



ICOM 4215: Computer Architecture and Organization

Introduction to Computer
Architecture
Nayda Santiago

**Slides modified from Dr. T. Noack course slides
Original source: Authors of Heuring and Jordan book
And Stallings book**



Administrative Details

- Web page
 - Slides
 - Access with own laptop
- Workshops
- No class on job fair day
 - We will make up on a workshop day



Architecture & Organization 1

- Architecture is those attributes visible to the programmer
 - Instruction set, number of bits used for data representation, I/O mechanisms, addressing techniques.
 - e.g. Is there a multiply instruction?
- Organization is how features are implemented
 - Control signals, interfaces, memory technology.
 - e.g. Is there a hardware multiply unit or is it done by repeated addition?

**This slide is from
Stallings Architecture**



Architecture & Organization 2

- All Intel x86 family share the same basic architecture
- The IBM System/370 family share the same basic architecture

- This gives code compatibility
 - At least backwards
- Organization differs between different versions



Structure & Function

- Structure is the way in which components relate to each other
- Function is the operation of individual components as part of the structure



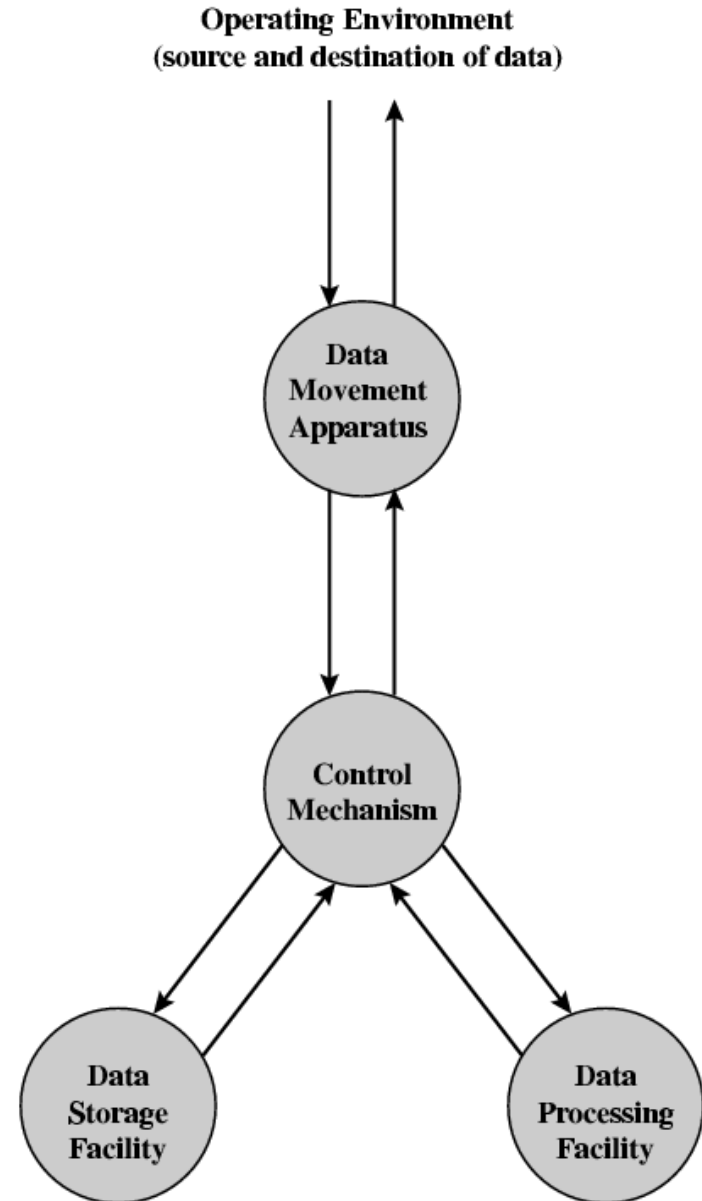
Function

- All computer functions are:
 - Data processing
 - Data storage
 - Data movement
 - Control

