

# COL788: Advanced Topics in Embedded Computing

Lecture 12 – Pipelining (Cont.)



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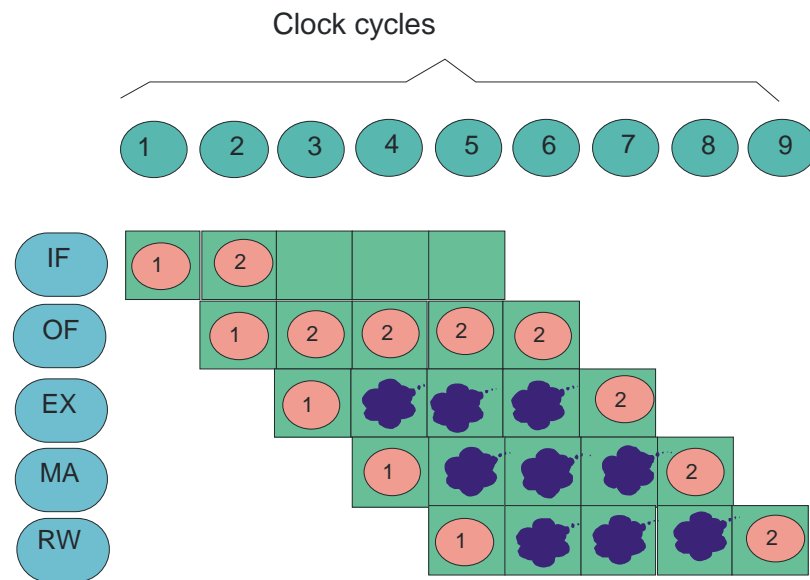
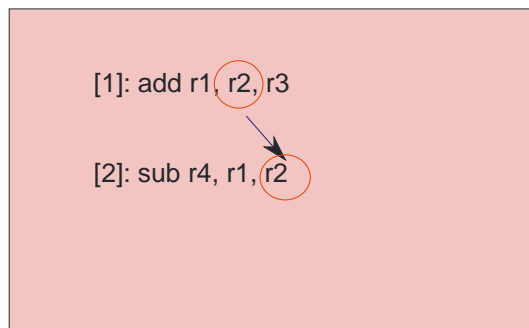
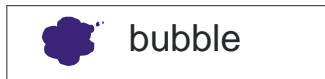
Semester I  
2022-2023

# Last Lectures

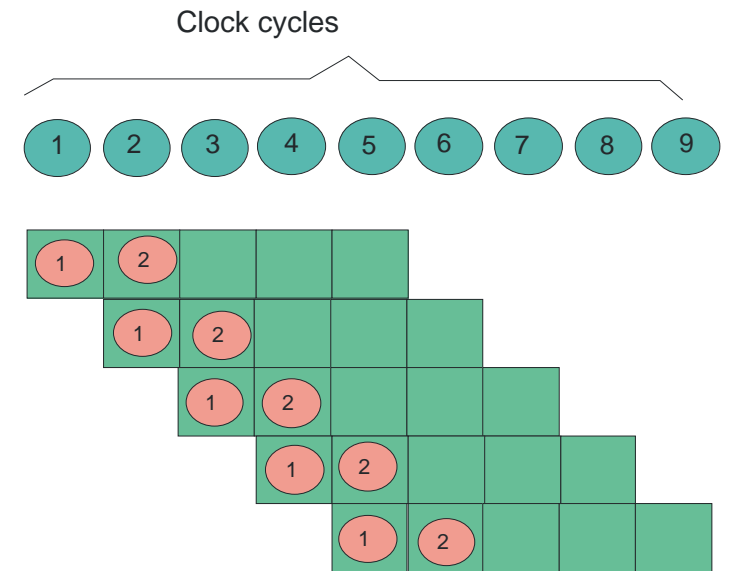
- Basics of Pipelining
- Data and Control Hazards
- Software and Hardware Solutions

# Relook at the Pipeline Diagram

- When does instruction 2 need the value of r1: Cycle 4, EX Stage
- When does instruction 1 produce the value of r1: End of Cycle 3, EX Stage

