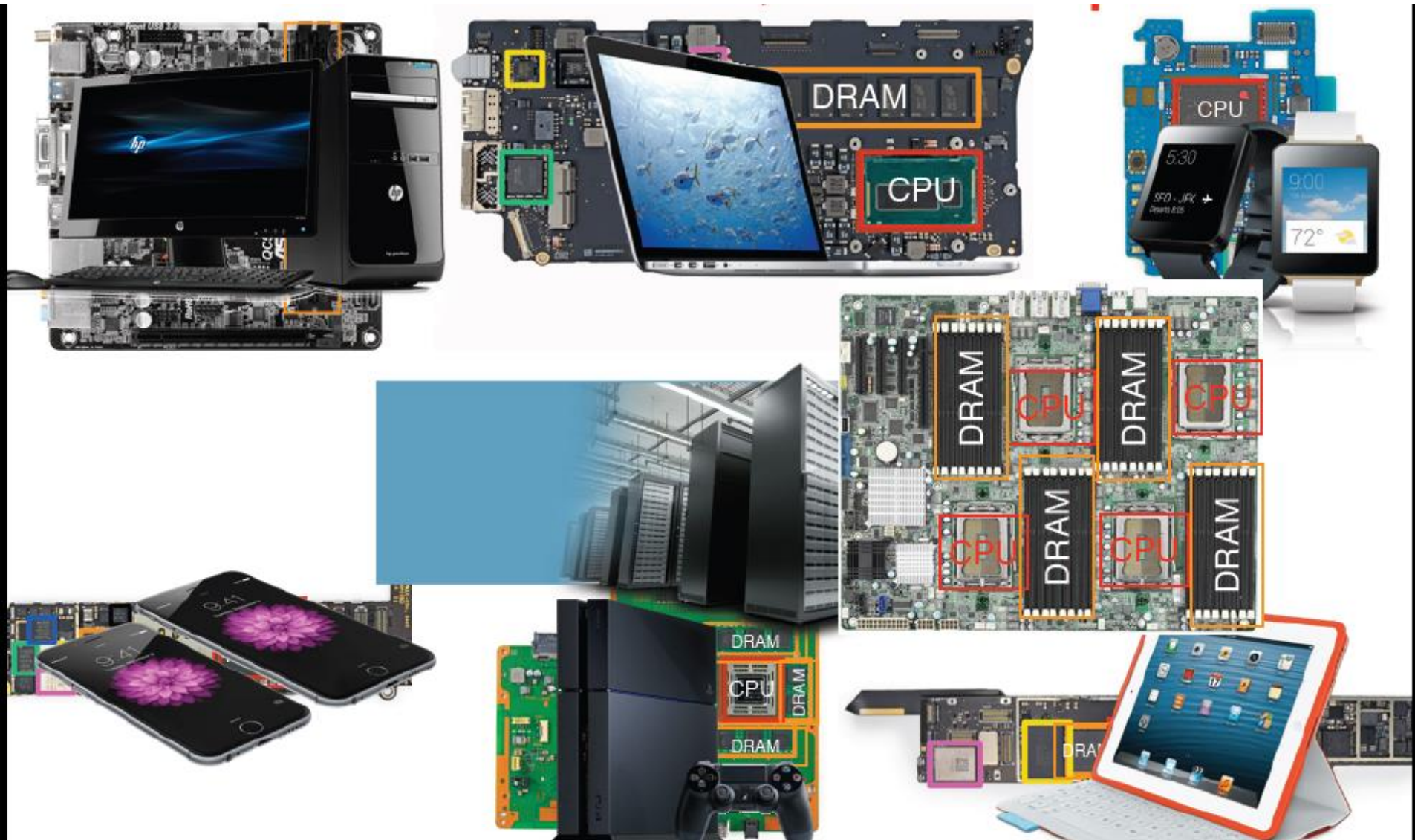
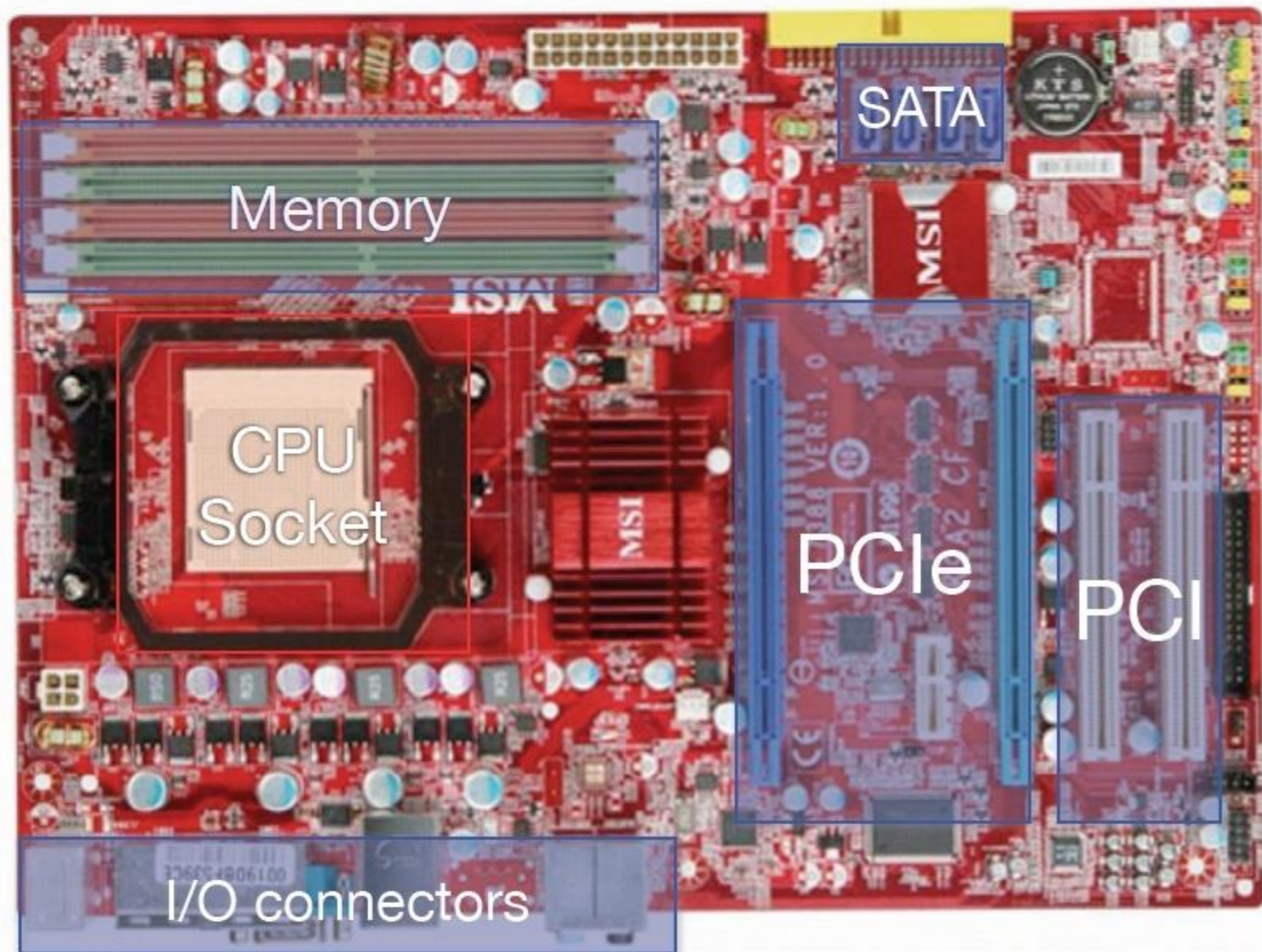


