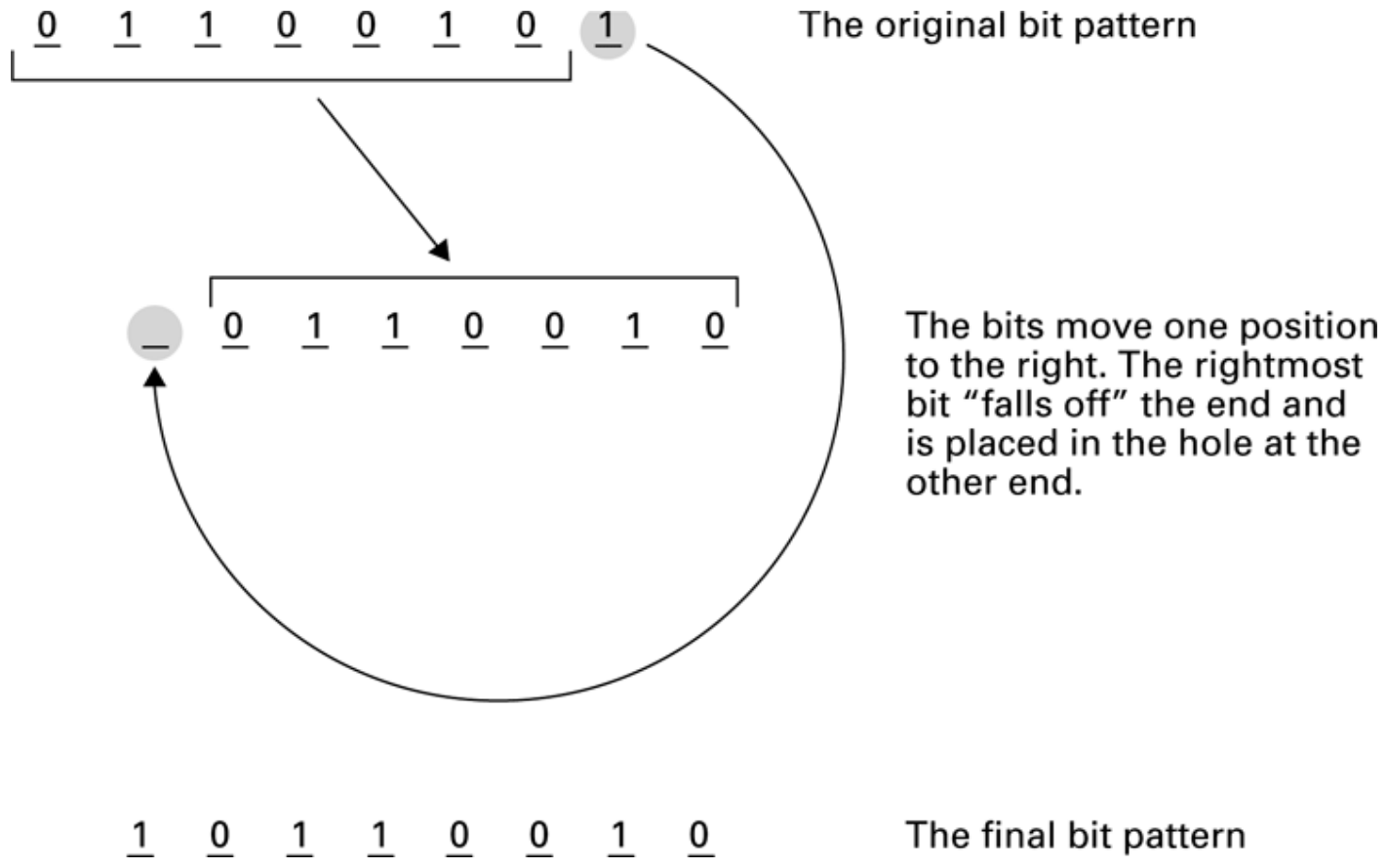
Arithmetic/Logic Operations

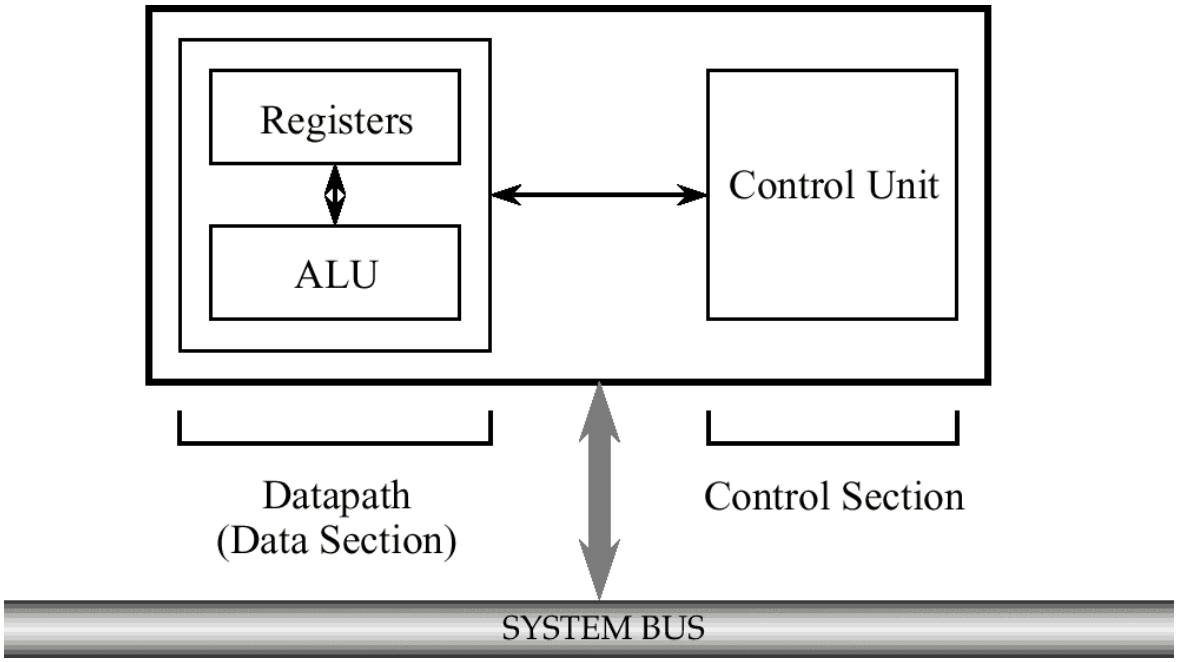
- Logic: AND, OR, XOR
  - Masking
- Rotate and Shift: circular shift, logical shift, arithmetic shift
- Arithmetic: add, subtract, multiply, divide
  - Precise action depends on how the values are encoded (two's complement versus floating-point).

