

Chapter 2

Computer Evolution and Performance – Part 06

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Design for Performance

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| Agenda

 Intro

 Microprocessor Speed

 ■ Branch Prediction

 ■ Data flow analysis

 ■ Speculative Execution

 Performance Balance

Performance Balance

- Adjusting of the organization and Architecture to compensate for the mismatch among capabilities of the various components

Improvement in Chip Organization and Architecture

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| Intro...

- Year by year, the cost of computer systems continues to drop dramatically, while the performance and capacity of those systems continue to rise equally dramatically



continue to rise equally dramatically

Cost ↓
Cloud

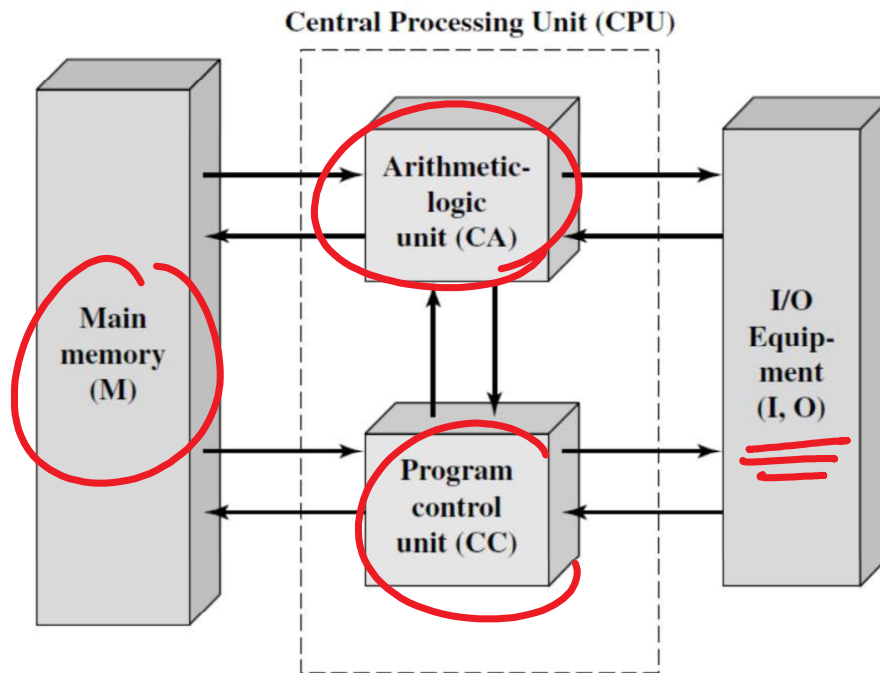
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- image processing
- speech recognition
- Video Conference
- modeling & simulation
- Deep learning ⁴

| Intro...

Central Processing Unit (CPU)

Von-Neumann



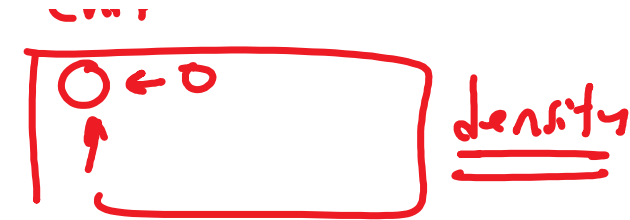
Von-Neumann
Processor

- Stored program Concept

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chip
IO ← 0

| Microprocessor Speed



- Raw speed of the microprocessor will not achieve its potential unless it is fed a constant stream of work to do in the form of computer instructions

✓ ✓ • Branch prediction

✓ ✓ • Data flow analysis

• Speculative execution

Busy

| Branch Prediction

- The processor looks ahead in the instruction code fetched from memory and predicts which branches, or groups of instructions, are likely to be processed next

| Data flow analysis

- The processor analyzes which instructions are dependent on each other's results, or data, to create an optimized schedule of instructions