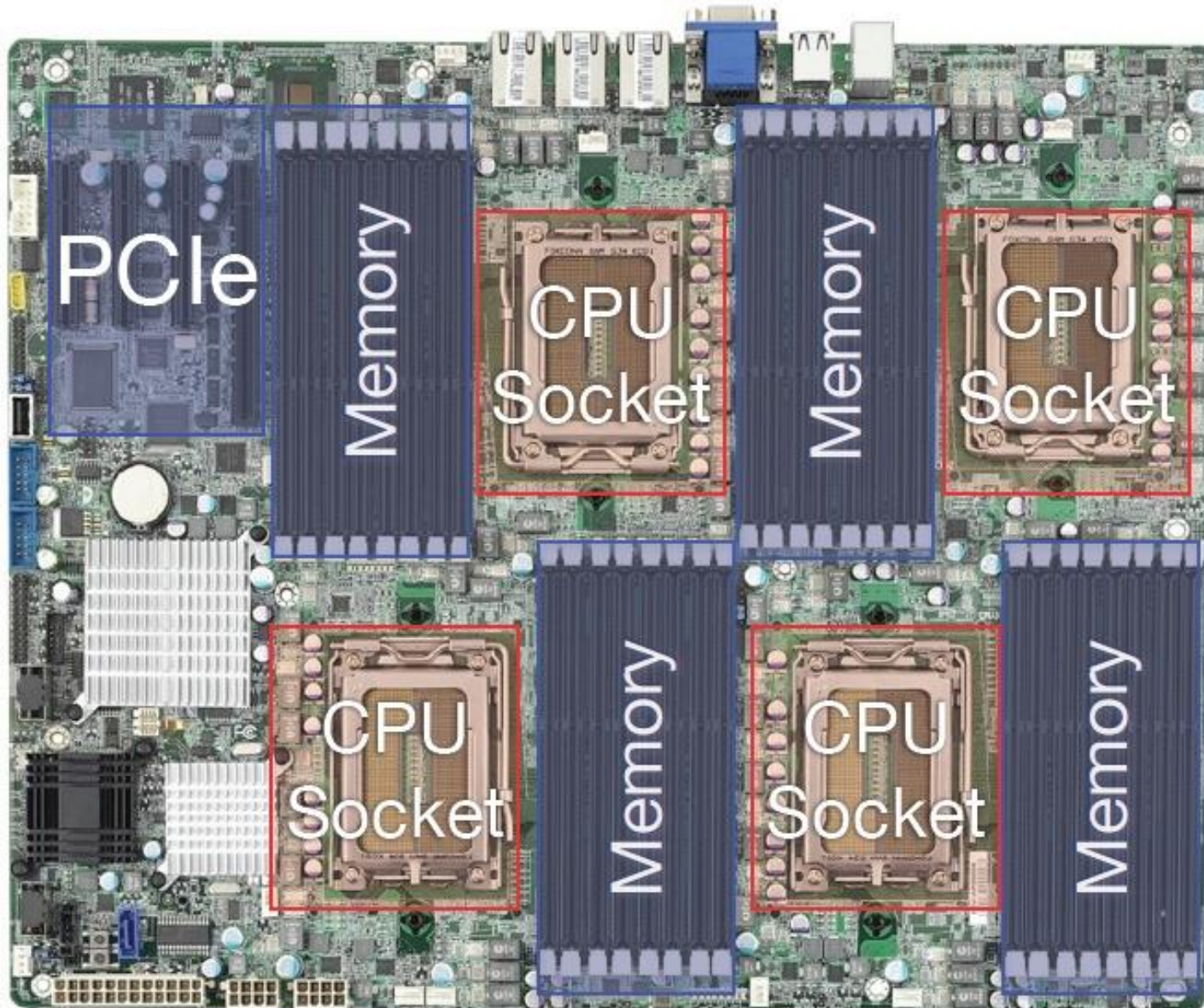
Memory



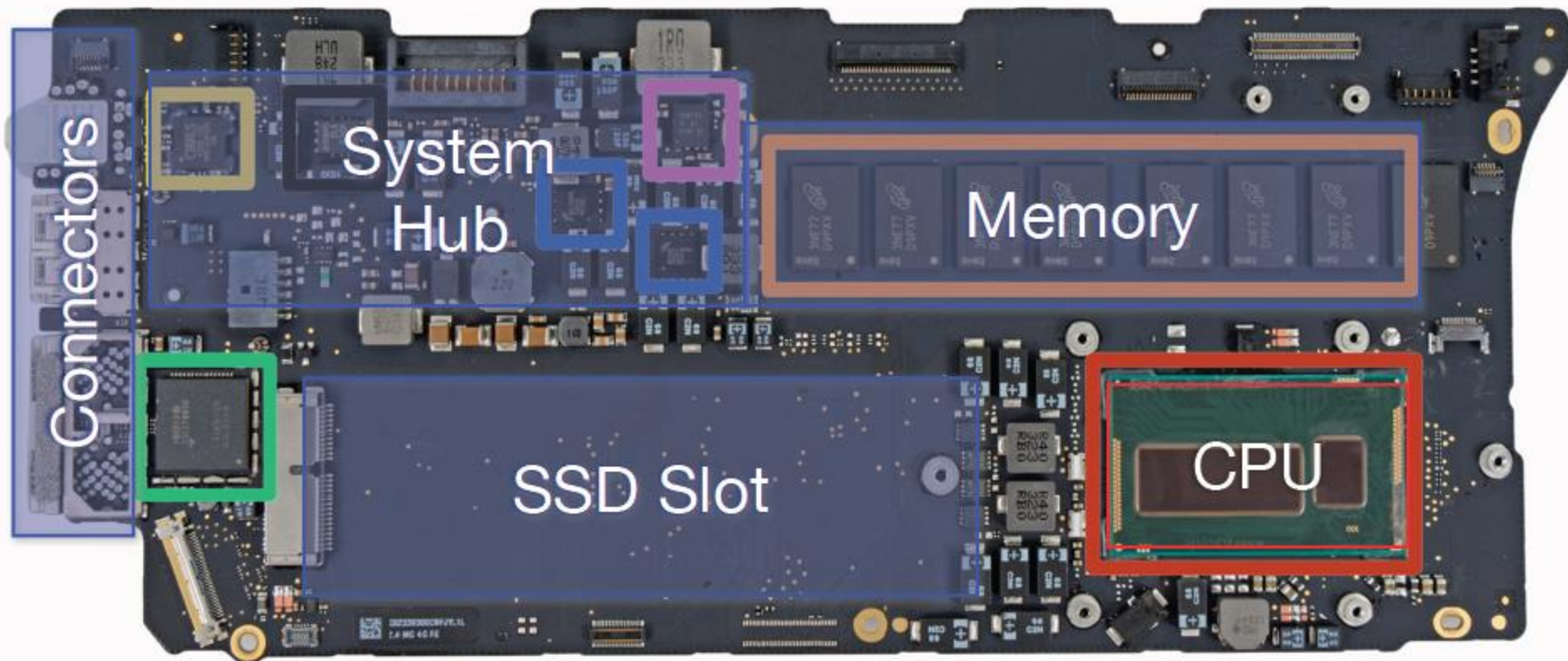
Desktop PC