Figure 2.12 Rotating the bit pattern 65 (hexadecimal) one bit to the right

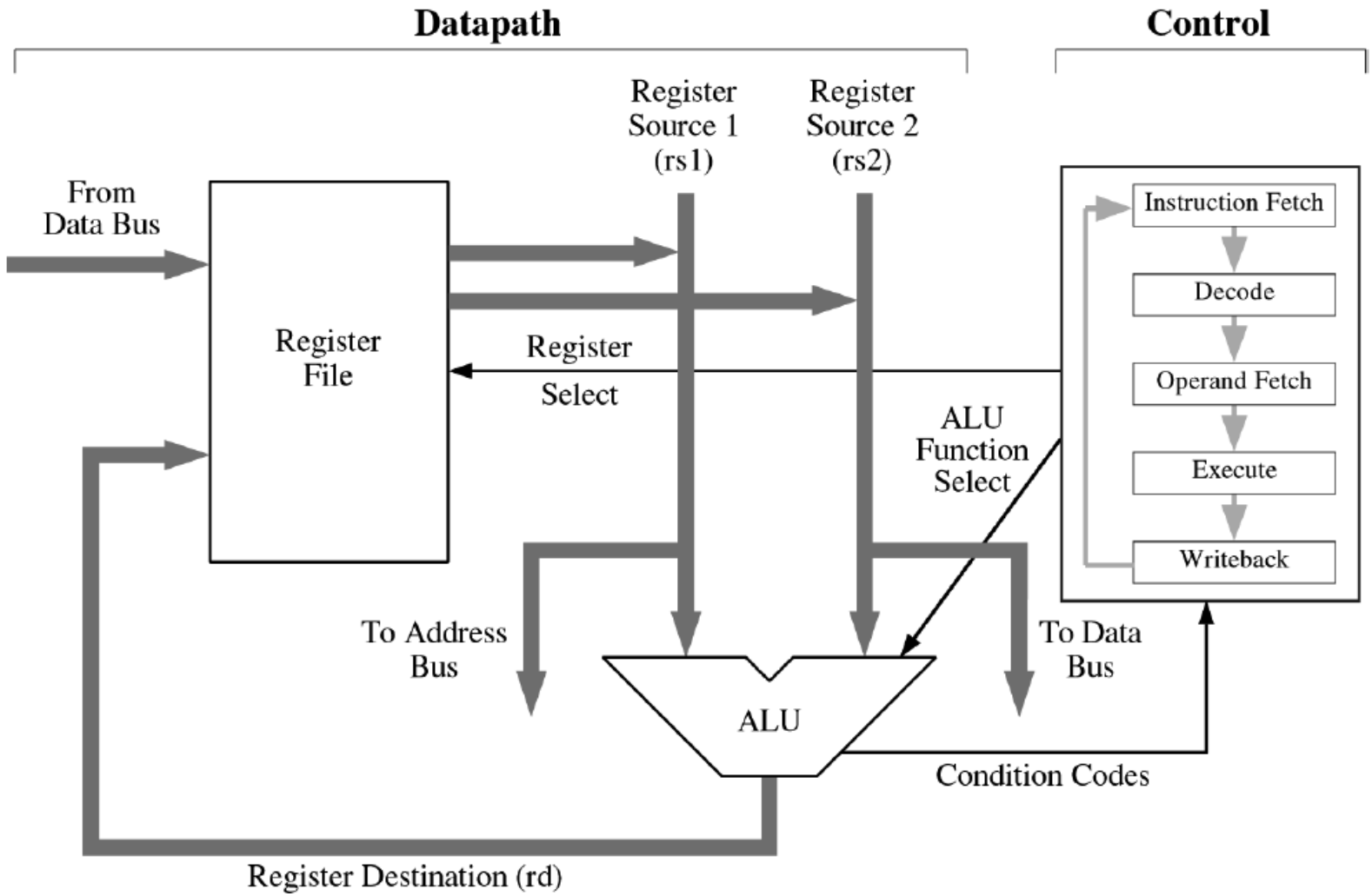


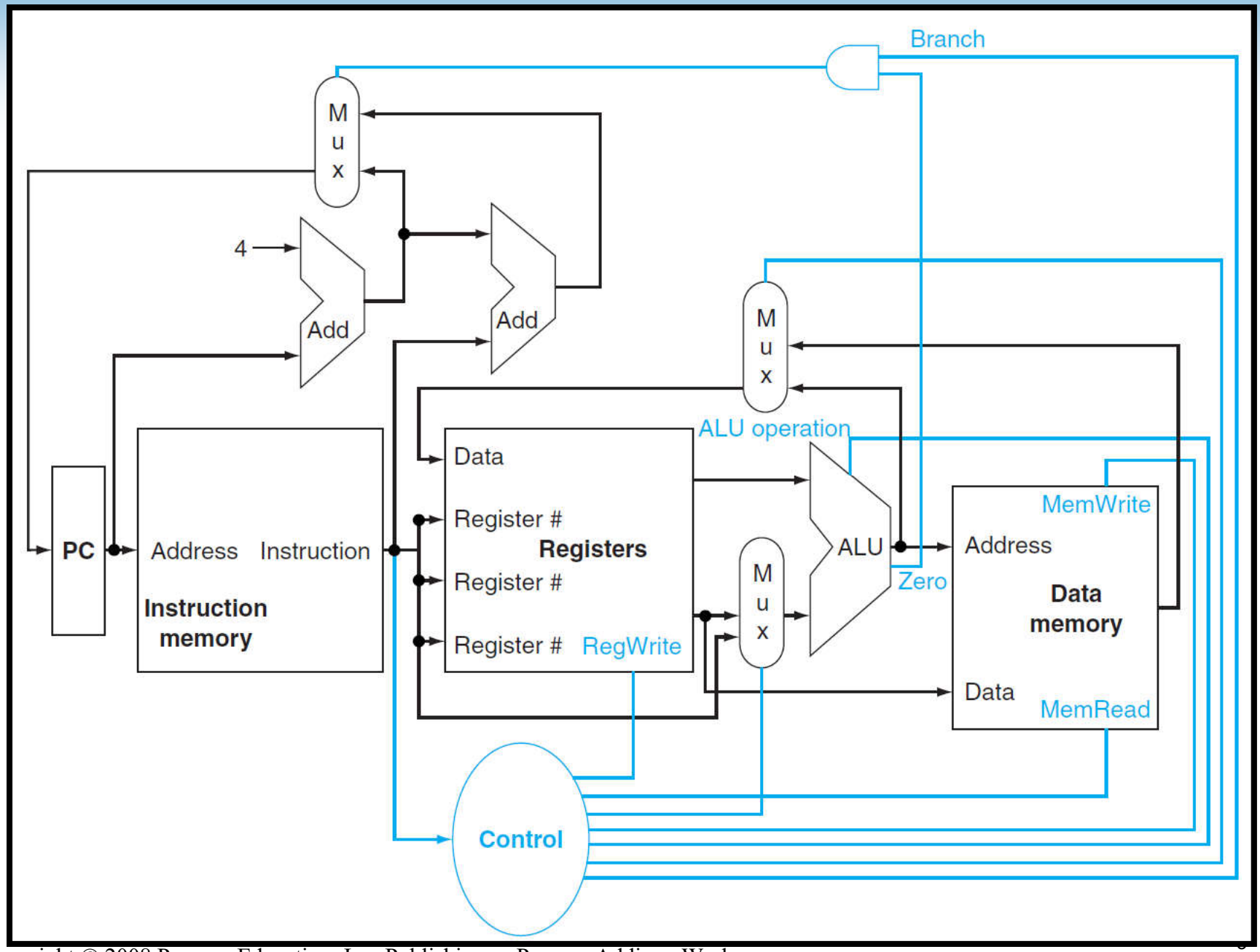
High Level View of Microarchitecture

- The microarchitecture consists of the control unit and the programmer-visible registers, functional units such as the ALU, and any additional registers that may be required by the control unit.



A More Detailed View





Datapath & Control

- Datapath
  - A *datapath* is a collection of functional units, such as arithmetic logic units or multipliers, that perform data processing operations.
- Control
