COS40003 Concurrent Programming

Lecture 3 (a): Scheduling I

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TOID 3059

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Outline

- CPU scheduling
- First-Come, First Served (FIFO)
- Shortest Job First (non-preemptive)
- Shortest Job First (with preemption)
- Round-Robin Scheduling
- Lottery Scheduling
- Multi-Level Feedback Queue

CPU Scheduling Criteria

- CPU Utilization
  - *how busy is the CPU?*
- Turnaround Time
  - *how long from job submission to job termination?*
- Response Time
  - *how long does it take to get a response*
- Missed deadlines

Scheduler Options

- Priorities
  - –May use priorities to determine who runs next
  - –Static vs. Dynamic algorithms
    - Static algorithms typically assign a fixed priority when the job is initially started
    - Dynamically alter the priority of the tasks while they are in the system (possibly with feedback)
- Preemptive vs. Non-preemptive
  - Preemptive systems allow the task to be interrupted at any time so that the O.S. can take over again

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First-Come, First-Served (FIFO)

- Start jobs in the order they arrive (FIFO queue)

- Run each job until completion

First-Come, First-Served (FIFO)

Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

First-Come, First-Served (FIFO)

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
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First-Come, First-Served (FIFO)

Process	Arrival Time	Processing Time	Delay	Turnaround Time
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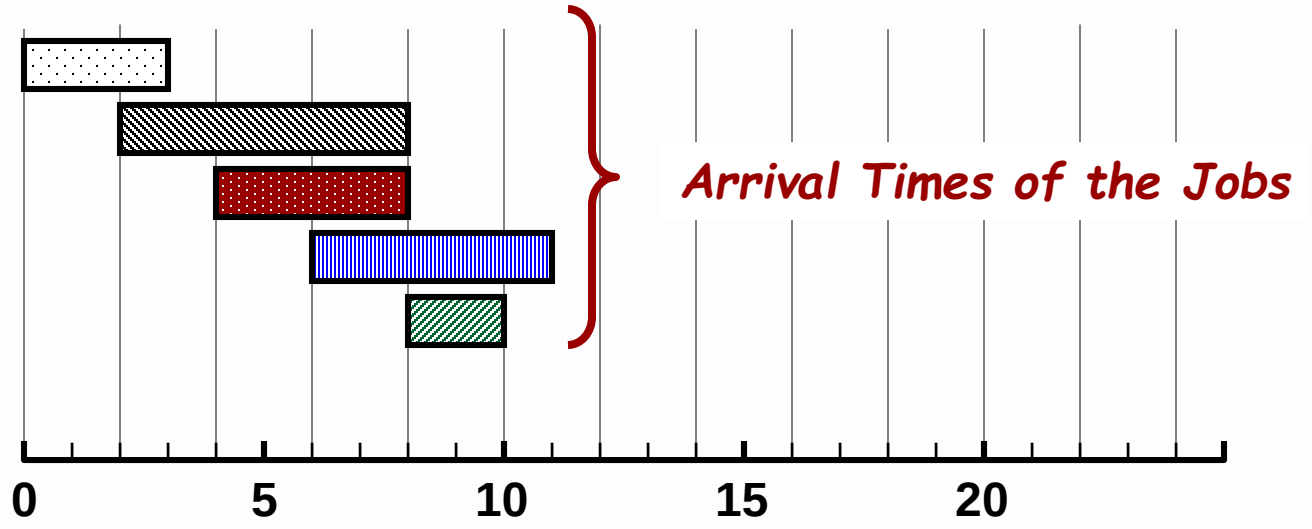

First-Come, First-Served (FIFO)

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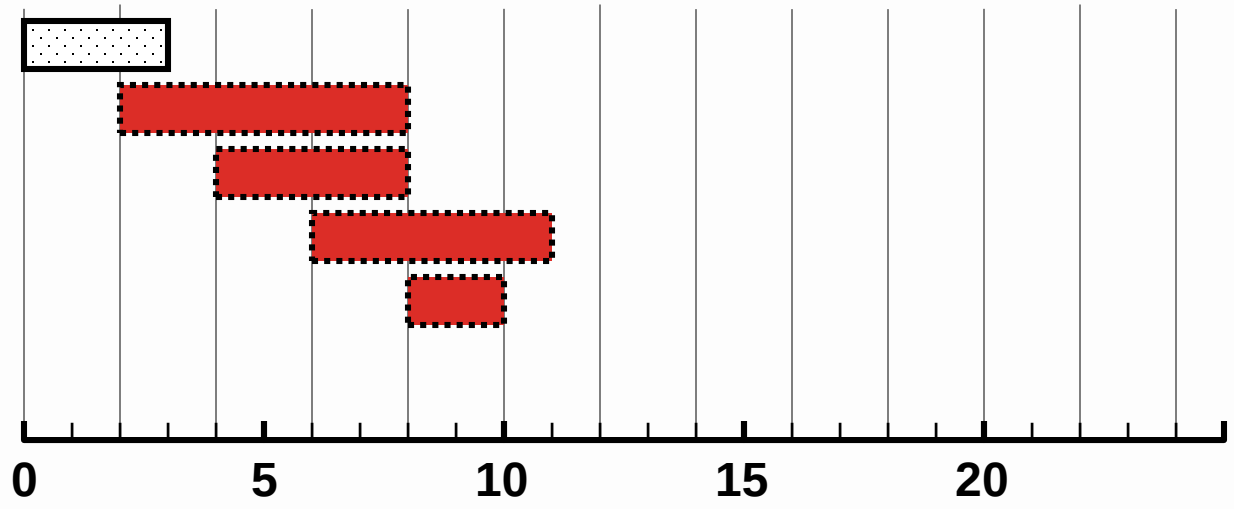

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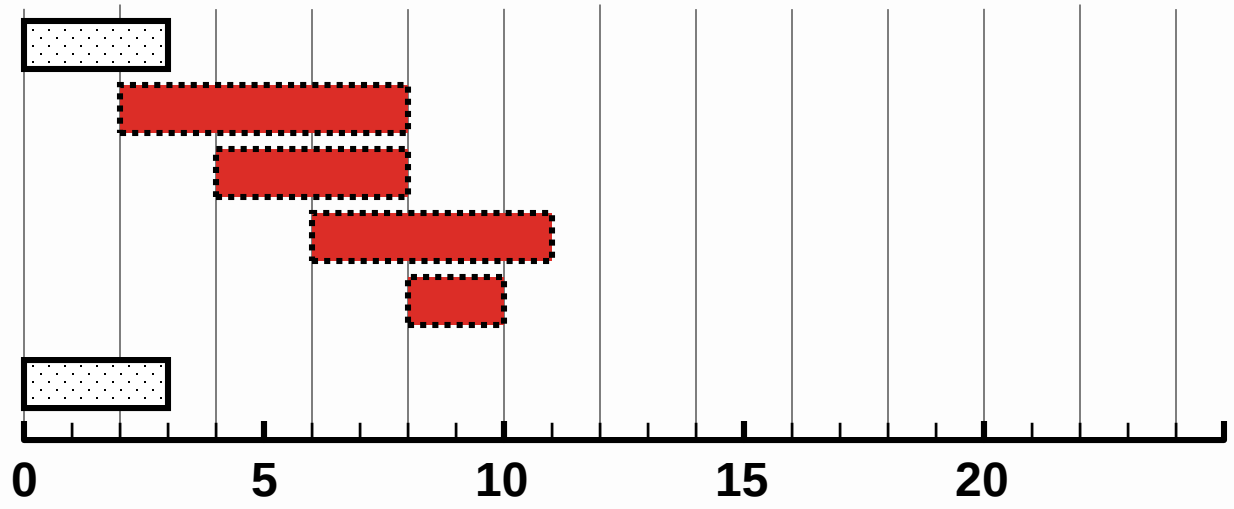

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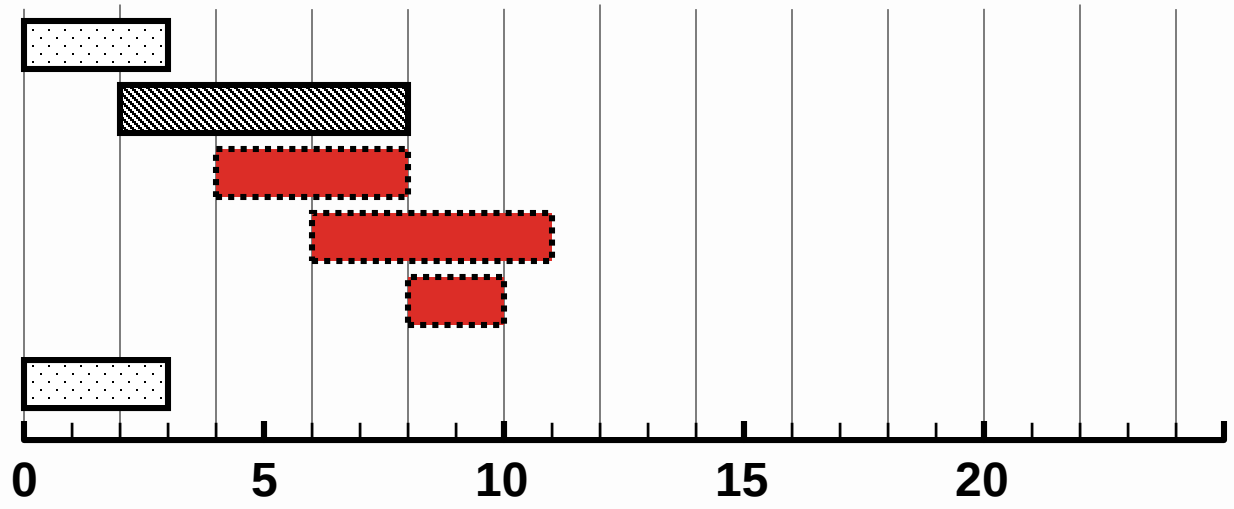

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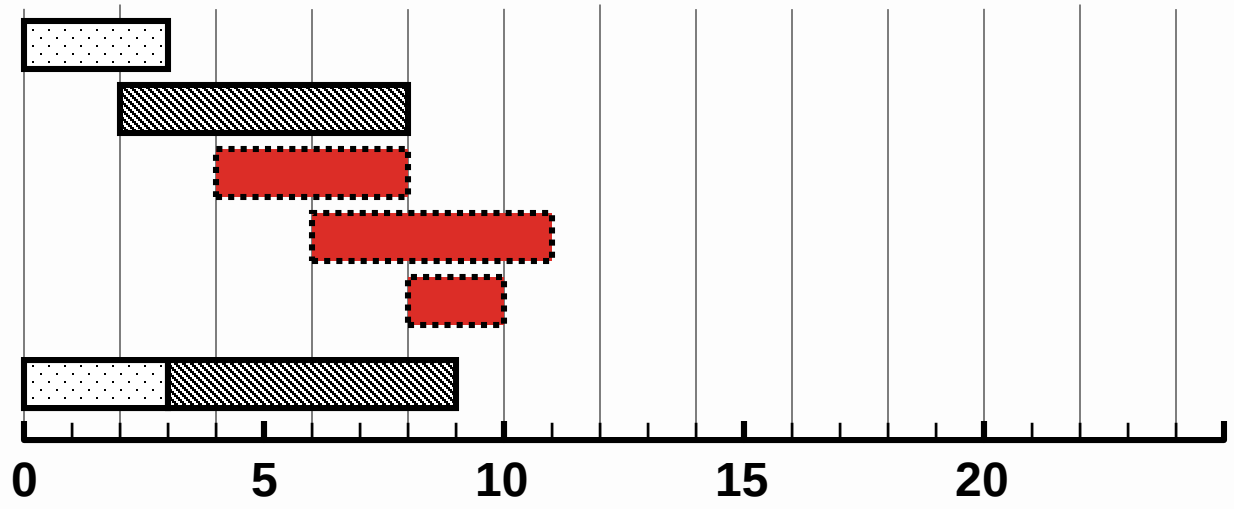

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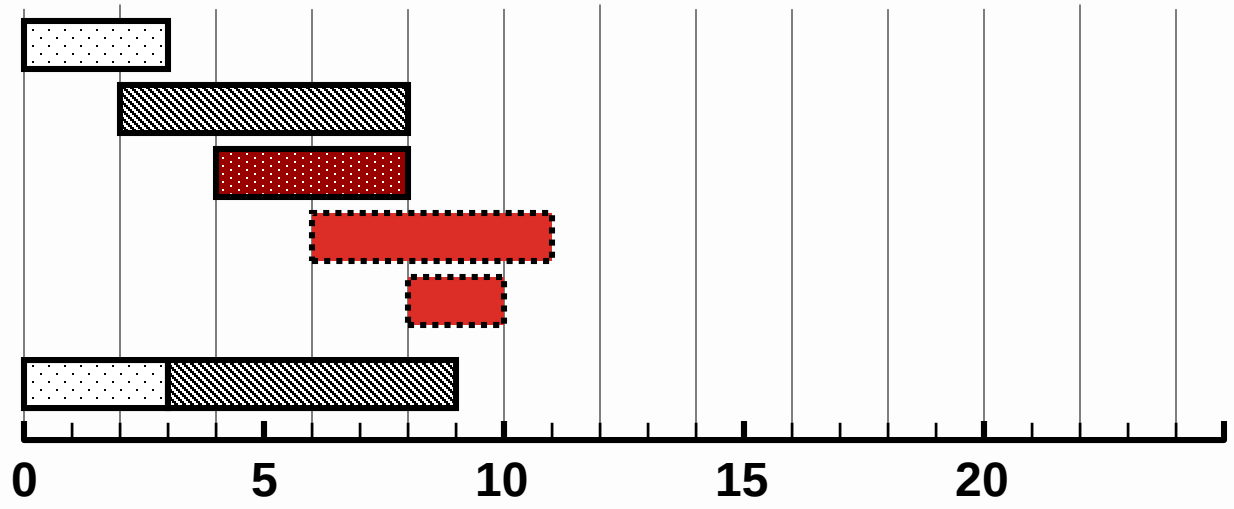

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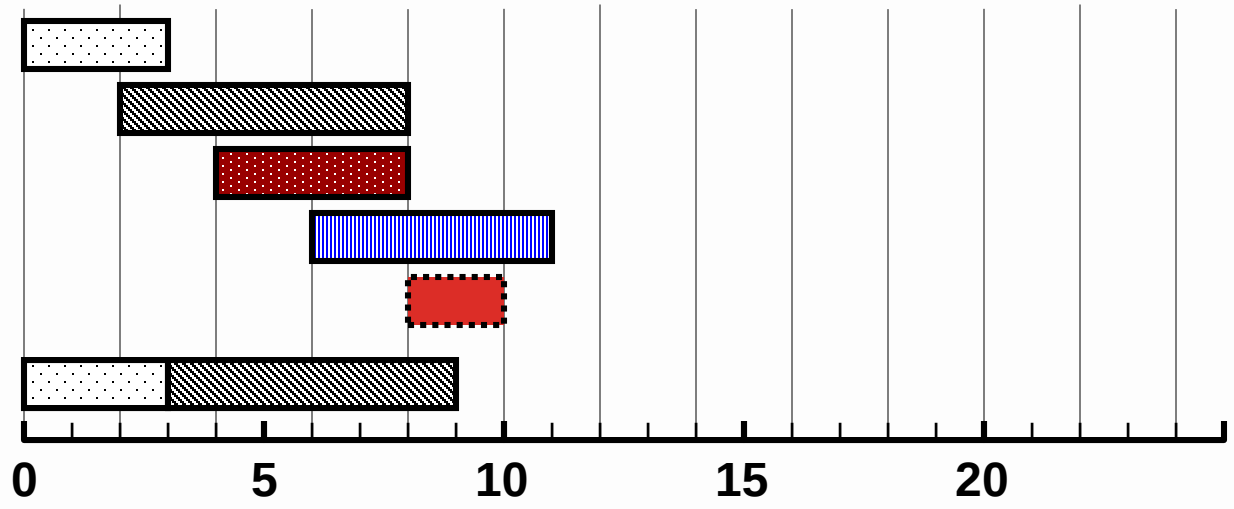

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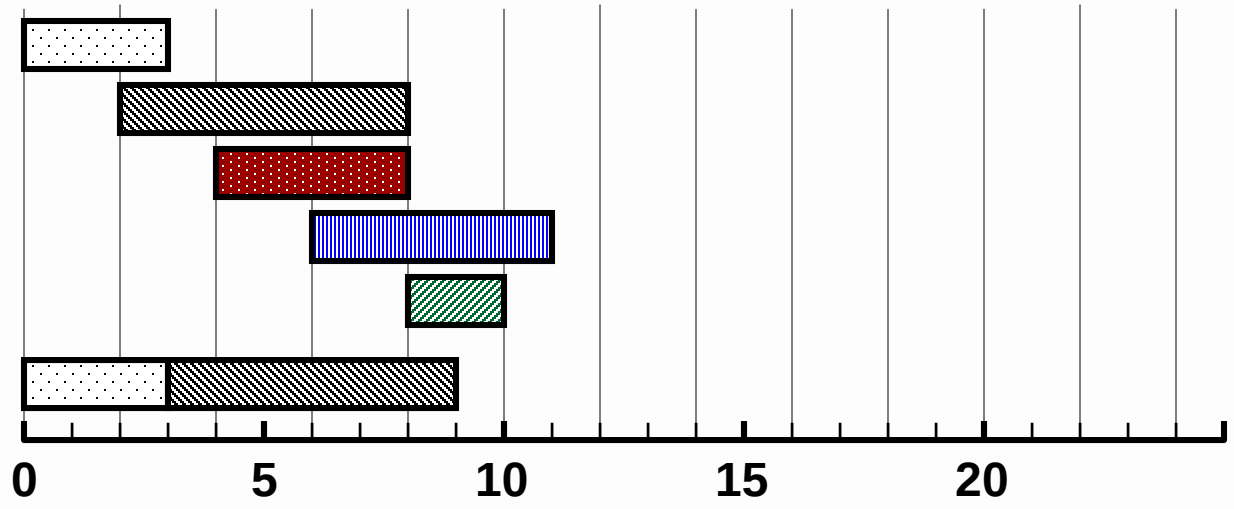

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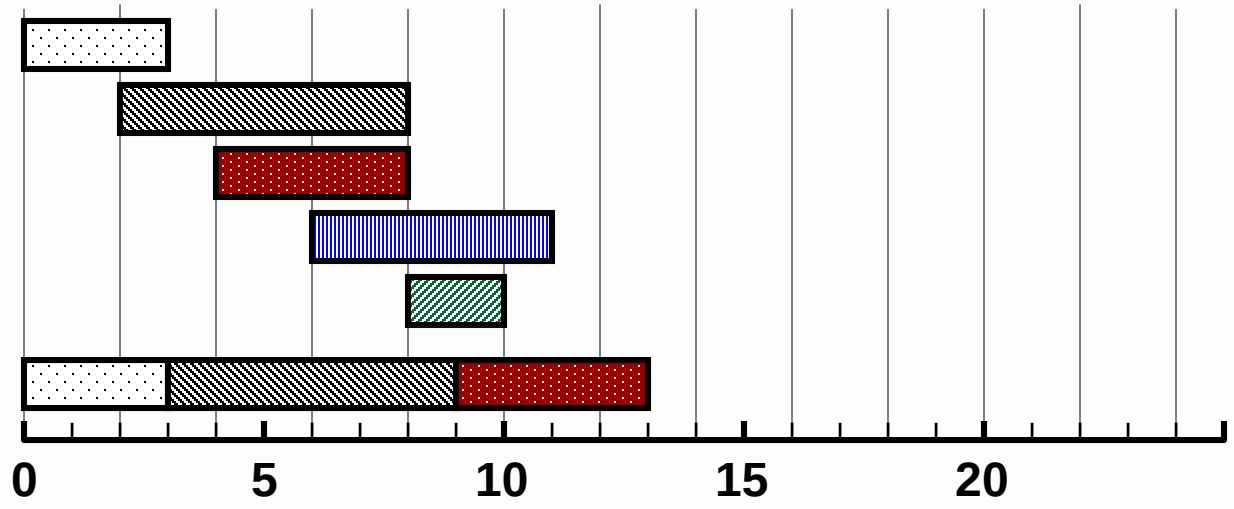

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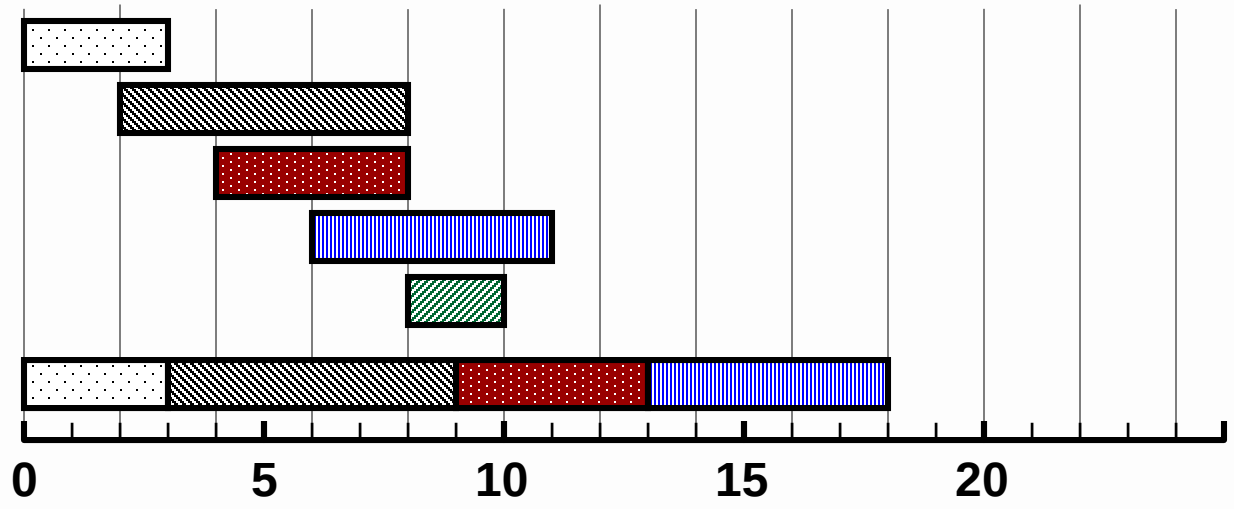