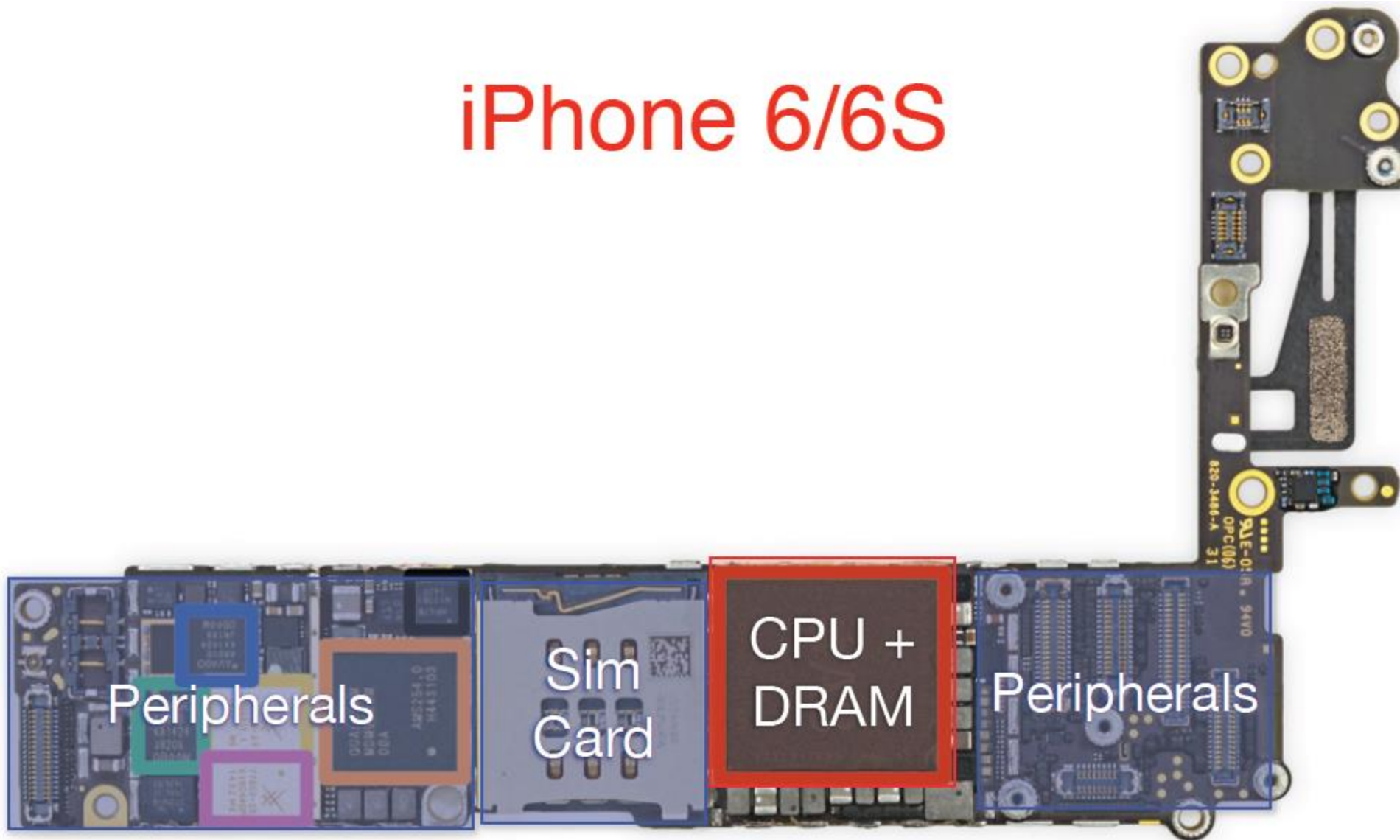
Server



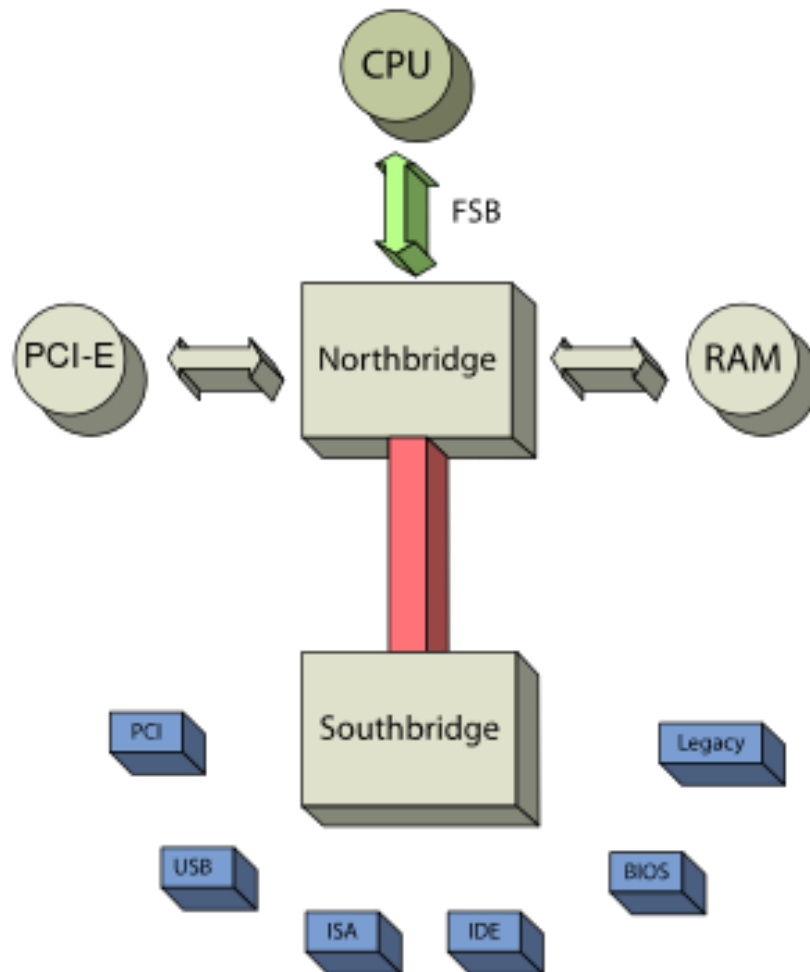
Macbook Pro w/ Retina



iPhone 6/6S



