



Microprocessor & Computer Architecture (μ pCA)

UE19CS252

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Microprocessor & Computer Architecture (μ pCA)

Introduction to Pipeline Processor

Dr. D. C. Kiran

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Microprocessor & Computer Architecture (μpCA)

Syllabus



~~Unit 1: Basic Processor Architecture and Design~~

Unit 2: Pipelined Processor and Design

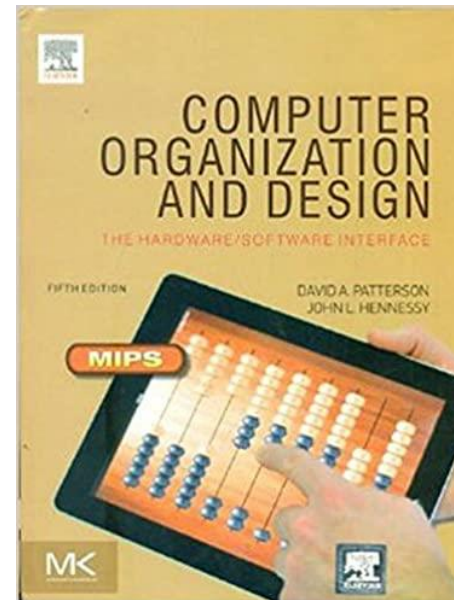
Chapter 4:

“Computer Organization and Design”, Patterson, Hennessey, 5th Edition, Morgan Kaufmann, 2014.

Unit 3: Memory Design

Unit 4: Input/Output Device Design

Unit 5: Advanced Architecture



Microprocessor & Computer Architecture (μpCA)

Processor

You're going
to love this

```
int main()  
{  
  a=a+b  
  c=a-b  
}
```

THE PROGRAMMER

I will execute
one by one
ADD R0 R0 R1
SUB R2, R0,R1



THE COMPUTER

Microprocessor & Computer Architecture (μpCA)

Processor

You're going
to love this

```
int main()  
{  
  a=a+b  
  c=a-b  
}
```

THE PROGRAMMER

If I execute both
at a time, can I
complete soon?

ADD R0 R0 R1
SUB R2, R0,R1



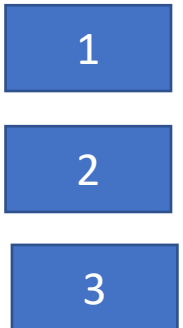
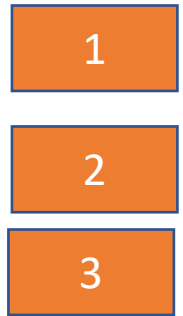
THE COMPUTER

Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 0

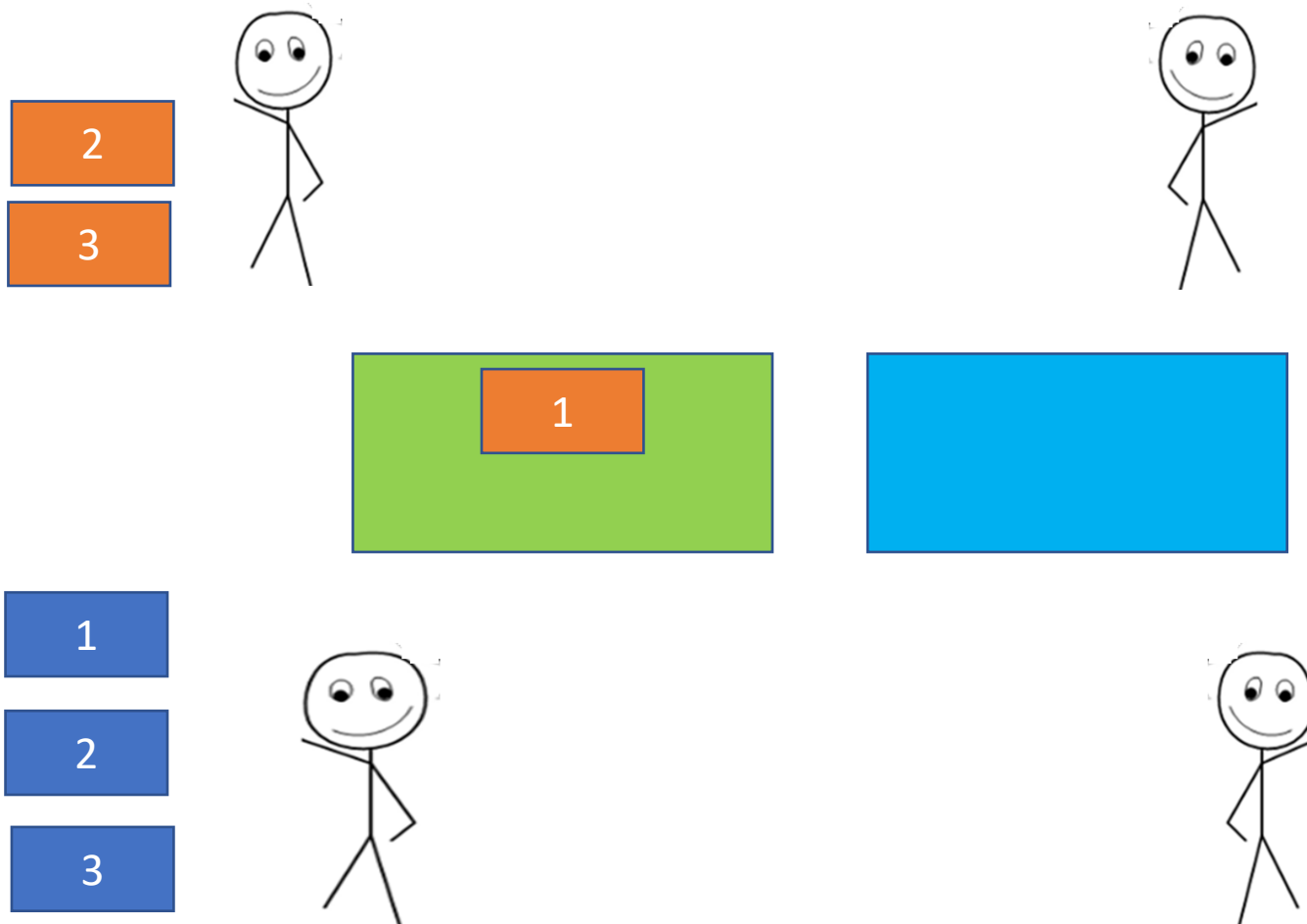


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Technique 1

Shifting One Brick take 10 mins

Timer: 5

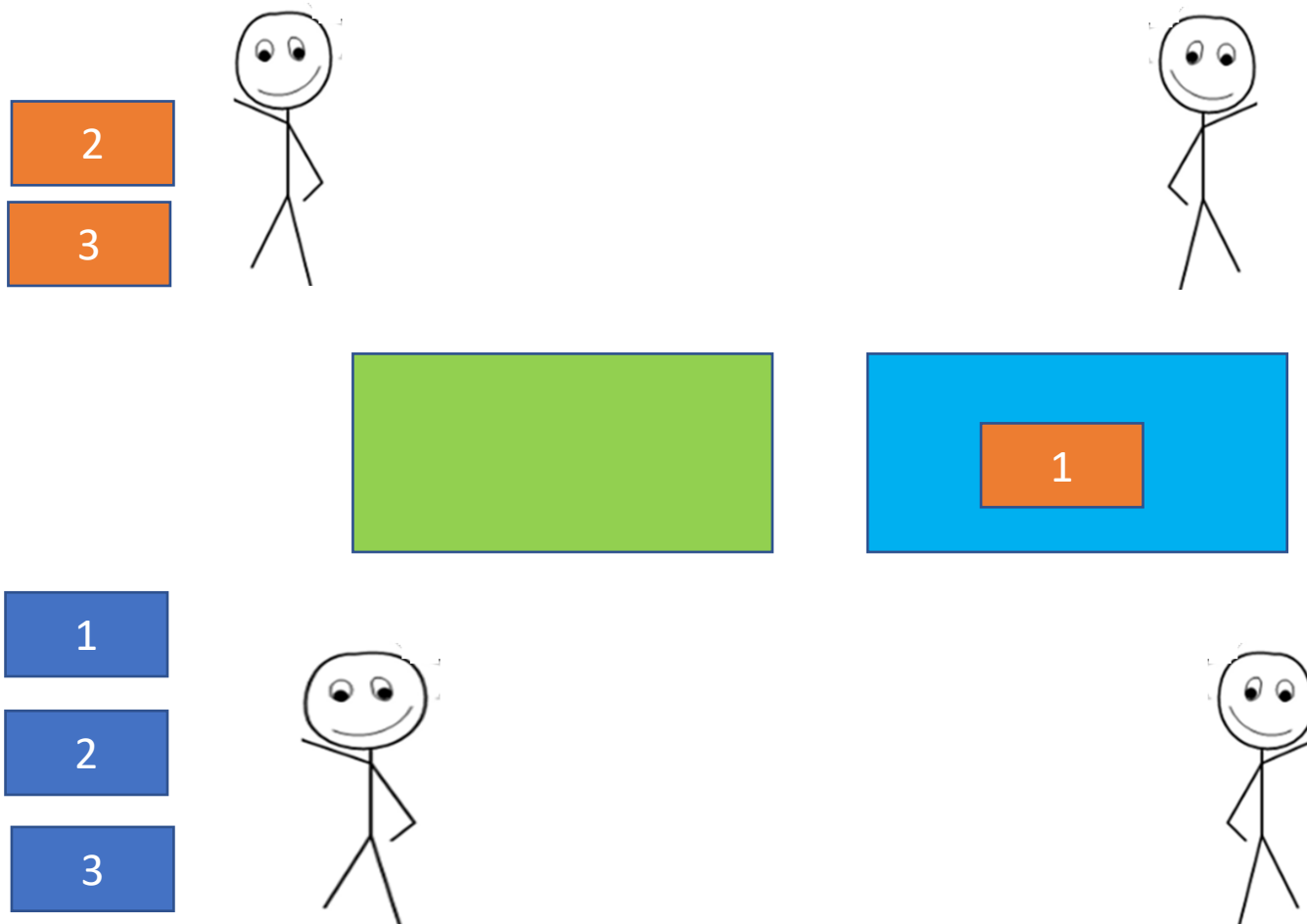


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 10



Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

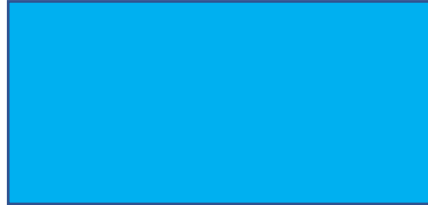