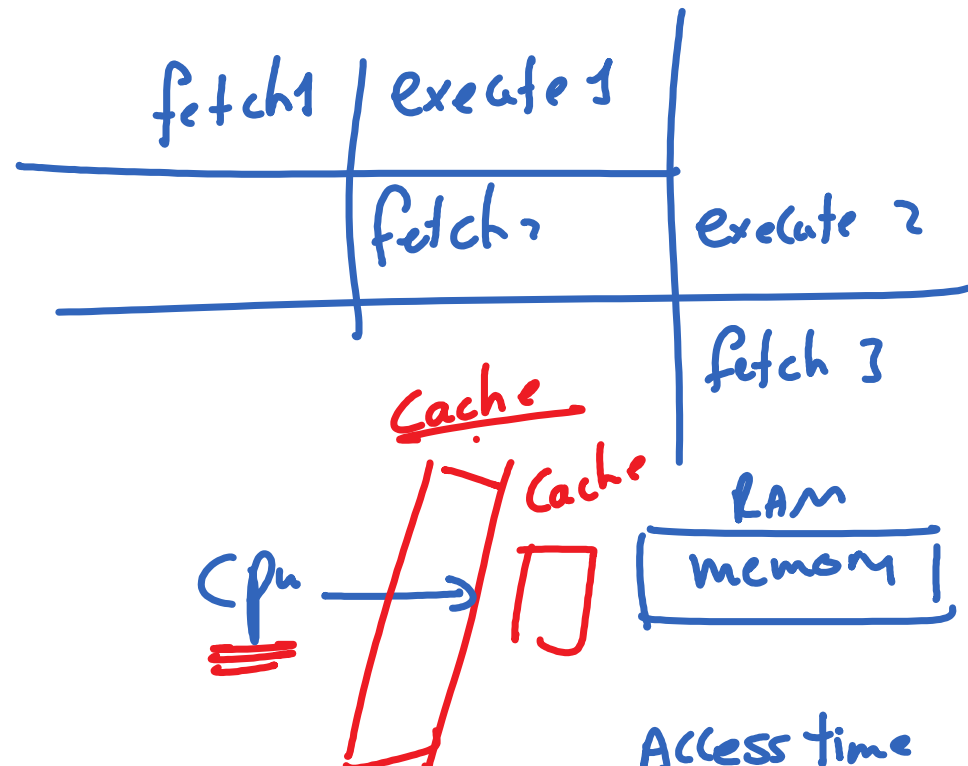
| Speculative execution

- Using **branch prediction** and **data flow analysis**, some processors speculatively execute instructions ahead of their actual appearance in the program execution, holding the results in temporary locations

| In Brief...

▪ Pipelining

- On board cache
- On board L1 & L2 cache
- Branch prediction
- Data flow analysis
- Speculative execution



✓

—
L
level

Access time

10

| Performance Balance

▪ While processor power has raced ahead at breakneck speed, other critical components of the computer have not kept up.

تواكب

- ✓ — Processor speed increased
- ✓ — Memory capacity increased
- Memory speed lags behind processor speed

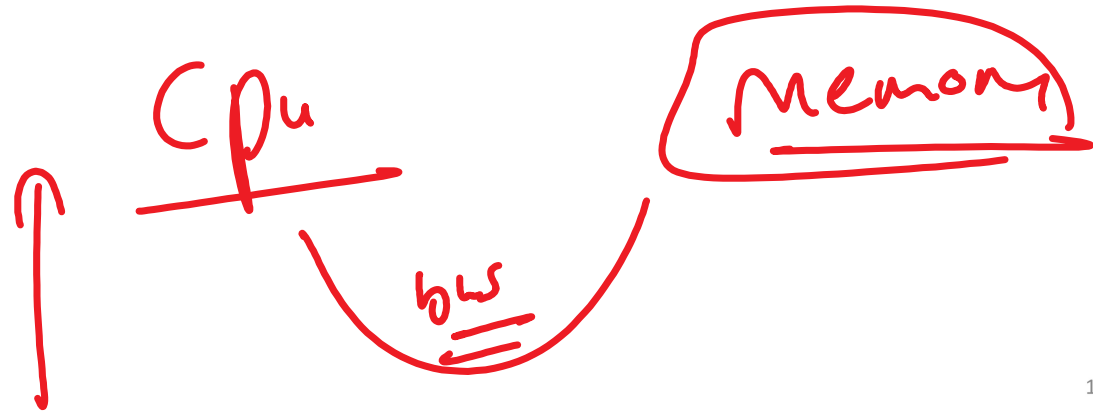
- Memory speed lags behind processor speed