Typical PC Architecture: **northbridge** or **host bridge**

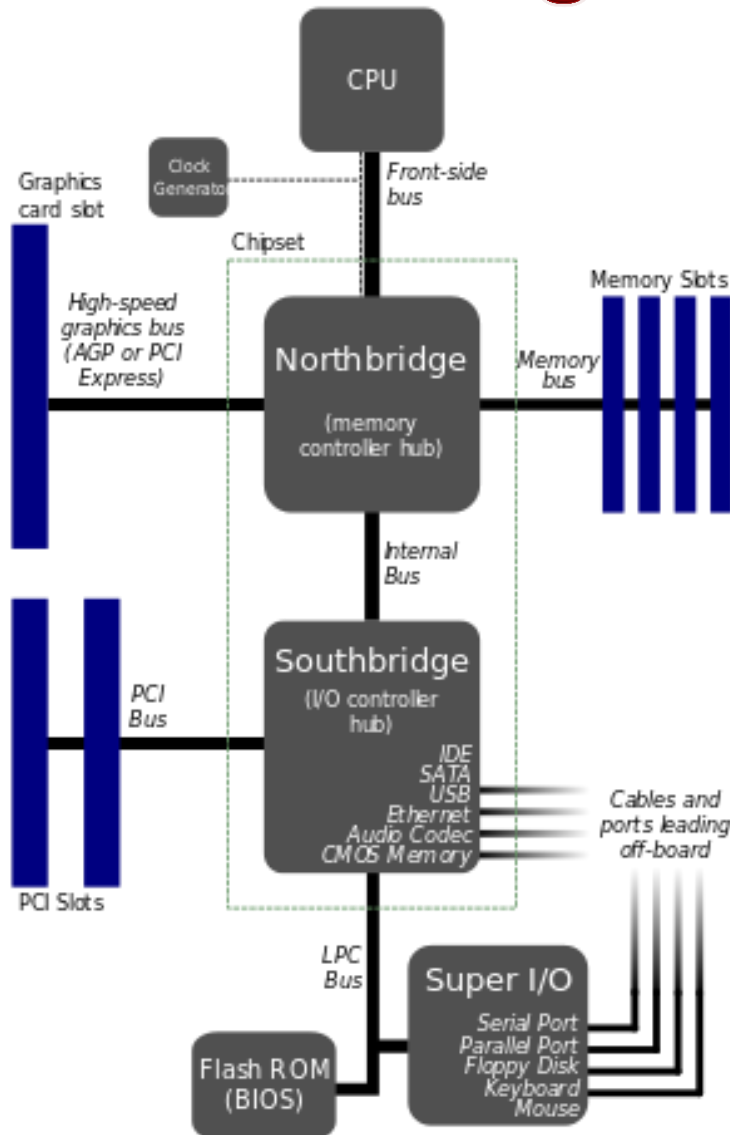


front-side bus (FSB)