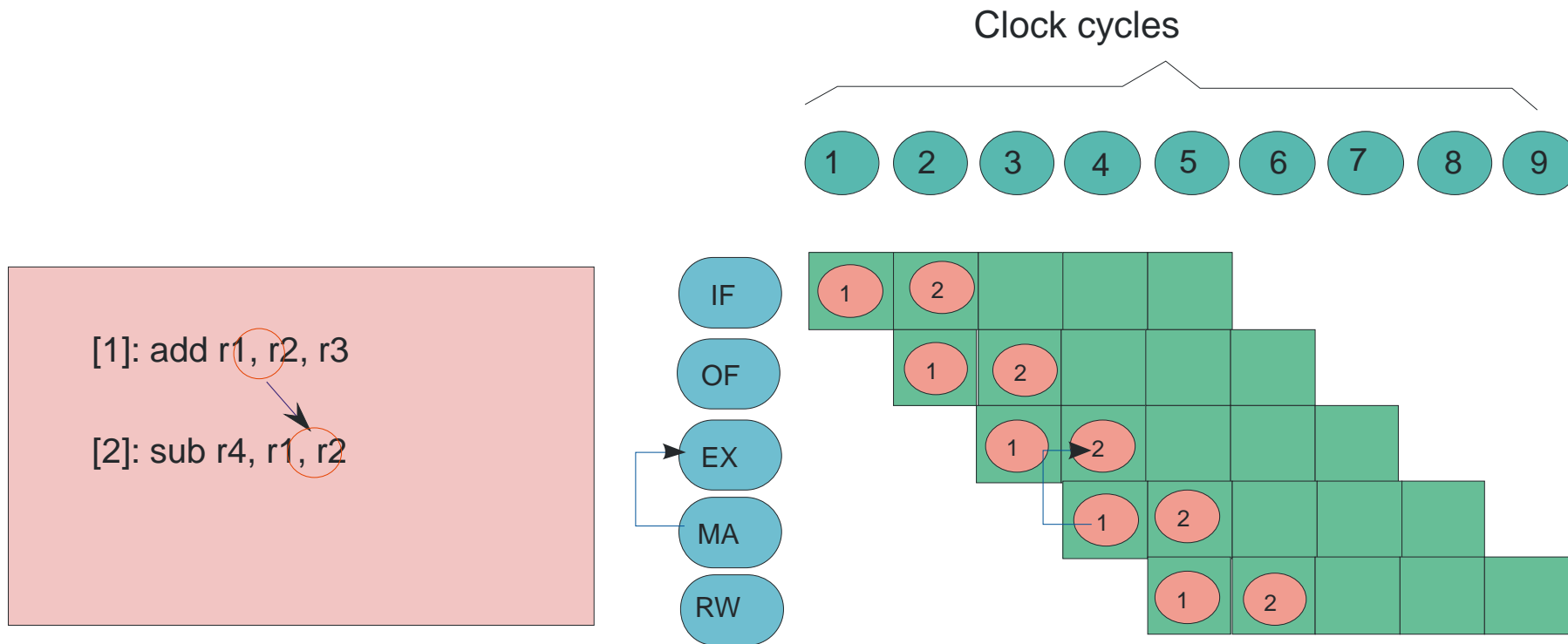


(a)



(b)