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| Performance Balance

- The interface between processor and main memory is the most crucial pathway in the entire computer because it is responsible for carrying a constant flow of program instructions and data between

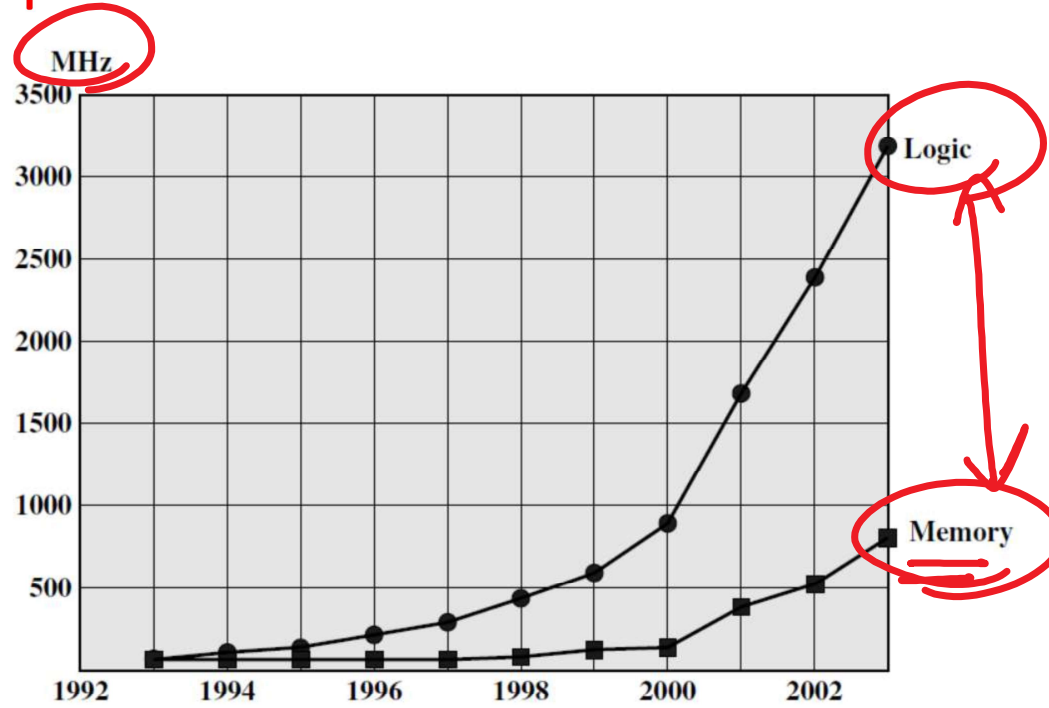
crucial pathway in the entire computer because it is responsible for carrying a constant flow of program instructions and data between memory chips and the processor.



