W9

1)

A small cluster has the following configuration:

•24 Intel CPU @ 4.20GHz, with each CPU containing 8 cores, and each core providing 10.0 GFLOPS

•12 Intel CPU @ 4.00GHz, with each CPU containing 12 cores, and each core providing 5.6 GFLOPS

The cluster has now been upgraded with two Nvidia GPU modules, each rated at 9322.46 GFLOPS.

Part A)

- What is the total aggregated cluster peak performance in GFLOPS?

Part B)

- Bob writes an application that can only be executed on 1 GPU and 1 multicore CPU. What is the peak cluster performance in GFLOPS the application could obtain, neglecting Amdahl's Law?

$P = NCFR$

P: performance (M/G) FLOPS
N: no. nodes
C: no. CPUs
F: operations / clock period
R: clock rate

$24 \times 8 \times 10 = 1920$ GFLOPS
$12 \times 12 \times 5.6 = 806.4$

a) $1920 + 806.4 + 9322.46 \times 2 = 21371.32$

b) $80 + 9322.46 = 9444.46$

2)

- Bob has just computed a floating point matrix of size 100,000 x 100,000, in a GPU employing 32-bit floating point operands.
- He has a machine with a GPU containing 48GB GDDR5 RAM, with an average memory bandwidth of 256 GB/s.
- Assume the matrix has already been computed in the GPU and is ready to move to the GPU RAM.
- How long would it take to transfer the matrix to another location in the GPU RAM? (in seconds at 3 decimal places)
- Note: 1 GB = 1024^3 bytes, 1 byte = 8 bit

1×10^{10} elements

$10^{10} \times 32$ bits

$\frac{10^{10} \times 32}{8 \times 1024^3} \approx 37$ GB

$t = \frac{37.25}{256}$

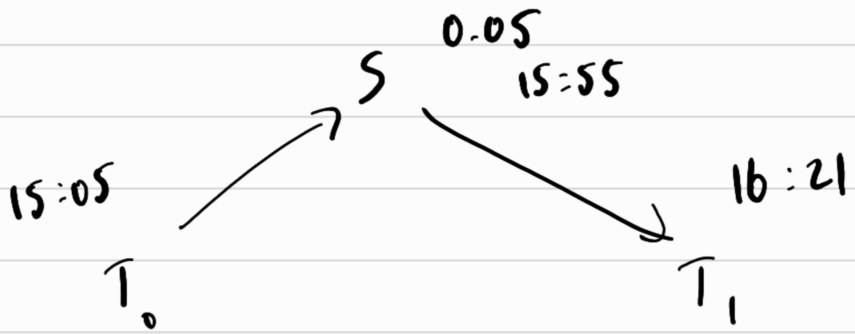
3)

- Bob wants to synchronize his machine to a time server using Cristian's Algorithm.
- His machine sends a request message at 13:15:05, receives a message from the timing server at 13:16:21 containing a reference time of 13:15:55.
- Assume interrupt handling time is 0.05s.
- By how many seconds does he need to adjust his machine?

Assumption:

+ve means forward and -ve means backward.

Rounded to 3 decimal places.



$$T_{sync} = T_s + \frac{T_1 - T_0 - I}{2}$$

$$15:55 + \frac{16:21 - 15:05 - 0.05}{2}$$

$$15:55 + \frac{75.95\,s}{2}$$

$$15:55 + 37.975\,s$$

$$= 13:16:32.975$$

forward +11.975s

4)

- Assume the use of the Averaging Algorithm.
- There are four machines (M1, M2, M3, and M4) in different geographical locations.
- M1 receives three messages from M2, M3, and M4 at noon (12:00:00), containing three reference times. M1 immediately corrects its time to 12:00:01.
- Bob diagnoses the two of the three messages and figures out M2 and M3 are sending a reference time of 11:59:40 and 11:59:50. Unfortunately, the third message from M4 is lost and he cannot figure out the reference time. Can you infer the reference time sent by M4?
- Assumption: We assume communication time and interrupt handling time are both insignificant (i.e., 0 seconds).

