Computer Architecture Assignment 1

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Problem1.11

[10/10/20] Availability is the most important consideration for designing servers, followed closely by scalability and throughput.

a. [10] We have a single processor with a failure in time (FIT) of 100. What is the mean time to failure (MTTF) for this system?

Solution: Given FIT = 100

MTTF for a system is defined by rate of failures, generally reported as failures per billion hours of operation, or FIT (for failures in time).

MTTF for given system = 10^9/100 = 10^7

b. [10] If it takes 1 day to get the system running again, what is the availability of the system?

Solution: Given MTTR (Mean time to repair) = 24 hr.

Module Availability = (MTTF/MTTF+MTTR)

= (10^7)+(10^7+24) ~= 0.99

c. [20] Imagine that the government, to cut costs, is going to build a supercomputer out of inexpensive computers rather than expensive, reliable computers. What is the MTTF for a system with 1000 processors? Assume that if one fails, they all fail.

Solution:

FIT(Failure in Time) for single processor is 100.

FITsystem = FIT for each computer \* 1000 = 10^5.

MTTF system  = 10^9/FITsystem

= 10^9/10^5 = 10^4;

1.15 [15/10] <1.9> Assume that we make an enhancement to a computer that

improves some mode of execution by a factor of 10. Enhanced mode is used 50%

of the time, measured as a percentage of the execution time when the enhanced

mode is in use. Recall that Amdahl’s law depends on the fraction of the original,

unenhanced execution time that could make use of enhanced mode. Thus, we

cannot directly use this 50% measurement to compute speedup with Amdahl’s

law.

a. What is the speedup we have obtained from fast mode?

Solution: Let Execution Time without enhancement be Exold

Let Execution Time with enhancement be Exnew

Fractionenhanced  = 50% = 0.5

Speedupenhanced = 10

Exold  = Exnew (1- 0.5) + (Exnew \* 0.5 \* 10) = 5.5 Exnew

Speedup = Exold / Exnew = 5.5

b. What percentage of the original execution time has been converted

to fast mode?

Solution:

Unenhanced part Execution time Old = 0.5T

Enhanced part Execution time Old = 0.5\*10 = 5T

Enhanced part Execution time new = 0.5T

Unenhanced part Execution time new = 0.5T

Percentage = (Enhanced part Execution time old/ Total Time) \* 100

= 500/5.5 = 1000/11 = 90.9%

<1.10> When parallelizing an application, the ideal speedup is

speeding up by the number of processors. This is limited by two things: percentage

of the application that can be parallelized and the cost of communication.

Amdahl’s law takes into account the former but not the latter.

a. What is the speedup with N processors if 80% of the application

is parallelizable, ignoring the cost of communication?

Solution: SpeedUp = Exold /Exnew

= 1/(1-fen) + (fen/s))

= 1/((1-0.8) + (0.8/N)

= 1/(0.2+0.8/N)

b. What is the speedup with 8 processors if, for every processor

added, the communication overhead is 0.5% of the original execution time.

Solution: Let the original execution time Exold. With every new processor

Execution time overhead increases by 0.005. With 8 processors

It becomes 8\*0.005. Add the enhancement factor to this to get the

Speedup.

Speedup = 1/((1-0.8) + (0.8/8) + 8\*0.005)

= 1/(0.2+0.1+0.04) = 1/0.34 = 2.94

c. What is the speedup with 8 processors if, for every time the number

of processors is doubled, the communication overhead is increased by

0.5% of the original execution time?

Solution: 1->2->4->8 here we are doubling the processors 3 times to get

8 processors.

Speedup = 1/((1-0.8) + (0.8/8) + (3\*0.005)) = 1/0.315 = 3.714

d. What is the speedup with N processors if, for every time the

number of processors is doubled, the communication overhead is increased

by 0.5% of the original execution time?

Solution: 1->2->4..->2^x series where 2^x= N => x = log2N

Speedup = 1/((1-0.8) + (0.8/N) + (log2N\*0.005))

= 1/(0.2+(0.8/N)+(logN\*0.005))

e. [25] <1.10> Write the general equation that solves this question: What is the

number of processors with the highest speedup in an application in which P %

of the original execution time is parallelizable, and, for every time the number

of processors is doubled, the communication is increased by 0.5% of the

original execution time?

Solution: f(N) = 1/(1-p)+ (p/N) + (logN\*0.005) is the speedup .

To maximize the speedup, Differentiate d(f(N))/dN = 0

To get the value of N . which gives

-1/((1-p)+ (p/N) + (logN\*0.005))2  \* ((0.005log2e)/N – P/N2 ) = 0

gives P = N\*0.005log2e or N = 200\*p\*log2e;