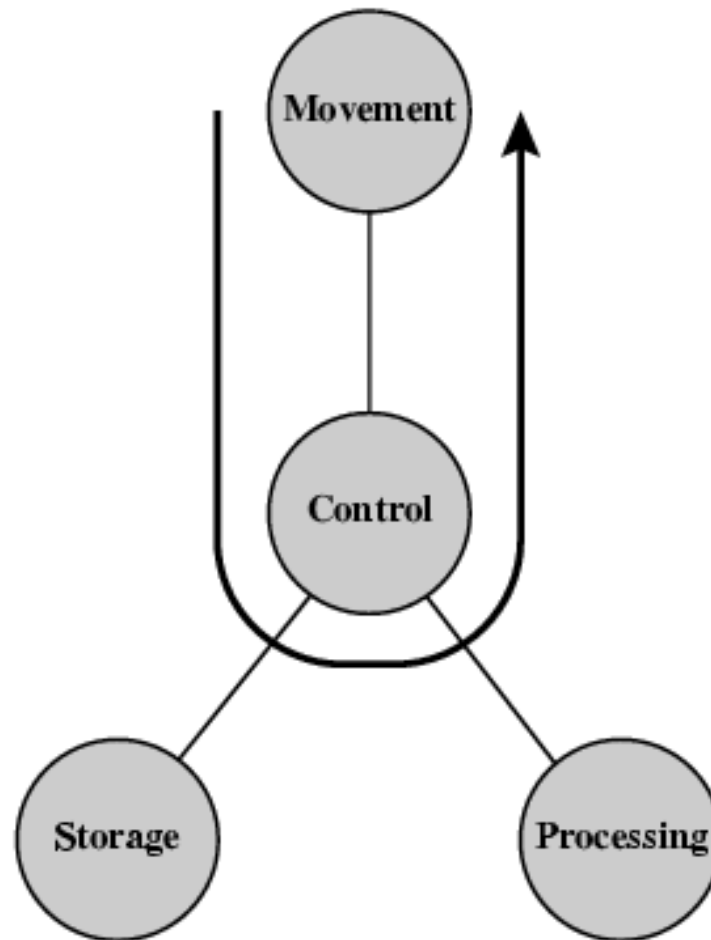
**This slide is from
Stallings
Architecture**

Functional View

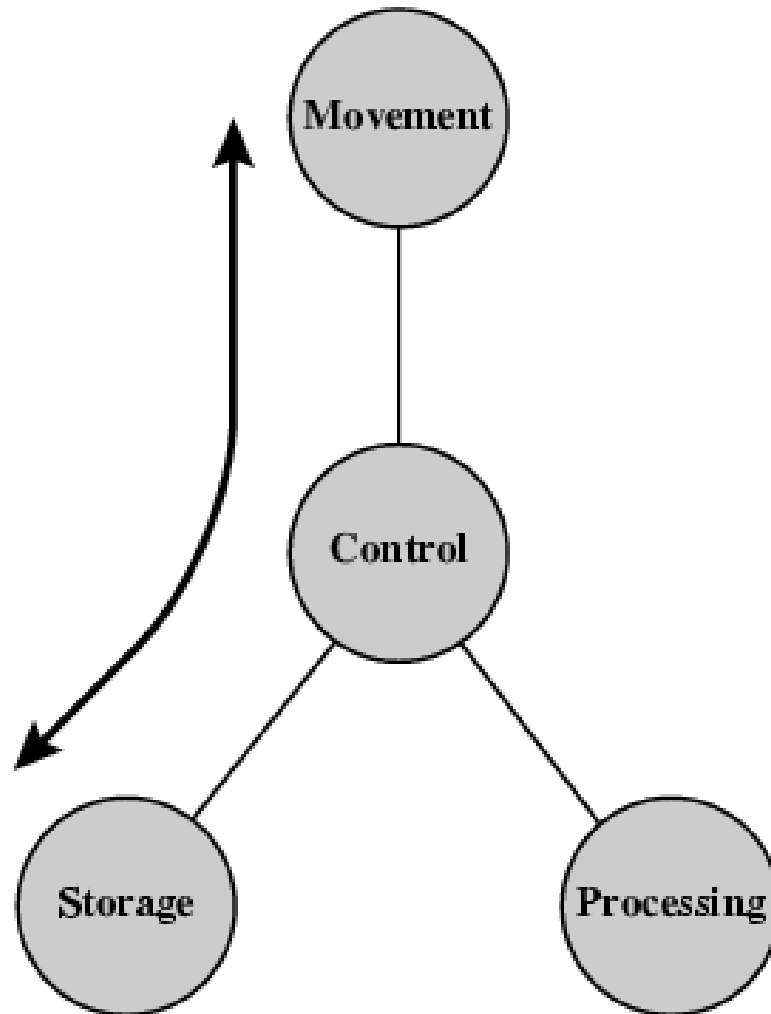
This slide is from
Stallings
Architecture