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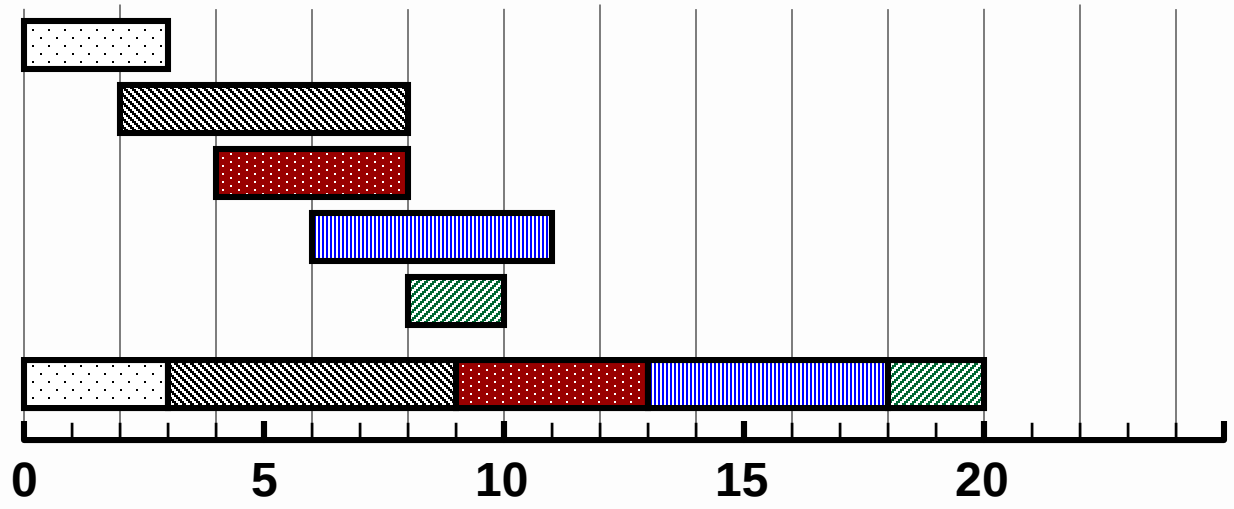

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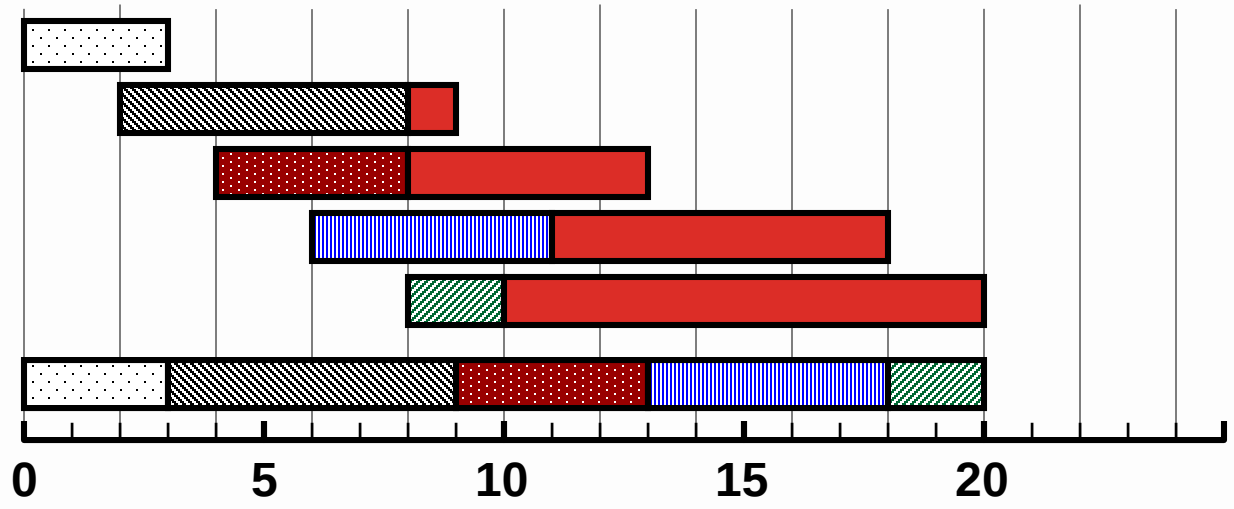

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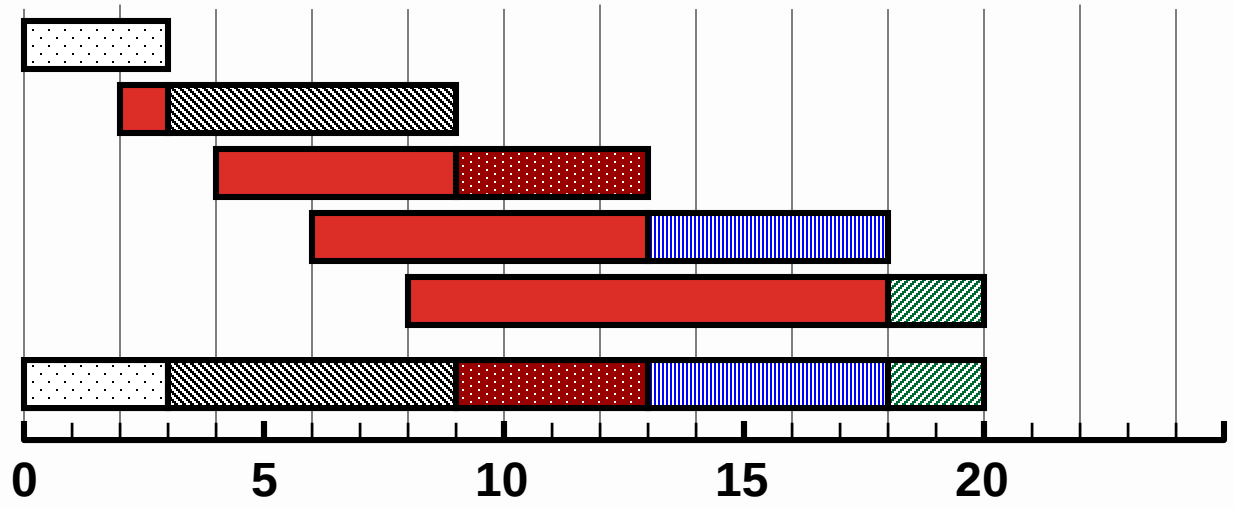
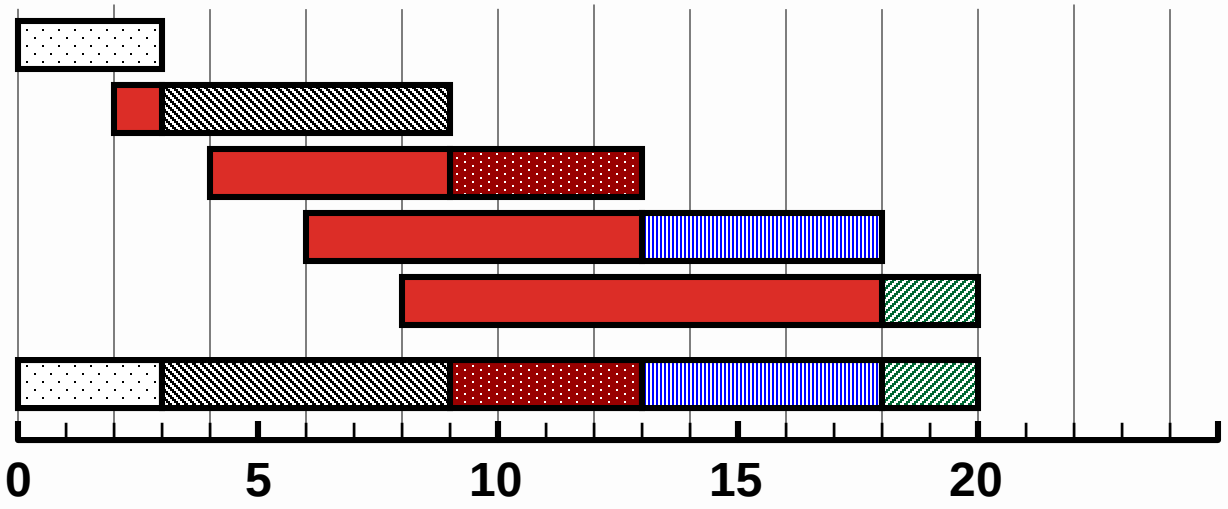


First-Come, First-Served (FIFO)

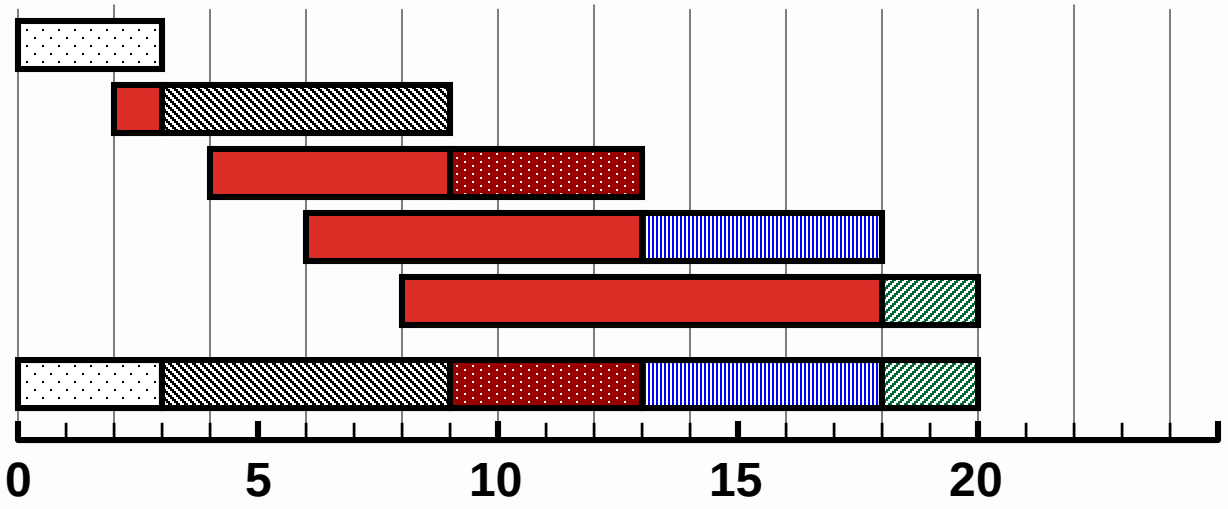
Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3	0	
2	2	6	1	
3	4	4	5	
4	6	5	7	
5	8	2	10	



First-Come, First-Served (FIFO)

Total delay: 23

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3	0	3
2	2	6	1	7
3	4	4	5	9
4	6	5	7	12
5	8	2	10	12



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Shortest Job First

- Select the job with the shortest (expected) running time
- Non-Preemptive

Shortest Job First

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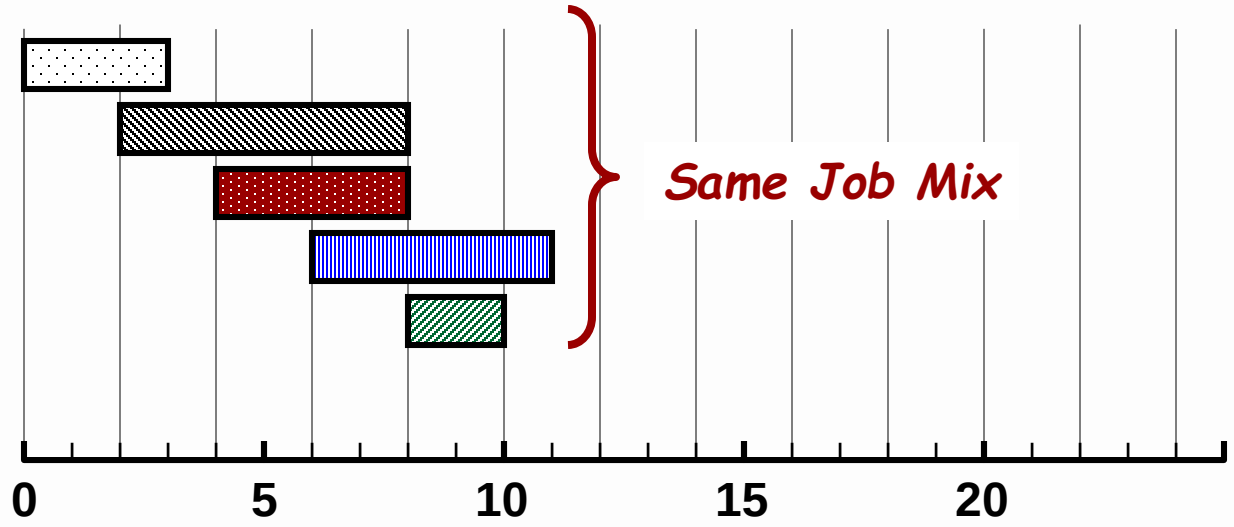

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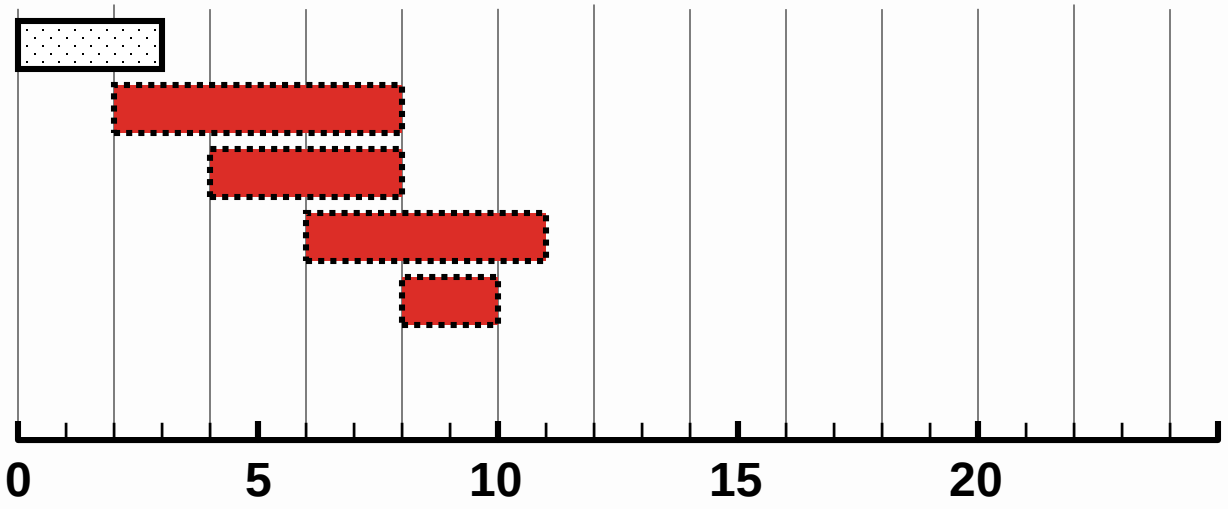

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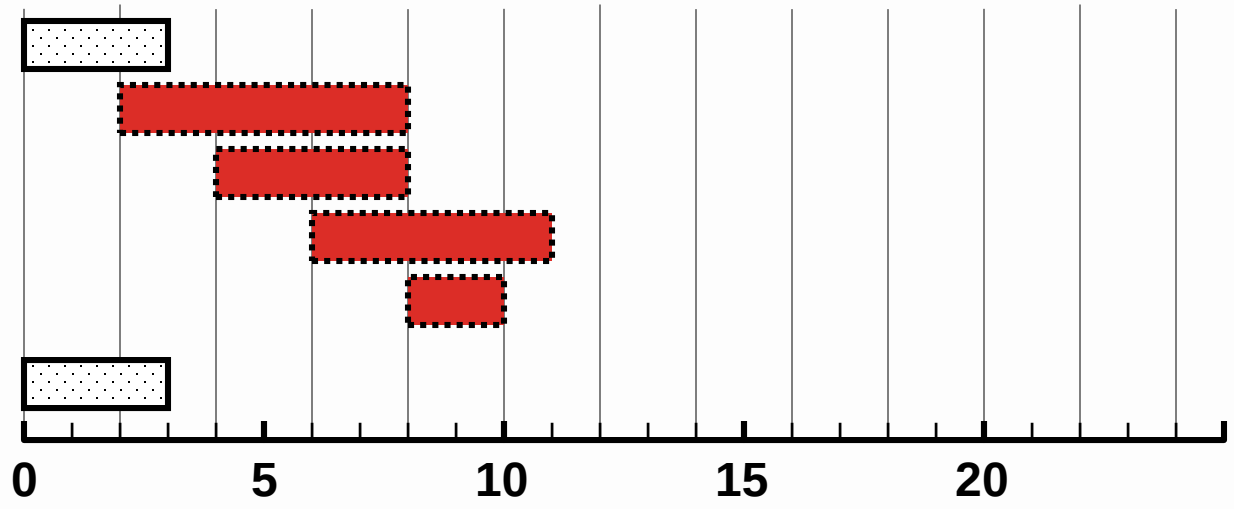

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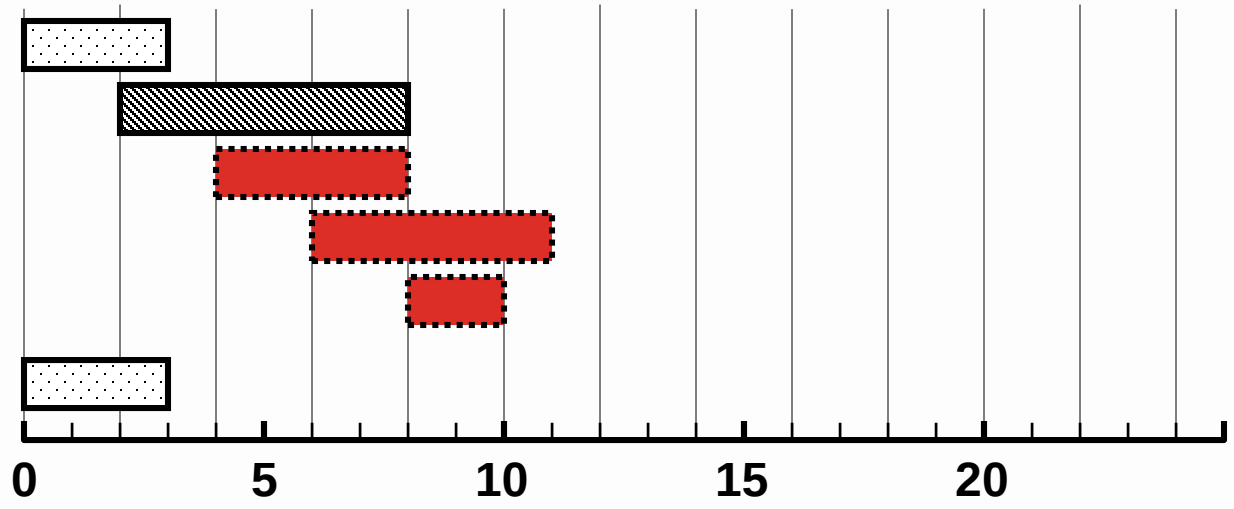

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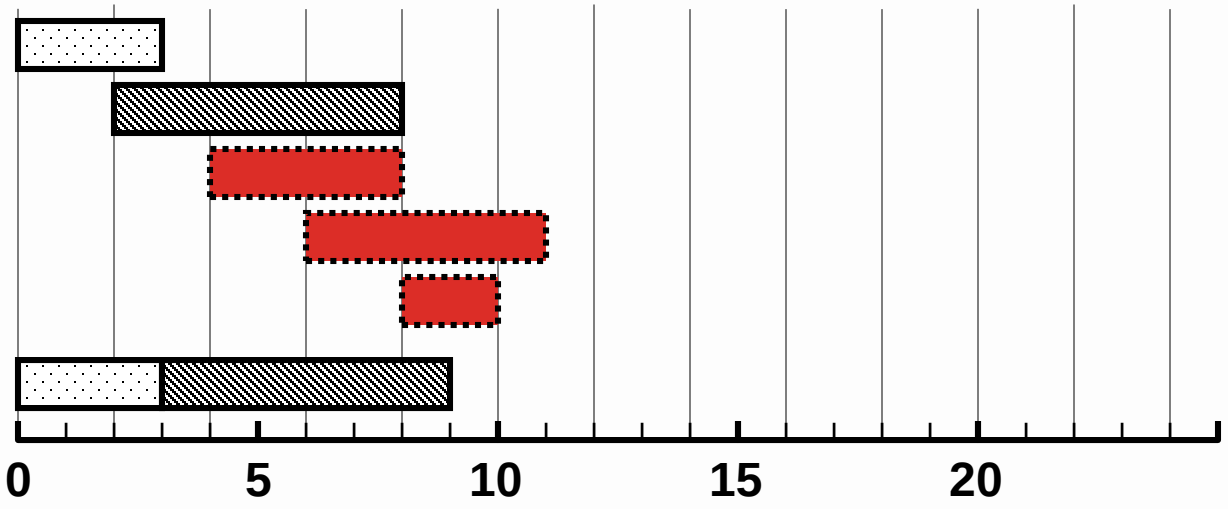

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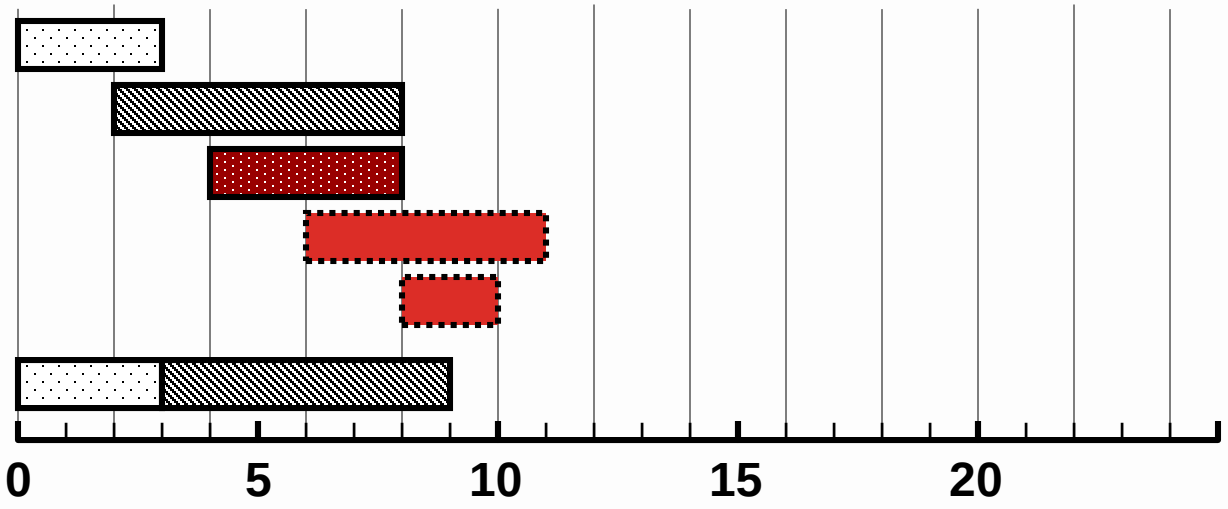