I/O controller hub

(Typical PC Architecture)

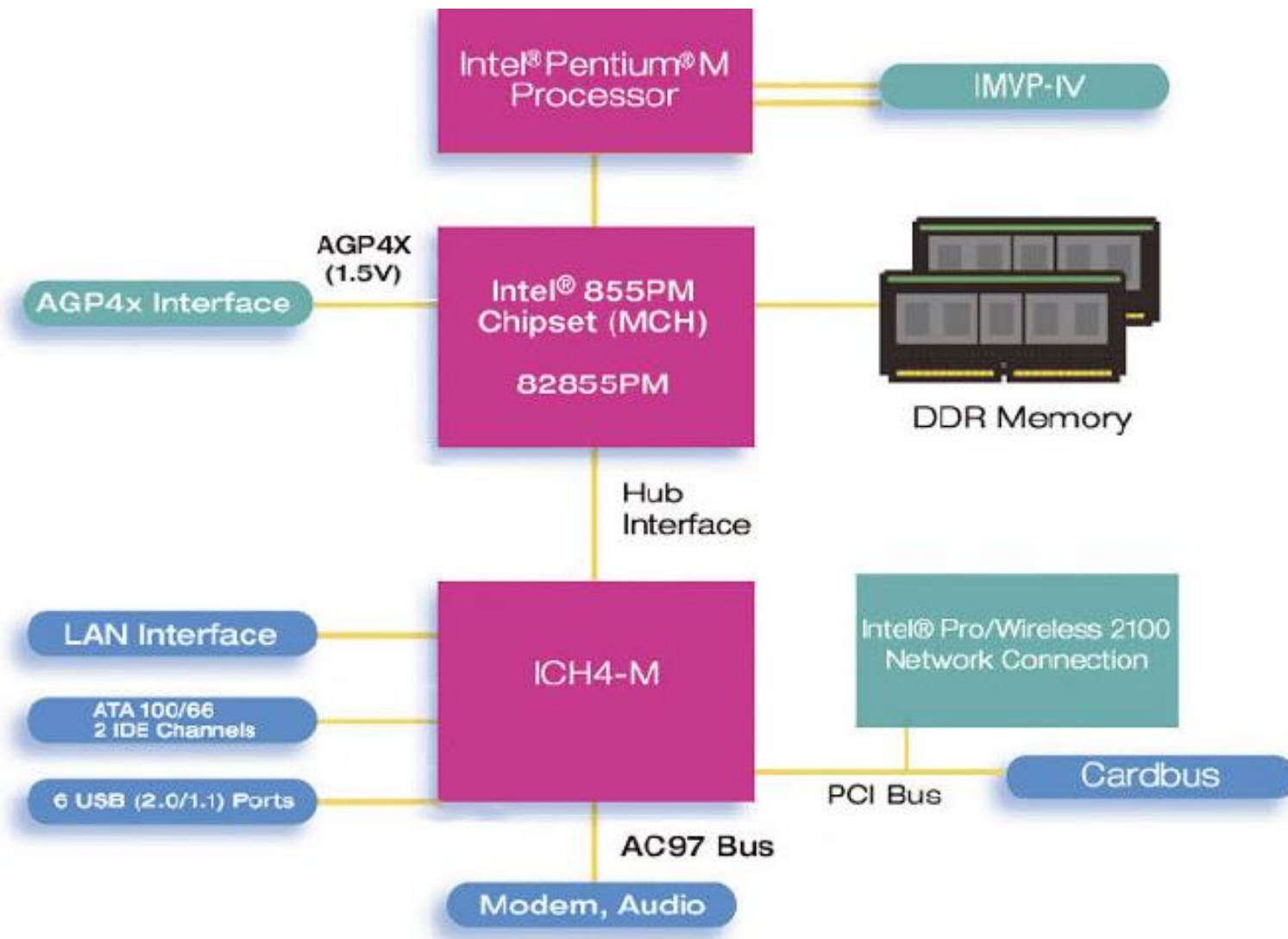
northbridge or host bridge



Graphics and Memory Controller Hub (GMCH)

I/O Controller Hub (ICH)

What is A Computer?