  - The control commands the datapath, memory, and I/O devices according to the instructions of the program.

CPU communicates with Other Devices

- **Controller:** An intermediary apparatus that handles communication between the computer and a device
  - Specialized controllers for each type of device
  - General purpose controllers (USB and FireWire)
- **Port:** The point at which a device connects to a computer
- **Memory-mapped I/O:** CPU communicates with peripheral devices as though they were memory cells

Figure 2.13 Controllers attached to a machine's bus

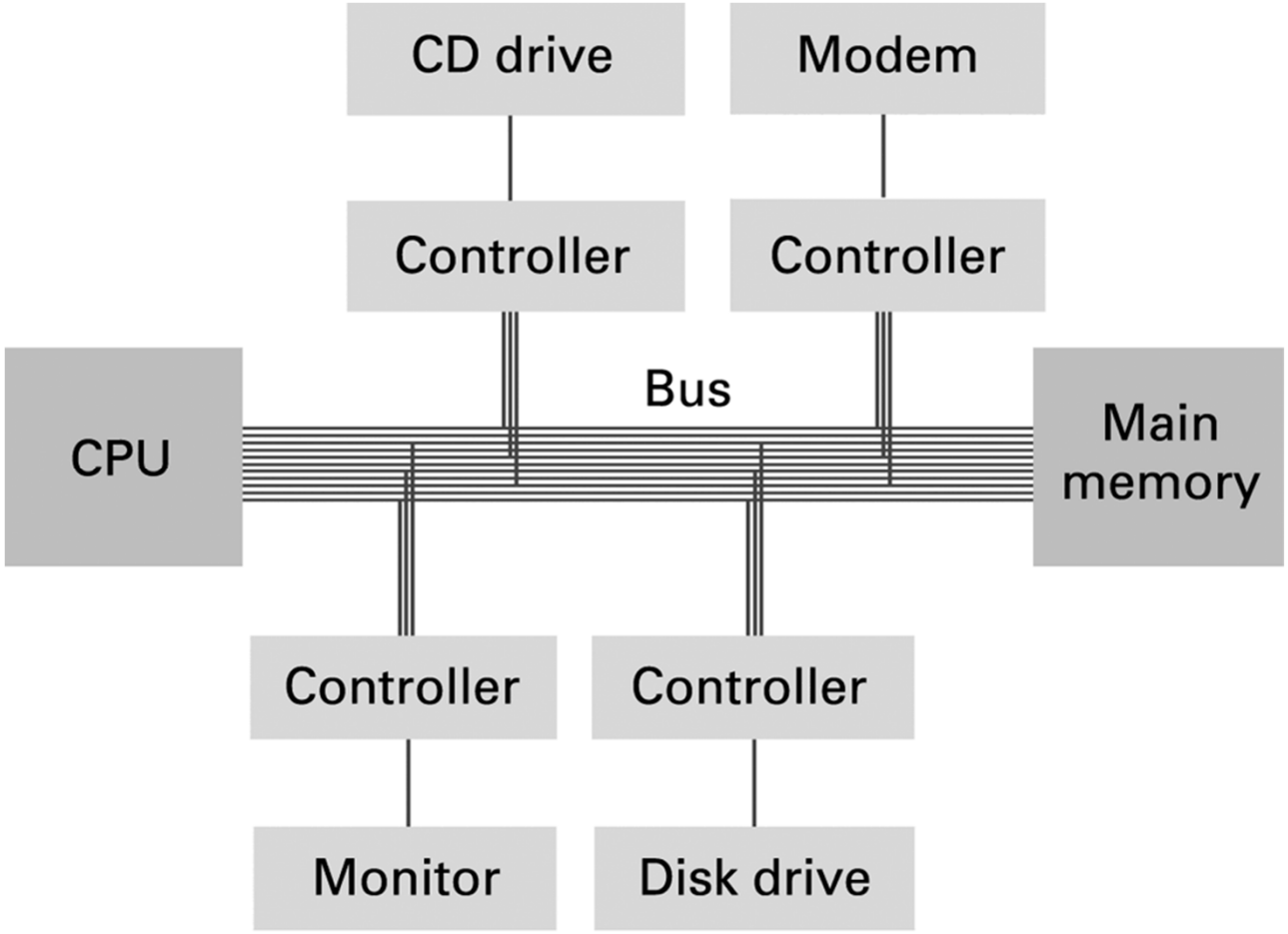
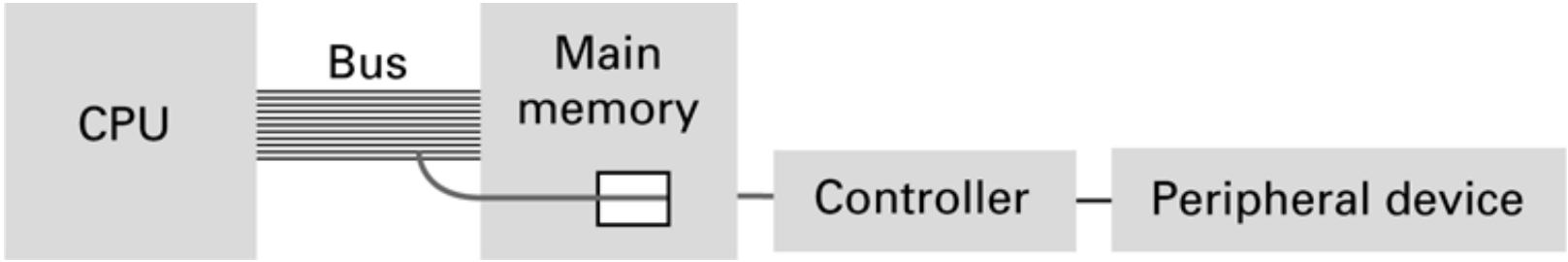
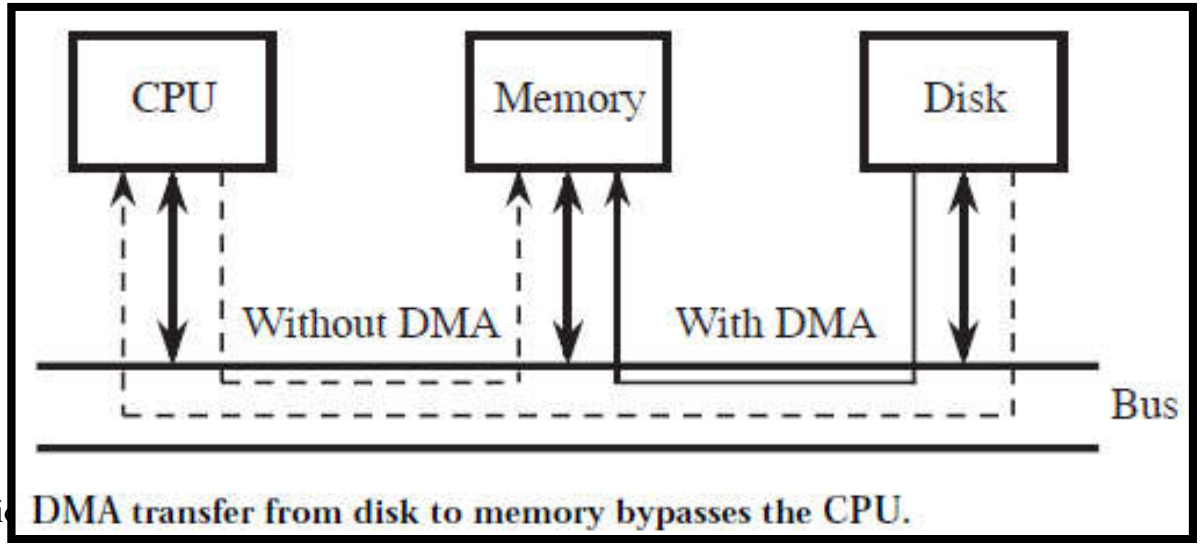