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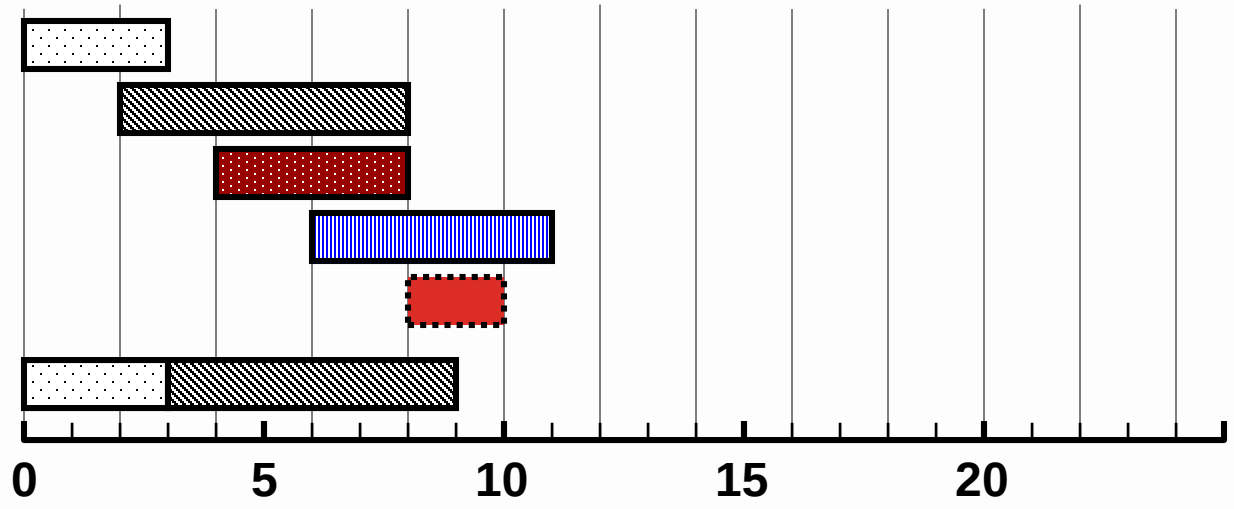

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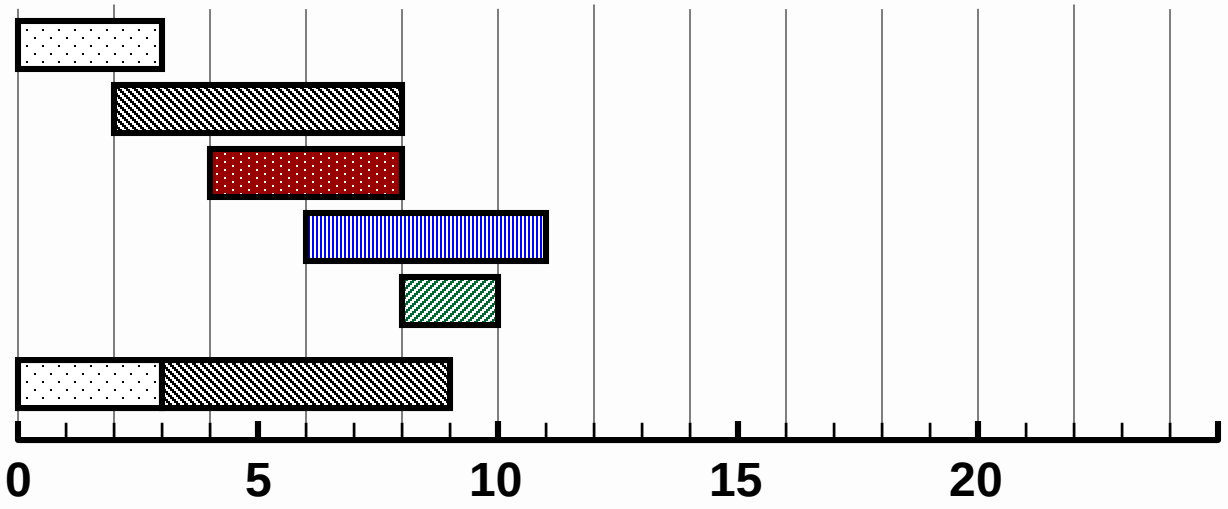

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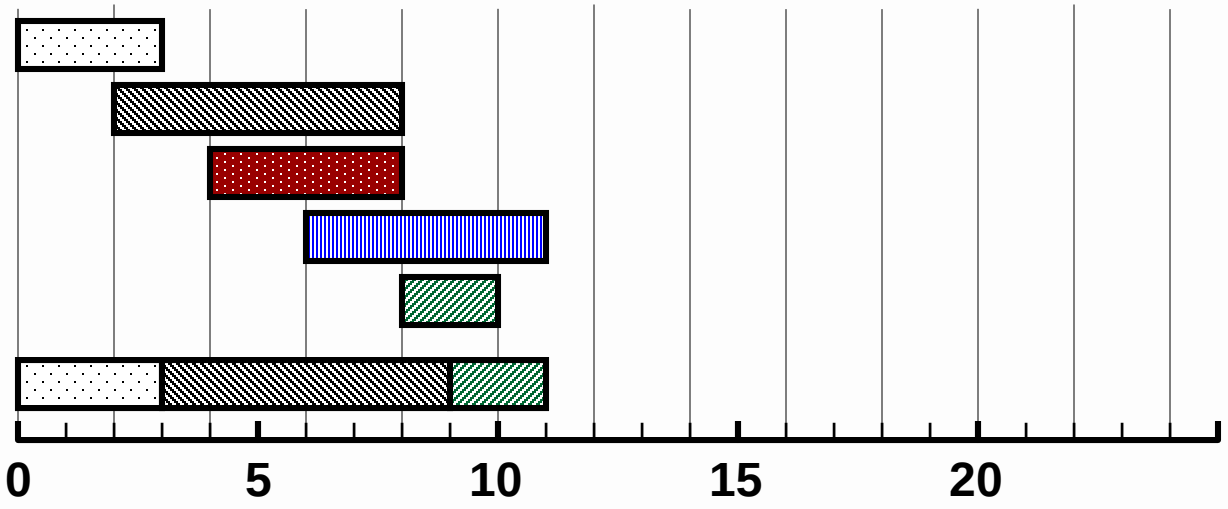

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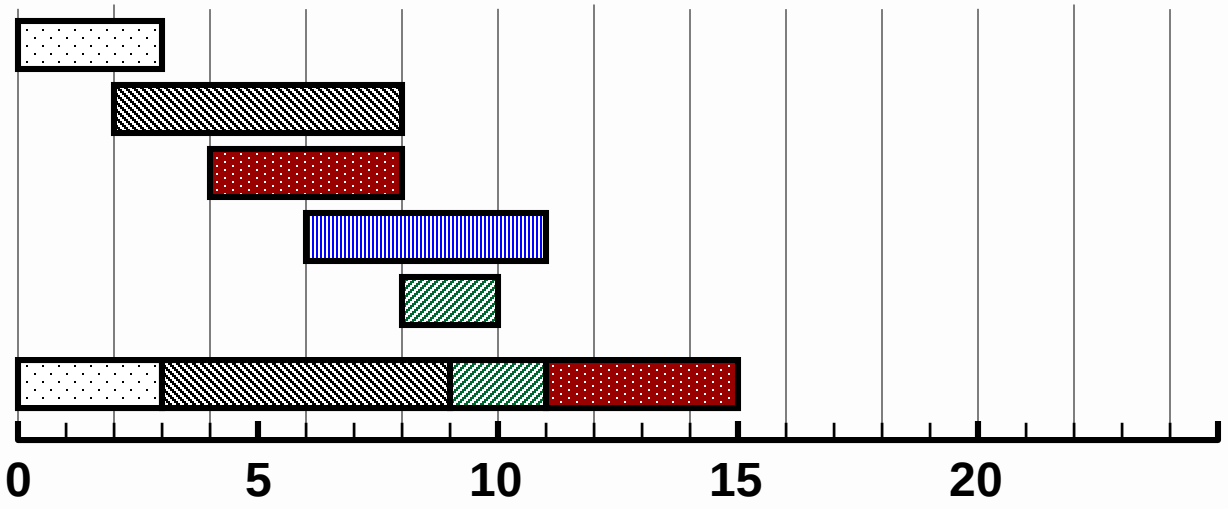

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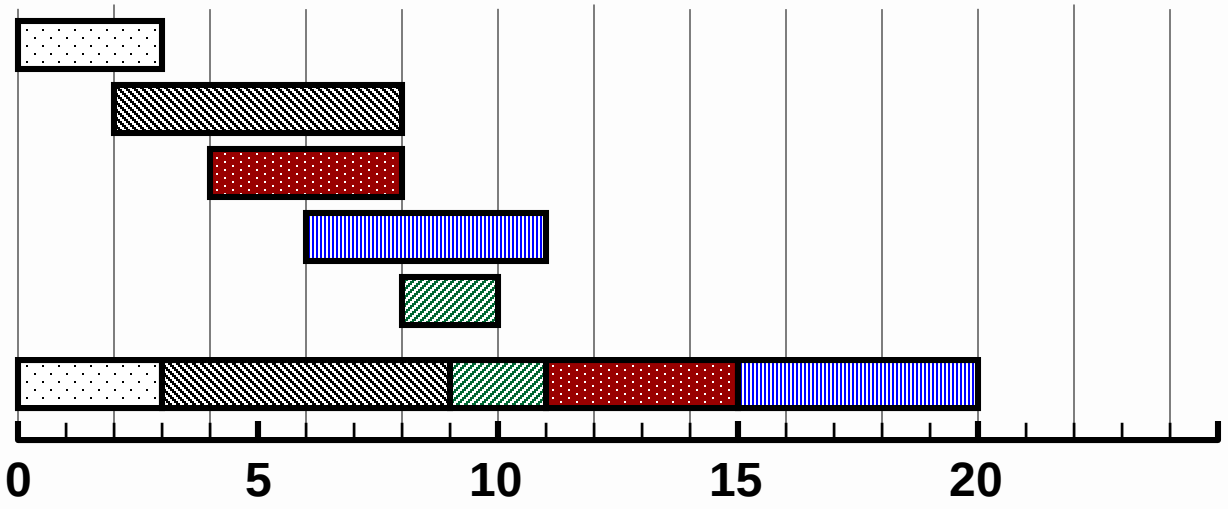

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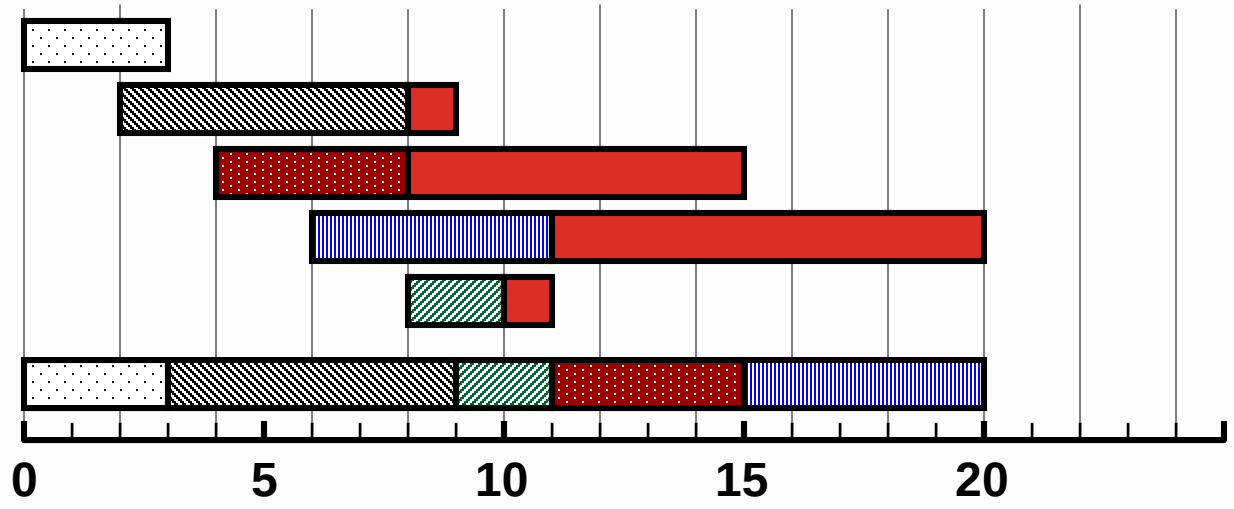

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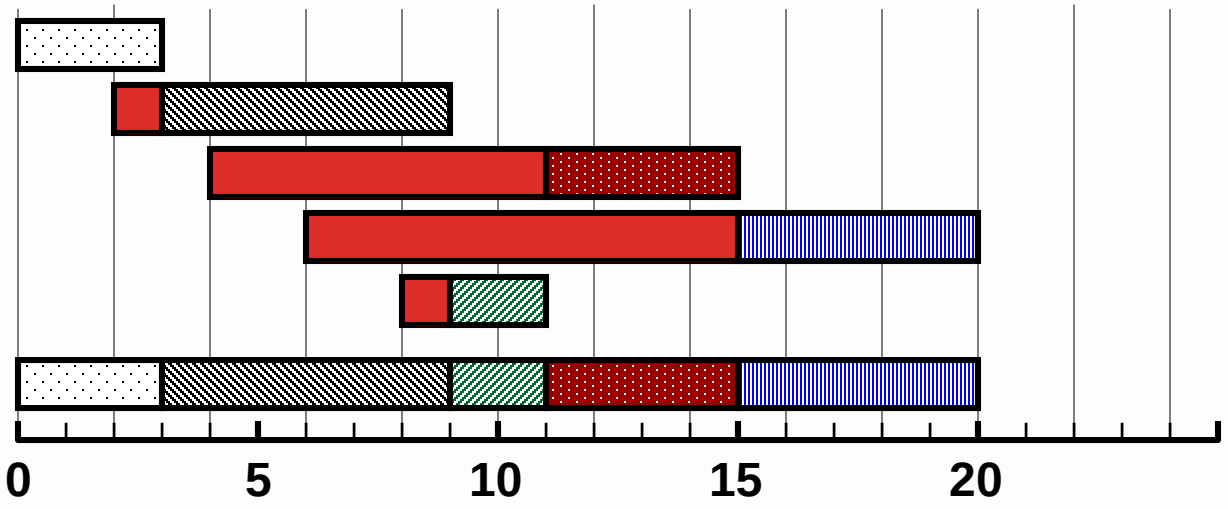
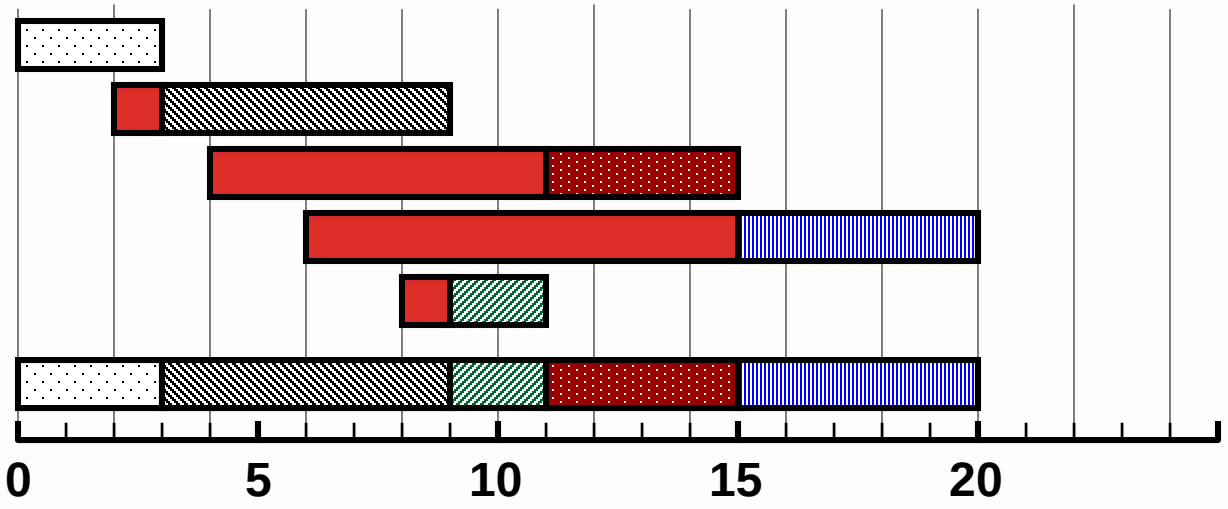


Shortest Job First

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3	0	
2	2	6	1	
3	4	4	7	
4	6	5	9	
5	8	2	1	



Shortest Job First

Total delay: 18

Process	Arrival Time	Processing Time	Delay	Turnaround Time
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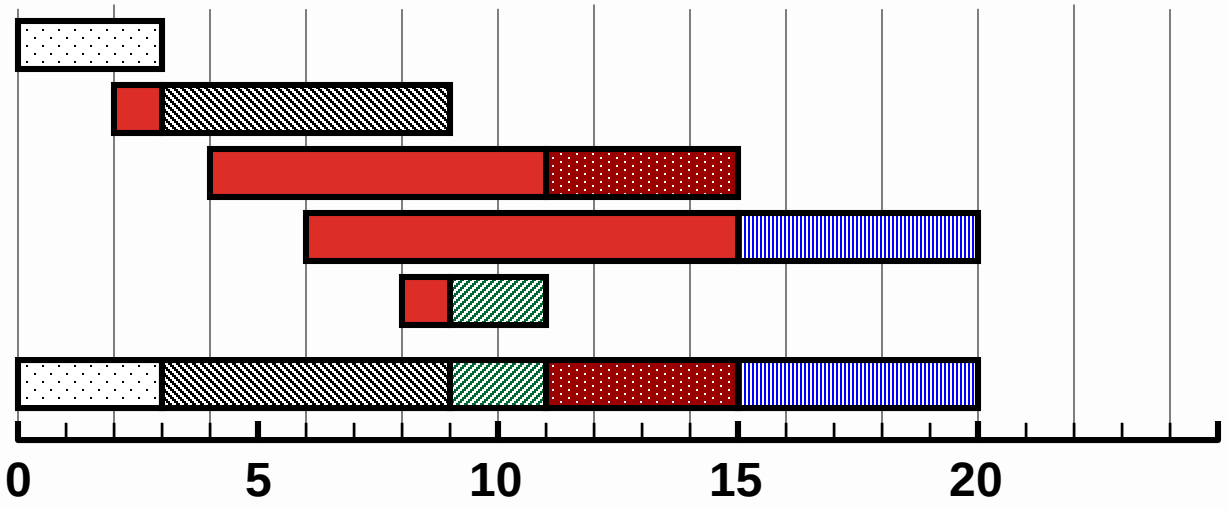
2	2	6	1	7
3	4	4	7	11
4	6	5	9	14
5	8	2	1	3



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Shortest Remaining Time

- Preemptive version of SJF

Process	Arrival Time	Processing Time	Delay	Turnaround Time
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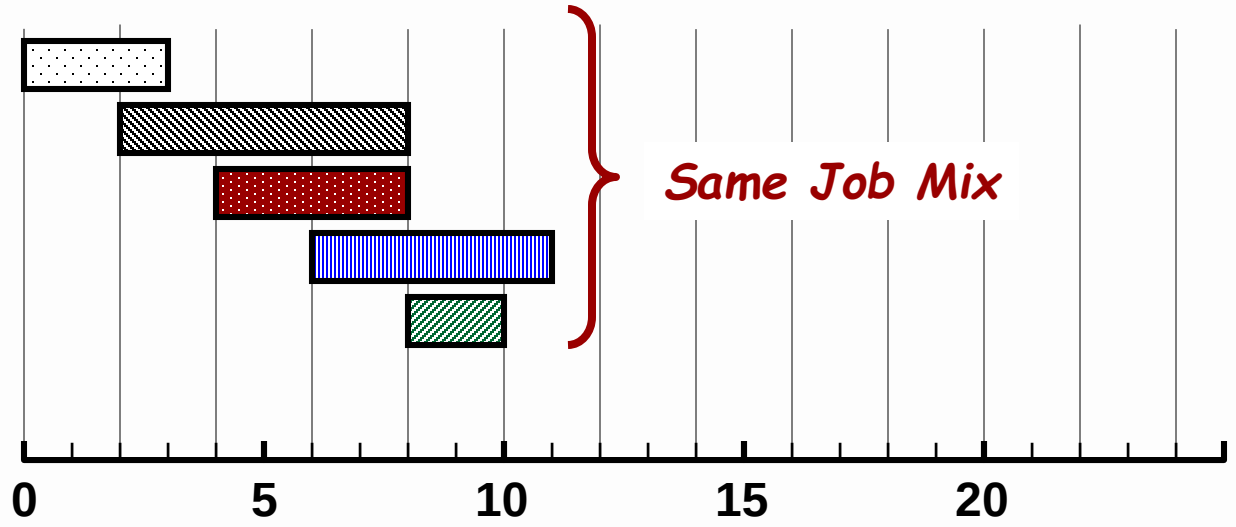

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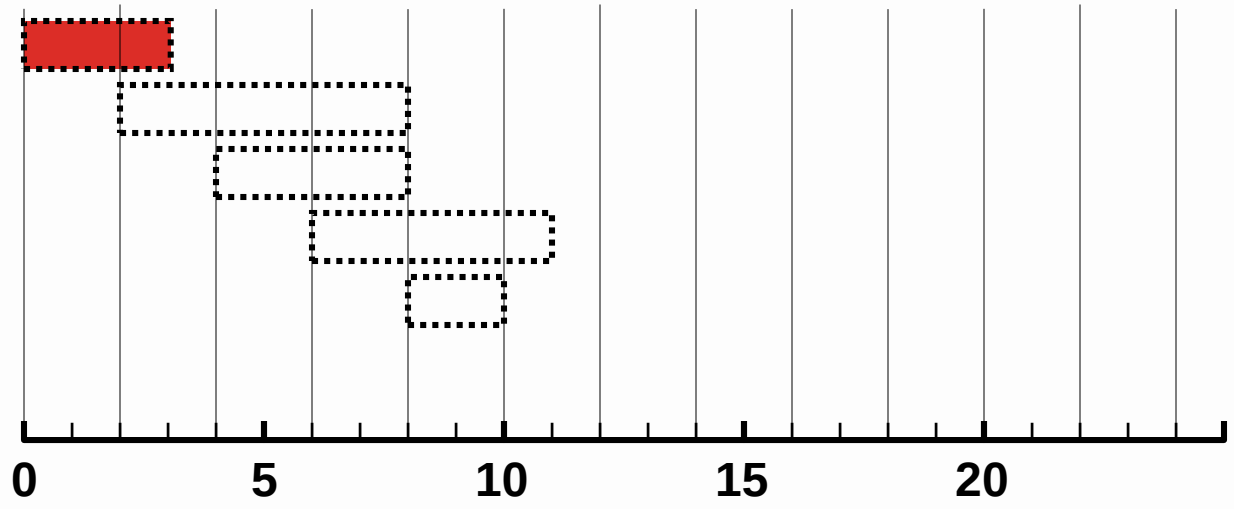