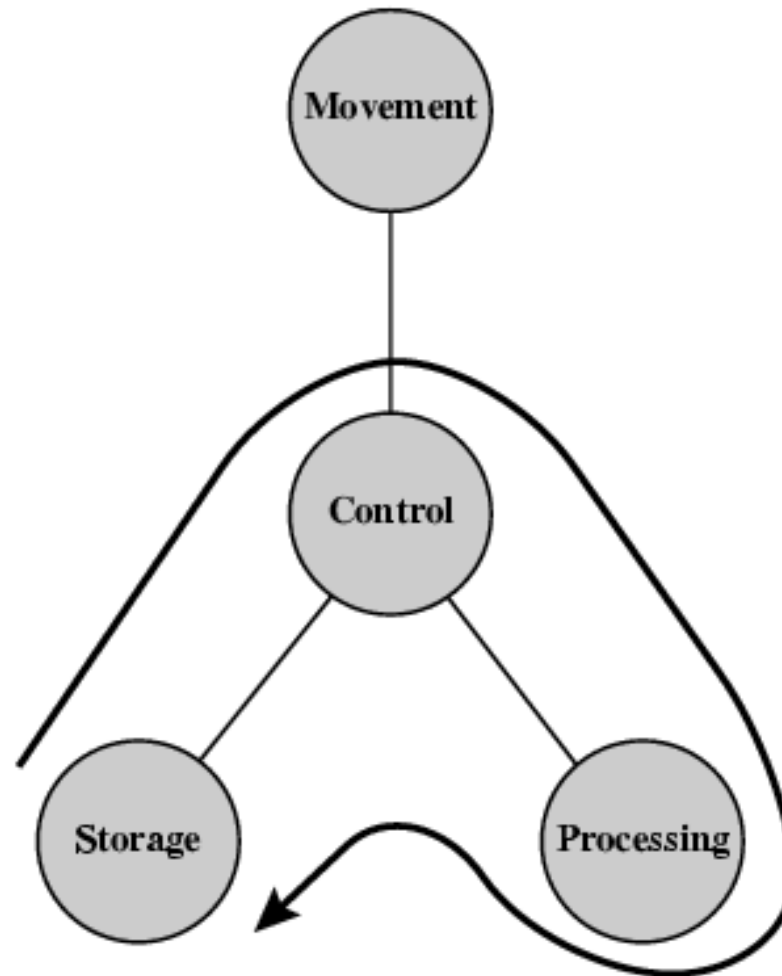
Operations (a) Data movement



Operations (b) Storage

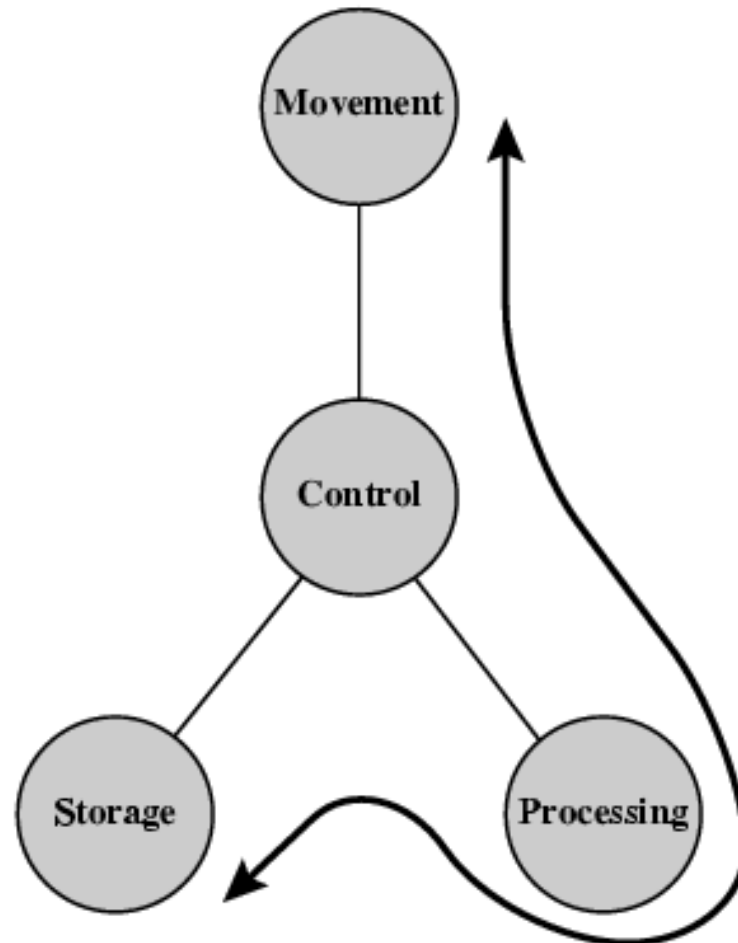