Timer: 10

2

3



1



1

2

3

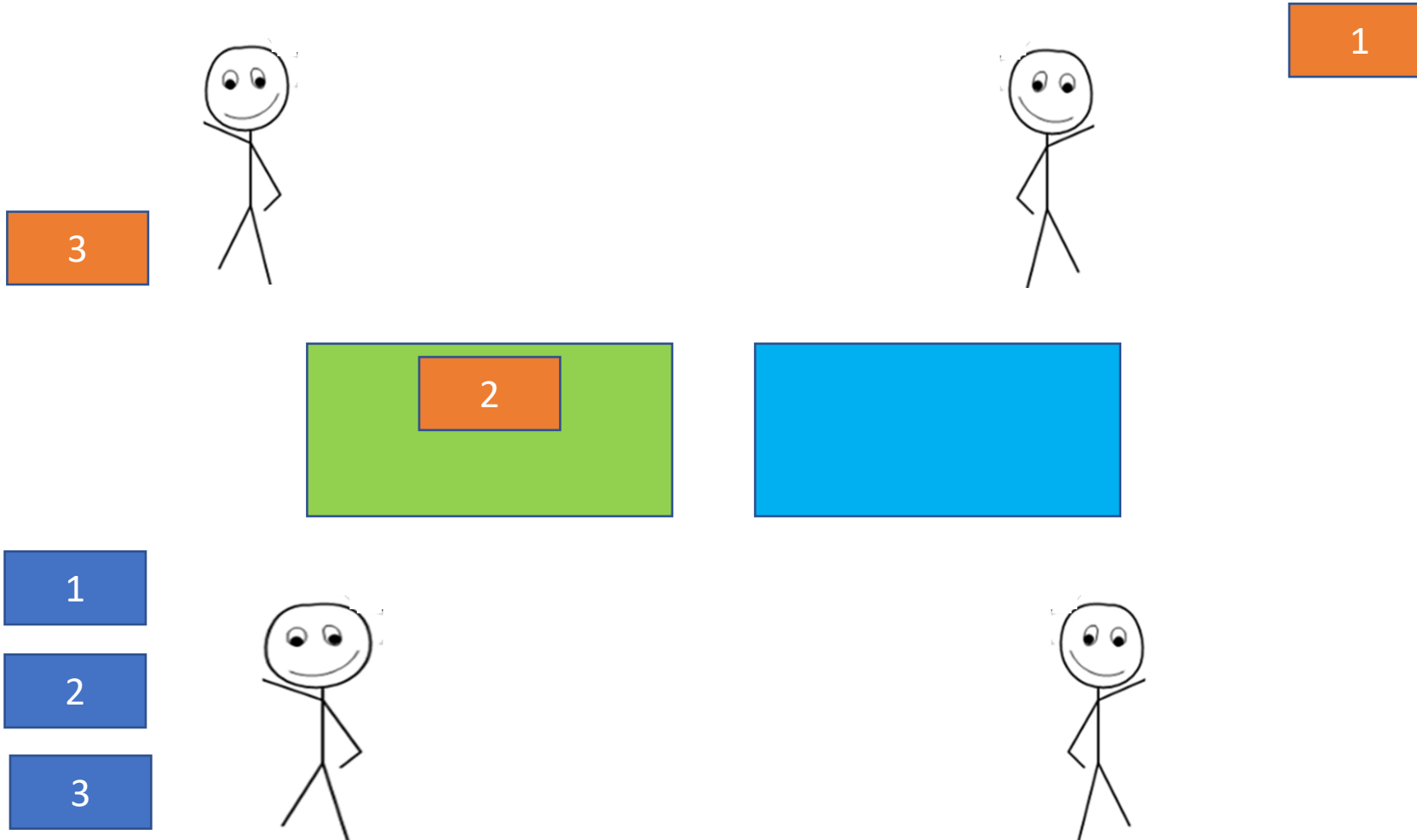


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 15

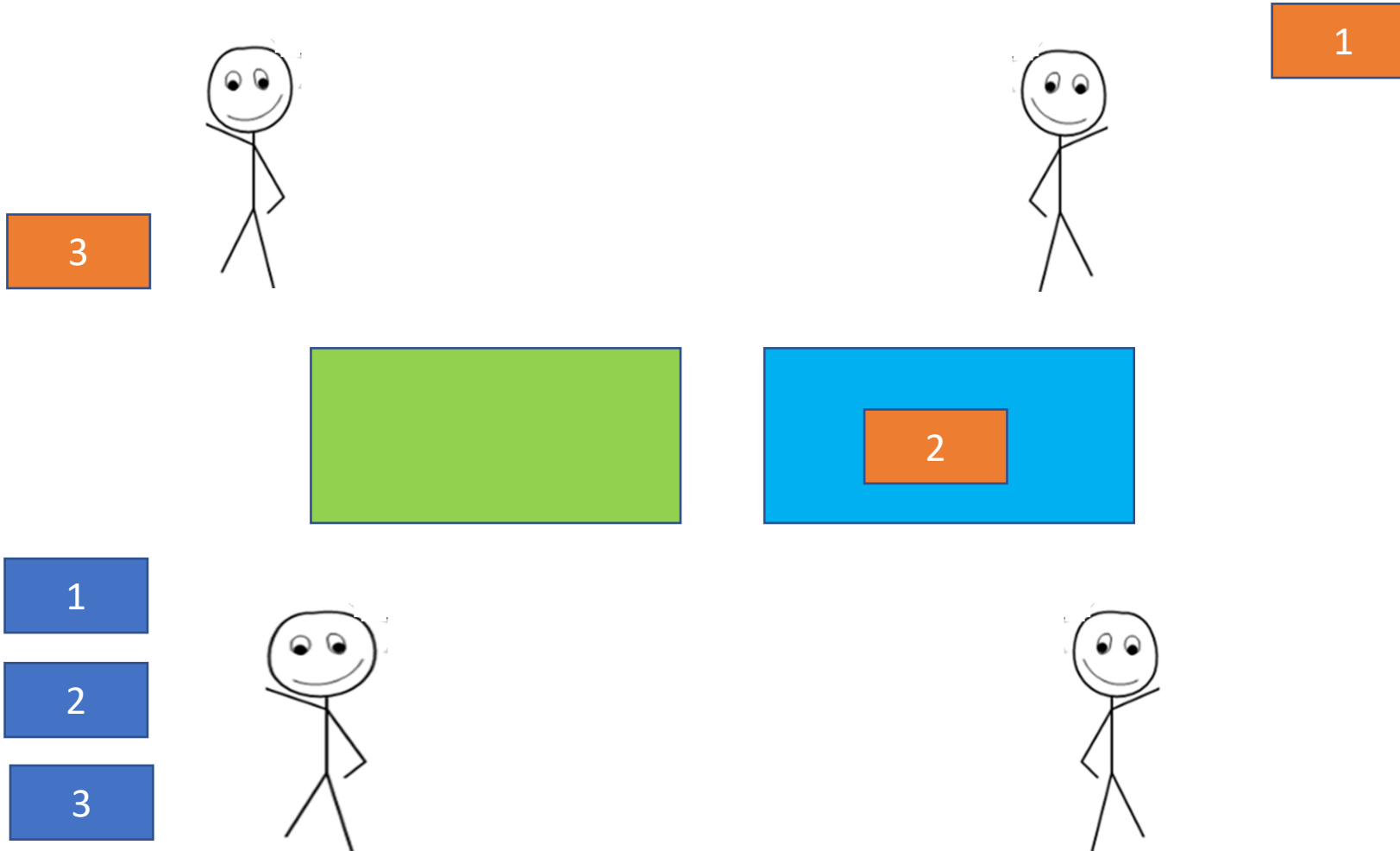


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 20

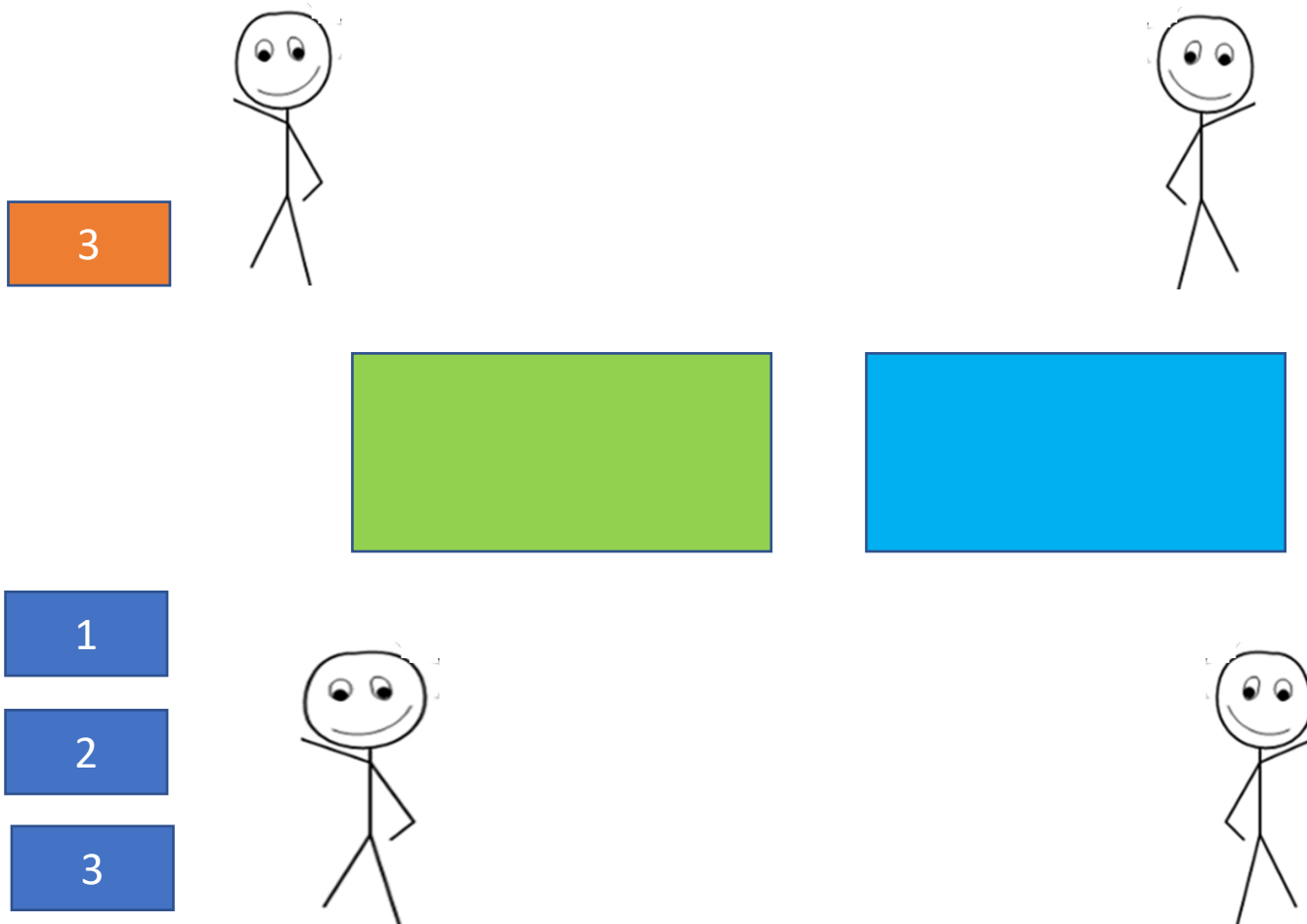


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 20

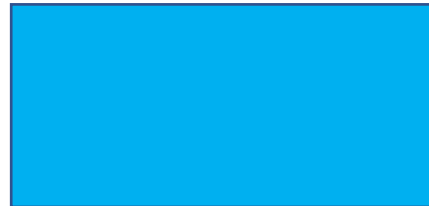


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 25

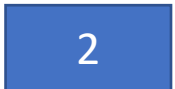
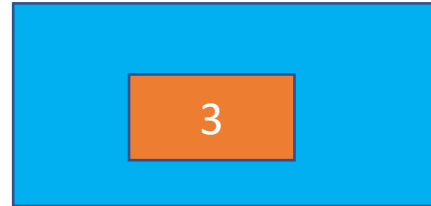


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 30



Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

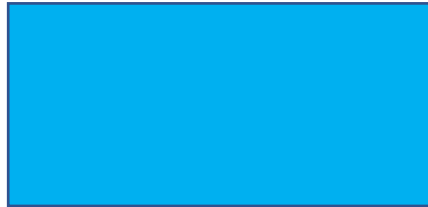
Timer: 30



1

2

3



1

2

3

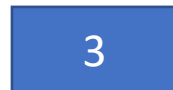
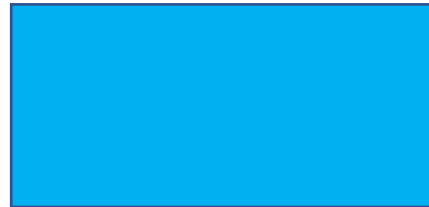