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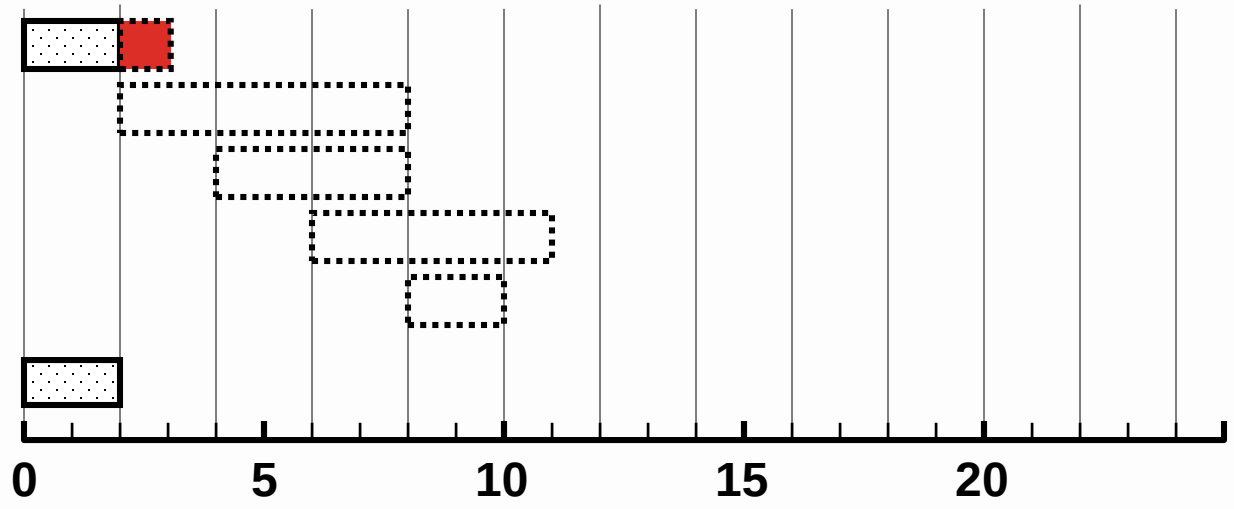

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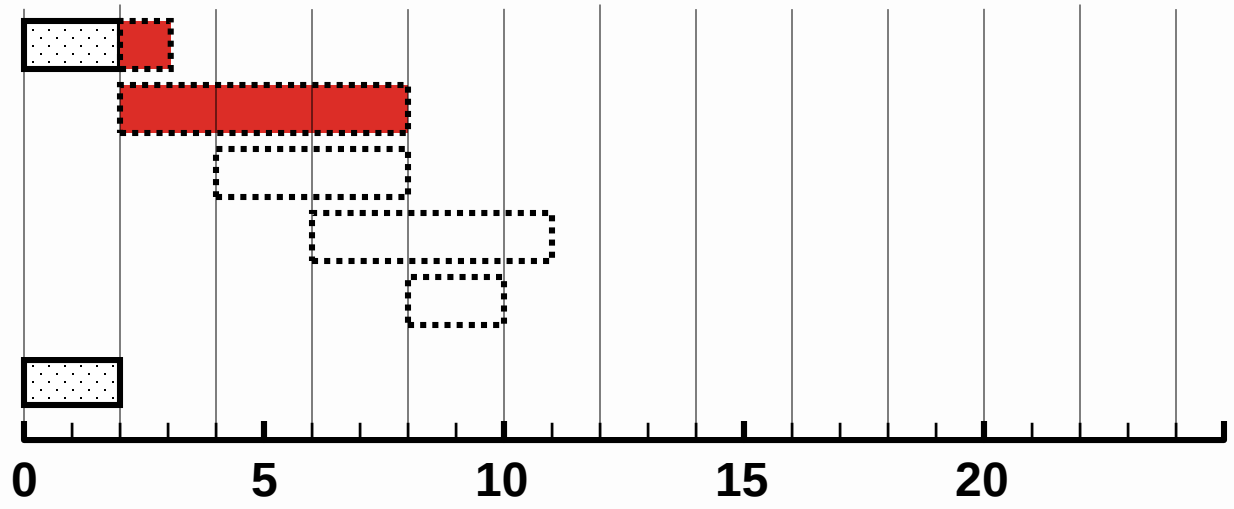

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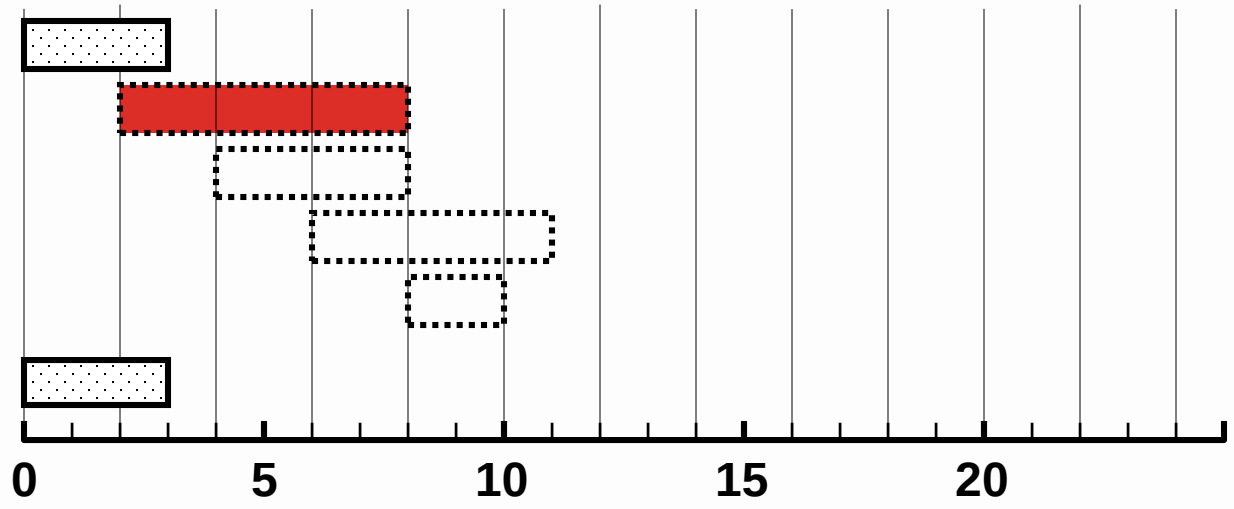

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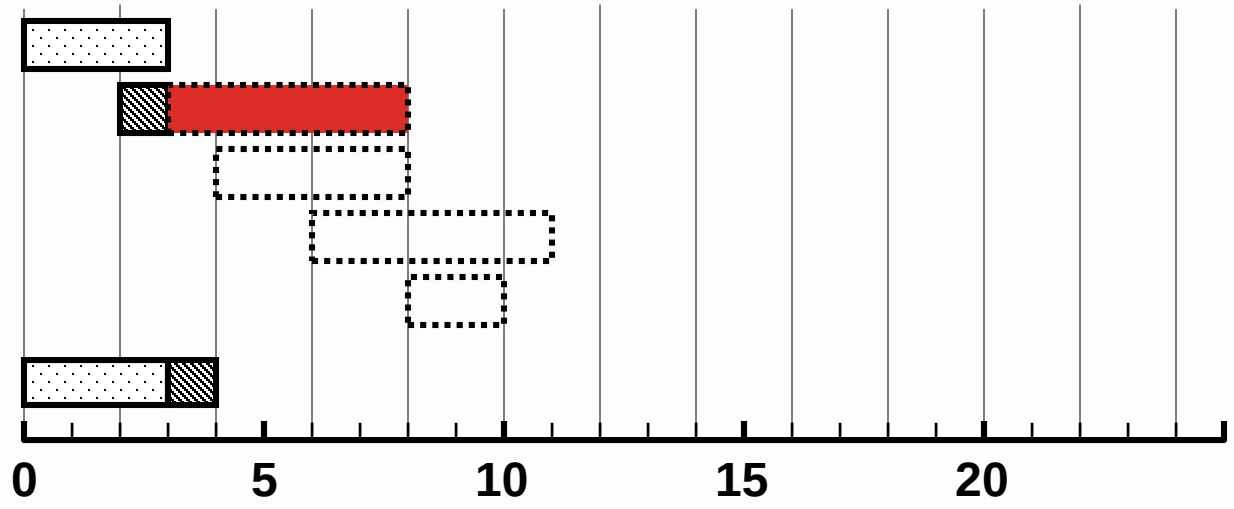
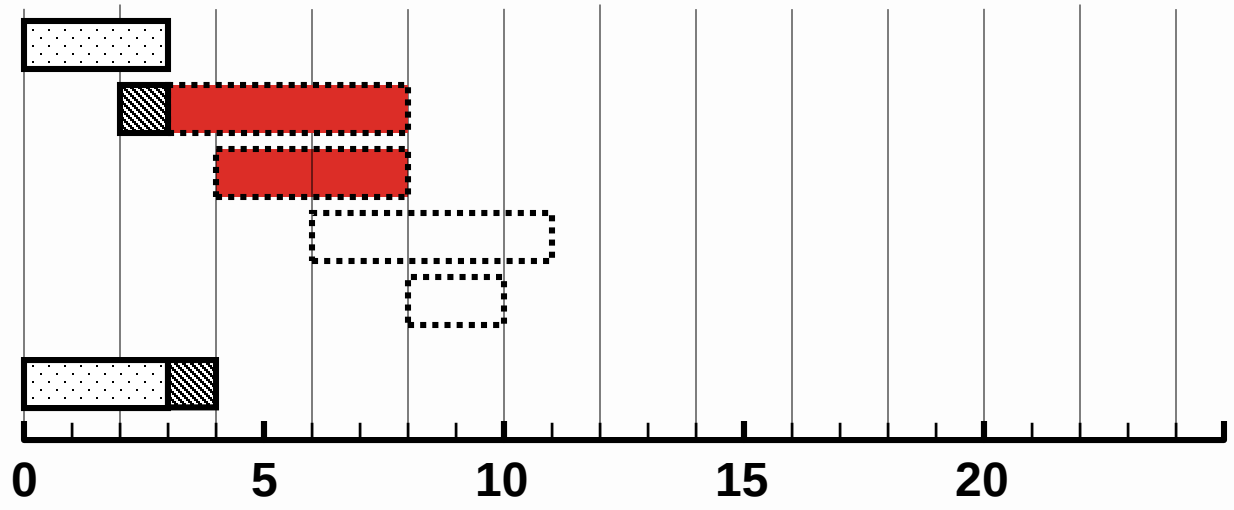
4	6	5		
5	8	2		



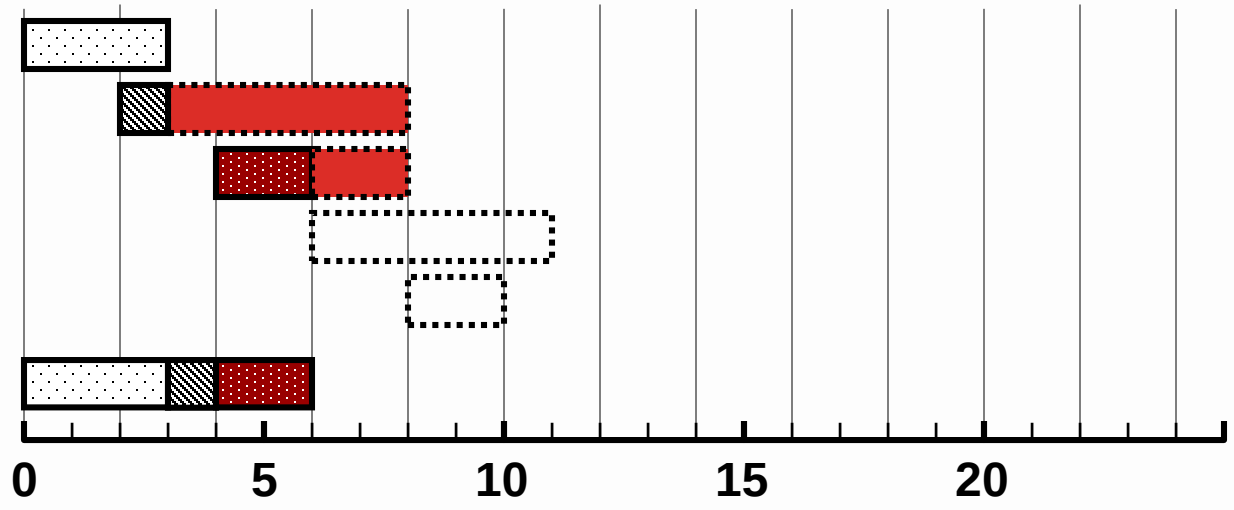
Shortest Remaining Time

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
2	2	6		
3	4	4		
4	6	5		
5	8	2		



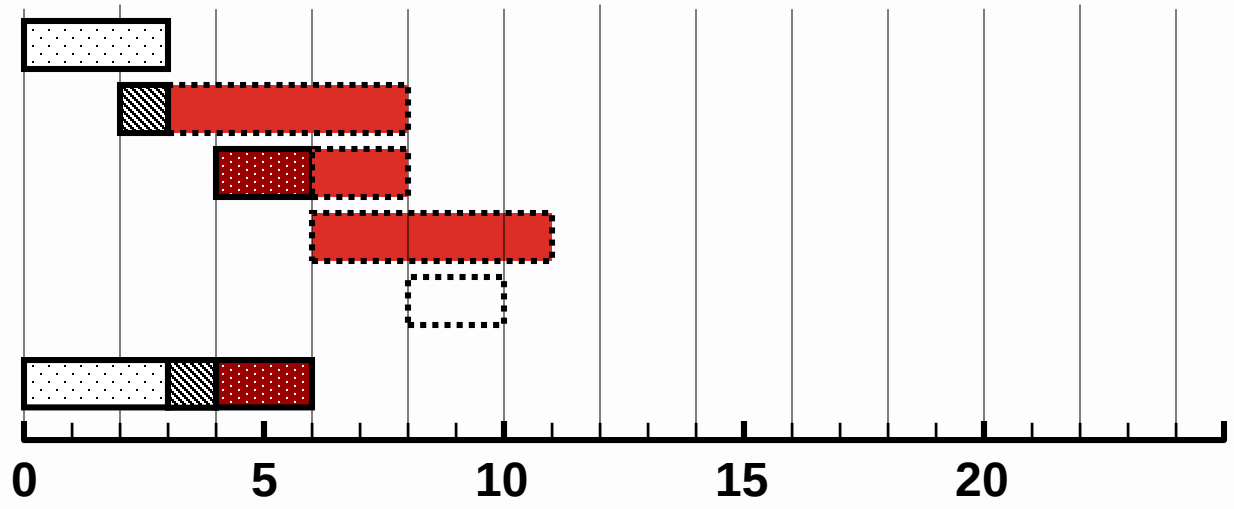
Shortest Remaining Time

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
2	2	6		
3	4	4		
4	6	5		
5	8	2		



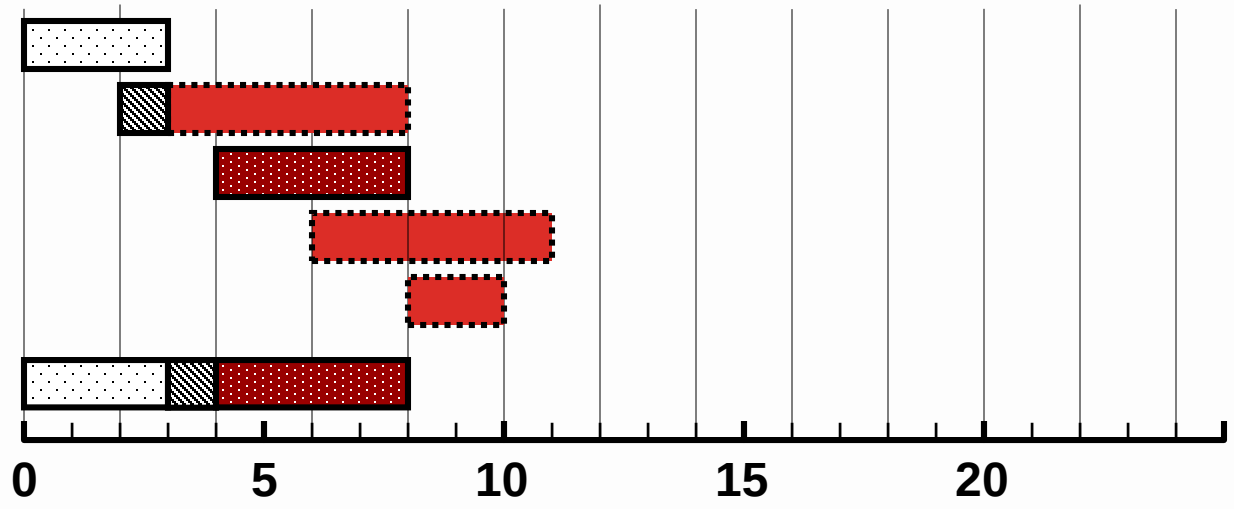
Shortest Remaining Time

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
2	2	6		
3	4	4		
4	6	5		
5	8	2		



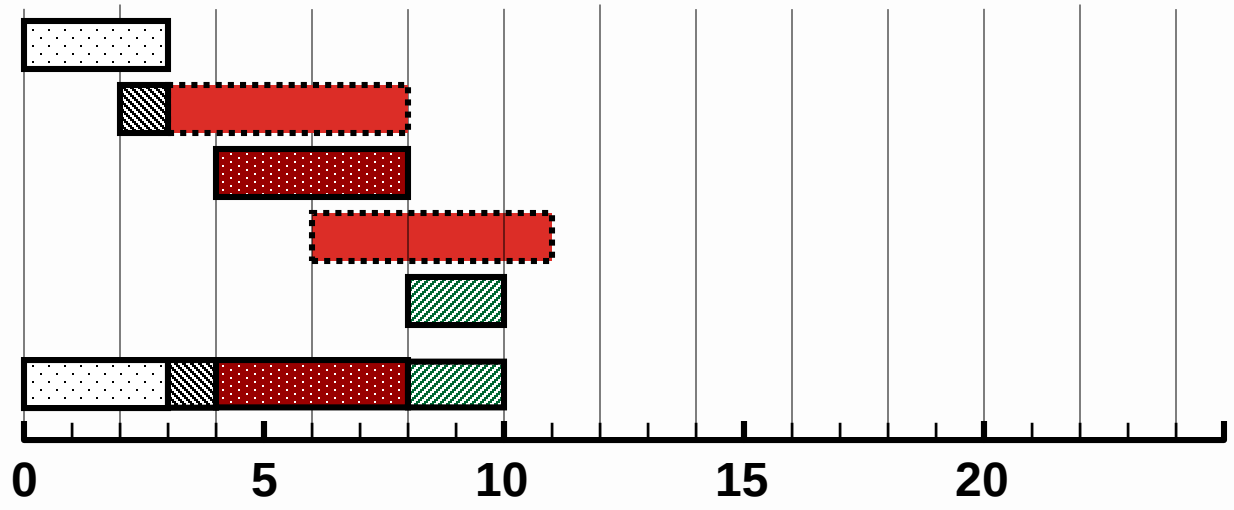
Shortest Remaining Time

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
2	2	6		
3	4	4		
4	6	5		
5	8	2		



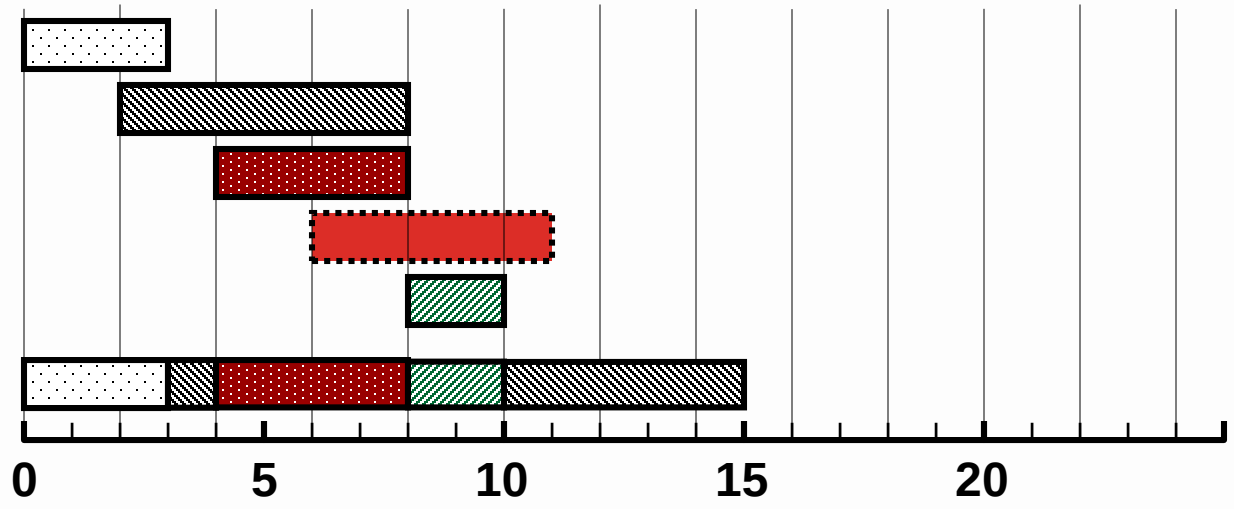
Shortest Remaining Time

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
2	2	6		
3	4	4		
4	6	5		
5	8	2		