Operation (c) Processing from/to storage

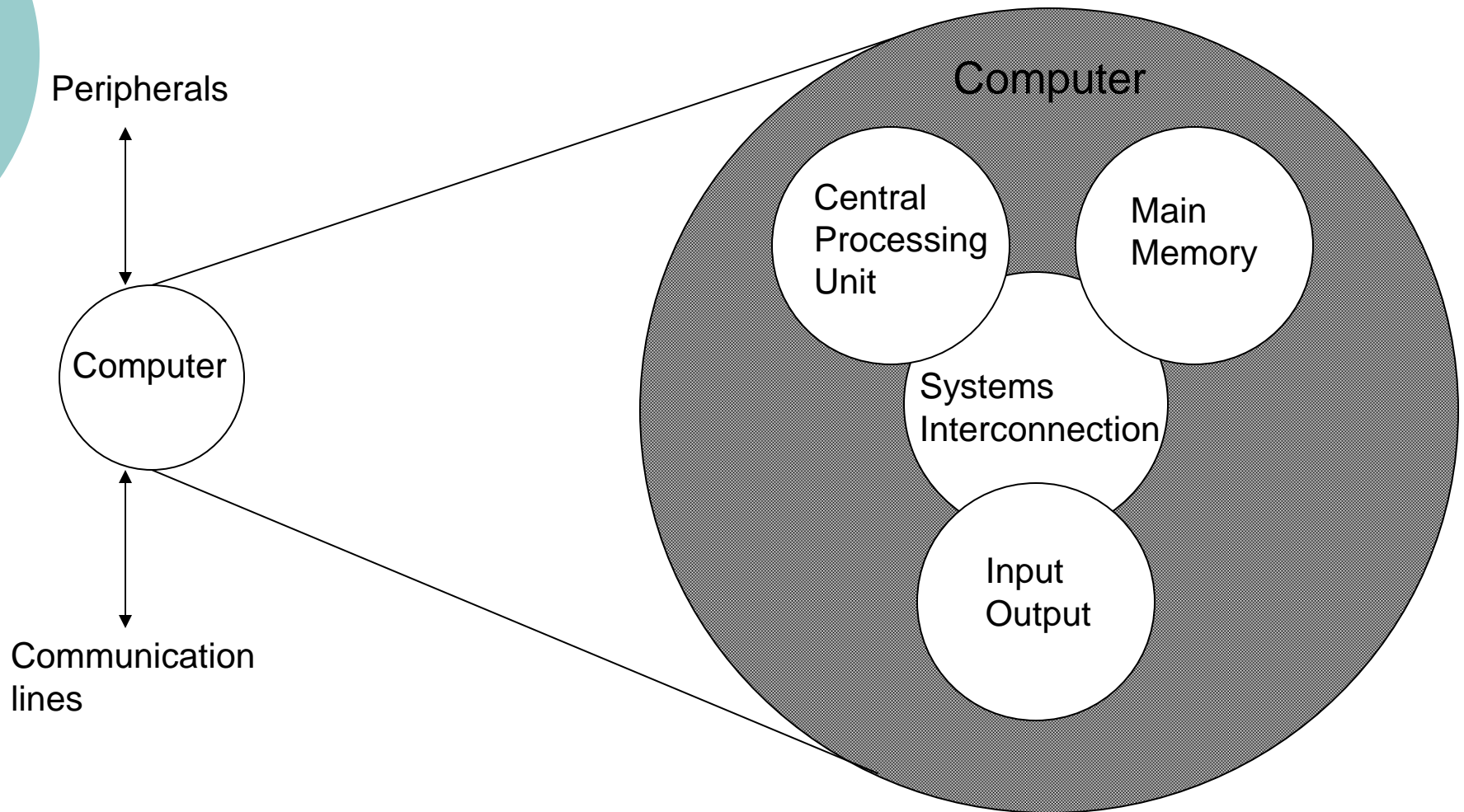


Operation (d)