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 35



Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 40



1

2

3



2

3



Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

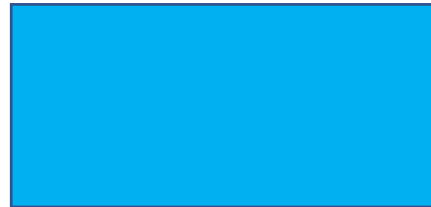
Timer: 40



1

2

3



1

2

3

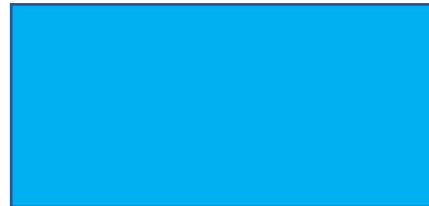
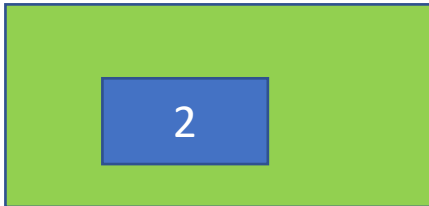


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 45



Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 50



Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 50



1

2

3



1

2

3

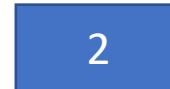


Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 55



Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 60



Microprocessor & Computer Architecture (μpCA)

Technique 1

Shifting One Brick take 10 mins

Timer: 60



1

2

3



1

2

3

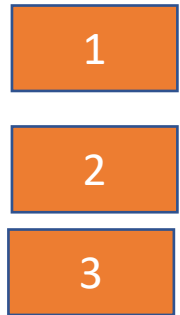


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Technique 2

Shifting One Brick take 10 mins

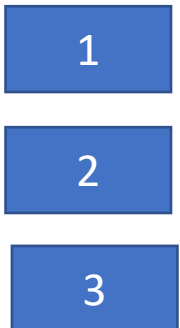
Timer: 0



5 Min



5 Min



Microprocessor & Computer Architecture (μpCA)

Technique 2

Shifting One Brick take 10 mins

Timer: 5

2

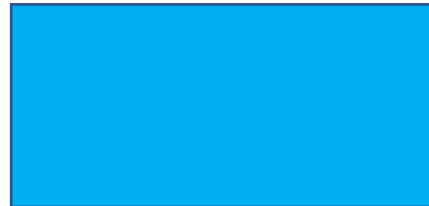
3



5 Min



5 Min



1

2

3



Microprocessor & Computer Architecture (μpCA)

Technique 2

Shifting One Brick take 10 mins

Timer: 10

2

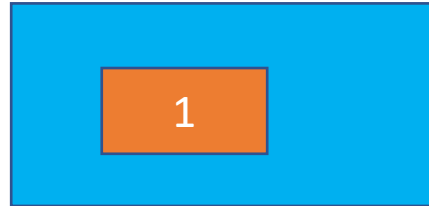
3



5 Min



5 Min



2

3



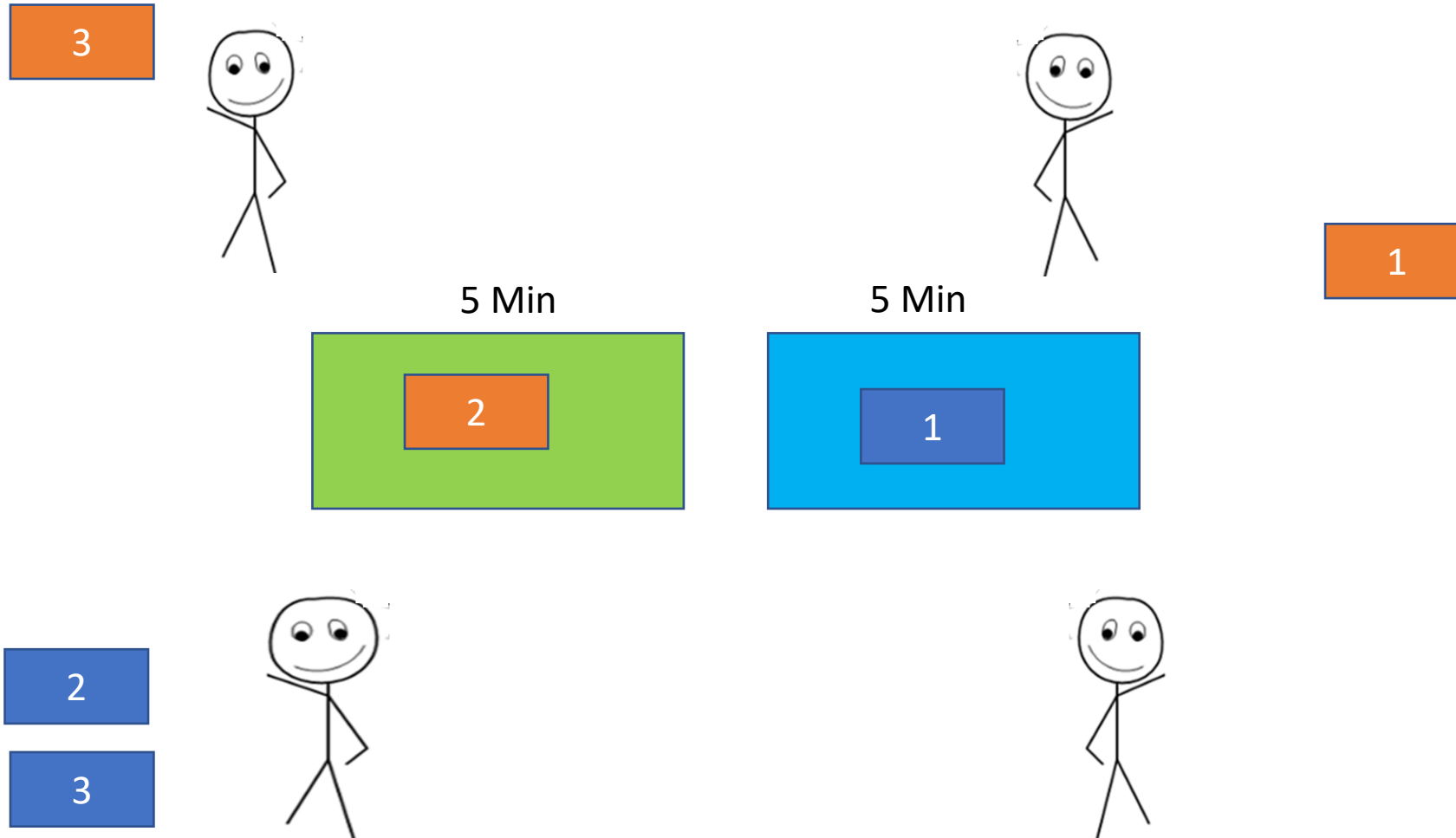
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Technique 2