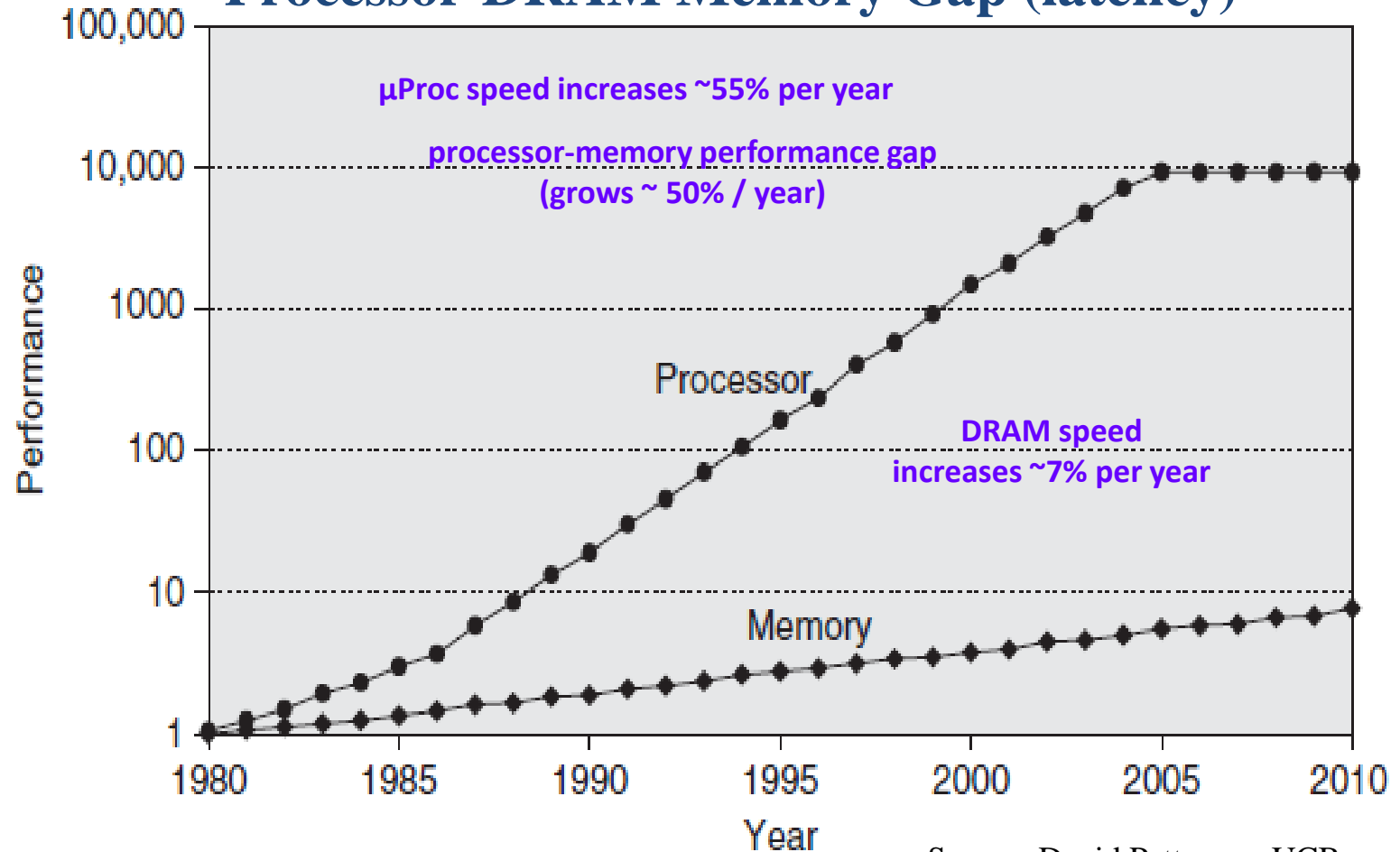
Courtesy, Intel

Memory in a Modern System

Overview

- **Review of Memory Technologies**
- **Overview of Memory Hierarchy**
- **Learning Objectives**
 - Why is that some memories slow ?
 - What is memory hierarchy?
 - Why do we need memory hierarchy?

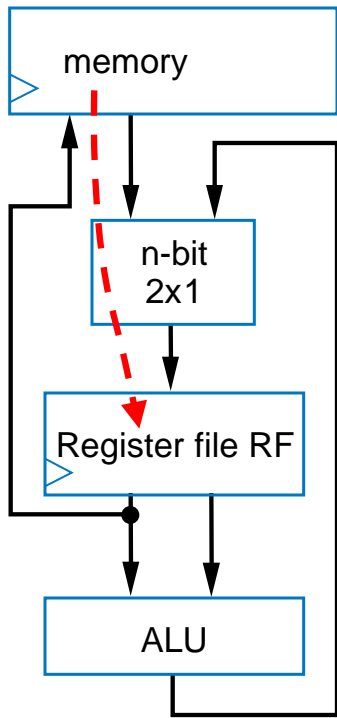
Processor-DRAM Memory Gap (latency)



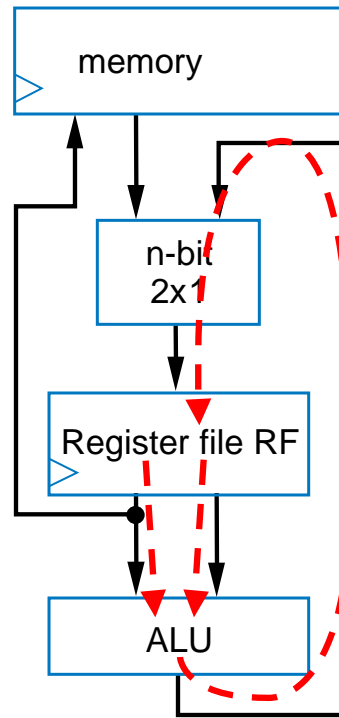
Source: David Patterson, UCB

Review: Datapath Operations

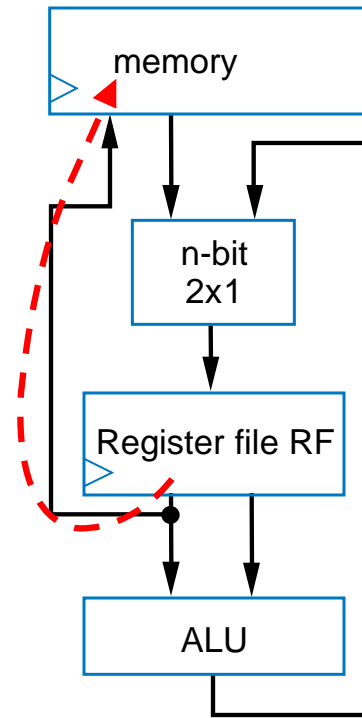
- Load operation: Load data from data memory to RF
- ALU operation: Transforms data by passing one or two RF register values through ALU, performing operation (ADD, SUB, AND, OR, etc.), and writing back into RF.
- Store operation: Stores RF register value back into data memory
- Each operation can be done in one clock cycle