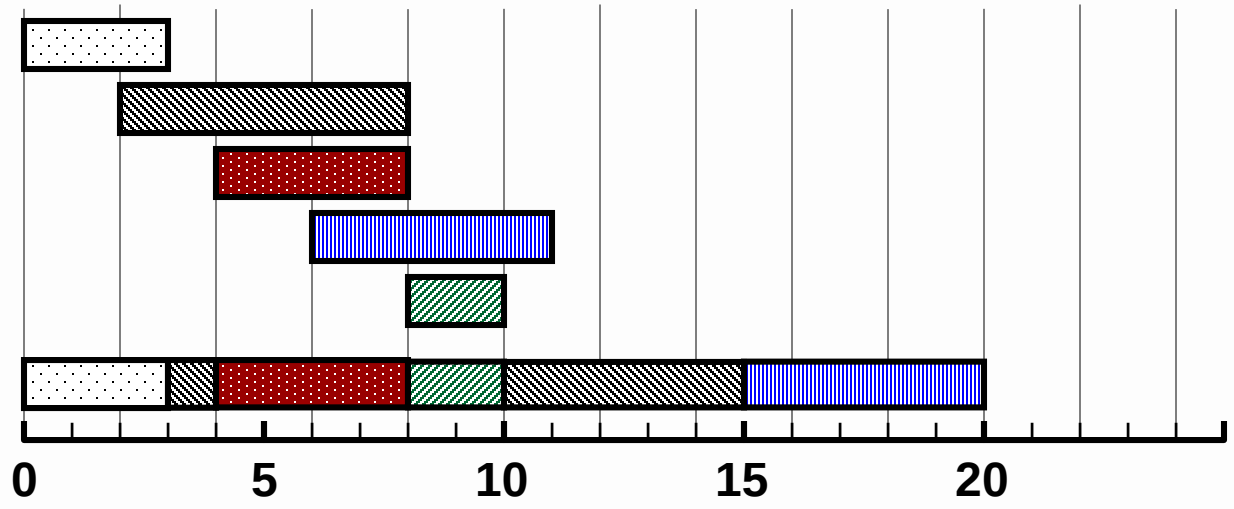
Shortest Remaining Time

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
2	2	6		
3	4	4		
4	6	5		
5	8	2		



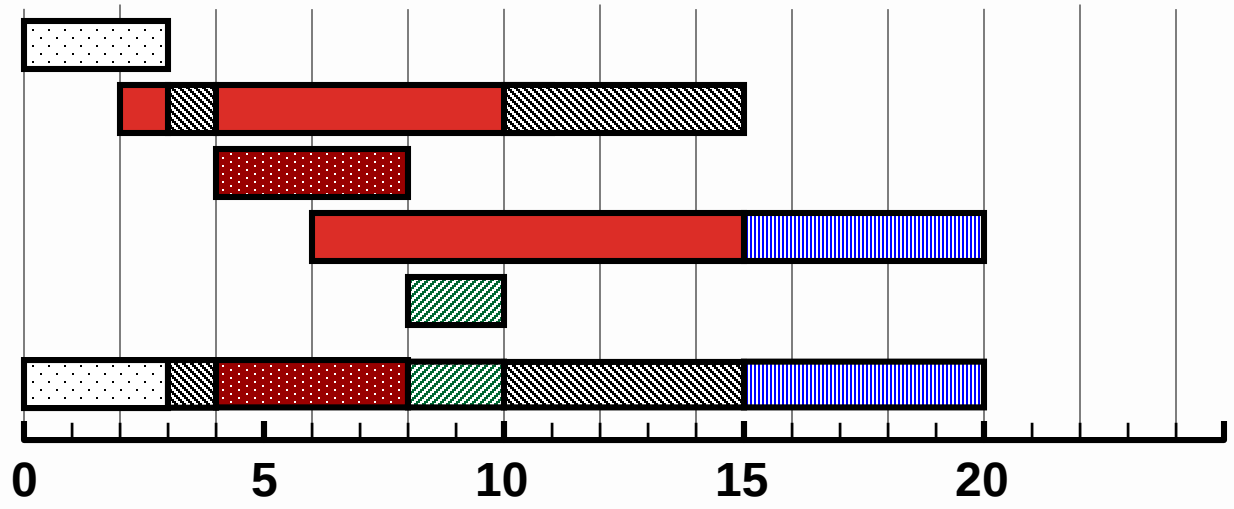
Shortest Remaining Time

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
2	2	6		
3	4	4		
4	6	5		
5	8	2		



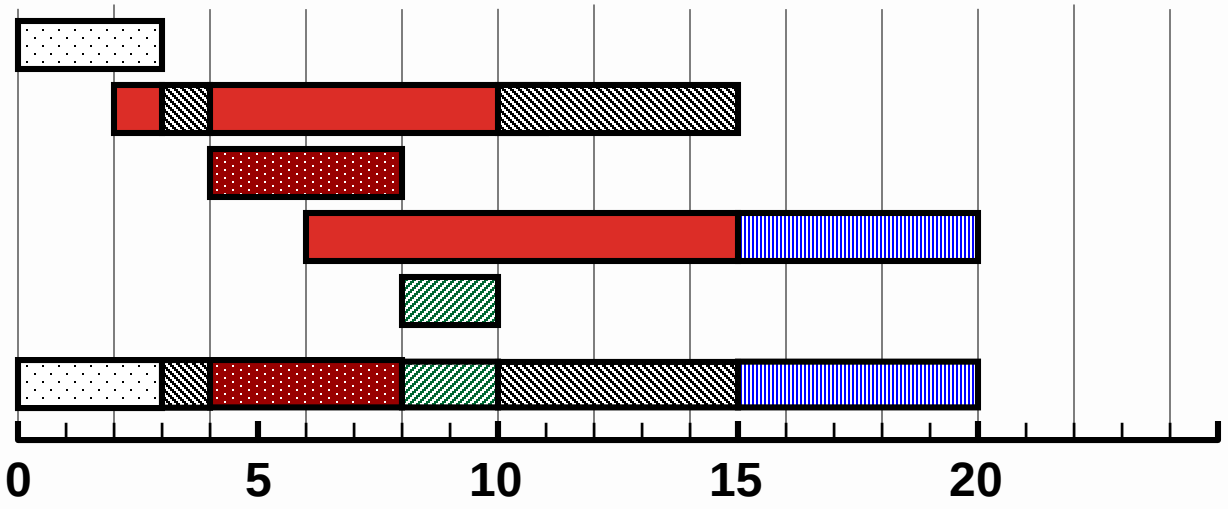
Shortest Remaining Time

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3		
2	2	6		
3	4	4		
4	6	5		
5	8	2		



Shortest Remaining Time

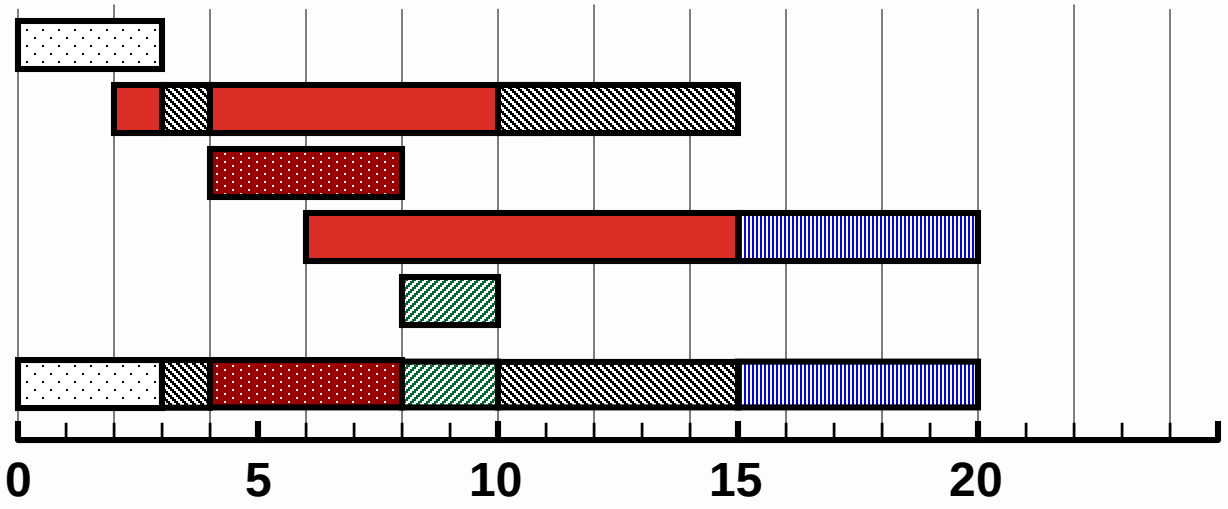
Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3	0	
2	2	6	7	
3	4	4	0	
4	6	5	9	
5	8	2	0	



Shortest Remaining Time

Total delay: 16

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3	0	3
2	2	6	7	13
3	4	4	0	4
4	6	5	9	14
5	8	2	0	2



Outline

- CPU scheduling
- First-Come, First Served (FIFO)
- Shortest Job First (non-preemptive)
- Shortest Job First (with preemption)
- Round-Robin Scheduling
- Lottery Scheduling
- Multi-Level Feedback Queue

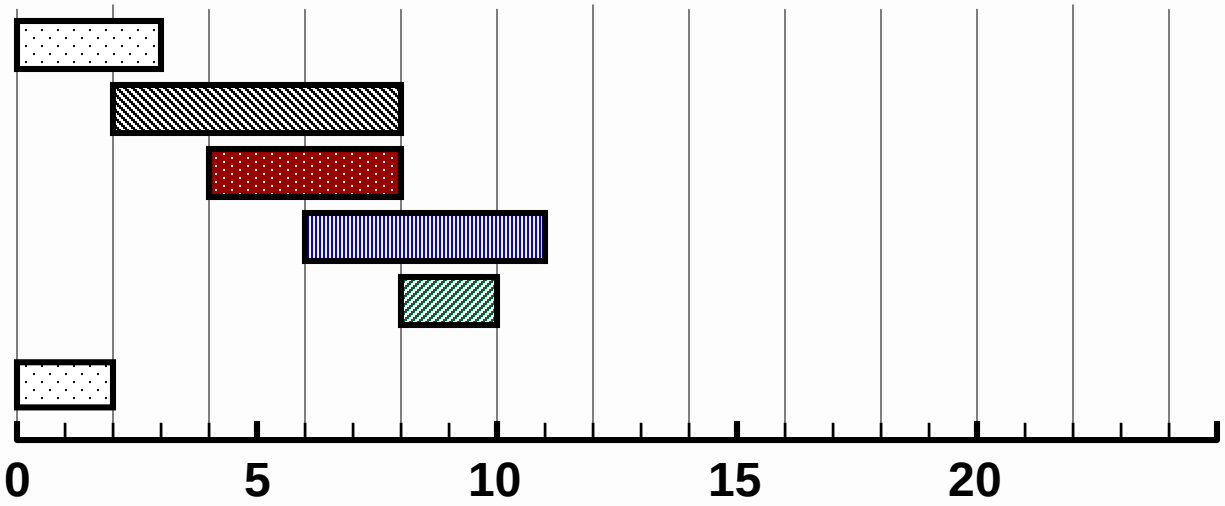
Round-Robin Scheduling

- Goal: Enable interactivity
  - Limit the amount of CPU that a process can have at one time.

- *Time quantum*
  - Amount of time the OS gives a process before intervention
  - The “time slice”
  - Typically: 1 to 100ms

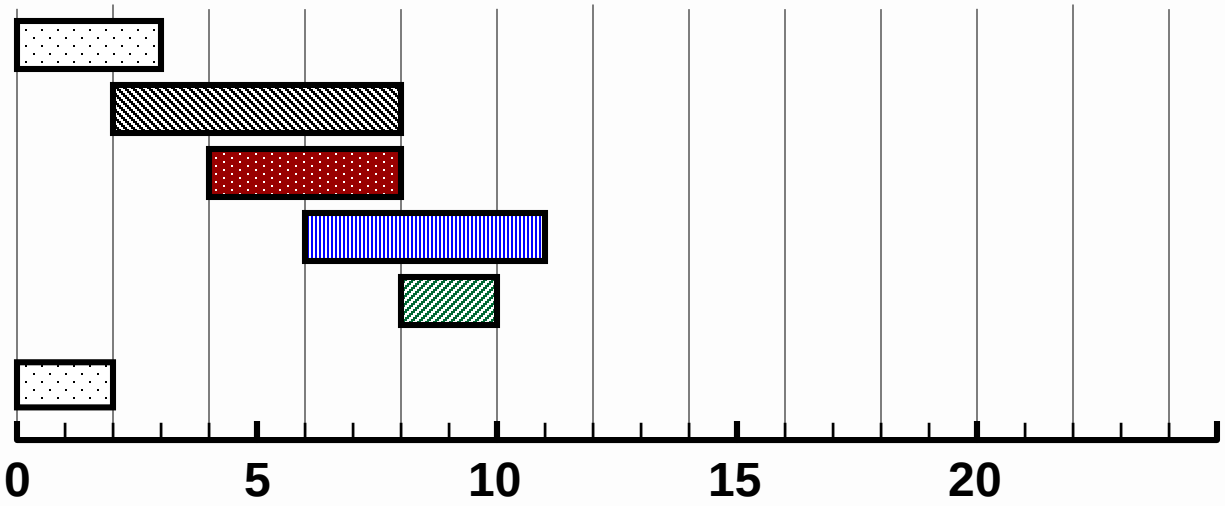
Round-Robin Scheduling

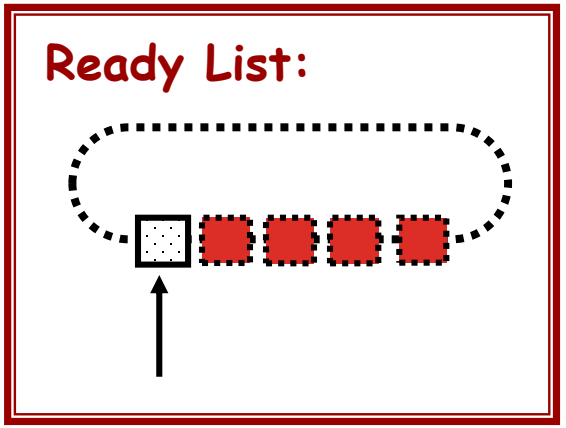
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2



Round-Robin Scheduling

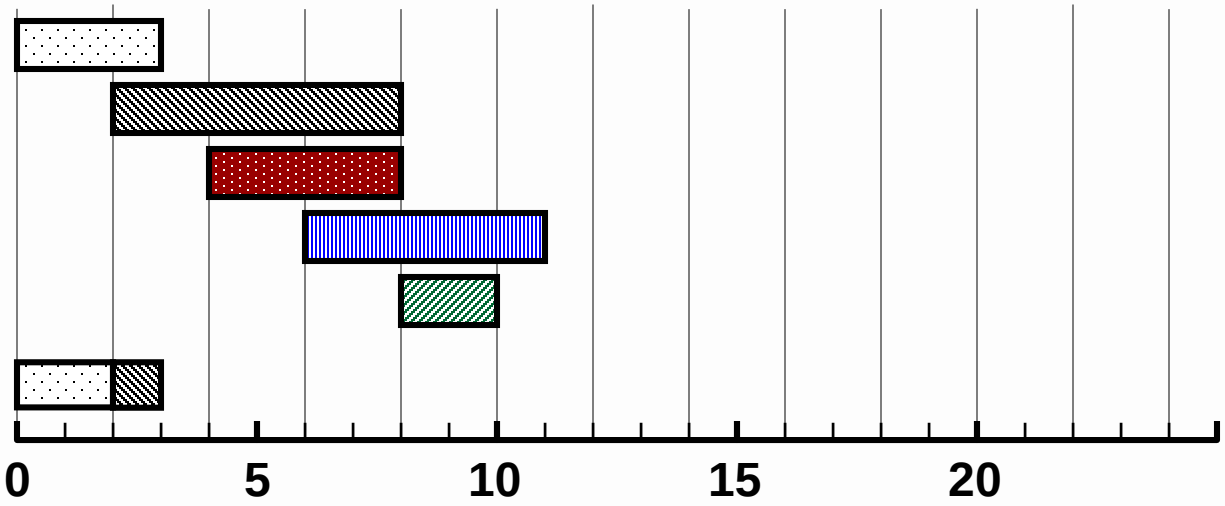
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

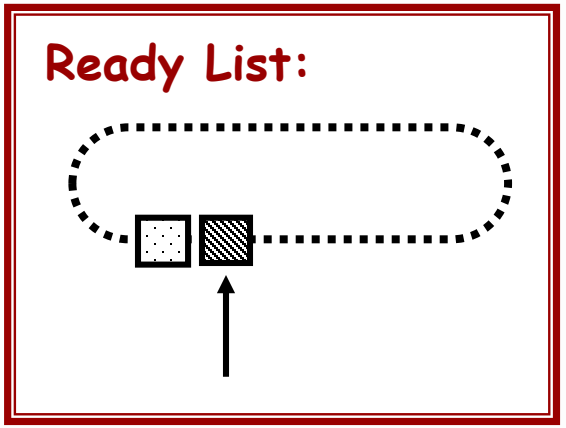




Round-Robin Scheduling

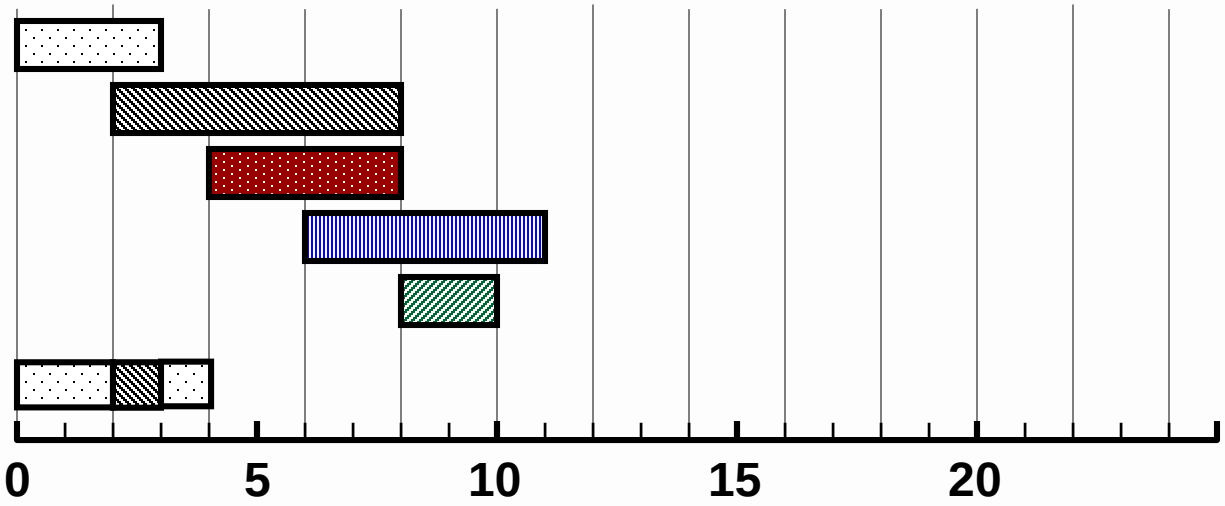
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

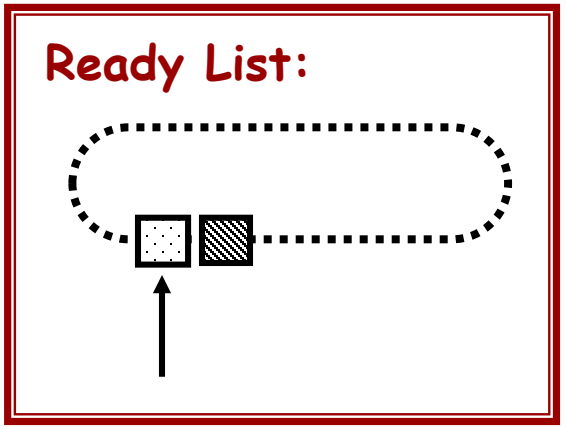




Round-Robin Scheduling

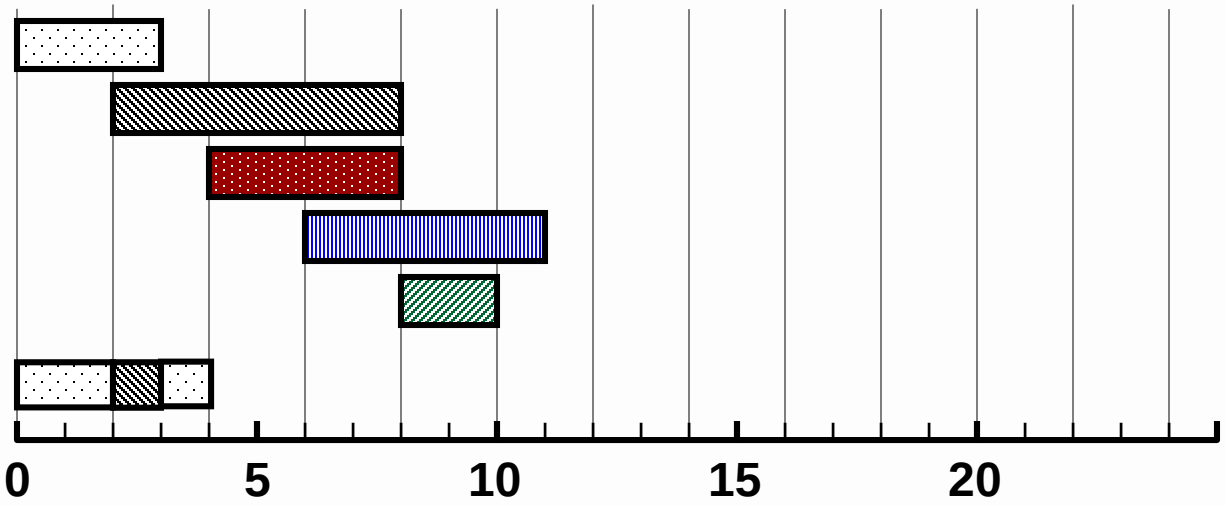
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

