HY425 – Computer Architecture
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Assignment 1

Problem 1

Chip	#Cores	Frequency (MHz)	Memory Performance	Dhrystone Performance
Athlon 64 X2 4800+	2	2400	3423	20718
Pentium EE 840	2	2200	3228	18893
Pentium D 820	2	3000	300	15220
Athlon 64 X2 3800+	2	3200	2941	17129
Pentium 4	1	2800	2731	7621
Athlon 64 3000+	1	1800	2953	7628
Pentium 4 570	1	2800	3501	11810
Processor X	1	3000	7500	5000

i. For the normalization of each processor's benchmarks we need to use the lowest frequency CPU (Athlon 64 3000+) as a base and then calculate the rest of the normalized values (formula: NormalValue=Value/BaseValue):

Memory Performance:

Chip	Frequency (MHz)	Memory Performance	Normal Values
Athlon 64 X2 4800+	2400	3423	1.16
Pentium EE 840	2200	3228	1.09
Pentium D 820	3000	300	0.1
Athlon 64 X2 3800+	3200	2941	1
Pentium 4	2800	2731	0.92
Athlon 64 3000+	1800	2953	1
Pentium 4 570	2800	3501	1.19
Processor X	3000	7500	2.54

Dhrystone Performance:

Chip	Frequency (MHz)	Dhrystone Performance	Normal Values
Athlon 64 X2 4800+	2400	20718	2.72
Pentium EE 840	2200	18893	2.48
Pentium D 820	3000	15220	2
Athlon 64 X2 3800+	3200	17129	2.25
Pentium 4	2800	7621	1
Athlon 64 3000+	1800	7628	1
Pentium 4 570	2800	11810	1.55
Processor X	3000	5000	0.66

ii. Lets now calculate the arithmetic mean of the performance and the normalized performance

Chip	Memory Performance	Dhrystone Performance	Arithmetic Mean
Athlon 64 X2 4800+	3423	20718	12070.5
Pentium EE 840	3228	18893	11060.5
Pentium D 820	300	15220	7760
Athlon 64 X2 3800+	2941	17129	10035
Pentium 4	2731	7621	5176
Athlon 64 3000+	2953	7628	5290.5
Pentium 4 570	3501	11810	7655.5
Processor X	7500	5000	6250

Based on the above table, the processor with the highest average performance is Athlon 64 X2 4800+

For the Average Normal value of each processor we will calculate as following:

Chip	Memory Normal Value	Dhrystone Normal Value	A.M. Normal Value
Athlon 64 X2 4800+	1.16	2.72	1.94
Pentium EE 840	1.09	2.48	1.78
Pentium D 820	0.1	2	1.05
Athlon 64 X2 3800+	1	2.25	1.62
Pentium 4	0.92	1	0.96
Athlon 64 3000+	1	1	1
Pentium 4 570	1.19	1.55	1.37
Processor X	2.54	0.66	1.6

Again we can observe that the maximum average normal value is of the processor Athlon 64 X2 4800+

iii. For the **Geometric Mean** of the single-core and dual-core processors we will calculate based on the following formula: $ratio_{gm} = \sqrt[2]{NormalValue_{memory} + NormalValue_{dhrystone}}$

Single-Core:

Chip	Memory Normal Value	Dhrystone Normal Value	G.M. Ratio
Pentium 4	0.92	1	1.39
Athlon 64 3000+	1	1	1.41
Pentium 4 570	1.19	1.55	1.65
Processor X	2.54	0.66	1.79

Dual-Core:

Chip	Memory Normal Value	Dhrystone Normal Value	G.M. Ratio
Athlon 64 X2 4800+	1.16	2.72	1.97
Pentium EE 840	1.09	2.48	1.89
Pentium D 820	0.1	2	1.45
Athlon 64 X2 3800+	1	2.25	1.8

As we can observe the single-core processor with the greatest g.m. ratio is Processor X and the dual-core with the greatest g.m. ratio is again Athlon 64 X2 4800+

iv. For the final comparison I will compare using **Weighted Arithmetic Mean**. Given that 85% of the time is memory tasks and 15% is compute bound tasks, I will use weights of $W_{mem}=0.85$ and $W_{proc}=0.15$. The formula I will use is $Ratio=W_{mem}*ratio_{memory}+W_{proc}*ratio_{dhrystone}$

The comparison table is as follows:

Chip	Memory Normal Value	Dhrystone Normal Value	WAM Normal Value
Athlon 64 X2 4800+	1.16	2.72	1.39
Pentium EE 840	1.09	2.48	1.3
Pentium D 820	0.1	2	0.39
Athlon 64 X2 3800+	1	2.25	1.18
Pentium 4	0.92	1	0.94
Athlon 64 3000+	1	1	1
Pentium 4 570	1.19	1.55	1.24
Processor X	2.54	0.66	2.26

We can clearly see that for the given application that 85% of the time is memory tasks and 15% is compute bound tasks, the processor with the best normal value is the Processor X.

Problem 2

i. In order to calculate the speedup of the first application when the 60% of it is parallelizable, we will do the following division:

$$ParallelizationSpeedup_1=\frac{1}{1-0.6}=2.5$$

We can observe that the parallelized application will outperform the single-core application by a factor of **2.5**

ii. To calculate the speedup of the second application when the 90% of it is parallelizable, we will calculate like above:

$$ParallelizationSpeedup_2=\frac{1}{1-0.9}=10$$

This also means that when parallelized, the second application will achieve a speedup of **10** times

iii. If only the first application is parallelized, the overall system speedup can be calculated as follows:

$$OverallSpeedup_1 = \frac{1}{(1-0.6)+\frac{0.6}{2.5}} = \frac{1}{0.4+0.24} = 1.56$$

As a result, the total system speedup will be equal to **1,56** if only the first application is parallelized

iv. In order to calculate the complete system speedup, we need to know the speedup of the second application as well:

$$OverallSpeedup_1 = \frac{1}{(1-0.9)+\frac{0.9}{10}} = \frac{1}{0.1+0.09} = 5.26$$

Thus the **Total System Speedup** will be equal to 1,56 + 5,26 = **6,82**

Problem 4

i. Based on basic calculations the MTTF of every component is the following

$$MTTF_{proc} = \frac{2\,days}{1\,processor} = 2\,days/processor$$

$$MTTF_{mem} = \frac{5\,days}{1\,node} = 5\,days/node$$

$$MTTF_{disk} = \frac{25\,days}{1\,disk} = 25\,days/disk$$

ii. In order to calculate the MTTF of the system as a whole we need to consider the failure rates of all the components:

$$MTTF_{system} = \frac{1}{\frac{1}{MTTF_{proc}}+\frac{1}{MTTF_{mem}}+\frac{1}{MTTF_{disk}}} = \frac{1}{\frac{1}{2}+\frac{1}{5}+\frac{1}{25}} = \frac{1}{0.74} = 1.35\,days$$

iii. In order to calculate the availability of the system we need to use the following formula:

$$SystemAvailability = \frac{MTTF}{MTTF+MTTR} = \frac{1.35*24}{(1.35*24)+1} = \frac{32.43}{33.43} = 0.97$$

Which leads us with a system with **97% availability**