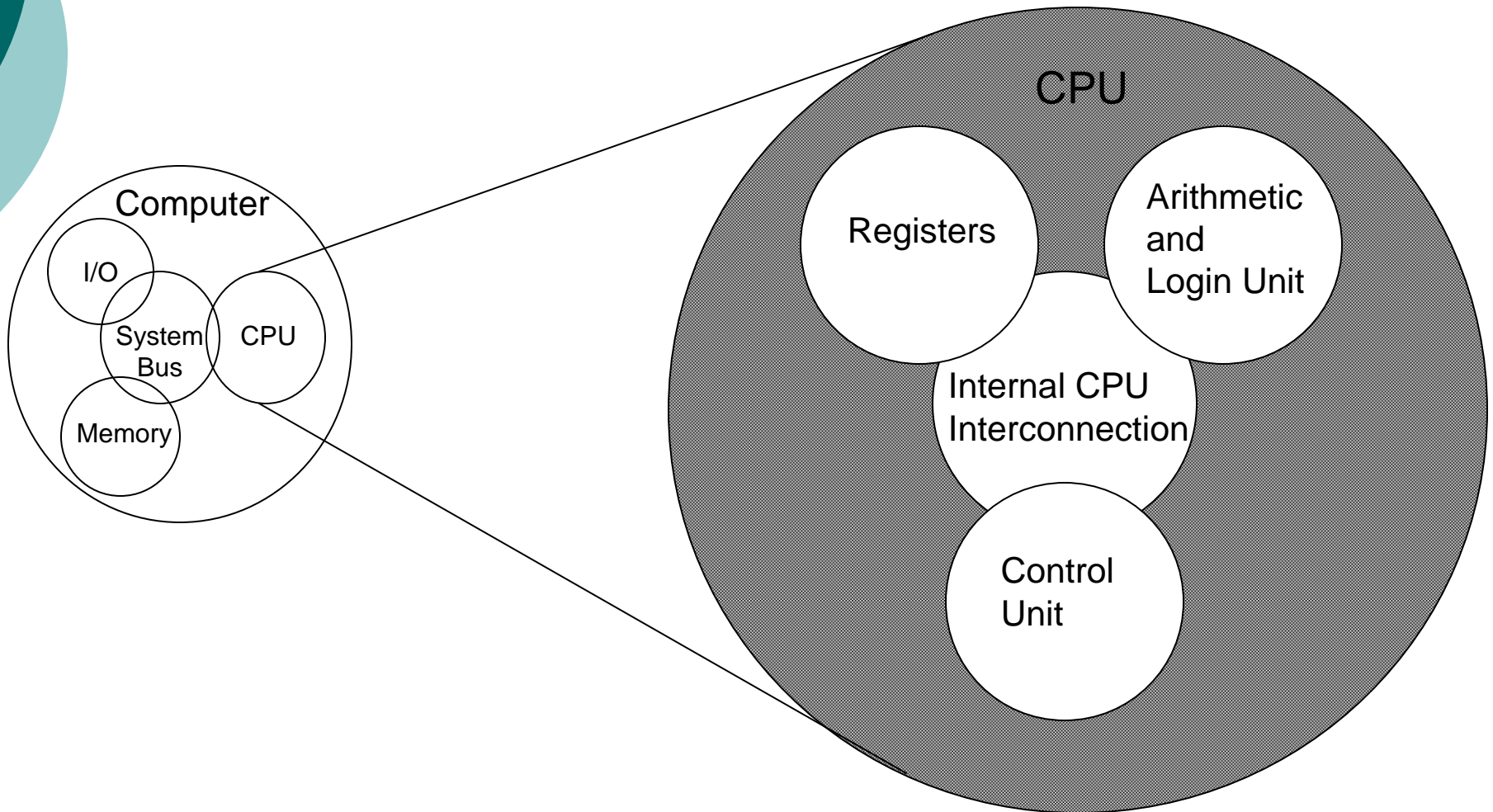
Processing from storage to I/O



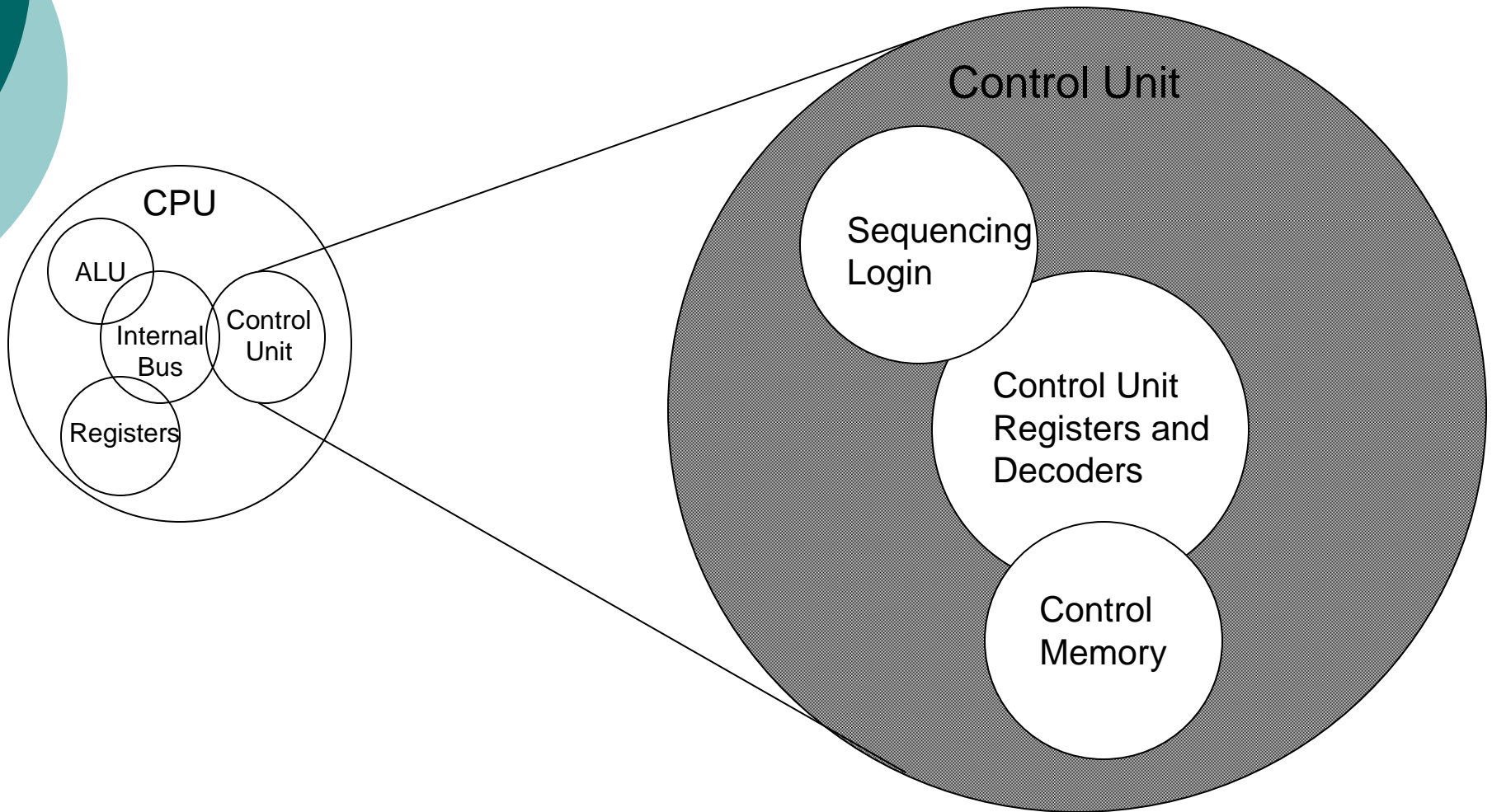
Structure - Top Level



Structure - The CPU



Structure - The Control Unit





Computer Architecture - Basics

Computer organization

The region of system design from HLL and basic functionality to ISA (Instruction set architecture)

Computer architecture

System design from ISA to VLSI specification

ISA (Instruction Set Architecture)