$$\Delta M_1 = \frac{M_1 + M_2 + M_3 + M_4}{4} - M_1$$

$$1 = \frac{0 - 20 - 10 + M_4}{4} - 0$$

$$1 = \frac{-30 + M_4}{4}$$

$$4 = -30 + M_4 \qquad M_4 = 34$$

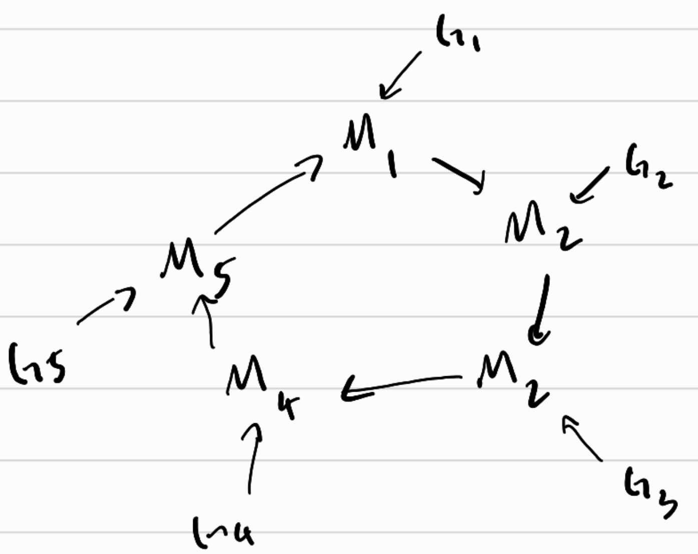
$$M_4 = 12:00:34$$

5)

- Bob manages a cluster containing 5 machines (M1, M2, M3, M4, and M5) in a ring topology. Each machine has one GPU for computation.
- Alice deploys a distributed application where the application will spawn 1 process per machine. Each process would need to exclusively acquire the GPU on its local machine and one extra GPU from one of its adjacent machines to perform its tasks.
- Assume processes can send its request to acquire GPU in any order (i.e., uncoordinated) and the process will not free the GPU after successfully acquiring it.
- Which of the following statements are correct?

Which of the following statements are correct?

1. The application will always have at least one process capable of completing its tasks, regardless of the request ordering.
2. The application will always have at least two processes capable of completing its tasks, regardless of the request ordering.
3. If there exists 1 process successfully acquiring 2 GPUs, then at least one more process will eventually manage to acquire 2 GPUs, regardless of the request ordering.
4. There exists one combination of request ordering where three processes can complete their tasks.
5. None of the statements are true.



1 3

4

$27:11 + 32.98\,s = 43.98$

$16:27:21 \rightarrow 16:27:43.98$

$+ 22.98\,s$

$22.98\,s$

$$\Delta M_1 = \frac{M_1 + M_2 + M_3 + M_4}{4} - M_1$$

$$S = \frac{-5:14 - 2:10 + M_4}{4}$$

$$S = \frac{-314 - 130 + M_4}{4}$$

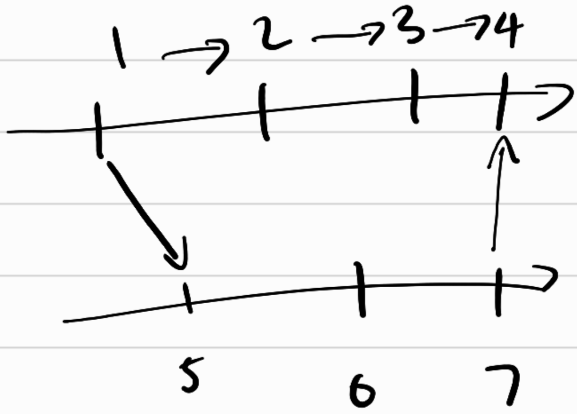
$M_4 = 464\,s$ ahead 10:00

$= 420\,s + 44\,s$

$M_4 = 10:07:44$

DW10

1)



① $C(E_1) < C(E_4)$
② $C(E_1) < C(E_5)$

2) 4, 5

3) $T(T_i) < T(T_j)$

1) T_i finishes 3 phases before T_j
2) T_i completes before T_j writes,
and T_i does not write to T_j reads
3) T_i completes read before T_j reads,
and T_i does no write to T_j read or write

③, ④

4) $S = \frac{1}{s + \frac{p}{n}}$ $\quad s + p = 1$

$= \frac{1}{0.5 + \frac{0.5}{2}}$

$S = 1.33$

original $t = 80s$
40s parallel, 20s serial,
20s comm

i) $\frac{40}{2} + 20 + \frac{20}{2} = 50s$
ii) $\frac{40}{2} + 20 + 5 = 45s$
iii) $40 + 20 + 10 = 70s$