Figure 2.14 A conceptual representation of memory-mapped I/O



Communicating with Other Devices (continued)

- **Direct memory access (DMA):** Main memory access by a controller over the bus
- **Von Neumann Bottleneck:** Insufficient bus speed impedes performance
- **Handshaking:** The process of coordinating the transfer of data between components



DMA transfer from disk to memory bypasses the CPU.

Communicating with Other Devices (continued)

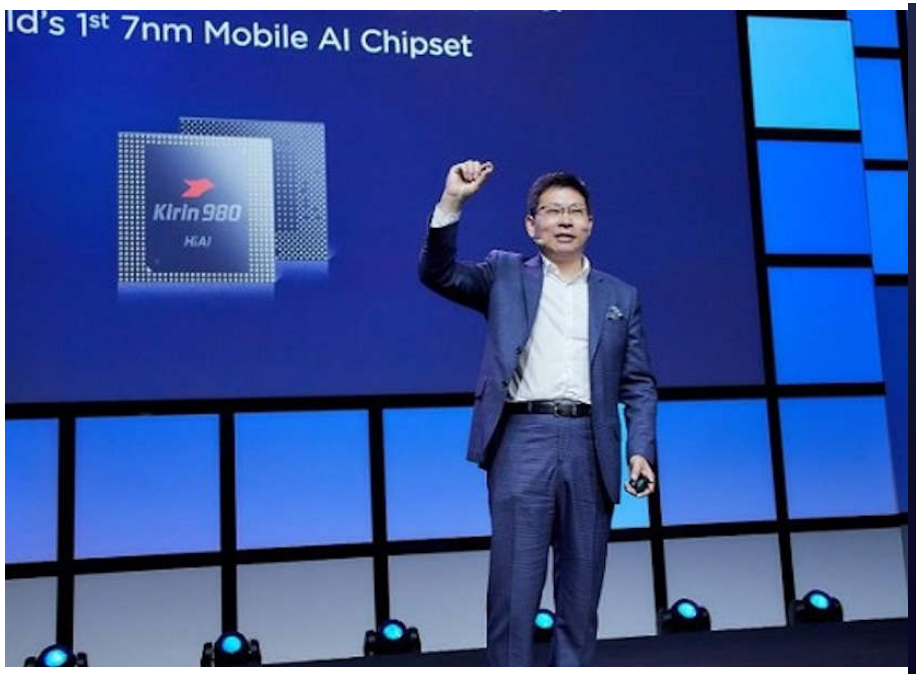
- **Parallel Communication:** Several communication paths transfer bits simultaneously.
- **Serial Communication:** Bits are transferred one after the other over a single communication path.