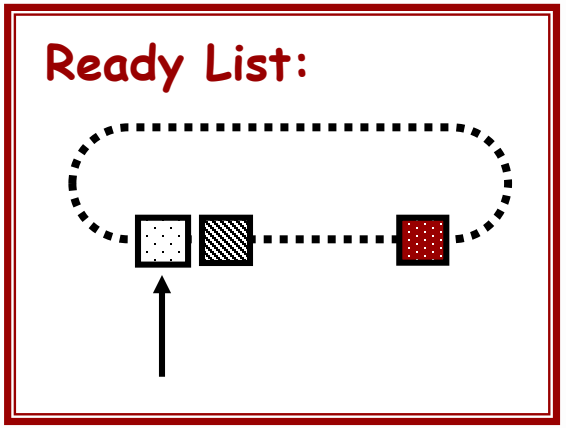




Round-Robin Scheduling

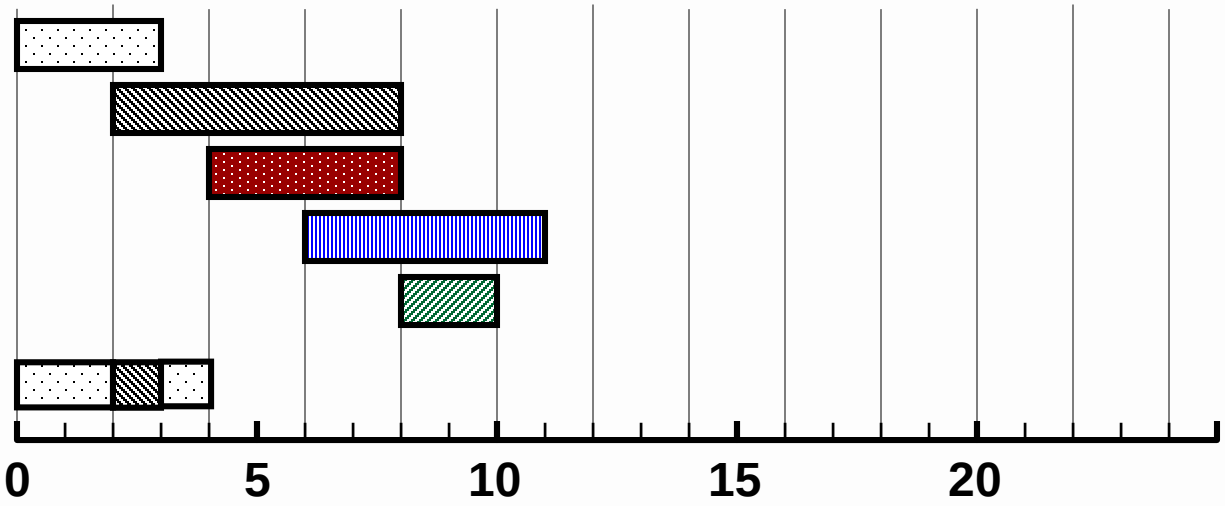
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

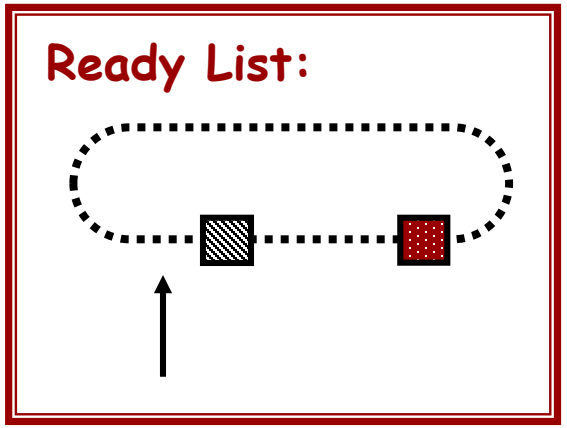




Round-Robin Scheduling

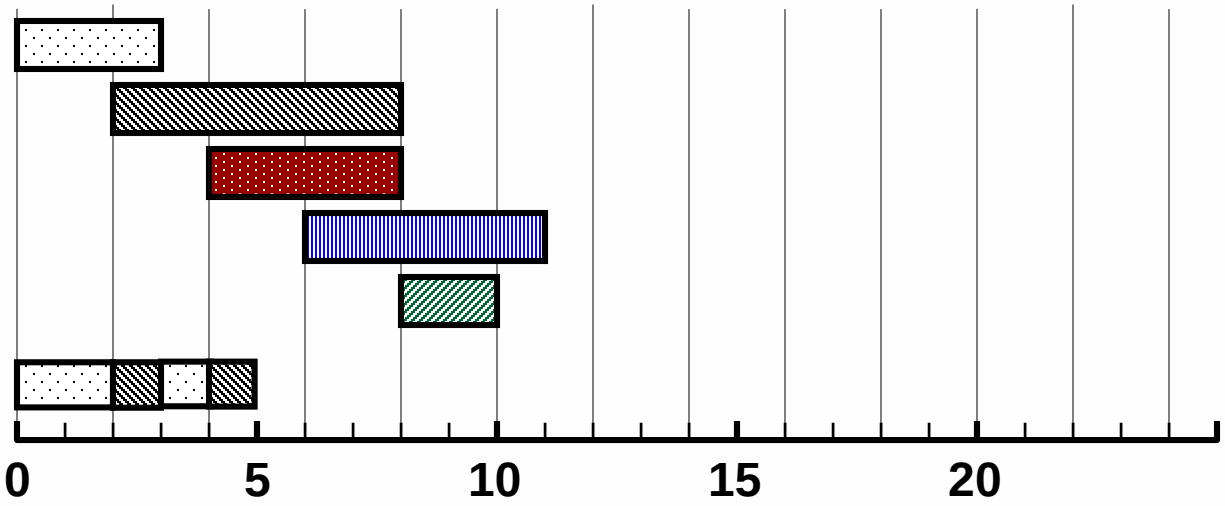
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

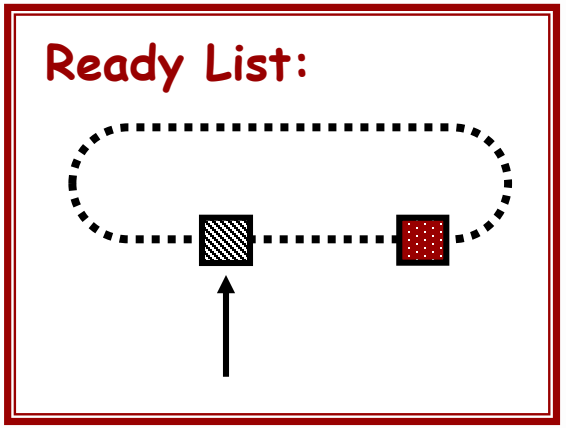




Round-Robin Scheduling

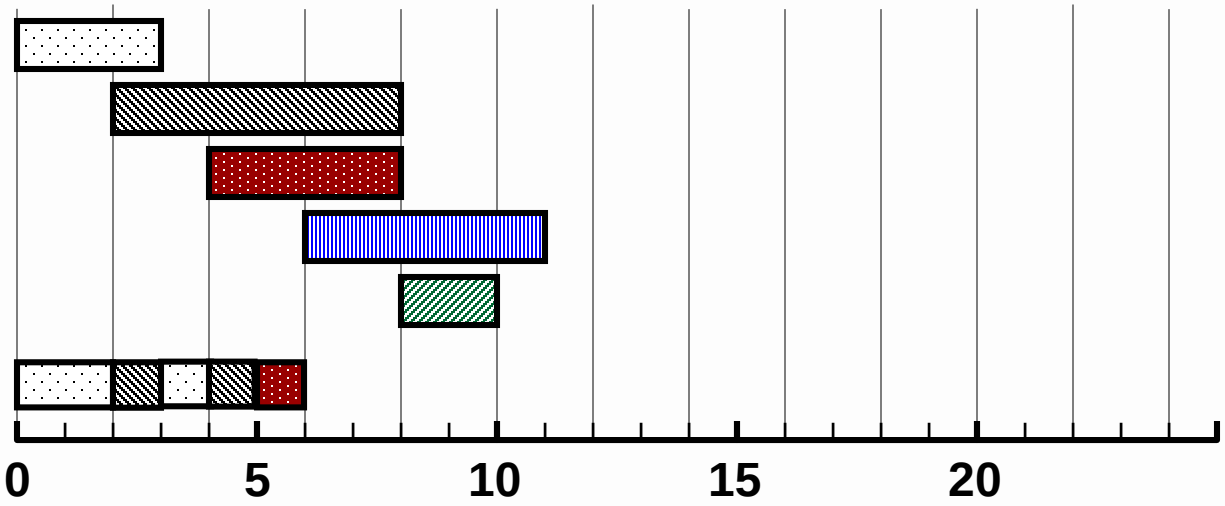
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

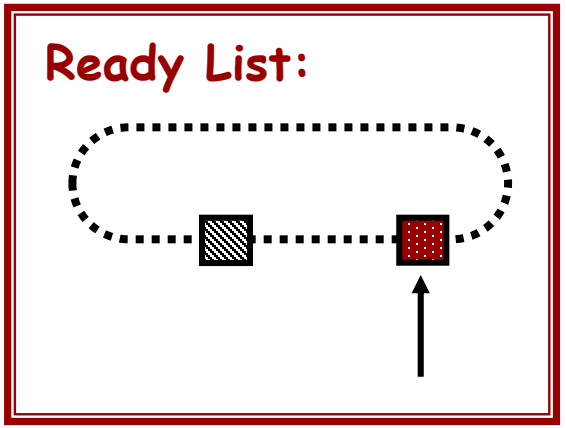




Round-Robin Scheduling

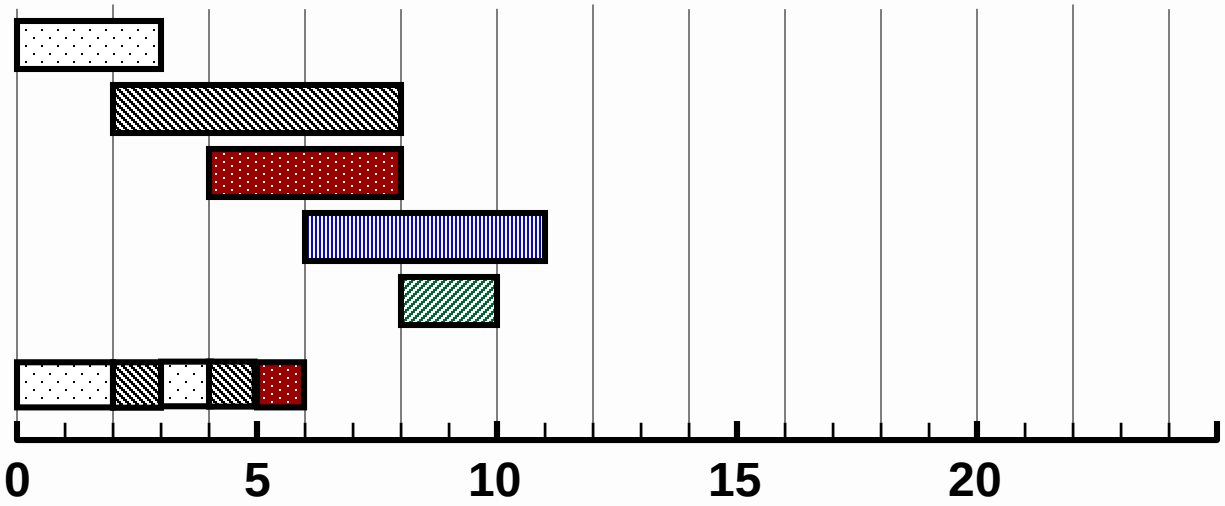
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

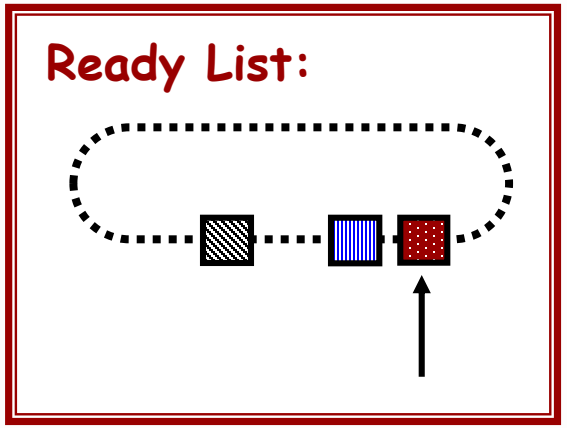




Round-Robin Scheduling

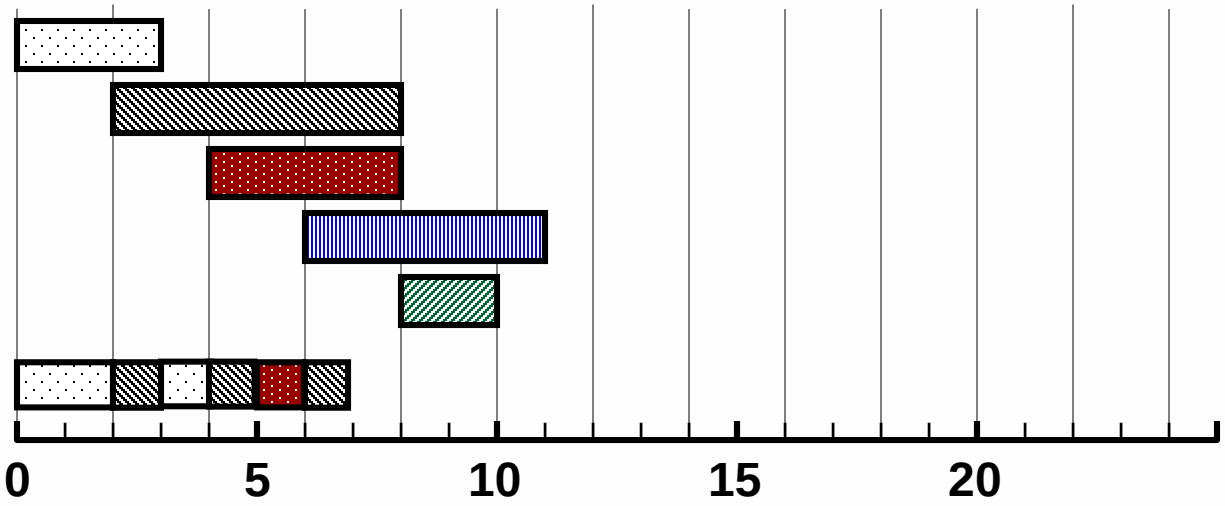
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

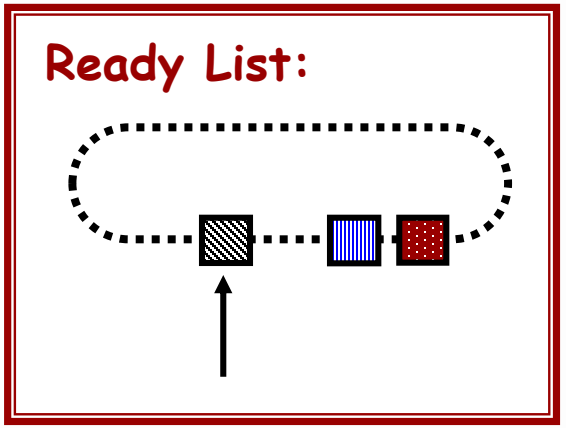




Round-Robin Scheduling

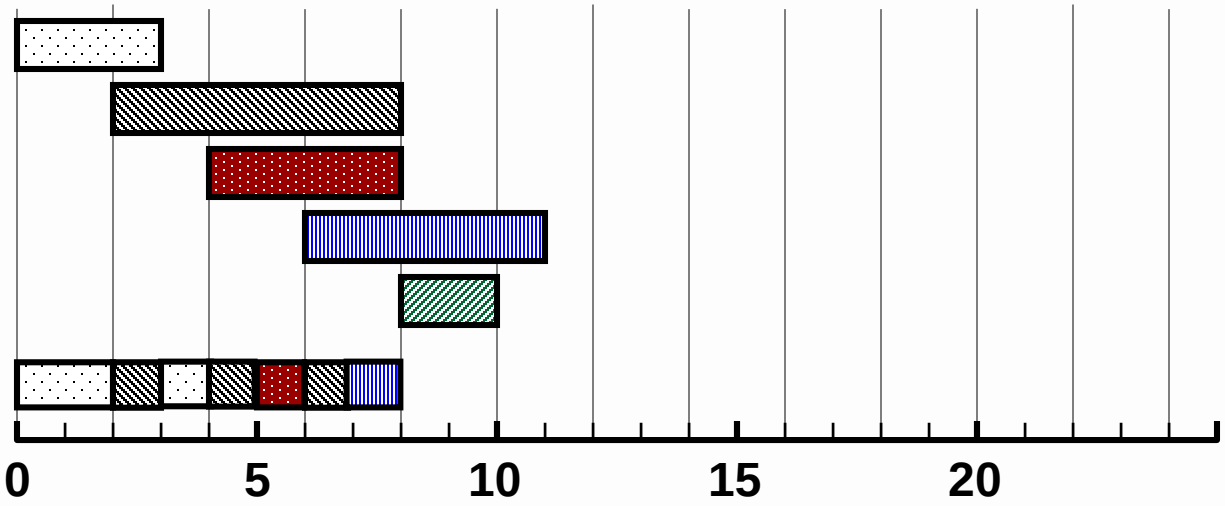
Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2

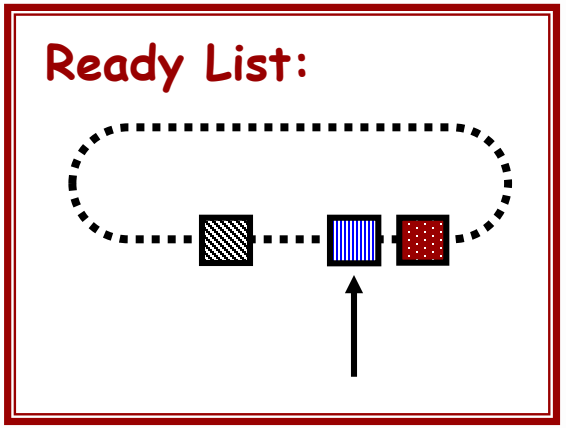




Round-Robin Scheduling

Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2





Round-Robin Scheduling

Process	Arrival Time	Processing Time
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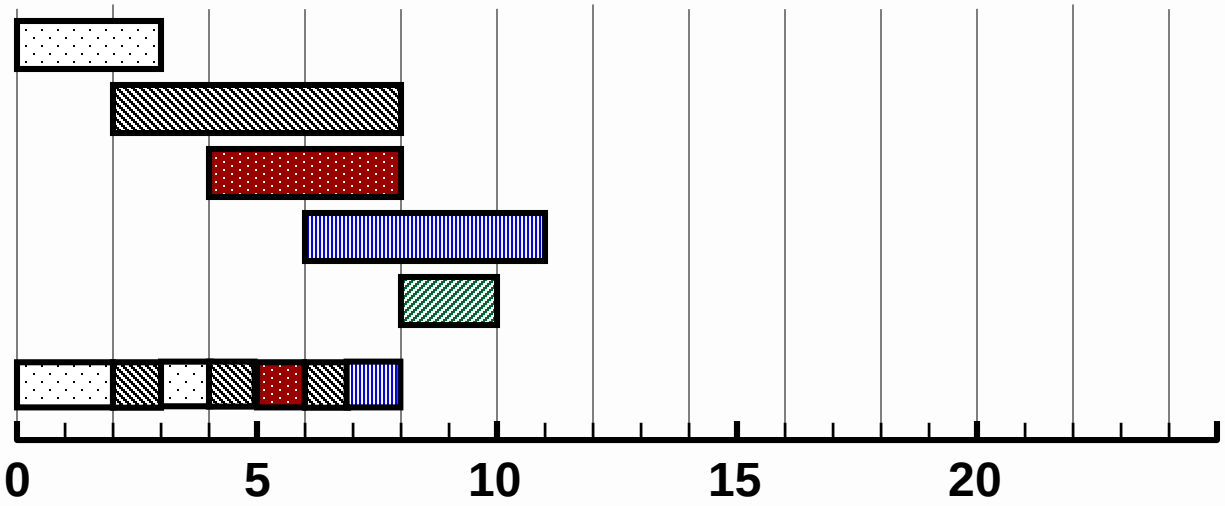
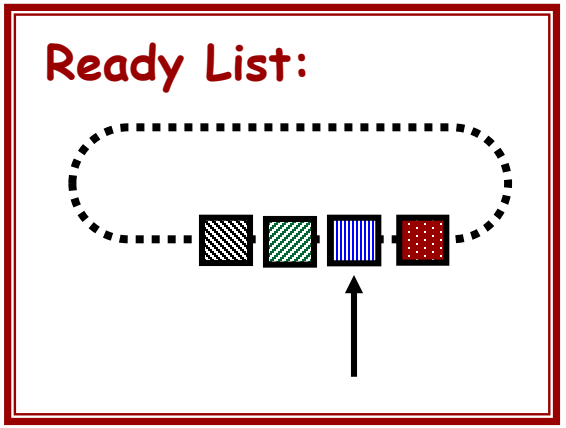
2	2	6
3	4	4
4	6	5
5	8	2





