpm hard drive?

We'll assume these maximum loads :

Intel Pentium 4 : 85 W.

2GB Kingston DRAM : 10 W.

7200 RPM HDD : 15 W.

So, our total component power comes out to 110 W.

Considering our power supply efficiency of 80% then the necessary wattage required comes out to :

$$Wattage\ Required = \frac{Total\ Power}{Efficiency} = \frac{110}{0.8} = 137.5\ W$$

b. How much power will the 7200-rpm disk drive consume if it is idle roughly 60% of the time?

If the HDD is idle 60% of the time, then considering it uses 15 W at full power (as we set previously) then the Idle Power is :

$$Idle\ Power = 15 * 0.4 = 6\ W$$

$$Average\ Power = 0.6 * 6 + 0.4 * 15 = 9.6\ W$$

c. Given that the time to read data off a 7200-rpm disk drive will be roughly 75% of a 5400-rpm disk, at what idle time of the 7200-rpm disk will the power consumption be equal, on average, for the two disks?

So, we know the following :

$$Reading\ Time\ For\ 7200\ HDD = 0.75\ x\ Reading\ Time\ for\ 5400\ RPM.$$

With 5400 HDD, let's assume :

It is idle for the same fraction of time as the 7200 HDD, which we'll denote as ***x***.

We'll denote the active power of the 5400 HDD as ***P***, because it is unknown.

Thus, we'll denote Idle power of 5400 HDD with : ***0.4 * P***

Now let's denote the Average Power for both HDDs :

$$Average\ Power\ (7200\ HDD) = (1 - x) * 15 + x * 6$$

$$Average\ Power\ (5400\ HDD) = (1 - x) * P + x * (0.4 * P)$$

Let's assume also that the work done is the same for both HDDs. Since the 7200 HDD completes the work in 75% of the time, its power consumption must be higher during active use. From this let's derive :

$$P = \frac{Max.Watt.For\ 7200\ HDD}{0.75} = \frac{15}{0.75} = 20\ W$$

Plugging this into our previous equations :

$$Average\ Power\ (7200\ HDD) = (1 - x) * 15 + x * 6 \rightarrow (unchanged)$$

$$Average\ Power\ (5400\ HDD) = (1 - x) * 20 + x * (0.4 * 20) \rightarrow (subbed\ 20\ in\ for\ P)$$

Now, we can set them equal then solve for ***x*** :

$$(1 - x) * 15 + x * 6 = (1 - x) * 20 + x * 8$$

$$15 - 15x + 6 = 20 - 20x + 8x$$

$$3x = 5$$

$$x = \frac{5}{3} \cong 1.67$$

However, with the value coming out to 1.67 it means its not feasible because the idle team cannot exceed 100% as 1.67 refers to 167% , and idle time cannot exceed 1 (100%). Thus, the 7200 HDD will always consume more power than the 5400 HDD, there exists no idle time where the two disks will have equal power.