- CPU架构是CPU厂商给属于同一系列的CPU产品定的一个规范，主要目的是为了区分不同类型CPU的重要标示
- 目前市面上的CPU指令集分类主要分有两大阵营，一个是intel、AMD为首的复杂指令集CPU，另一个是以IBM、ARM为首的精简指令集CPU。
- 两个不同品牌的CPU，其产品的架构也不相同，例如，Intel、AMD的CPU是X86架构的，而IBM公司的CPU是PowerPC架构，ARM公司是ARM架构。
- CPU架构主要有：X86/Atom、ARM、MIPS、PowerPC等等

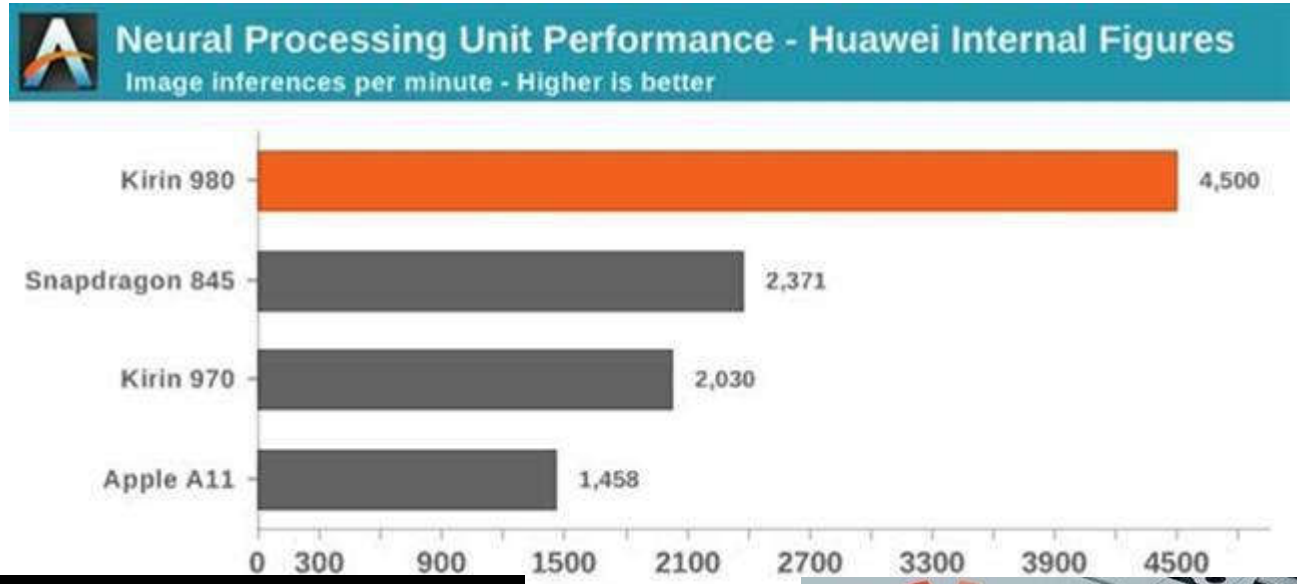
架构名称	推出公司	推出时间	采用此架构主要授权商
X86	美国Intel、美国AMD	1978年	天津海光
ARM	英国ARM(正在被软银收购)	1985年	苹果、三星、英伟达、博通、AMD、Marvell、TI、ST、NXP、东芝、微芯、英飞凌、高通、联发科、展讯、海思、瑞芯微、晶晨、瑞昱、炬力、全志、Mstar等等
MIPS	美国MIPS技术公司(被Imagination收购)	80年代	龙芯、瑞昱、炬力等等
PowerPC	美国IBM	1991年	
Scorpion(基于ARMv7-A指令集)	美国高通	2009年	高通S2/S3处理器
Krait(基于ARMv7-A指令集)	美国高通	2012年	[illegible]骁龙处理器