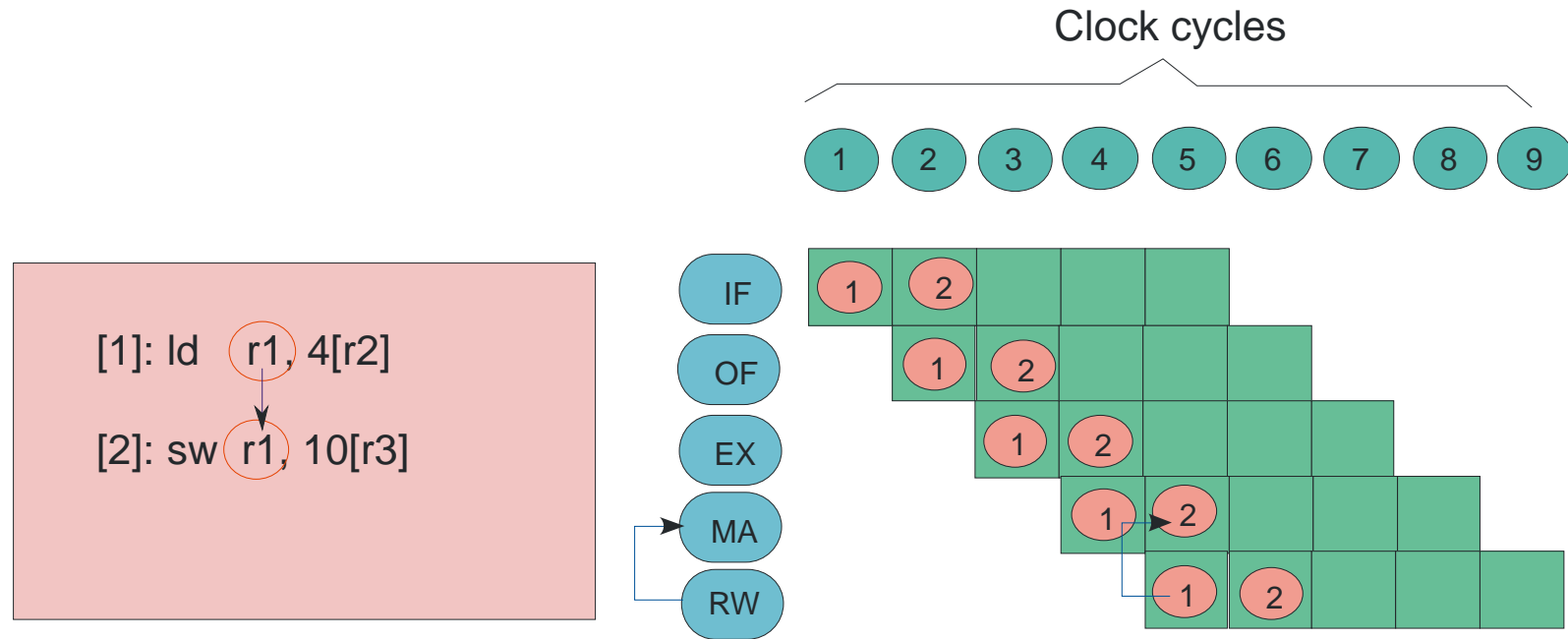
# Forwarding



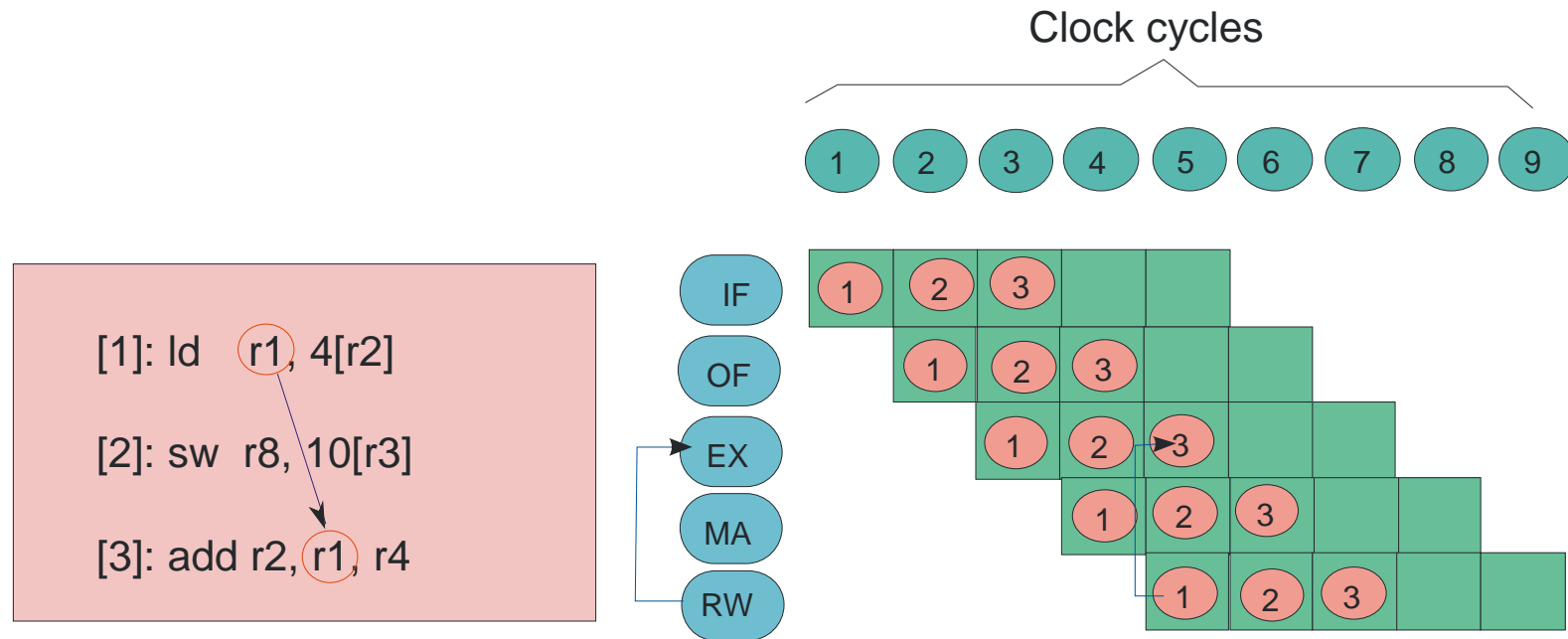
# Forwarding Path

- 3 Stage Paths
  - RW → OF
- 2 Stage Paths
  - RW → EX
- 1 Stage Paths
  - RW → MA (load to store)
  - MA → EX (ALU Instructions, load, store)