Shifting One Brick take 10 mins

Timer: 10

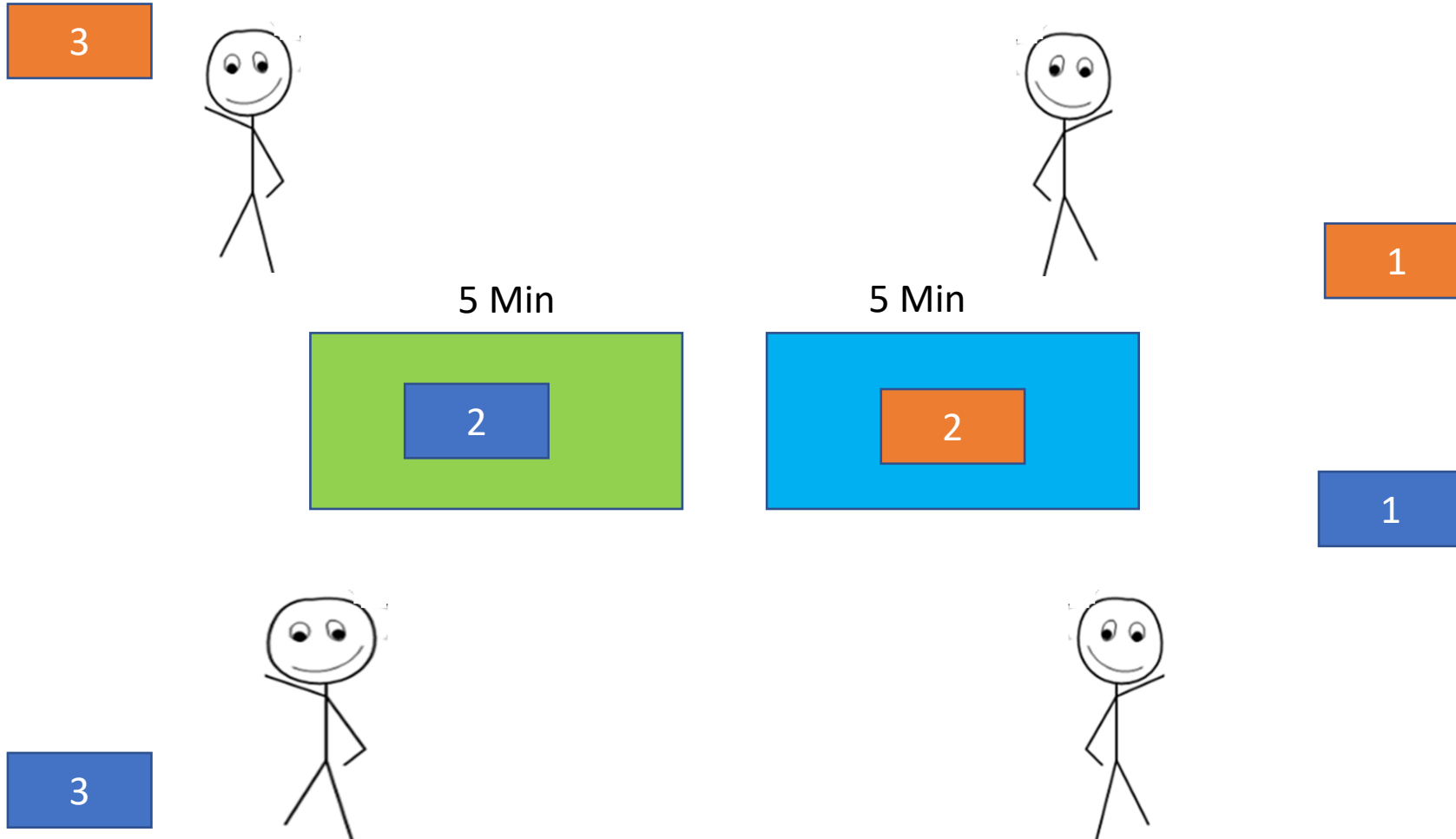


Microprocessor & Computer Architecture (μpCA)

Technique 2

Shifting One Brick take 10 mins

Timer: 15



Microprocessor & Computer Architecture (μpCA)

Technique 2

Shifting One Brick take 10 mins

Timer: 20



5 Min



5 Min



Microprocessor & Computer Architecture (μpCA)

Technique 2

Shifting One Brick take 10 mins

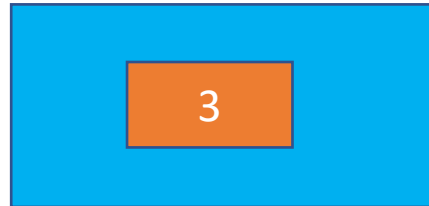
Timer: 25



5 Min



5 Min



Microprocessor & Computer Architecture (μpCA)

Technique 2

Shifting One Brick take 10 mins

Timer: 30



5 Min



5 Min



Microprocessor & Computer Architecture (μpCA)

Technique 2

Shifting One Brick take 10 mins

Timer: 35



I took 30 Mins to Complete



5 Min



5 Min



1

2

3

1

2

3



I took 30 Mins to Complete



But we together took 35 Mins to Complete

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Technique1 Vs Technique 2



Technique 1: Is called Non-Pipelined Execution

Technique 2: Is called Pipelined Execution

Lesson Learnt

Latency: Time taken to complete the task by each team in both Techniques is 30 Mins each

Throughput: Time taken to complete 2 tasks.