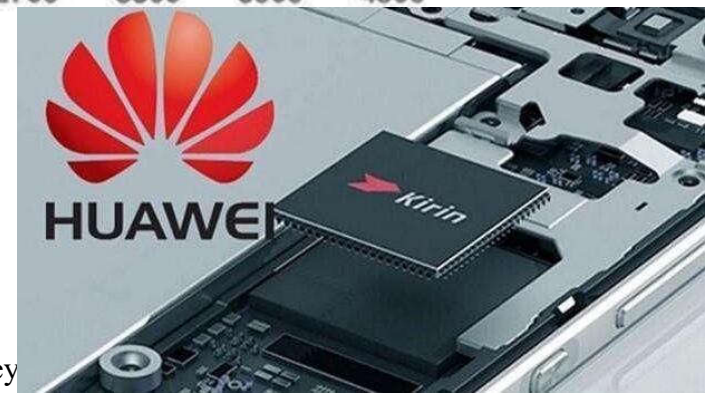
华为麒麟980

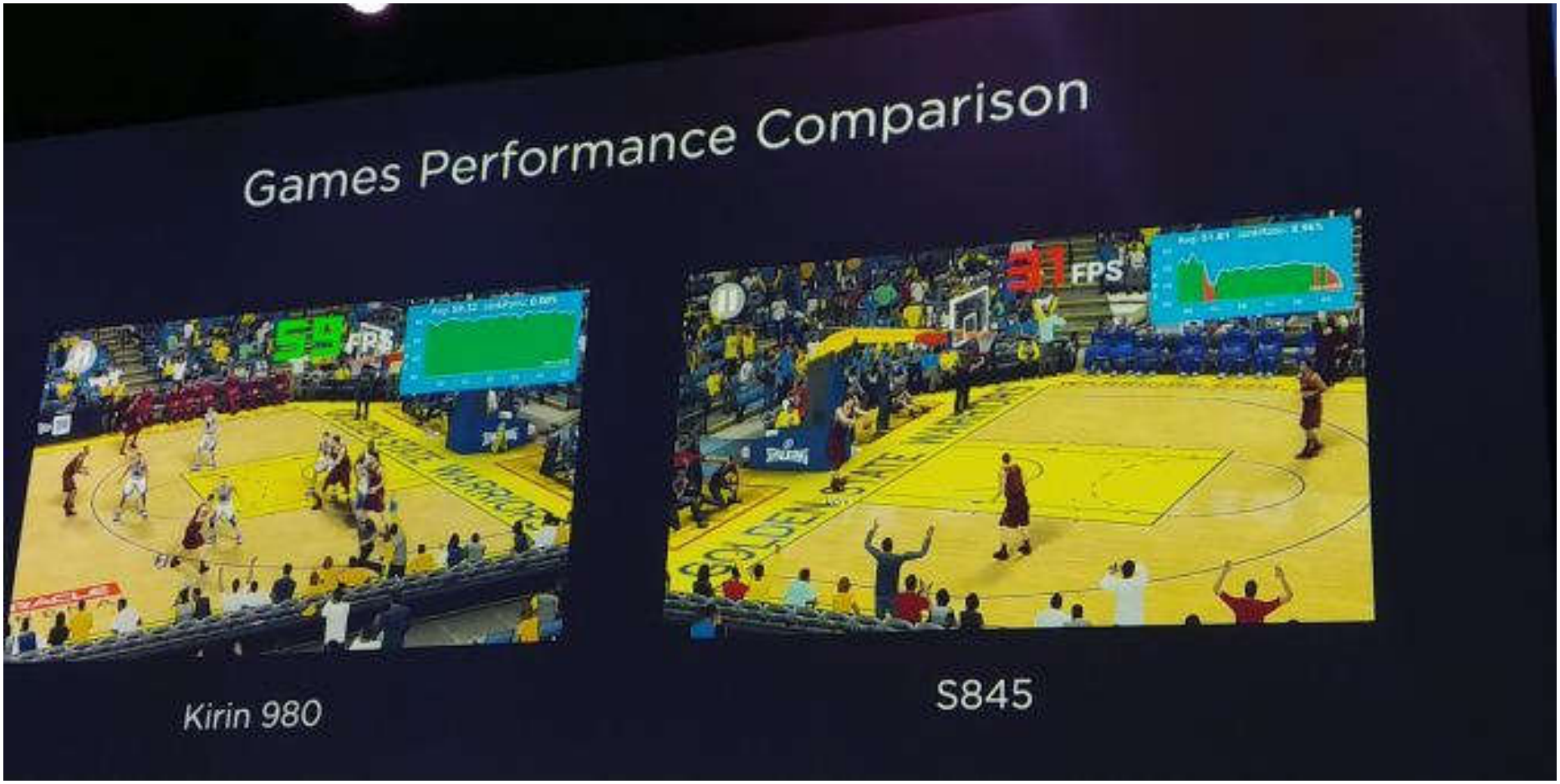
- 2018华为推出处理器麒麟980芯片，全球首发7nm制程工艺，**集成了69亿个晶体管**
- 全球六项第一
- 历时三年，花费数十亿美元

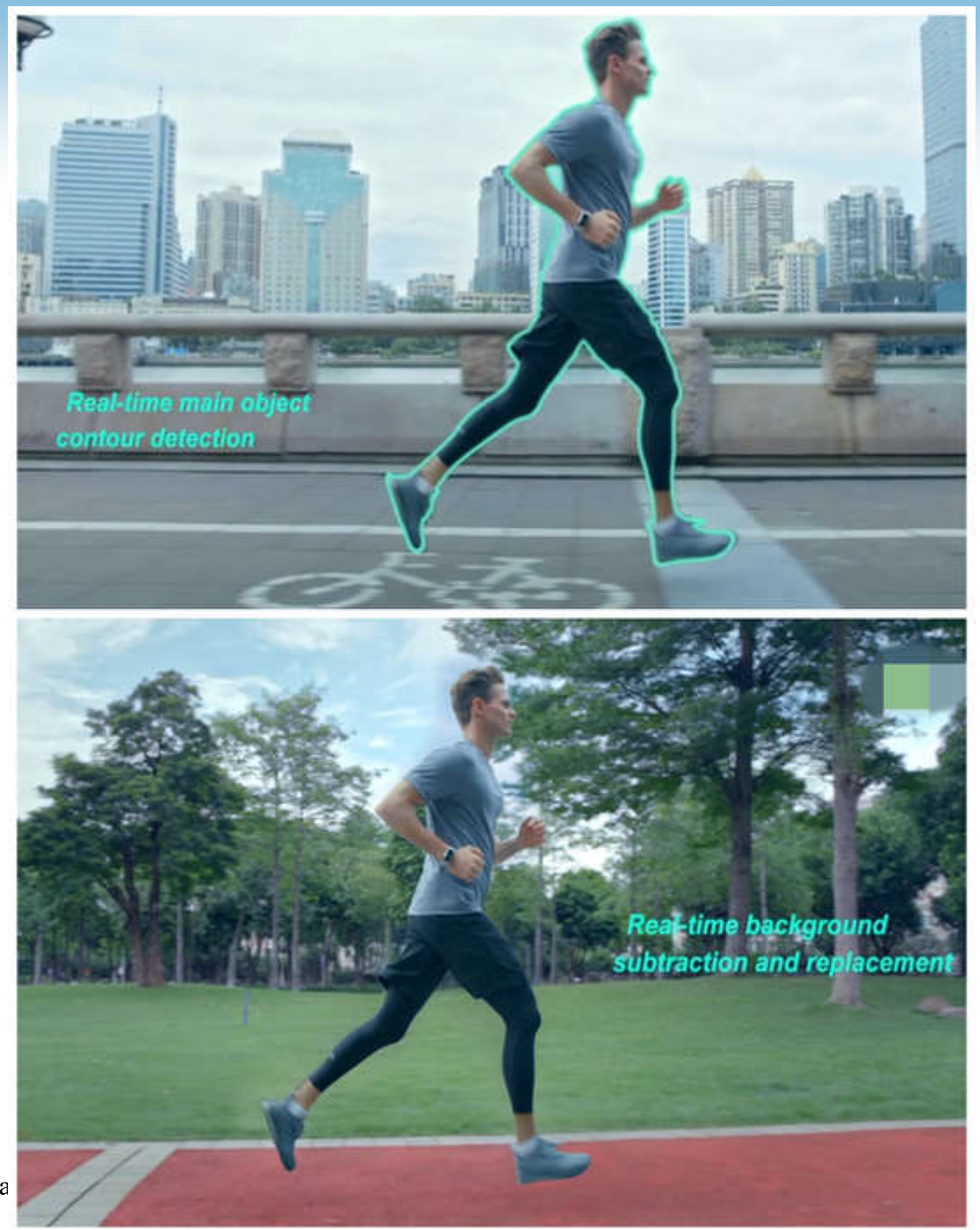


- 麒麟980芯片性能超越高通骁龙845处理器









计算机性能

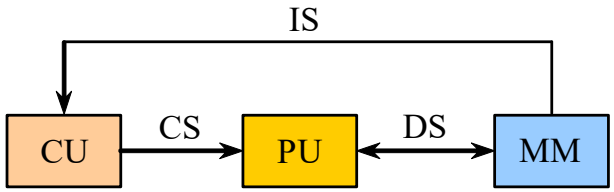
- 计算机时钟
  - Hz
  - 1GHz=1000MHz, 1MHz=10^6Hz
  - 不同CPU在一个时钟周期完成的工作量不同
- 基准测试 benchmark