Round-Robin Scheduling

Process	Arrival Time	Processing Time
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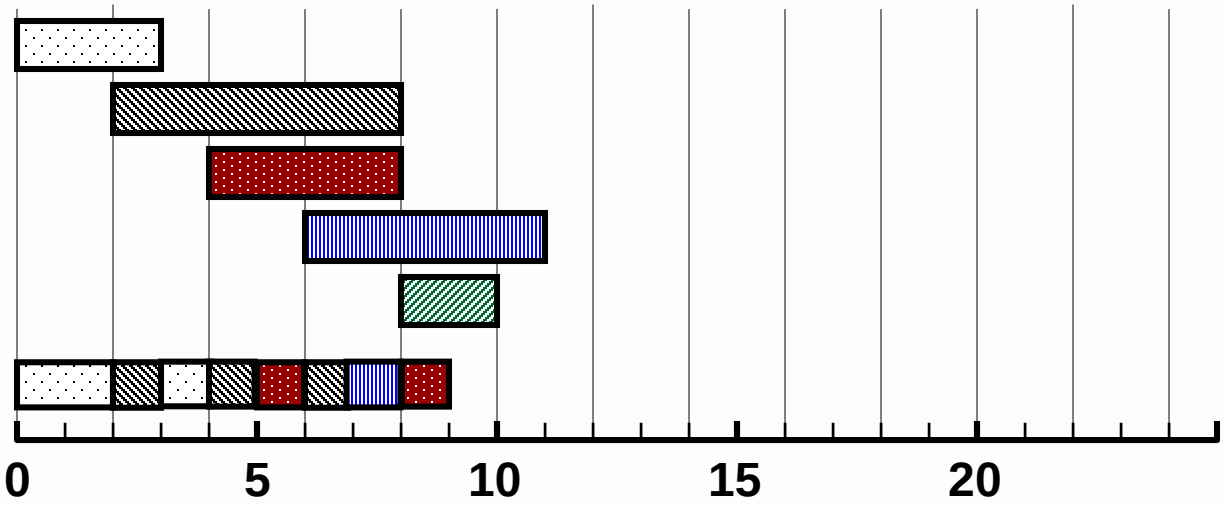
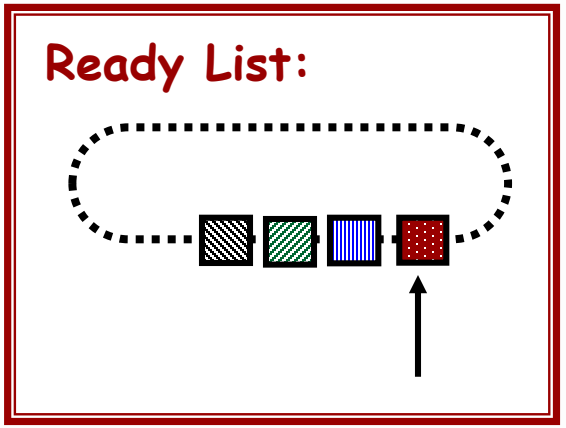
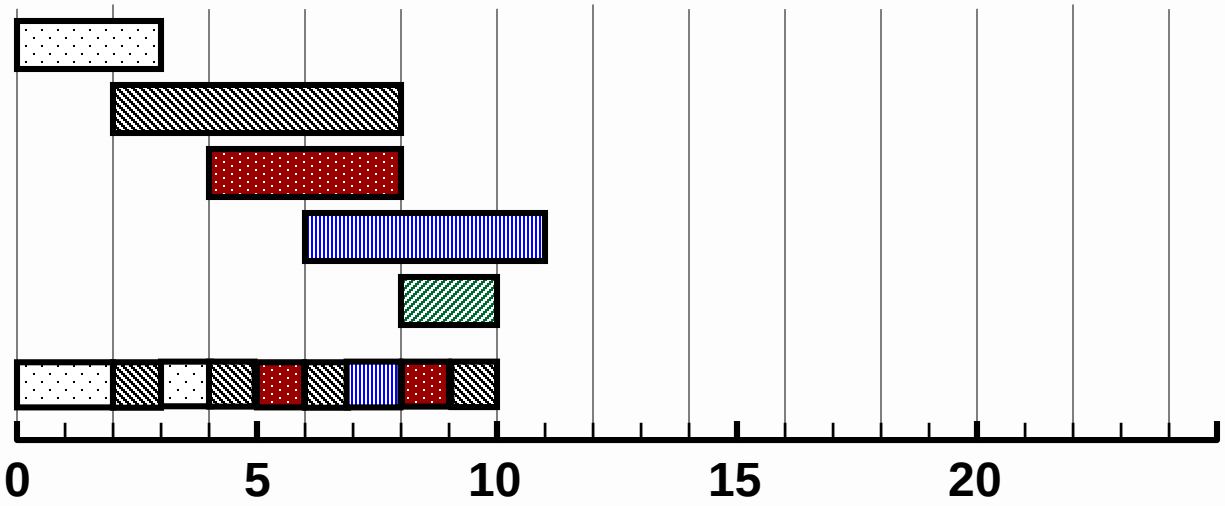
2	2	6
3	4	4
4	6	5
5	8	2

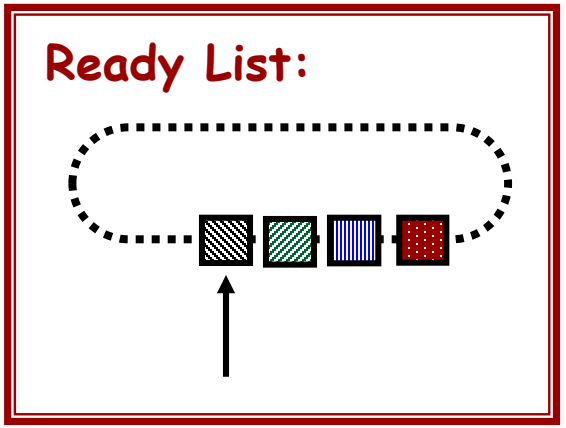




Round-Robin Scheduling

Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2





Round-Robin Scheduling

Process	Arrival Time	Processing Time
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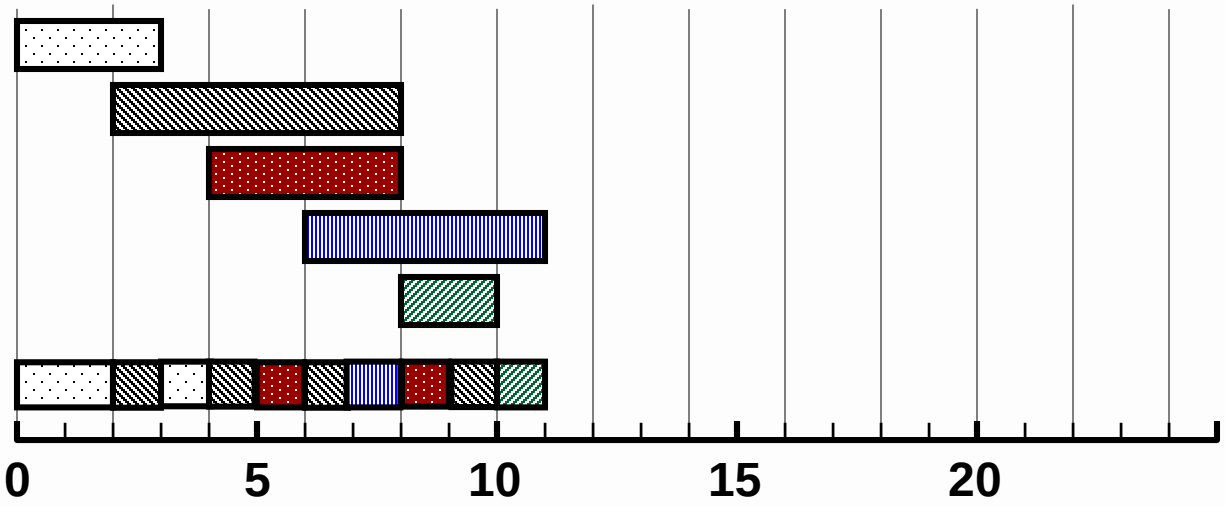
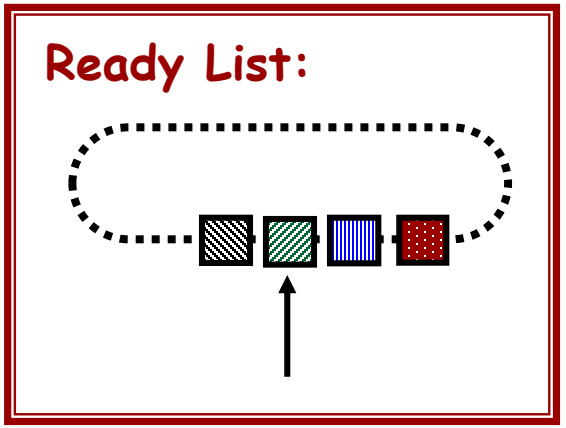
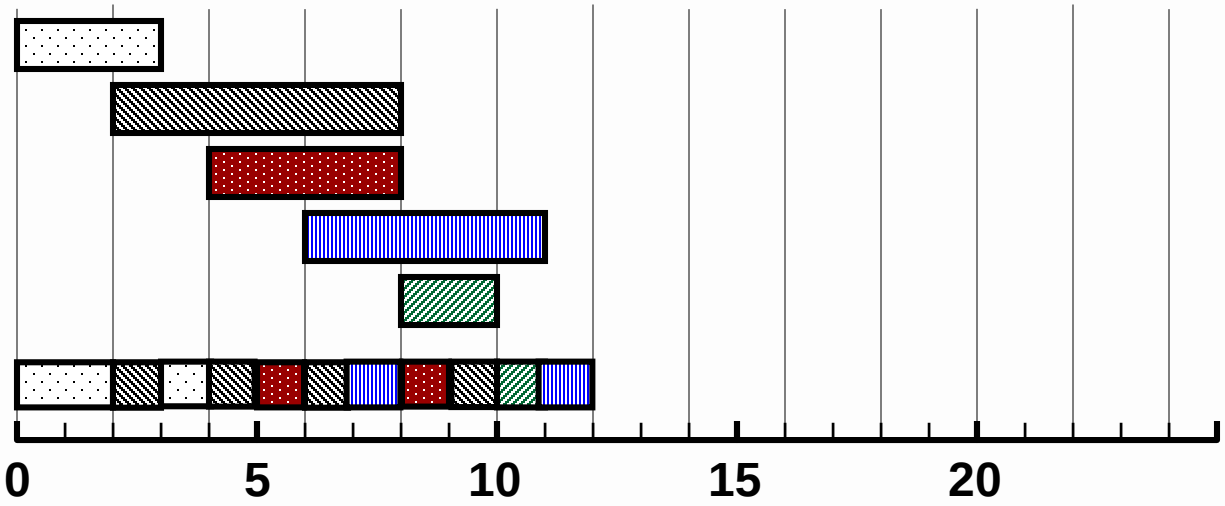
2	2	6
3	4	4
4	6	5
5	8	2

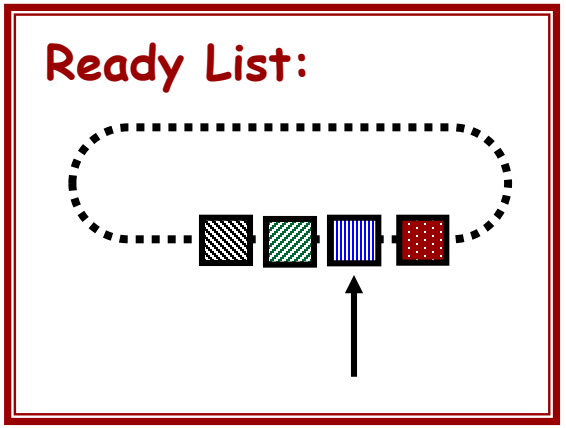




Round-Robin Scheduling

Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2





Round-Robin Scheduling

Process	Arrival Time	Processing Time
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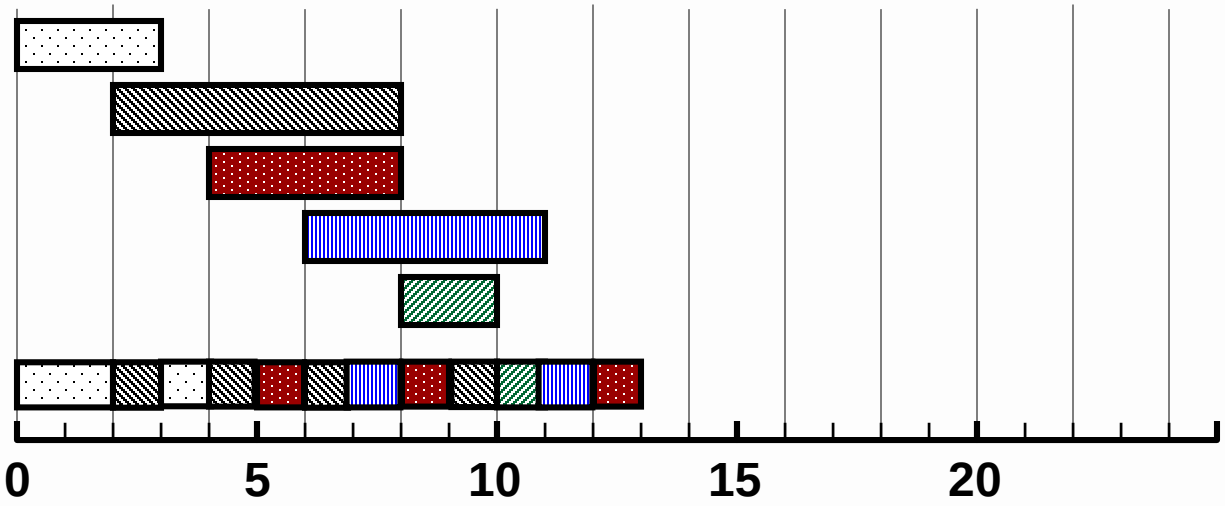
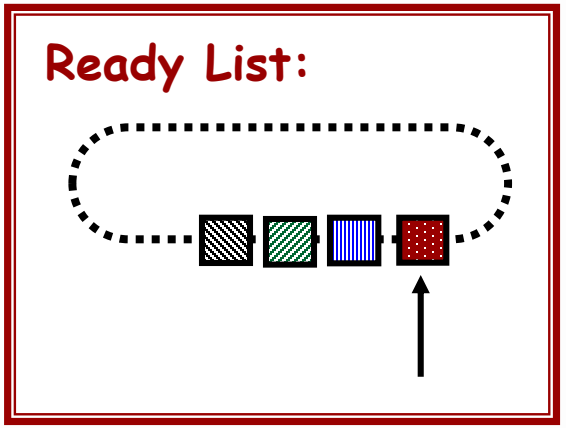
2	2	6
3	4	4
4	6	5
5	8	2





Round-Robin Scheduling

Process	Arrival Time	Processing Time
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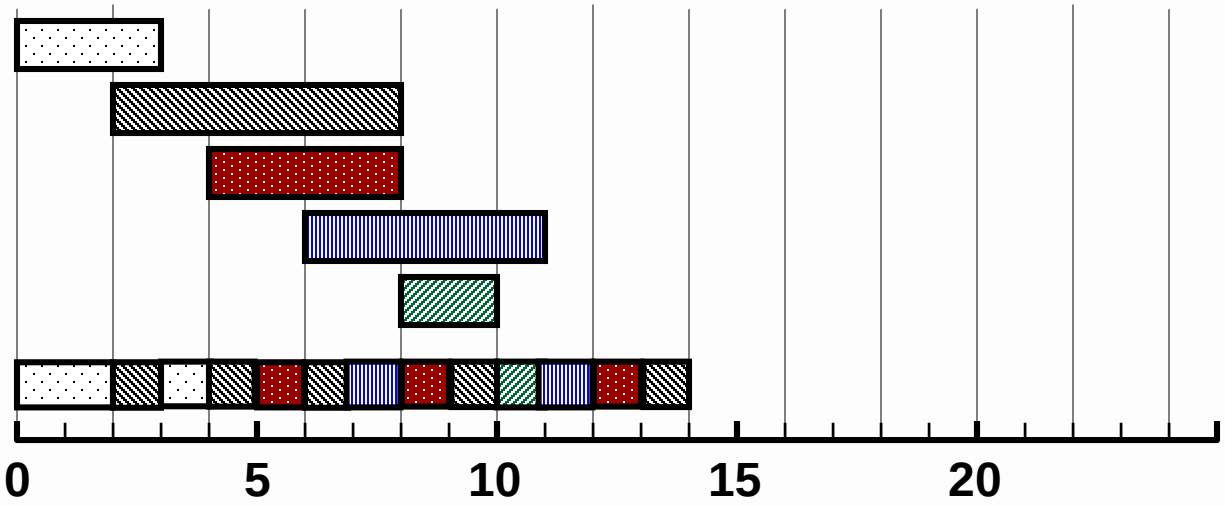
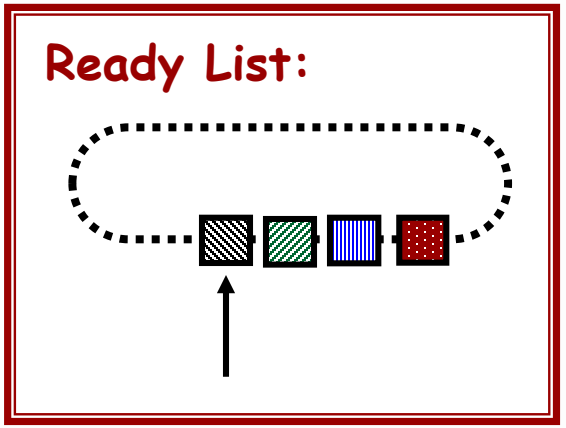
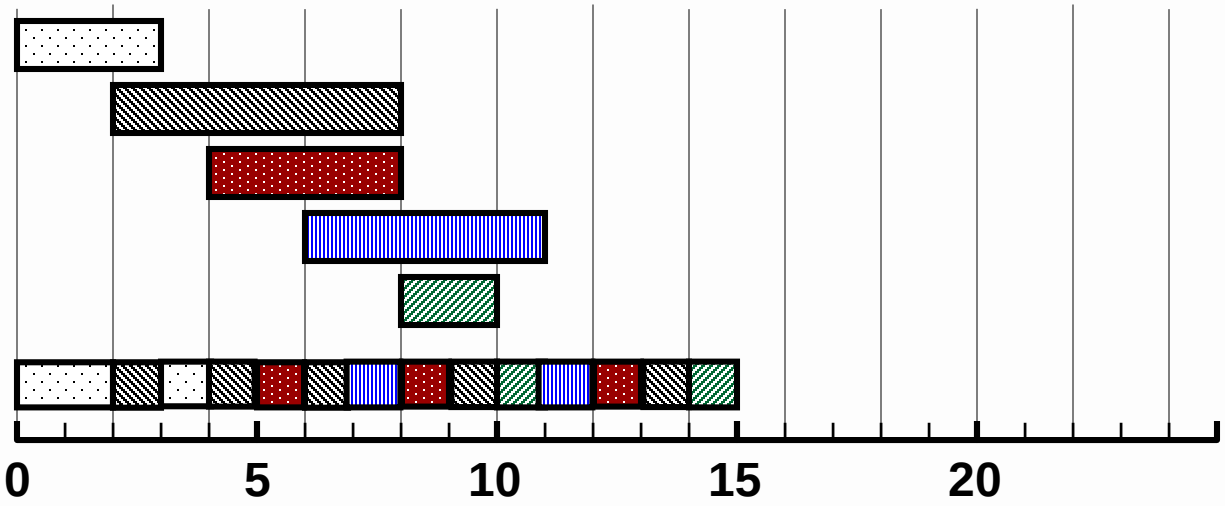
2	2	6
3	4	4
4	6	5
5	8	2

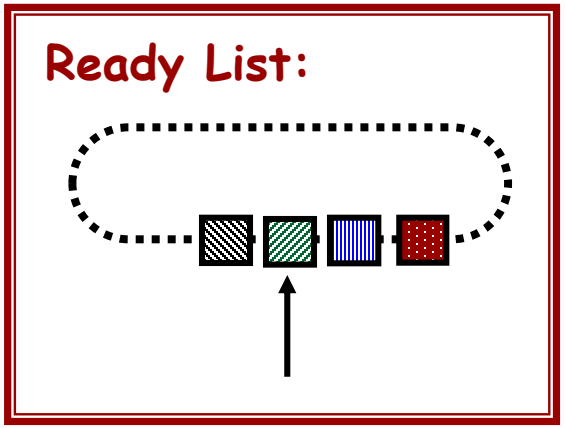




Round-Robin Scheduling

Process	Arrival Time	Processing Time
1	0	3
2	2	6
3	4	4
4	6	5
5	8	2





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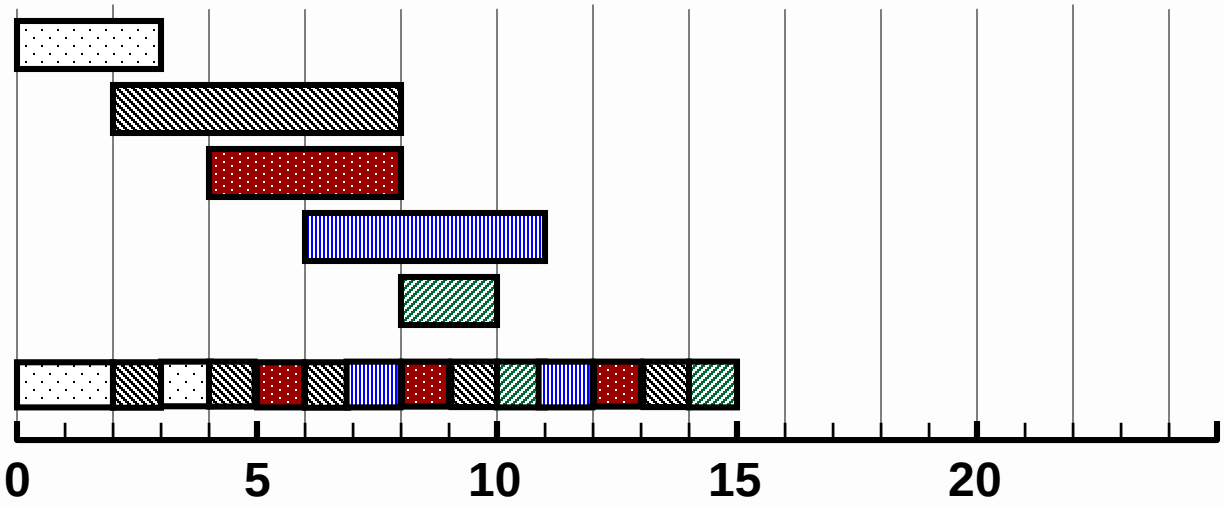