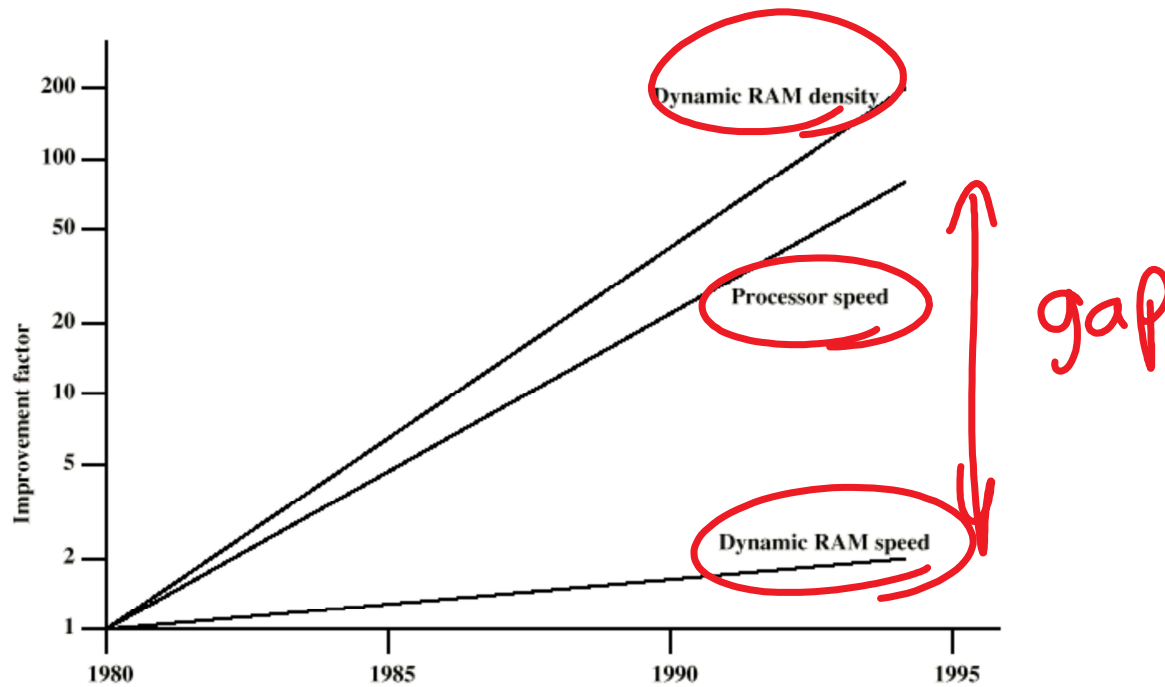
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| Performance Balance
MHz