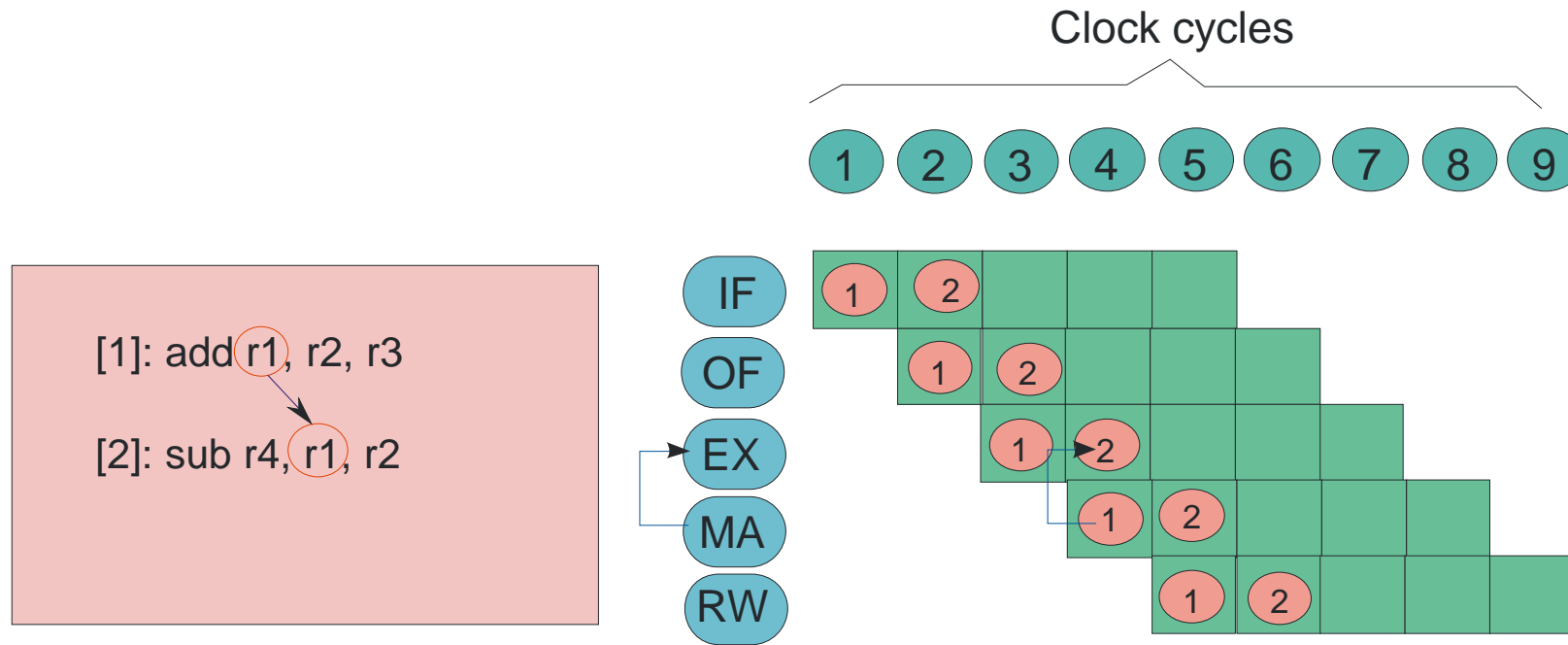
# Forwarding Path: RW → MA



# Forwarding Path: RW → EX

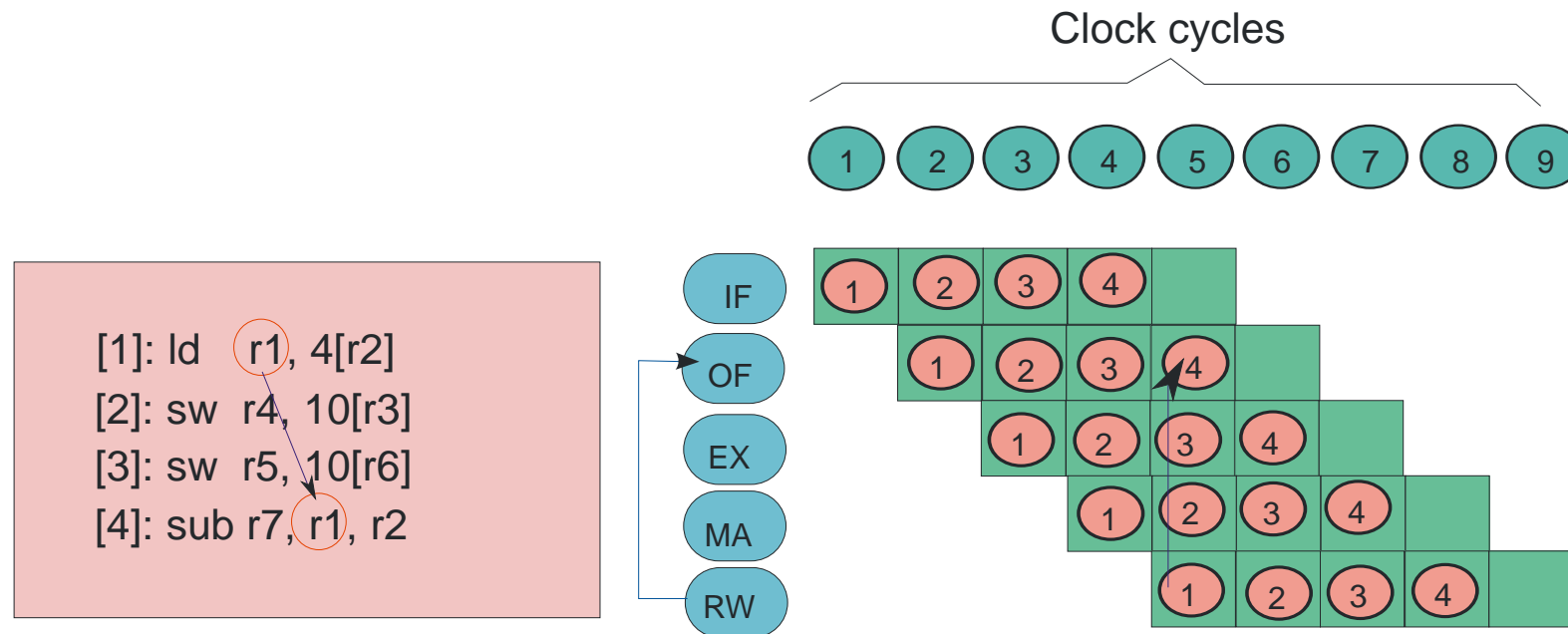