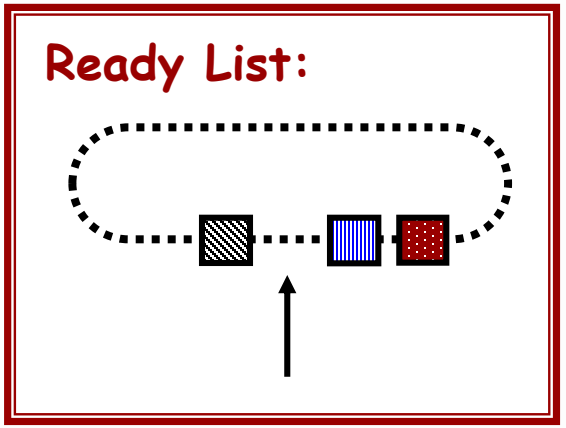

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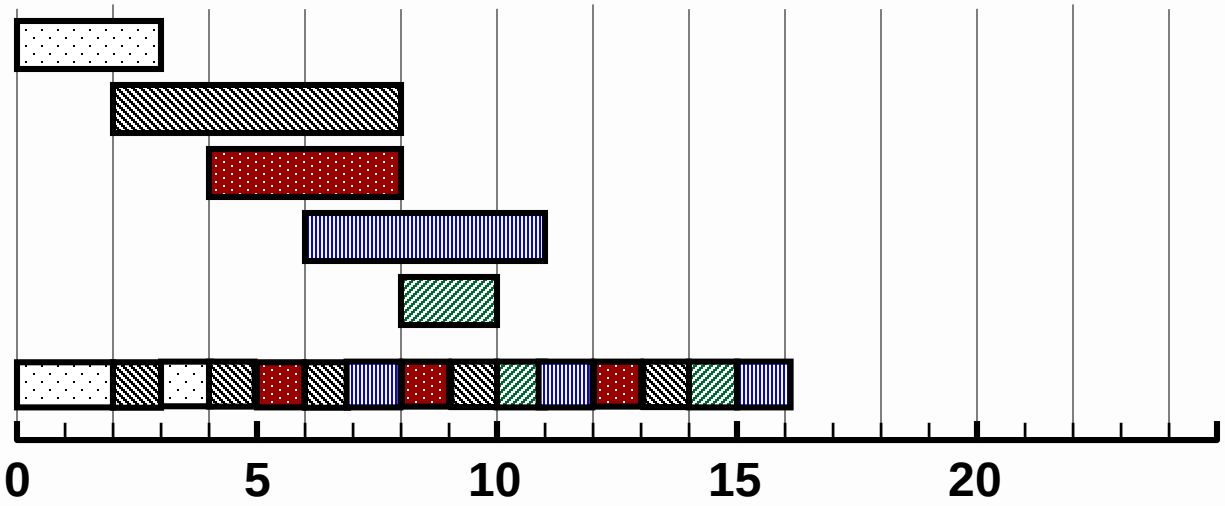

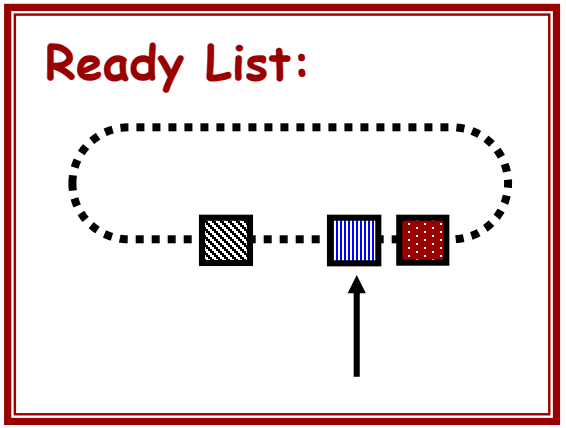

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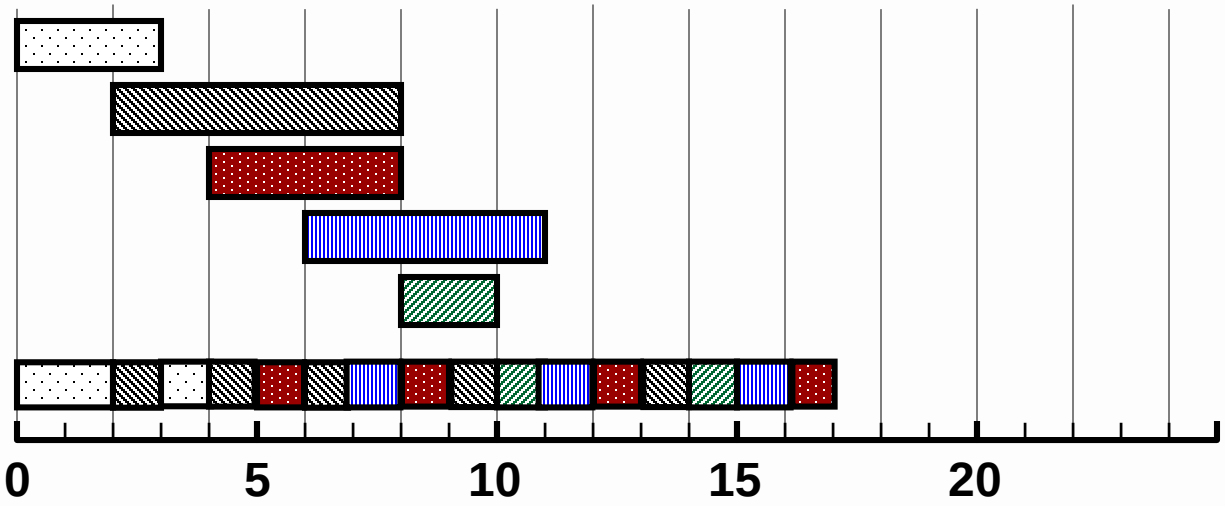

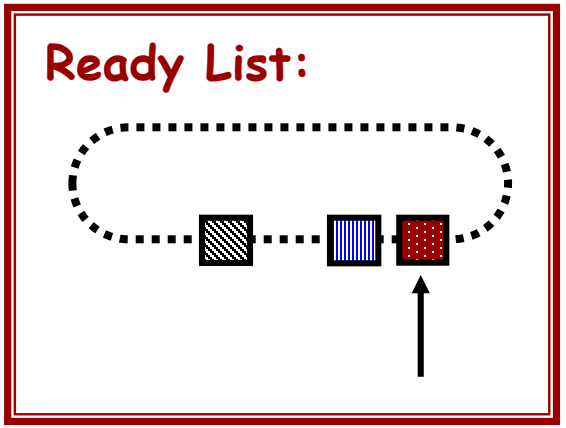

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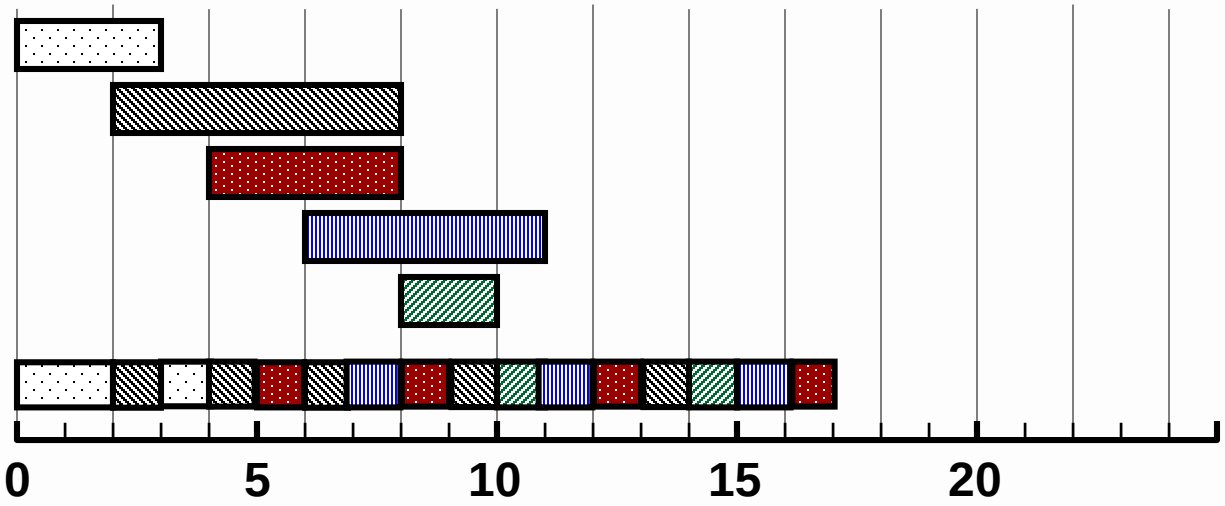

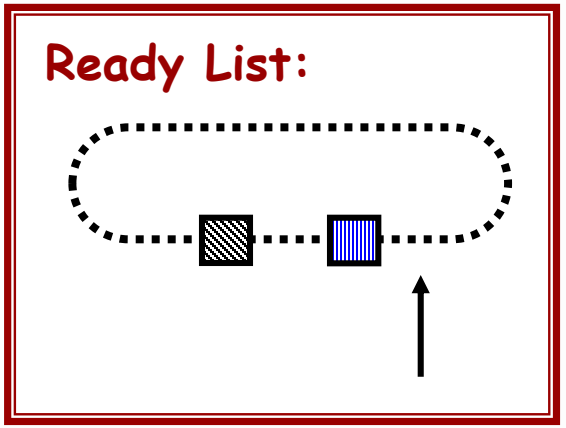

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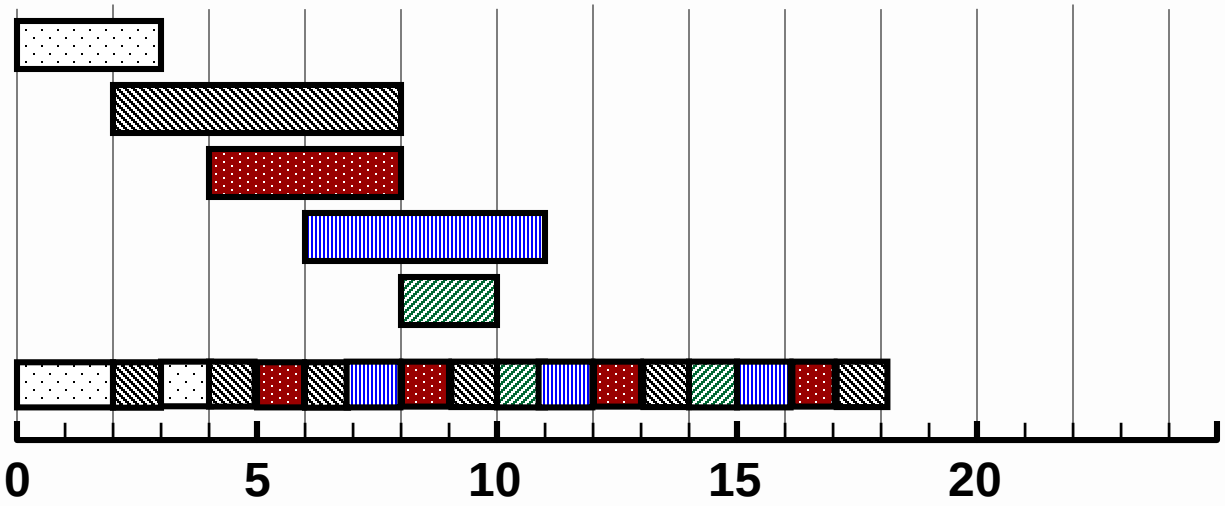

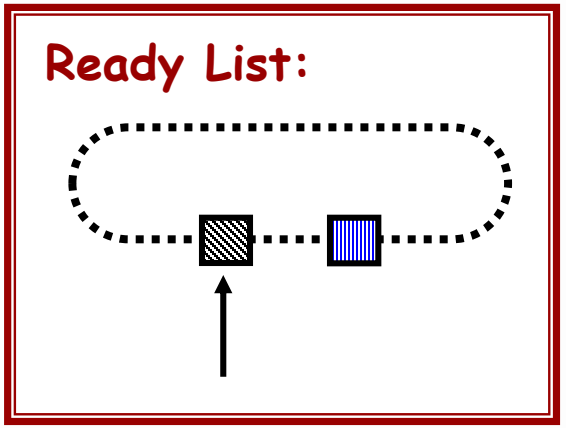

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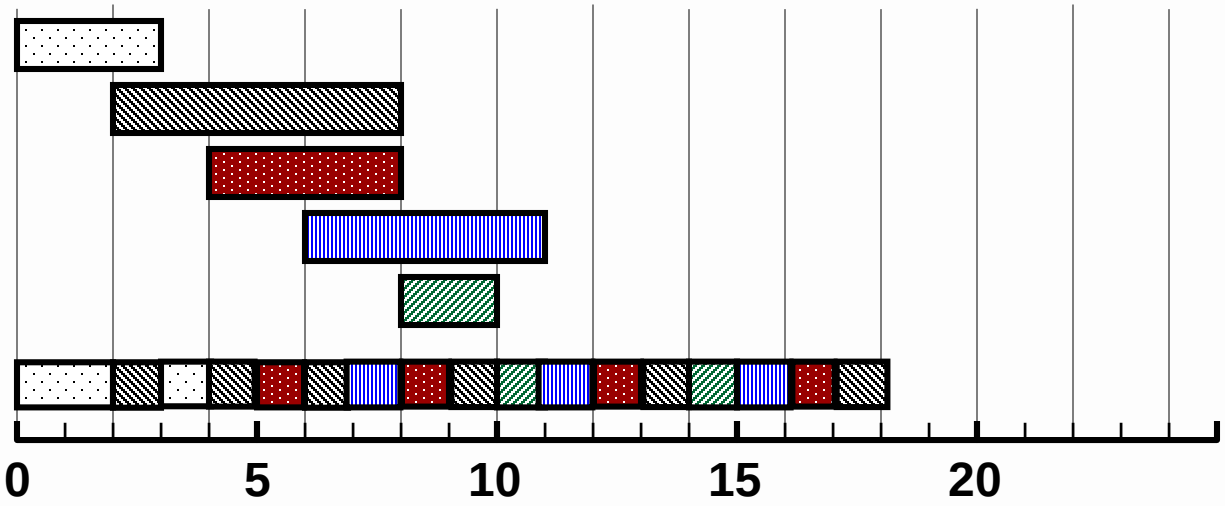

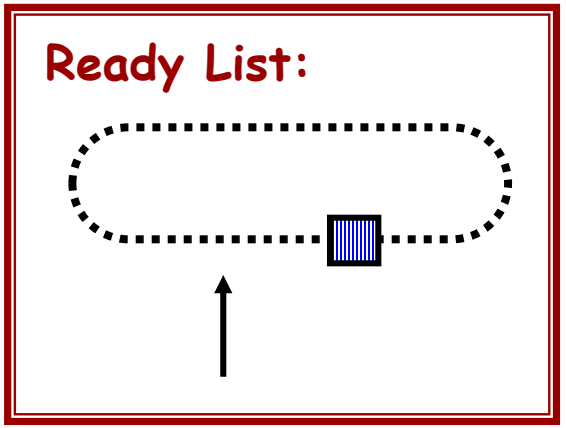

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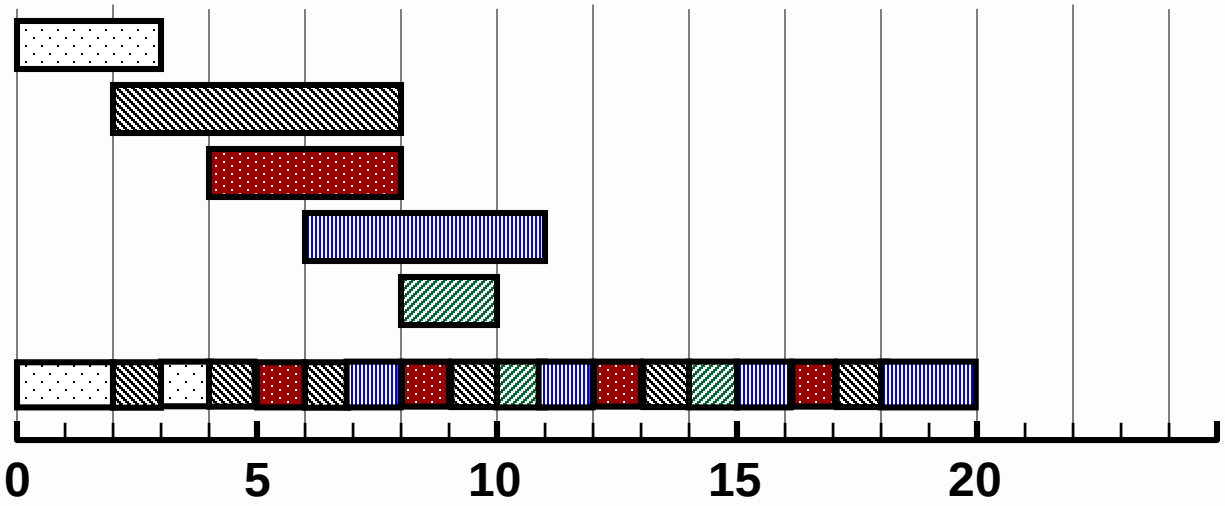

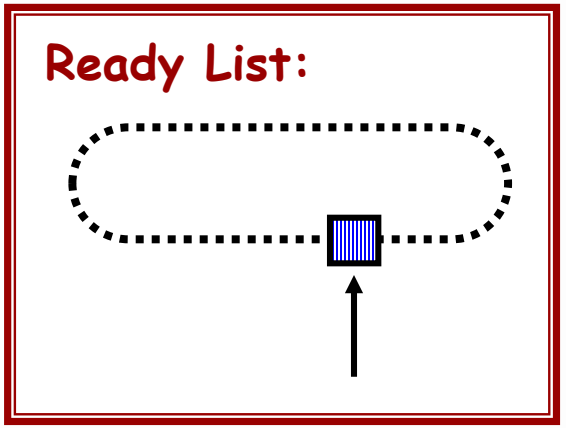

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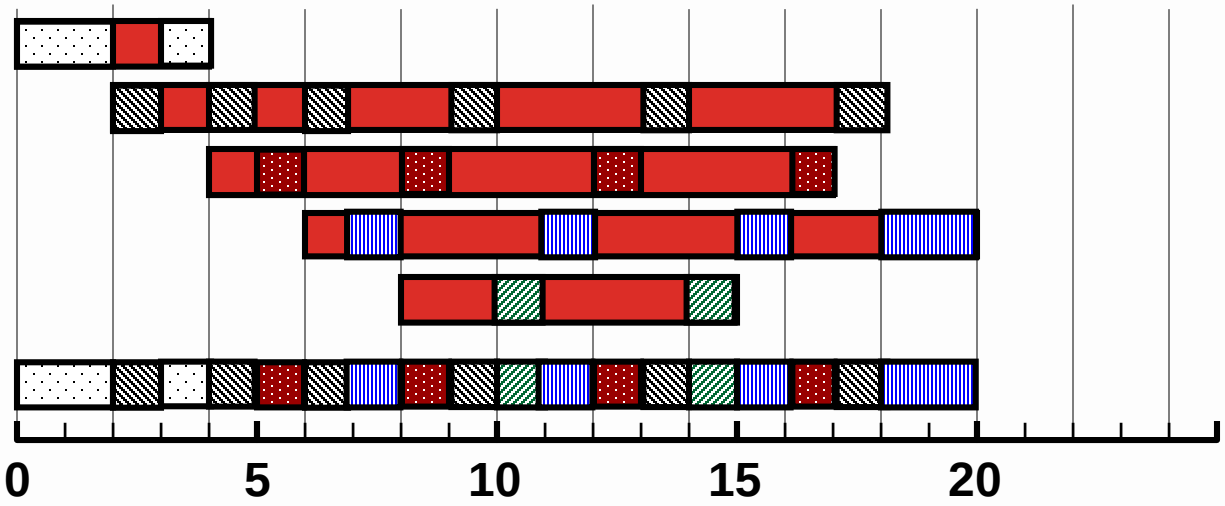
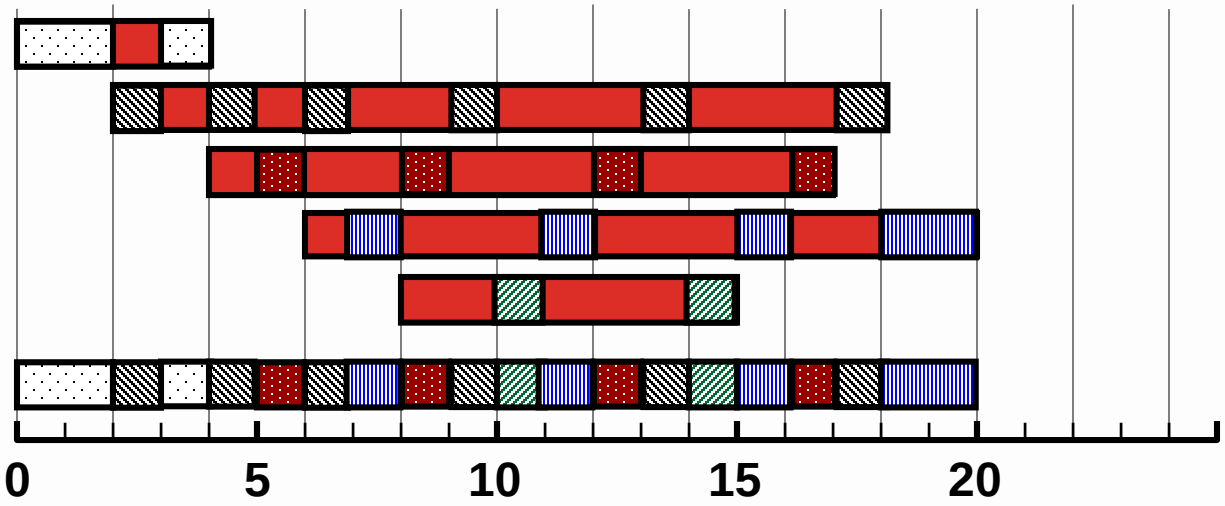


Round-Robin Scheduling

Total delay: 34

Process	Arrival Time	Processing Time	Delay	Turnaround Time
1	0	3	1	4
2	2	6	10	16
3	4	4	9	13
4	6	5	9	14
5	8	2	5	7



Round-Robin Scheduling

- Effectiveness of round-robin depends on
  - -- The number of jobs, and
  - -- The size of the time quantum.

- Large # of jobs means that the time between scheduling of a single job increases
  - -- Slow responses

- Larger time quantum means that the time between the scheduling of a single job also increases
  - -- Slow responses

- Smaller time quantum means better response time but also more overhead!

Outline

- CPU scheduling
- First-Come, First Served (FIFO)
- Shortest Job First (non-preemptive)
- Shortest Job First (with preemption)
- Round-Robin Scheduling
- Lottery Scheduling
- Multi-Level Feedback Queue

Lottery Scheduling

- A kind of proportional share scheduling
- Scheduler gives each task some lottery tickets
- To select the next process to run…
  - The scheduler randomly selects a lottery number
  - The winning process gets to run

- *Example*

Task A gets 50 tickets
Task B gets 15 tickets
Task C gets 35 tickets
There are 100 tickets outstanding

Lottery Scheduling

- A kind of proportional share scheduling
- Scheduler gives each task some lottery tickets.
- To select the next process to run…
  - The scheduler randomly selects a lottery number
  - The winning process gets to run

- *Example*

Task A gets 50 tickets → 50% of CPU
Task B gets 15 tickets → 15% of CPU
Task C gets 35 tickets → 35% of CPU
There are 100 tickets outstanding

Acknowledgement

- Chapter 7-9
  - Operating Systems: Three Easy Pieces

- 8.ppt
  - Intro to Operating System at Portland State University
  - by Jonathan Walpole

SWINBURNE UNIVERSITY OF TECHNOLOGY

Questions?