PERFORMANCE BALANCE

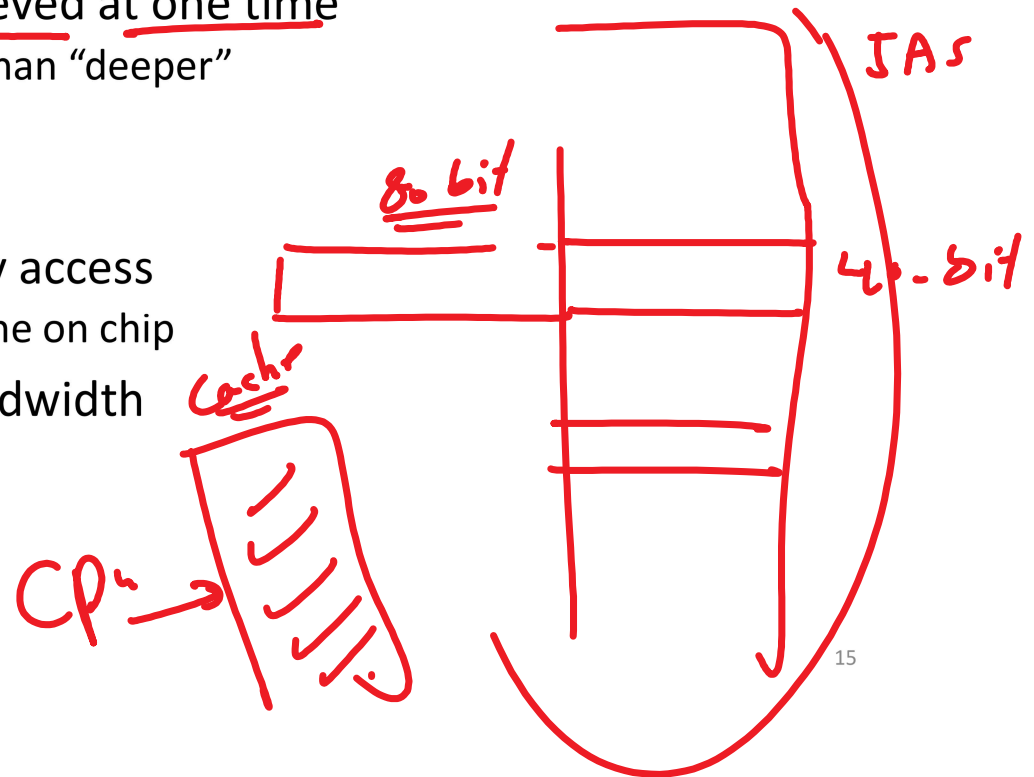


| Performance Balance



| Solution

- Increase number of bits retrieved at one time
 - Make DRAM “wider” rather than “deeper”
- Change DRAM interface
 - Cache
- ✓ ▪ Reduce frequency of memory access
 - More complex cache and cache on chip
- Increase interconnection bandwidth
 - — High speed buses
 - Hierarchy of buses



| Handling of I/O devices

- As computers become faster and more capable, more sophisticated applications are developed that support the use of peripherals with intensive I/O demands

| Handling of I/O devices

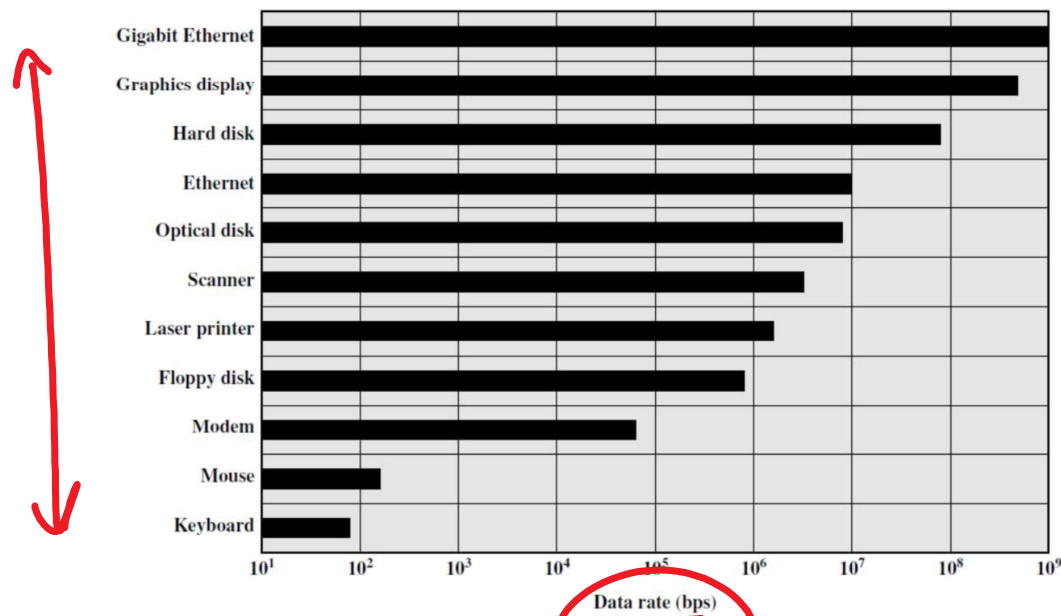


Figure 2.11 Typical I/O Device Data Rates

Speed
Protocol

bit per second

Figure 2.11 Typical I/O Device Data Rates

Data rate (bps)

