Justin Li
6/7/23

COEN 239 HW 8

1. 33.1 - During a 10 second observation period, 400 packets were serviced by a gateway whose CPU can service 200 pps. What was the utilization of the gateway CPU?
   Lambda = 400/100
   pps = 40
   u = 200 pps
   E = lambda/u = 1/50 = 0.02*10 = 0.2

2. 33.2 - The throughput of a timesharing system was observed to be 5 jobs/sec over a 10 minute observation period. If the average number of jobs in the system was four during this period, what was the average response time?
   X = 5 jobs/sec
   T = 600 sec
   Q = 4
   Q = XR => R = Q/X = ⅘ = 0.8 sec

3. 33.3 - During a 10 second observation period, 40 requests were serviced by a file server. Each request requires two disk accesses. The average service time at the disk was 30 msec. What was the average disk utilization during this period?
   T = 10 sec; 40 requests
   Lambda = 40/10 = 4 requests/sec

4. 33.4 - A Distributed System has a print server with a printing speed of 60 pages/minute. The server was observed to print 500 pages over a 10 minute observation period. If each job prints five pages on the average, what was the job completion rate?
   Printer Speed = 60 pages/minute = 1 page/sec
   Server prints 500 pages/10 minutes = 500/10(60) = ⅚ pages/sec
   1 Job takes 5 pages, this job takes 5/(⅚) = 6 sec
   therefore, Job Completion rate = ⅙ jobs/sec
   = ⅙ * 60 jobs/min = 10 jobs/min

5. 33.5 - For a timesharing system with 2 disks (User and System), the probabilities for jobs completing the service art the CPU were found to be 0.80 to Disk A, 0.16 to Disk B, and 0.04 to terminals. The user think time was measured to be 5 seconds, the disk service times were 30 and 25 milliseconds, and the average service time per visit to the CPU was 40 msec. Using the queueing network model shown in Fig. 32.8, answer the following for this system:
   a. For each job, what are the visit ratios for CPU, Disk A, and Disk B
   b. For each device, what is the total service demand?
   c. If Disk A Utilization is 60%, what is the utilization of the CPU and Disk B?

d. If the Utilization of Disk B is 10%, what is the average response time when there are 20 users on the system.

$P_{CPU,A} = 0.8$; $P_{CPU,B} = 0.16$; $P_{CPU,T} = 0.04$

$Z = 5$ sec, $S_A = 30$ msec; $S_B = 25$ msec; $S_{CPU} = 40$ msec; $V_T = 1$

$V_A = V_A P_{A,A}(0) + V_B P_{B,A}(0) + V_{CPU} P_{CPU,A} + V_T P_{T,A}(0)$

$V_B = V_A P_{A,B}(0) + V_B P_{B,B}(0) + V_{CPU} P_{CPU,B} + V_T P_{T,B}(0)$

$V_{CPU} = V_A P_{A,CPU}(1) + V_B P_{B,CPU}(1) + V_{CPU} P_{CPU,CPU}(0) + V_T P_{T,CPU}(1)$

$V_T = V_A P_{A,T}(0) + V_B P_{B,T}(0) + V_{CPU} P_{CPU,T} + V_T P_{T,T}(0)$

$V_{CPU} = V_A + V_B + V_T = V_A + V_B + 1$

$V_A = 0.8\ V_{CPU}$

$V_B = 0.16\ V_{CPU}$

$V_T = 0.04\ V_{CPU} \Rightarrow V_{CPU} = 1/0.04 = 25$

$V_A = 0.8(25) = 20$

$V_B = 0.16(25) = 4$

a) $V_{CPU} = 25$; $V_A = 20$; $V_B = 4$

b) $D_{CPU} = V_{CPU} S_{CPU} = 25(40\text{x}10^{-3}) = 1$ sec
$D_A = V_A S_A = 20(30*10^{-3}) = 0.6$ sec
$D_B = V_B S_B = 4(25*10^{-3}) = 0.1$ sec

c) $U_A = D_A X = 0.6 \Rightarrow x = 1$
$U_B = D_B X = 0.1$
$U_{CPU} = D_{CPU} X = 1$

d) $U_B = 0.1 \Rightarrow U_B = D_B X$ AND $x = 1$
$N = (R + Z)X \Rightarrow 20 = (R + 5)1 \Rightarrow R = 15$ SE

6. 33.6 - For the System of Exercise 33.5, Answer the following:

a) What is the bottleneck device?
$D_{CPU} = 1$, $D_A = 0.6$, $D_B = 0.1$
$D_{MAX} = D_{CPU} \Rightarrow$ Bottleneck Device is CPU

b) What is the min avg response time?
$R_{MIN} = D_{CPU} + D_A + D_B = 1.7$ sec

c) What is the max possible Disk A utilization for this configuration?
$U_A = D_A X = 0.6X$; $x \le \min\{N/(D+Z), 1/D_{MAX}\}$
$x \le \min\{N/(6.7), 1\}$

N	N/6.7	C	$U_A = 0.6x$
1	0.15	0.15	0.09
2	0.30	0.30	0.18
3	0.45	0.45	0.27
4	0.60	0.60	0.36
5	0.75	0.75	0.45
6	0.90	0.90	0.54
7	1.05	1	0.60
8		1	0.6

U_A max is 0.6

d) What is the max possible throughput of this system?