- Technique 1 took 60 Mins
- Technique 2 took 35 Mins.
- Since Resource and Time was shared without overlapping of the task.

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Technique1 Vs Technique 2



Lesson Learnt 2

Time taken to complete the task in **Technique 1** is 6 bricks X 10 Mins= 60 Mins

In **Technique 2**,

1st Brick took 10 Mins

Rest of the bricks were shifted in every 5 Mins

$[(1 \text{ Brick} \times 10 \text{ Mins})] + [(6-1) \times 5] = 10 + 25 = 35 \text{ Mins}$

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Which Technique Shows Best Performance?



Time taken by Technique 1= 60

Time taken by Technique 2= 35

How better is Technique 2 over Technique 1

$$\frac{\text{Execution time of Technique 1}}{\text{Execution Time of Technique 2}} = \frac{60}{35} = 1.714$$

Technique 2 is **1.714** times faster than Technique 1

If Technique 2 is ***n*** times faster than Technique 1

$$n = \frac{\text{Execution Time of Technique 1}}{\text{Execution Time of Technique 2}}$$

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Technique1 Vs Technique 2



Also, If Technique 2 is ***n*** times faster than Technique 1

$$n = \frac{\text{Performance of Technique2}}{\text{Performance of Technique1}}$$

$$\text{Performance} = \frac{1}{\text{Execution Time}}$$

Computer X vs Computer Y

If Computer X is ***n*** times faster than Computer Y

$$n = \frac{\text{Execution Time of Computer Y}}{\text{Execution Time of Computer X}}$$

or

If Computer X is ***n*** times faster than Computer Y

$$n = \frac{\text{Performance of Computer X}}{\text{Performance of Computer Y}}$$

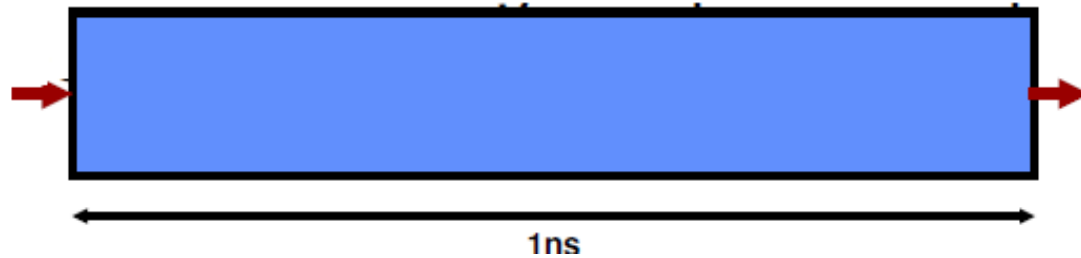
$$\text{CPU}_{\text{Time}} = \text{Instruction Count (IC)} \times \text{Clock Cycle} \times \text{CPI}$$

Reducing any of the 3 factors will lead to improve performance
or Reduce Execution time is

- CPI: Cycles per instruction
- Clock Cycle
- Instruction count

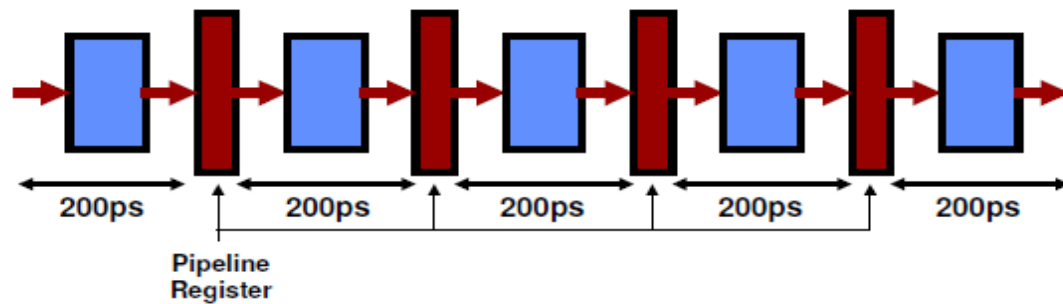
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How to Reduce ?



