Sheet #1

Rules

Recall

- Arrival rate $\lambda_i = \frac{A_i}{T}$ (1) — A_i: arrivals
- # of completed jobs C_i
  - ↳ Completion rate $X_i = \frac{C_i}{T}$ (2)
- Busy time B_i
- Utilization $U = \frac{B_i}{T}$ (3)
- mean service time $S_i = \frac{B_i}{C_i}$ (4)

$$S_i = \frac{1}{\text{speed of device } i} \quad (5)$$

operational laws

- $U_i = X_i S_i$ (6)

- Job flow balance from (1) & (2)

$$A_i = C_i \iff \lambda_i = X_i \quad (7)$$

* if a job needs several visits to device i to be performed V_i (visit ratio) then, X_i is

$$X_i = X V_i \quad (8)$$

- Job demand $D_i = V_i S_i$ (9)

from $U_i = X_i S_i = X V_i S_i = X D_i$ (10)

- Little's law $Q_i = X_i R_i$ (11) — R_i: mean response time

↳ mean customers in system

Examples

1) During a T = 10 sec. observation period, C = 400 packets were served by a gateway whose CPU can serve 200 pps (speed)

? what was the utilization of the gateway CPU?

$$S = \frac{1}{\text{speed}} = 5 \times 10^{-3} \text{ sec}$$

$$X = \frac{C}{T} = \frac{400}{10} = 40$$

$$U = XS = 40 \times 5 \times 10^{-3} = 0.2 \#$$

2) For given system of 2 devices A & B, $V_A = 2$, $V_B = 3$, during T = 10 sec., the system served C = 3 jobs. What was the throughput of each device?

$$X = \frac{C}{T} = \frac{3}{10} = 0.3$$

$$X_A = X V_A = 0.3(2) = 0.6$$
$$X_B = X V_B = 0.3(3) = 0.9$$

3) Dist. sys has a printer server with a printing speed of 60 pages per minute. The server was observed to print C = 500 pages over a T = 10 min observation period. If each job prints V_p = 5 pages (5 pages/job) on average,

? what was the job completion rate?

$$X_p = X V_p$$
$$50 = X(5) \rightarrow X = 10 \text{ jobs/min}$$

4) During a 10 sec. observation period, 40 requests were served by a file server. Each request requires 2 disks accesses. The average service time at the disk was 30 msec.

a) What is the avg disk utilization?

$$U_d = X V_d S_d = \frac{C}{T} V_d S_d$$

$$= \frac{40}{10}(2)(0.03) = 0.24$$

5) Consider a desktop computer with one disk that serves page faults. We measured that the disk utilization is 0.8, and the mean time to handle (serve) a page faults is 0.01 sec. If on average 5 tasks per second arrive to the system, what is the average number of page faults per task?

$$U = X V S = \lambda V S$$

$$0.8 = (5)(V)(0.01)$$

$V = 16$ page fault / task

6) A web server is monitored for 10 minutes & its CPU is observed to be busy 90%. The web server log reveals that 30,000 requests are completely processed in that period.

a) What is the CPU service demand of the web server?

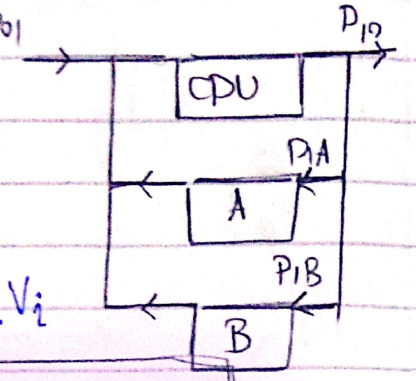
$$U = XD$$

$$D = \frac{U}{X} = \frac{UT}{C} = 3 \times 10^{-4} \text{ min}$$

7) The throughput of a timesharing system was observed to be 5 jobs per sec over 1 min. If the avg number of jobs in the system was 4, What is the avg response time?

$$Q = XR \Rightarrow R = \frac{4}{5} = 0.8 \text{ sec}$$

Central Server Model



$P_{21} = 1$

$P_{ii} = 0$

$V_i = V_0 + \sum P_{i1} V_i$

$$V_1 = 1 + V_A + V_B + \cdots \quad (12)$$

$V_A = V_1 P_{1A}$, $V_B = P_{1B} V_1$

$$V_1 = V_{CPU} = \frac{1}{P_{10}} \quad (13)$$

$$V_A = \frac{P_{1A}}{P_{10}} \quad , \quad V_B = \frac{P_{1B}}{P_{10}} \quad (14)$$

(1) In a time-sharing system, accounting log data produced the following user profile for user programs. The avg think time is 18 sec. From the devices specs, it was determined that disk A takes 50 msec & disk B takes 30 msec per request. With 17 active users, disk A throughput was observed to be 15.7 I/O req. per sec.

* Each program requires 5 sec of CPU time & makes 80 I/O req to disk A and 100 I/O to disk B

i) System throughput X

$$X_A = X V_A$$

$$X = \frac{15.7}{80} = 0.19625 \text{ rps}$$

ii) The utilization of each device

$$U_A = X_A S_A = (15.7)(50 \times 10^{-3}) = 0.785$$

$$U_B = X_B S_B = X V_B S_B$$

$$= (0.19625)(100)(30 \times 10^{-3}) = 0.58875$$

$$U_{CPU} = X D_{CPU} = (0.19625)(5) = 0.98125$$

iii) Visit ratio of CPU

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

$$= 1 + 80 + 100 = 181 \text{ visit/prog}$$

(2) Consider the open queueing nw model for a file server, shown in the figure ... during 1 hour

CPU Busy time = 1728 s

Disk A Busy time = 1512 s

Disk B Busy time = 2592 s

# of I/O operations to disk A = 75,600

# of I/O op to disk B = 86,400

i) Service demand & visit ratio for the 3 devices

$$S_i = \frac{B_i}{C_i} \rightarrow S_A = \frac{1512}{75\,600} = 0.02 \text{ sec}$$

$S_B = \frac{B_B}{C_B} = \frac{2592}{86400} = 0.03$ sec

S_{CPU}

$D_A = V_A S_A = \frac{1728}{10800} = 0.16$ sec

$X = \frac{C}{T} = \frac{10,800}{3600} = 3$ req/sec

75,600

$X_A = \frac{C_A}{T} = \frac{2592}{3600} = 21$ req/sec

$X_B = \frac{C_B}{T} = \frac{84,400}{3600} \approx 24$ req/sec

$V_A = \frac{X_A}{X} = \frac{21}{3} = 7$ vi/req ←

$V_B = \frac{X_B}{X} = \frac{24}{3} = 8$ Vi/req ←

$V_{CPU} = 1 + V_B + V_A = 16$ /req ←

$D_A = V_A S_A = 7(0.02) = 0.14$ sec

$D_B = V_B S_B = 8(0.03) = 0.24$ sec

$D_{CPU} = V_{CPU} S_{CPU} = 16(0.16) = 2.56$ sec

ii) device utilization

$U_{CPU} = \frac{B_{CPU}}{T} = \frac{1728}{3600} = 0.48$

$U_A = \frac{B_A}{T} = \frac{1512}{3600} = 0.42$

$U_B = \frac{B_B}{T} = \frac{2592}{3600} = 0.72$