Max throughput is x <= min{N/(6.7), 1}
x <= 1

e) What changes in CPU speed would you recommend to achieve a response time of 10 sec with 25 users? Would you also need a faster Disk A or Disk B?
N = 25; Max{D, ND_{MAX} - Z} <= R <= 10
Max{D, $25D_{MAX}$ - 5} <= 10
⇒ $25D_{MAX}$ - 5 <= 10 ⇒ $25D_{MAX}$ <= 15 ⇒ D_{MAX} <= 0.6
Thus if D_{CPU} = 0.6, D = D_{CPU} + D_A + D_B = 0.6 + 0.6 + 0.1 = 1.3, then the required response time goal is met without changing Disk A

7. 33.7 - For the System of Exercise 33.6, which device would be the bottleneck if…
   a) The CPU is replaced by another unit that is twice as fast
      D_A = 0.6, D_B = 0.1, D_{CPU} = 0.5
      ⇒ Disk A would be the bottleneck
   b) Disk A is replaced by another unit that is twice as slow
      D_A = 1.2, D_B = 0.1, D_{CPU} = 1
      ⇒ Disk A would be the bottleneck
   c) Disk B is replaced by another unit that is twice as slow
      D_A = 0.2, D_B = 0.6, D_{CPU} = 1
      ⇒ Disk CPU would be the bottleneck
   d) The memory size is reduced so that the jobs make 20 times more visits to DIsk B due to increased page faults
      D_B = 20(0.1) = 2
      V_{CPU} = V_A + V_B + 1 = 20 + 4(20) + 1 = 101
      D_{CPU} = $V_{CPU}S_{CPU}$ = 101(40x10^{-3}) ~= 4.04
      ⇒ CPU is the bottleneck

8. 34.1 - A Transaction Processing System can be modeled by an open queueing network shown in figure 32.1. The transactions arrive at a rate of 0.8 transactions per second, use 1 sec of CPU time, make 20 I/O's to Disk A and 4 I/O's to Disk B. Thus, the total number of visits to the CPU is 25. The Disk Service times are 30 and 25 msec, respectively. Determine the average number of transactions in the system and the average response time.
   x = 0.8, D_{CPU} = 1 sec, V_A = 20, V_B = 4
   V_{CPU} = V_A + V_B + 1 = 20 + 4 + 1 = 25
   S_A = 0.03 sec, S_B = 0.025 sec
   Q = ? R = ?
   D_A = V_AS_A = 0.6
   D_B = V_BS_B = 0.1
   U_{CPU} = XD_{CPU} = 0.8
   U_A = XD_A = 0.48
   U_B = XD_B = 0.08
   D_{CPU} = $V_{CPU}S_{CPU}$ = S_{CPU} = 1/25
   R_{CPU} = S_{CPU}/1-U_{CPU} = 1/[25(1-0.8)] = 0.2 sec

$R_A = S_A/1-U_A = 0.03/(1-0.48) = 3/52$ sec
$R_B = S_B/1-U_B = 0.025/(1-0.08) = 5/184$ sec
$Q_{CPU} = U_{CPU}/1-U_{CPU} = 0.8/(1-0.8) = 4$
$Q_A = U_A/1-U_A = 0.48/(1-0.48) = 12/13$
$Q_B = U_B/1-U_B = 0.08/(1-0.08) = 2/23$
$R = Sum(R_iV_i) = R_{CPU}V_{CPU} + R_AV_A + R_BV_B$
$= (0.2)25 + 3/52 * 20 + 5/184 * 4 = 6.26$ sec
$Q = Q_{CPU} + Q_A + Q_B = 4 + 12/13 + 2/23 = 5.01$ transactions

9. Iteration 3:
Number of users: N = 3
Device response times:
$R_{CPU} = S_{CPU}(1 + Q_{CPU}) = 0.125(1 + 0.421) = 0.178$
$R_A = S_A(1 + Q_A) = 0.3(1 + 0.684) = 0.505$
$R_B = S_B(1 + Q_B) = 0.2(1 + 0.193) = 0.239$
System response time is:
$R = V_{CPU}R_{CPU} + V_AR_A + V_BR_B = 16 * 0.178 + 10 * 0.505 + 5 * 0.239 = 9.088$ seconds
System throughput:
$X = N/(R + Z) = 3/(9.088 + 4) = 0.229$
Device queue lengths:
$Q_{CPU} = XR_{CPU}V_{CPU} = 0.229 * 0.178 * 16 = 0.651$
$Q_A = XR_AV_A = 0.229 * 0.505 * 10 = 1.158$
$Q_B = XR_BV_B = 0.229 * 0.239 * 5 = 0.273$

Iteration 4:
Number of users: N = 3
Device response times:
$R_{CPU} = S_{CPU}(1 + Q_{CPU}) = 0.125(1 + 0.651) = 0.206$
$R_A = S_A(1 + Q_A) = 0.3(1 + 1.158) = 0.647$
$R_B = S_B(1 + Q_B) = 0.2(1 + 0.273) = 0.255$
System response time is:
$R = V_{CPU}R_{CPU} + V_AR_A + V_BR_B = 16 * 0.206 + 10 * 0.647 + 5 * 0.255 = 11.051$ seconds
System throughput:
$X = N/(R + Z) = 4/(11.051+ 4) = 0.266$
Device queue lengths:
$Q_{CPU} = XR_{CPU}V_{CPU} = 0.266 * 0.206 * 16 = 0.878$
$Q_A = XR_AV_A = 0.266 * 0.647 * 10 = 1.721$
$Q_B = XR_BV_B = 0.266 * 0.255* 5 = 0.338$