Step 1: Divide instruction execution into multiple stage with small Clock

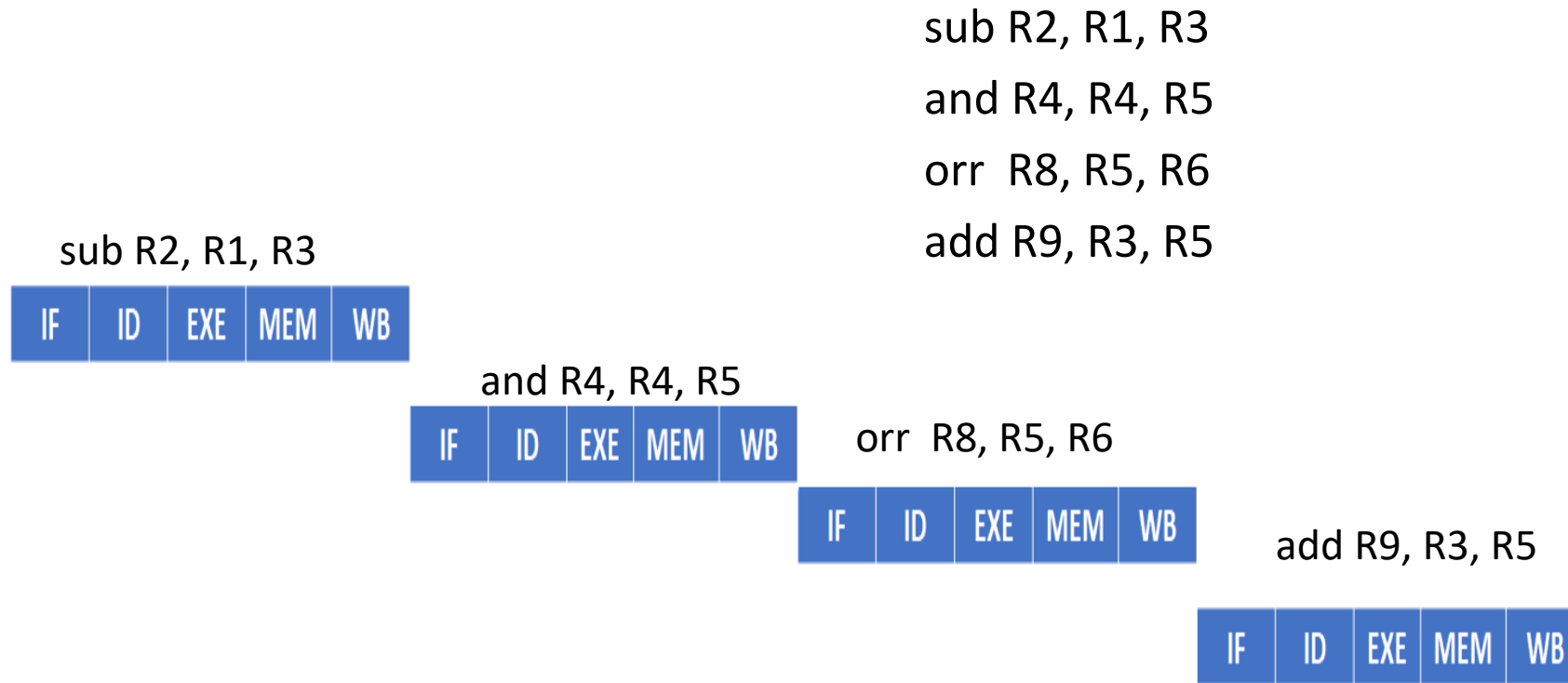
- Fetch - [IF]
- Decode – [ID]
- Execute – [EX]
- Buffer/Data or Memory Access-[MEM]
- Write back – [WB]



Step 2: Overlap the Execution time of instructions such that, more than one instruction will use different stages in different time slice

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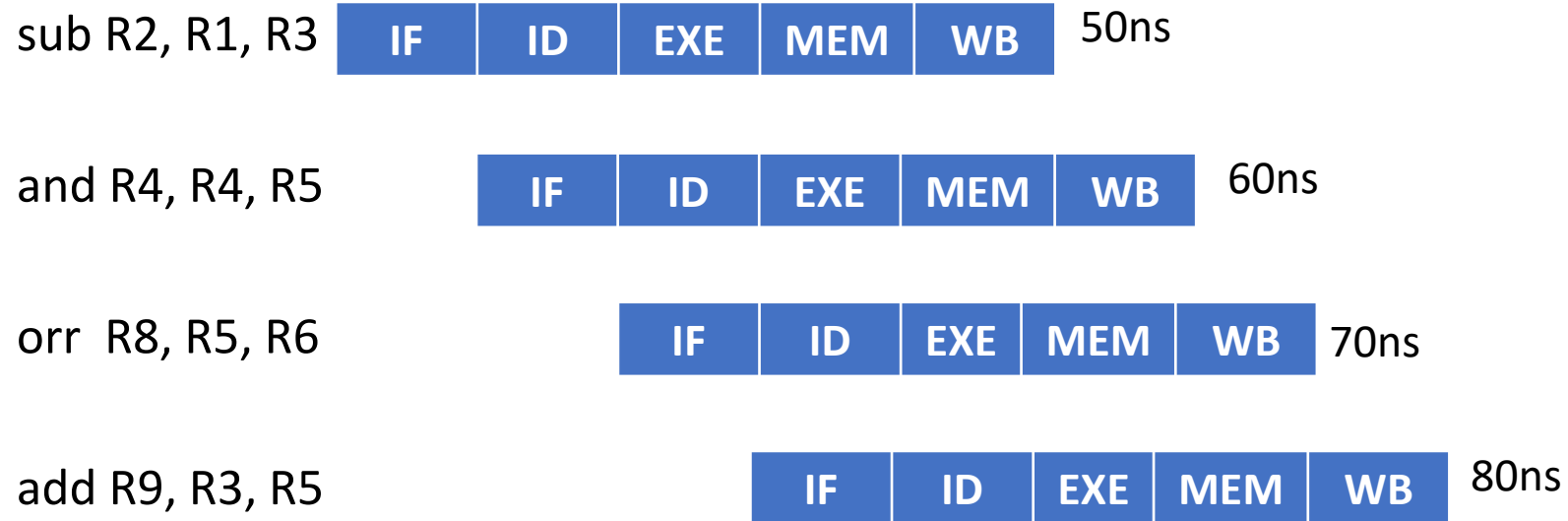
Computer Y Without Overlapping of Time



If Each stage takes 10ns, the latency will be 50 ns and the throughput is 200 ns

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Computer X With Overlapping of Time



If Each stage take 10ns, the latency will be 50 ns

If Each stage take 10ns, the throughput is 80 ns instead of 200 ns

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Which Computer Shows Best Performance?

Execution Time of Computer Y= 200

Execution Time of Computer X= 80

How better is Computer X over Computer Y

$$\frac{\text{Execution time of Computer Y}}{\text{Execution Time of Computer X}} = \frac{200}{80} = 2.5$$

Computer X is **2.5** times faster than Computer Y



**Technique 2 is Called Pipelining
or
Computer x has a Pipelined Processor**



What May Go Wrong?





THANK YOU

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