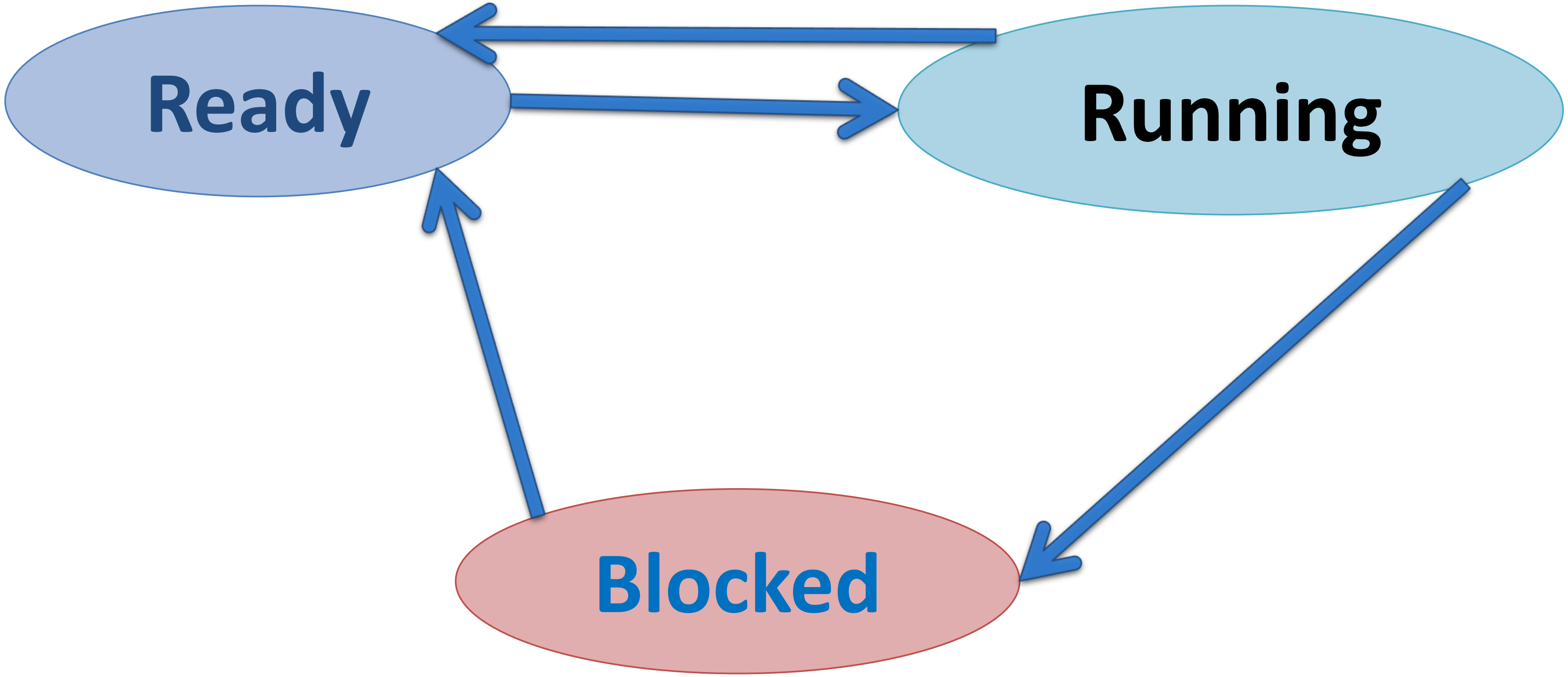
Introduction to Operating Systems and SQL for Data Science

Practice 2 – Scheduling

Process states:



Scheduling algorithm types

1. Preemptive – make a running process into ready state (such as timer interrupt)

2. Non-preemptive – a process is running until its blocked or done.

Scheduling goals

1. Fairness – fair CPU time for each process (define fair…)

2. Policy enforcement – different priorities. for example, OS processes will get preference over other processes.

3. Balance – we want that all recourses will operate in parallel (CPU + IO)

4. Throughput – number of process that ends in a given time frame (we want to maximize)

5. Turnaround – the time of each process takes to end (we want to minimize)

6. Respond time – The time from the moment a user creates a request (for example, presses a button) until the request is executed.

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Utilization

- $P(pi = B)$: probability of process I to be blocked
- $\prod_i P(pi = B)$: probability of all processes are blocked
- $P(pi = R)$: probability of process i to be running
- $P(pi = \neg B)$: probability of process i to be non blocked
- CPU Utilization = $1 - \prod_i P(pi = B)$
- $t(pi)$: time left for process i to run (gross)
- $tCPU(pi) = t(pi) * P(pi = R)$: $time\ process\ needs\ to\ run\ on\ CPU$
- $t(pi) = \frac{tCPU(pi)}{CPUUtil * P(pi=\neg B) / \sum P(pj=\neg B)} = \frac{tCPU(pi)}{P(pi=R)}$

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Question #1

A system contains the following processes.

a. What is the CPU utilization in each time point: 1,3,5

b. At point 4, how much time left for each process to finish?