Data Communication Rates

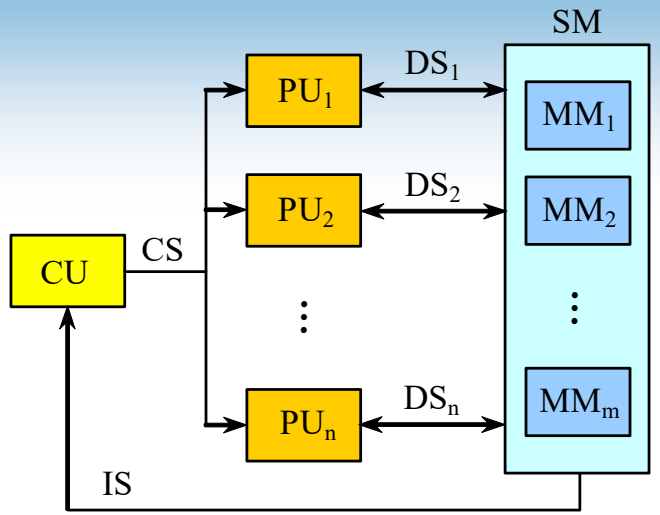
- Measurement units
  - Bps: Bits per second
  - Kbps: Kilo-bps (1,000 bps)
  - Mbps: Mega-bps (1,000,000 bps)
  - Gbps: Giga-bps (1,000,000,000 bps)
- Bandwidth: Maximum available rate

Other Architectures

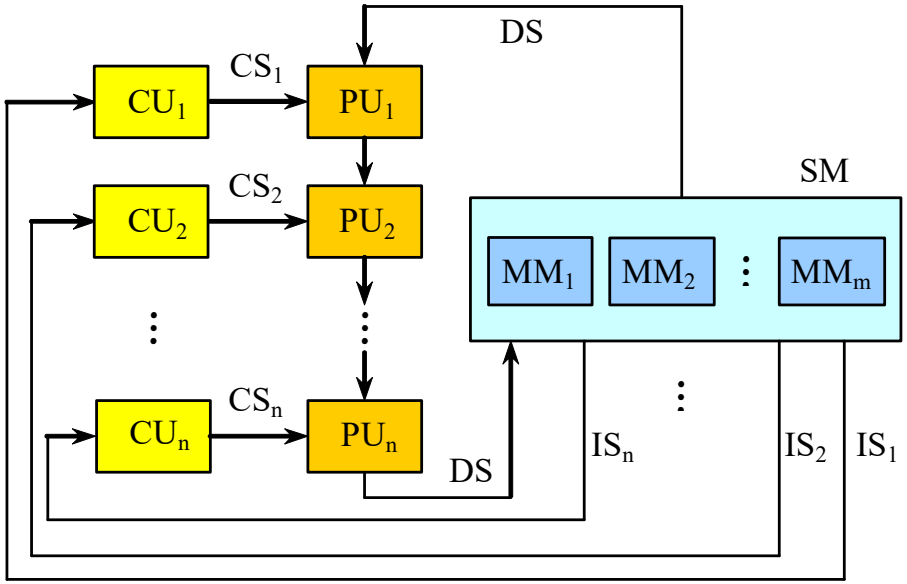
- Technologies to increase throughput:
  - Pipelining: Overlap steps of the machine cycle
  - Parallel Processing: Use multiple processors simultaneously
    - SISD: No parallel processing
    - MIMD: Different programs, different data
    - SIMD: Same program, different data



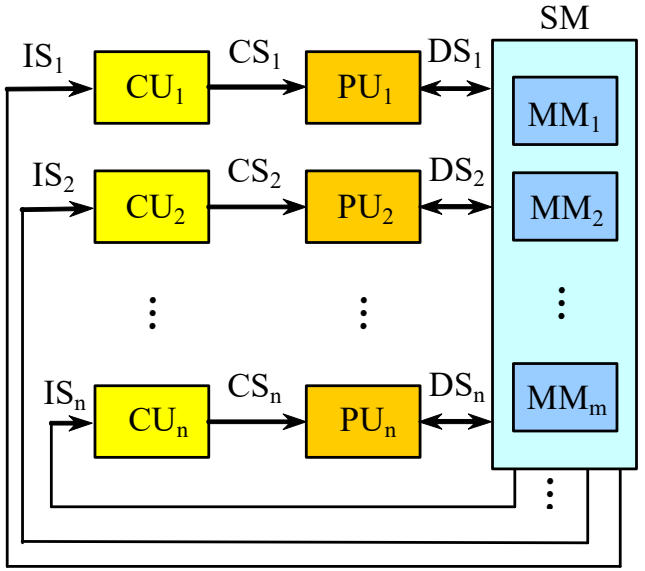
（a）SISD 计算机



（b）SIMD 计算机



（c）MISD 计算机



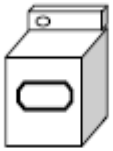
（d）MIMD 计算机

- 单指令流单数据流机器（SISD）
  - SISD机器是一种传统的串行计算机，它的硬件不支持任何形式的并行计算，所有的指令都是串行执行。并且在某个时钟周期内，CPU只能处理一个数据流，早期的计算机都是SISD机器
- 单指令流多数据流机器（SIMD）
  - SIMD是采用一个指令流处理多个数据流，我们现在用的单核计算机基本上都属于SIMD机器。
- 多指令流单数据流机器（MISD）
  - MISD是采用多个指令流来处理单个数据流。由于实际情况中，采用多指令流处理多数据流才是更有效的方法，因此MISD只是作为理论模型出现，没有投入到实际应用之中。
- 多指令流多数据流机器（MIMD）
  - 同时执行多个指令流，这些指令流分别对不同数据进行操作，比如多核计算平台。

Pipeline

- Laundry Example
  - A, B, C, D each have one load of clothes to wash, dry, and fold