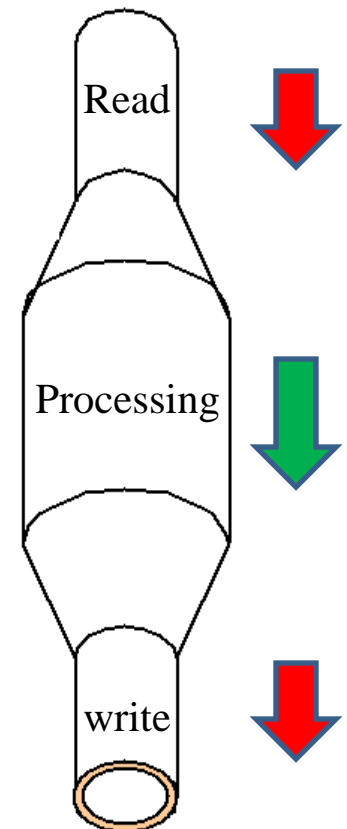
Load operation



ALU operation

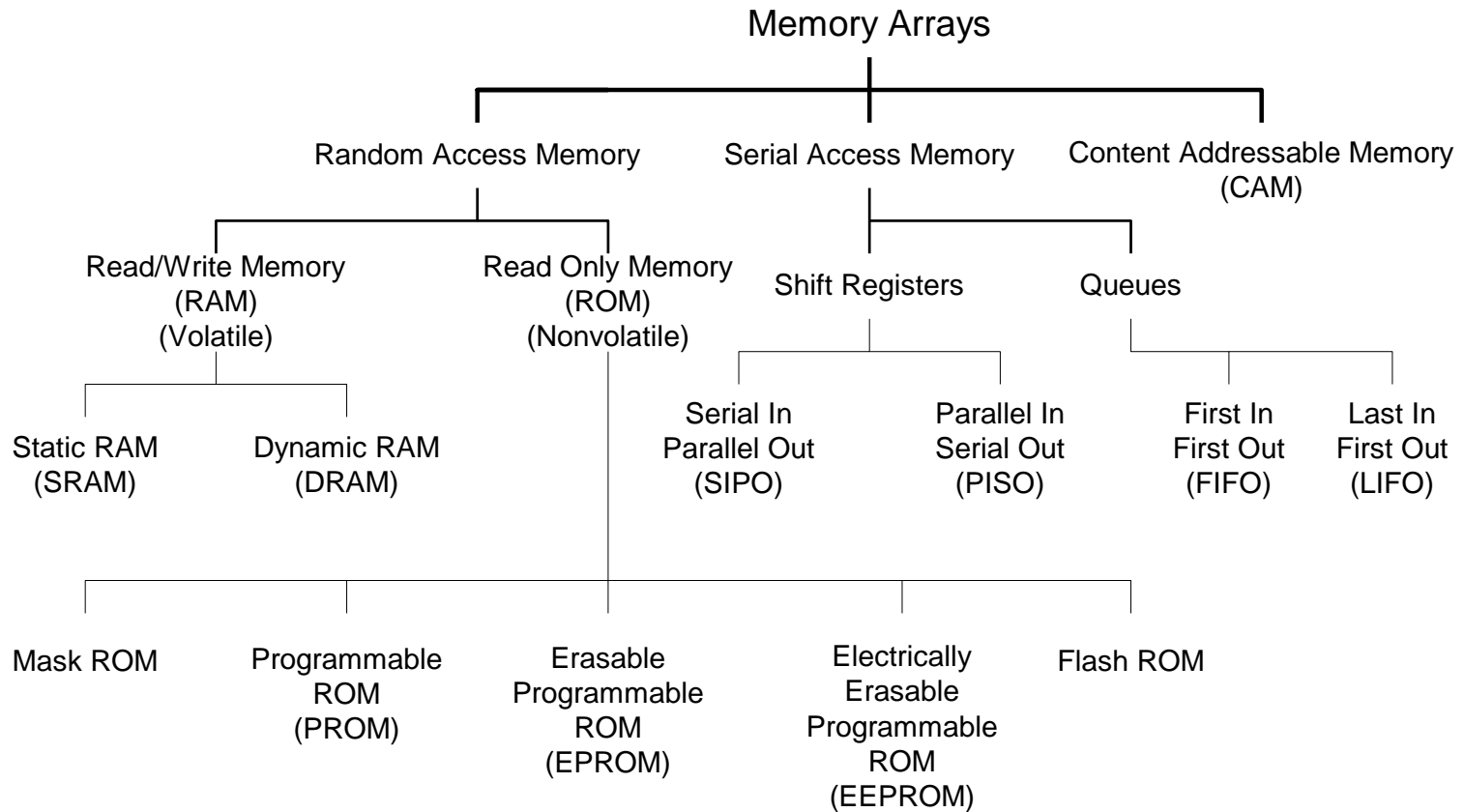


Store operation

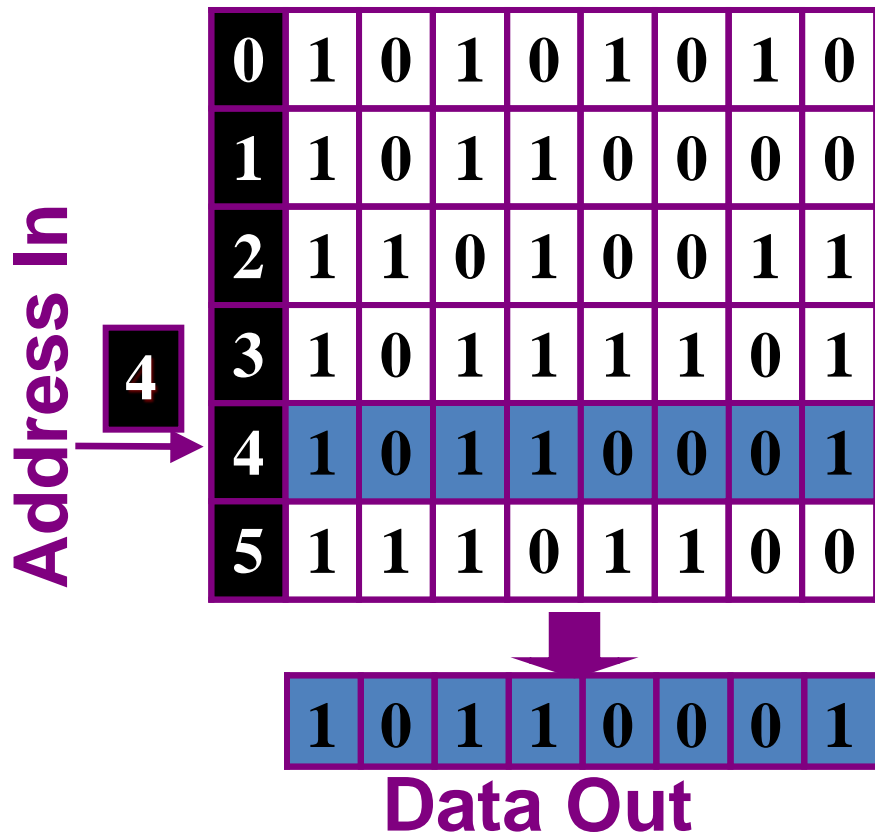


What are the Common Memory Technologies?