CPU Time needed	P(pi=B)	Arrival Time	Process
0.75	50%	0	A
1.5	50%	0	B
6	50%	2	C
3	40%	4	D
4	30%	4	E

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Solution

a. What is the CPU utilization in each time point: 1,3,5

CPU Utilization = $1 - \prod_i P(pi = B)$

In order to calculate CPU utilization in each point we need to understand which process are alive at each point.

<u>Time point 1:</u>

Process A and B arrive on second #0 we should check if they are still alive on second #1:

- $t(pA) = ? = \frac{tCPU(pA)}{P(pA=R)}$
  - $tCPU(pA) = 0.75$
  - $P(pA = R) = 0.5 * (0.5 + 0.50 * 0.5) = 0.375$
  - $t(pA) = \frac{0.75}{0.375} = 2$

Process A finishes on second 2.

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Solution

What is the CPU utilization in each time point: 1,3,5

CPU Utilization = $1 - \prod_i P(pi = B)$

<u>Time point 1 - cont.:</u>

Process A and B arrive on second #0 we should check if they are still alive on second #1:

- $t(pB) =? = \frac{tCPU(pB)}{P(pB=R)}$
  - $tCPU(pB) = 1.5$
  - $P(pB = R) = 0.5 * (0.5 + 0.50 * 0.5) = 0.375$
  - $t(pB) = \frac{1.5}{0.375} = 4$

Process B finishes on second 4.

Now we can calculate CPU Utilization:

$$\mathbf{U(t = 1) = 1 - \{P(pA = B) * p(pB = B)\} = 0.75}$$

Solution

What is the CPU utilization in each time point: 1,3,5

CPU Utilization = $1 - \prod_i P(pi = B)$

<u>Time point 3:</u>

Process A finished on second 2 therefore will not be on second 3,

Process B finished on second 4 therefore will be in second 3.

Process C Arrived on second 2 but its tCPU is 6 therefore will be in second 3.

Now we can calculate CPU Utilization:

$$U(t = 3) = 1 - \{P(pB = B) * p(pC = B)\} = \mathbf{0.75}$$

Solution

What is the CPU utilization in each time point: 1,3,5

CPU Utilization = $1 - \prod_i P(pi = B)$

<u>Time point 5:</u>

Process C Arrived on second 2 but its tCPU is 6 therefore will be in second 5.

Process D and E arrived on second 4 but their tCPU is greater than 1 therefore will be in second 5.

Now we can calculate CPU Utilization:

$$U(t = 5) = 1 - \{P(pC = B) * p(pD = B) * p(pE = B)\} = \mathbf{0.94}$$

Question #1

A system contains the following processes.

a. What is the CPU utilization in each time point: 1,3,5

b. At point 4, how much time left for each process to finish?

CPU Time needed	P(pi=B)	Arrival Time	Process
0.75	50%	0	A
1.5	50%	0	B
6	50%	2	C
3	40%	4	D
4	30%	4	E

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Solution

b. At point 4, how much time left for each process to finish?

$$t(pi) = \frac{tCPU(pi)}{CPUUtil \ * P(pi = \neg B)/\sum P(pj = \neg B)}$$

As we saw the processes remaining on point 4 are C D and E and the CPU utilization in this point is 0.94.

What is tCPU left for each of them?

Process D and E arrive at point 4 so they didn't run on the CPU yet at all.

$tCPU(pD) = 3\ ,\ \ tCPU(pE) = 4$

Process C arrived at point 2 so it used the CPU $t*P(pC=R)$ until point 4:

$tCPU(pC) = 6 - 2 * 0.375 = 5.25$

Solution

b. At point 4, how much time left for each process to finish?

$$t(pi) = \frac{tCPU(pi)}{CPUUtil \ * P(pi = \neg B)/\sum P(pj = \neg B)}$$

U(t=4)=0.94.

$tCPU(pD) = 3\ ,\ \ tCPU(pE) = 4\ ,tCPU(pC) = 5.25$

$P(P_C = \neg B) + P(P_D = \neg B) + P(P_E = \neg B) = 1.8$

<u>**C :**</u> $5.25\ /\ (\frac{0.5}{1.8} \cdot 0.94) = 20.19$

<u>**D :**</u> $3/\left(\frac{0.6}{1.8} \cdot 0.94\right) = 9.67$

<u>**E :**</u> $4\ /(\frac{0.7}{1.8} \cdot 0.94) \ \ = 10.81$

Question #2

- The following processes arrive to a batch system.
- The system uses a shortest job first scheduling,
- Non-preemptive.
- **What is the average turnaround?**

Work time	Arrival time	Process
5	0	**P1**
4	0	**P2**
6	0	**P3**
1	2	**P4**
1	4	**P5**

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Solution

- Turnaround time (TAT) is the time interval from the time of submission of a process to the time of the completion of the process.
- What is the selected scheduling?

Solution

- Turnaround time (TAT) is the time interval from the time of submission of a process to the time of the completion of the process.
- What is the selected scheduling?
- P2 (0-4)
- P4 (2-5 running 4-5)
- P5 (4-6 running 5-6)
- P1 (0-11 running 6-11)
- P3 (0-17 running 11-17)
- average turnaround = 4+3+2+11+17 / 5 = 7.4