# Forwarding Path : MA $\rightarrow$ EX

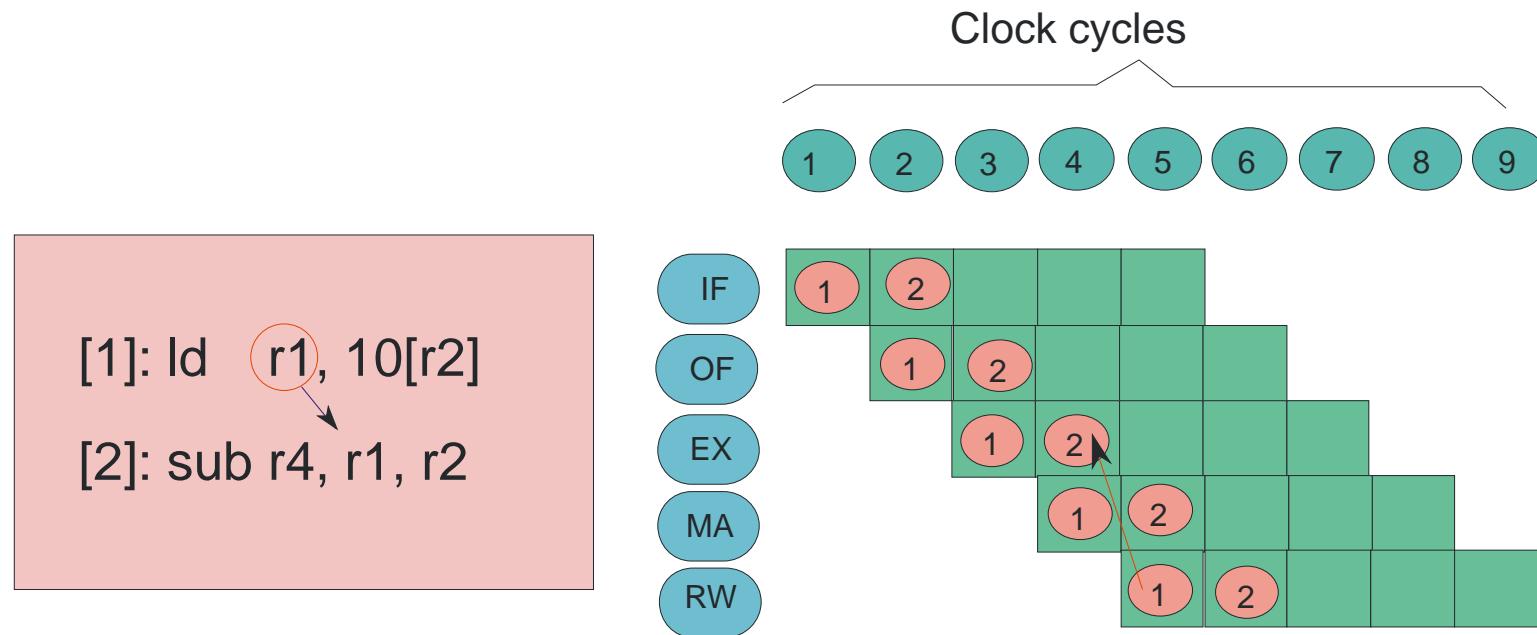




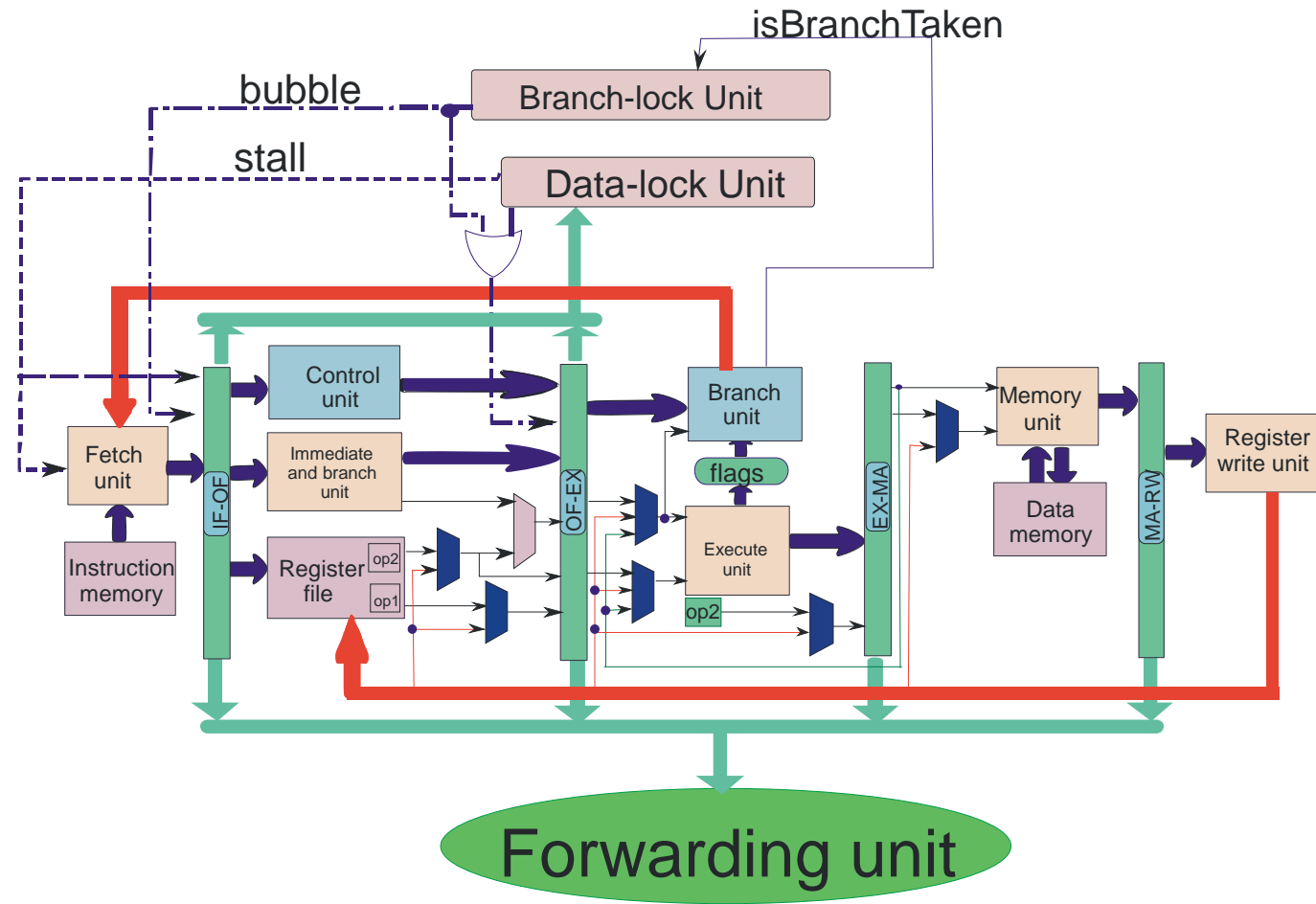
# Forwarding Path : RW → OF



# Load-Use Hazard



# Complete Data Path



# What's Next?

- Next Lecture (September 7, Wednesday, 11 am – 12 pm)
  - Lecture 13