Memory



RAM



Memory

Address	Data
000000	00111110
000001	01101011
000010	01011101
000011	01100011
000100	00111110
000101	00000000
000110	11111111
000111	01010101
001000	10101010
001001	00100001
001010	11011010

64x8 RAM	
A3	D7
A2	D6
A1	D5
A0	D4
	D3
	D2
	D1
Write	D0

8x4 RAM

Address

Data

000



001



010



011



100



101



110



111

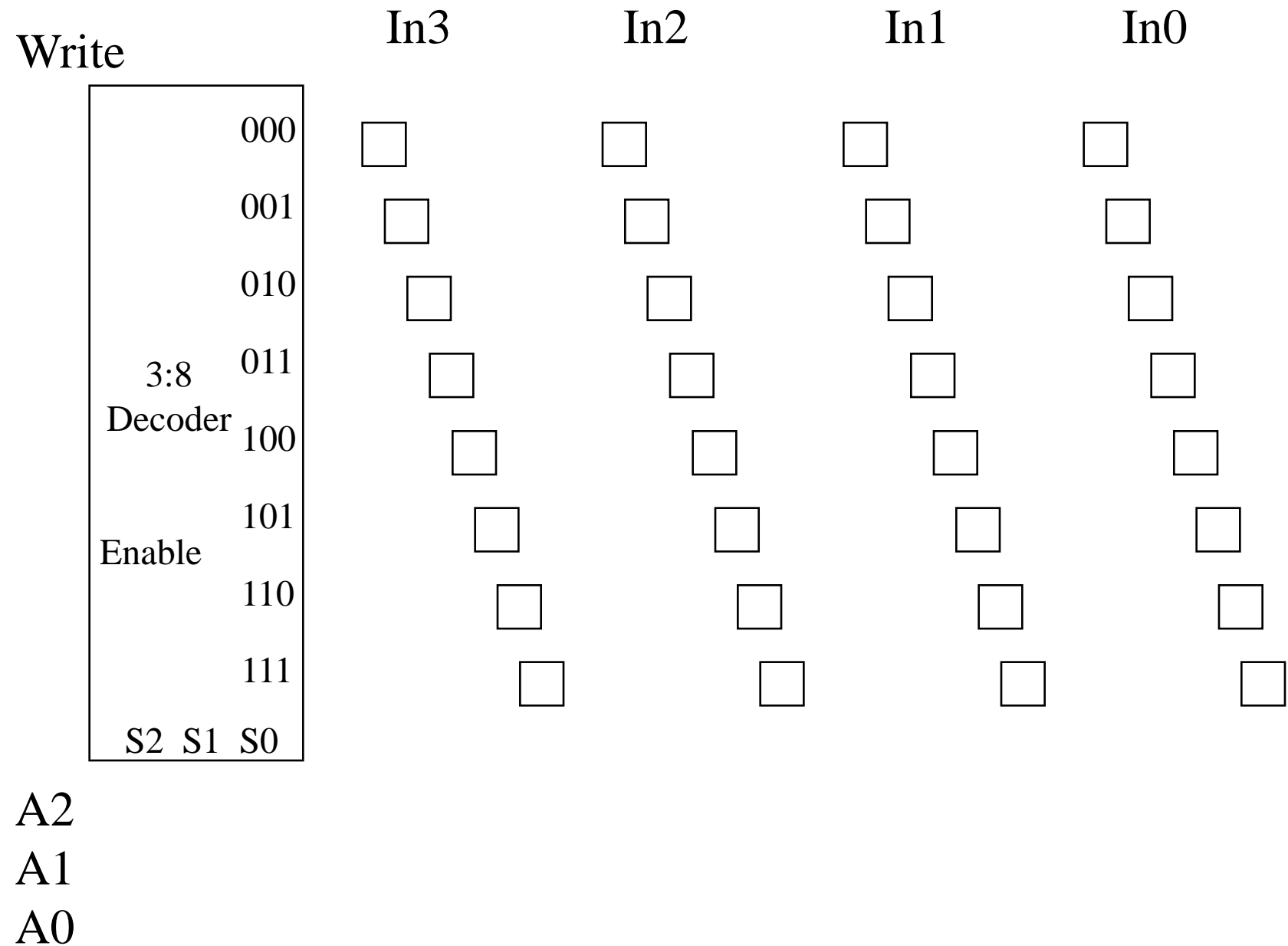


A2

A1

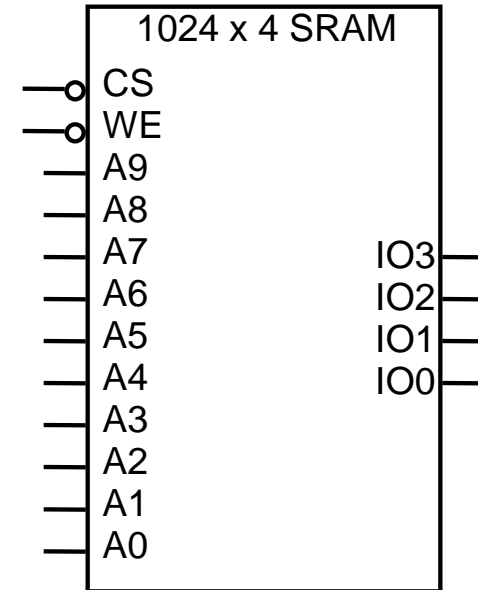
A0

8x4 RAM



Static RAM Organization

Chip Select Line (active lo)
Write Enable Line (active lo)
10 Address Lines
4 Bidirectional Data Lines



RAM Organization

Long thin layouts are not the best organization for a RAM