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| Handling of I/O devices

- Strategies here include caching and buffering schemes plus the use of higher-speed interconnection buses and more elaborate structures of buses

data channel

| Improvements in Chip Organization and Architecture

There are three approaches to achieving increased processor speed

- Increase the hardware speed of the processor
- Increase the size and speed of caches
- Parallelism

propagation delay
time ↓

■ Parallelism



↓ time ↓

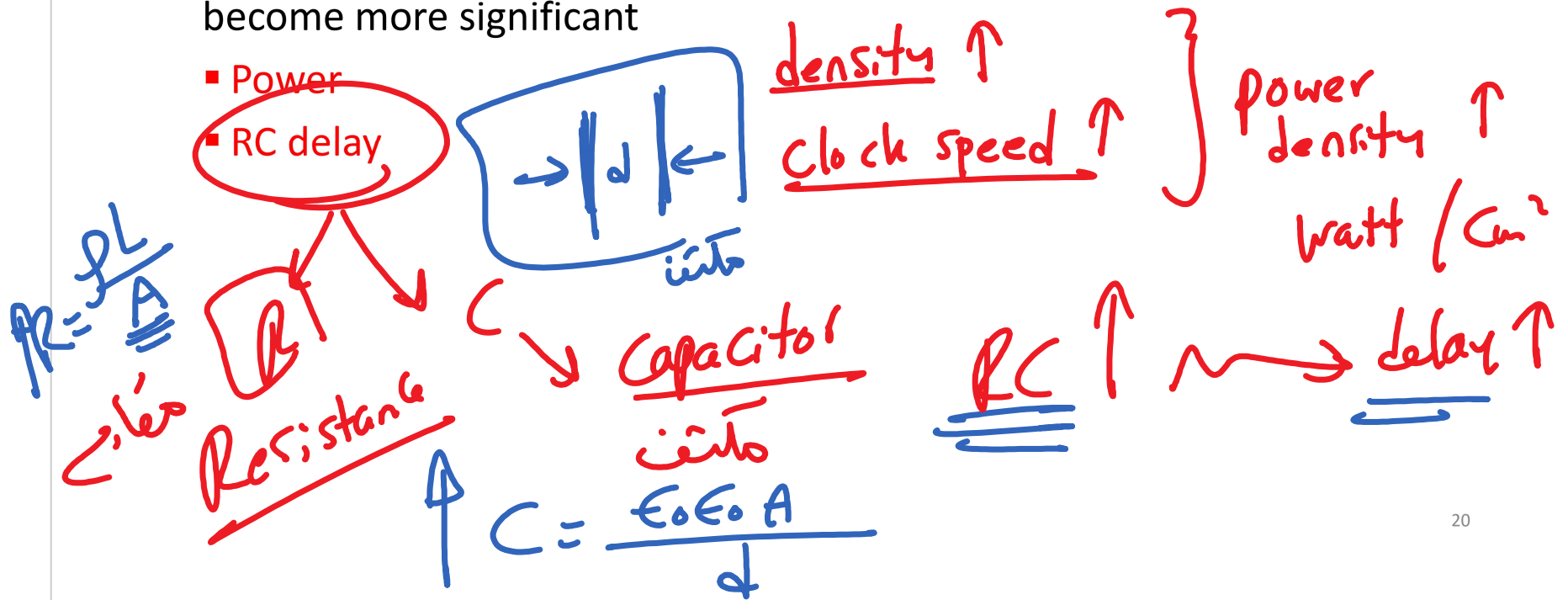
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| Increasing Clock speed – Logic Density

as clock speed and logic density increase, a number of obstacles become more significant



as clock speed and logic density increase, a number of obstacles become more significant



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| Other Strategies to increase performance

| Other Strategies to increase performance

- ✓ ■ Increase in cache capacity and Level of cache
- ✓ ■ pipelining and superscalar
- The use of multiple processors on the same chip, also referred to as multiple cores, or multicore

✓ ✓