- Wash takes 30 minutes

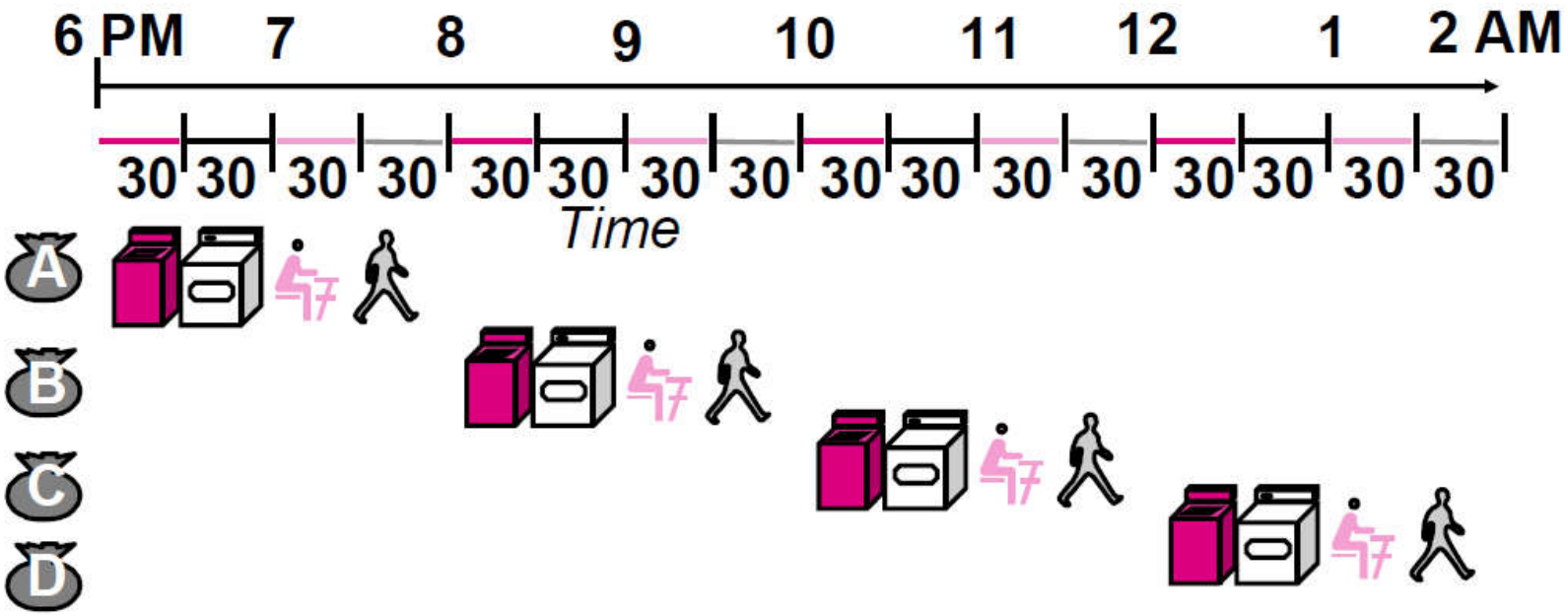


- Dryer takes 30 minutes

- “Folder” takes 30 minutes

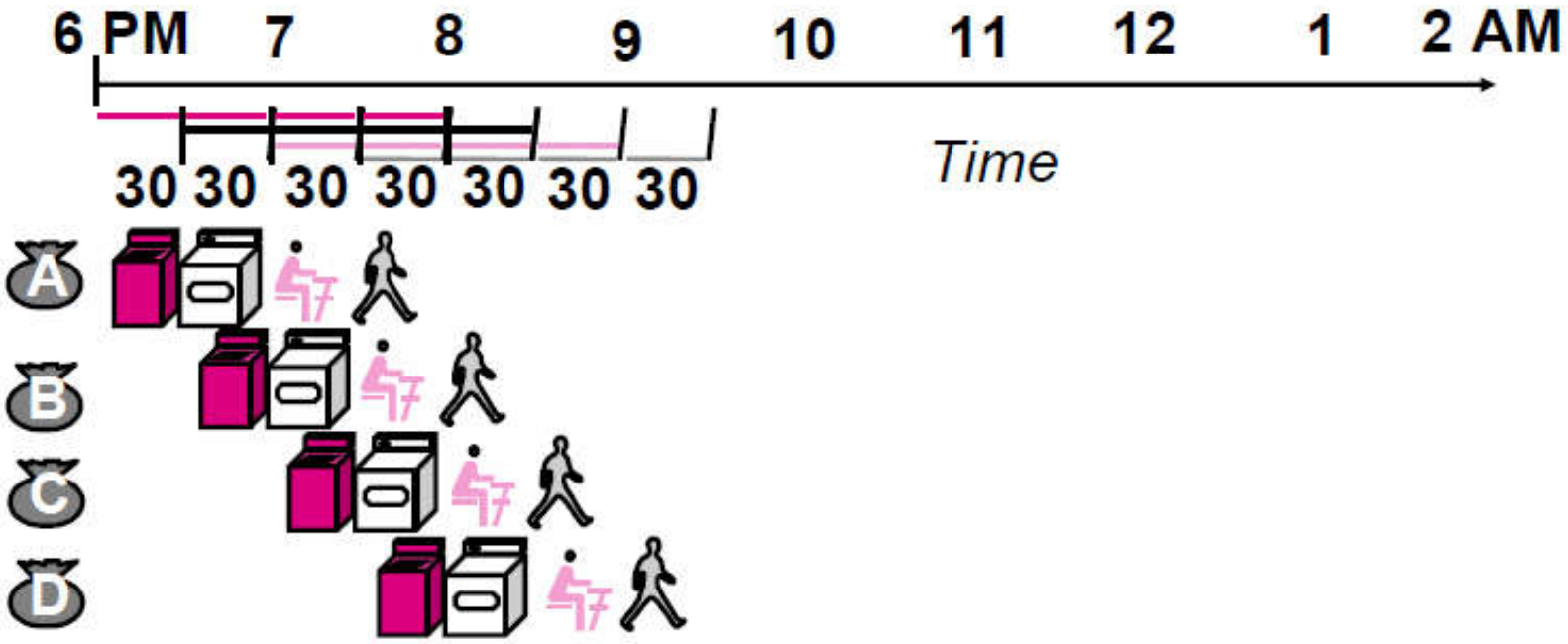
- “Stasher” takes 30 minutes to put clothes into drawers

Pipeline



- Sequential laundry takes 8 hours for 4 loads
- If they learned pipelining, how long would laundry take?

Pipeline



– Pipelined laundry takes 3.5 hours for 4 loads!