Registers and memory organization

Instruction formats

Addressing modes

Instruction set

Exception and interrupt handling

**This slide is from
Heuring and
Jordan**



Logic and system performance, then and now

Comments

Logic speed has improved much more than
memory speed – one solution – cache memory

This slide doesn't show density improvement

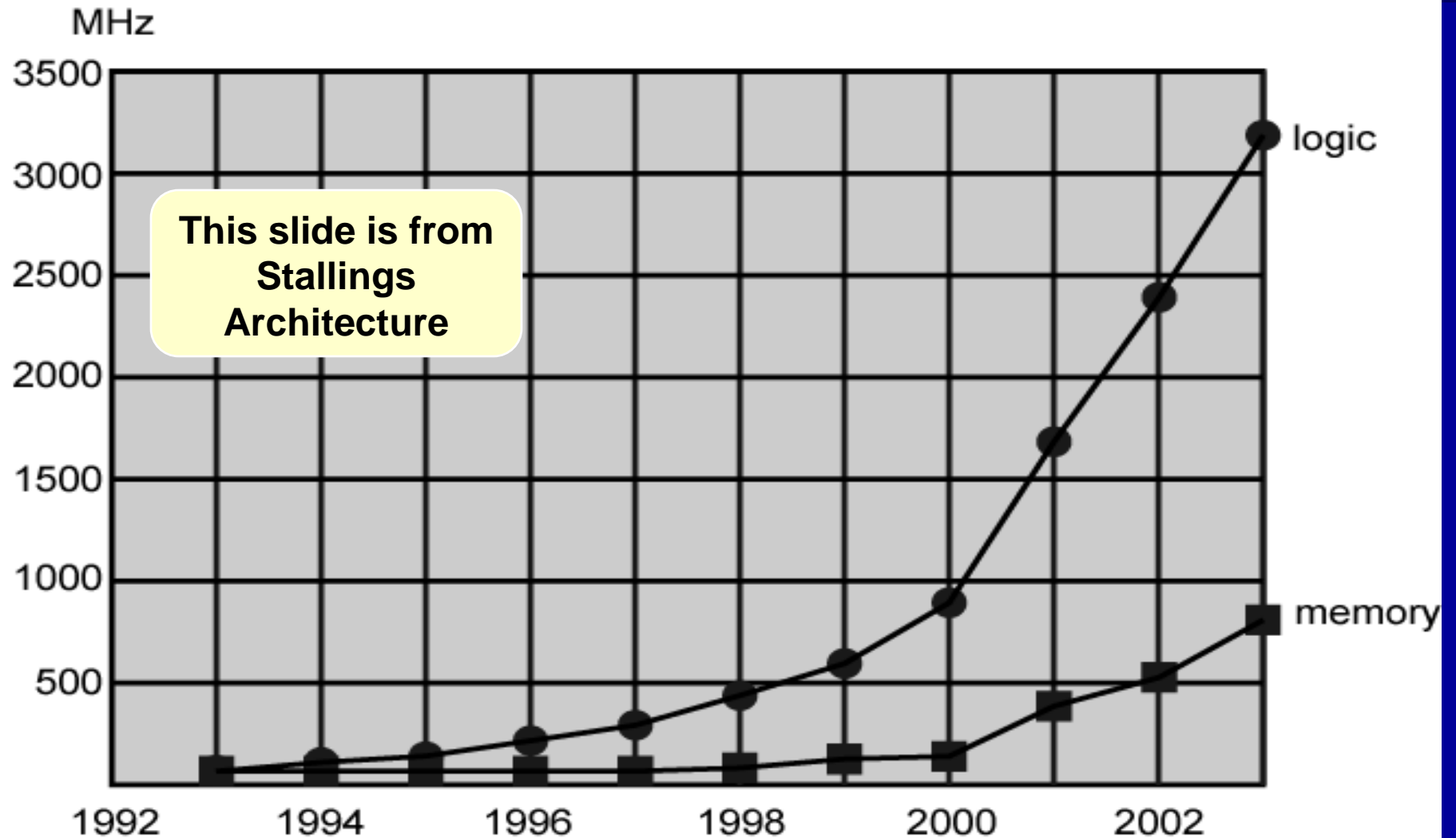
In the intel performance slide

Light gray area shows process improvement

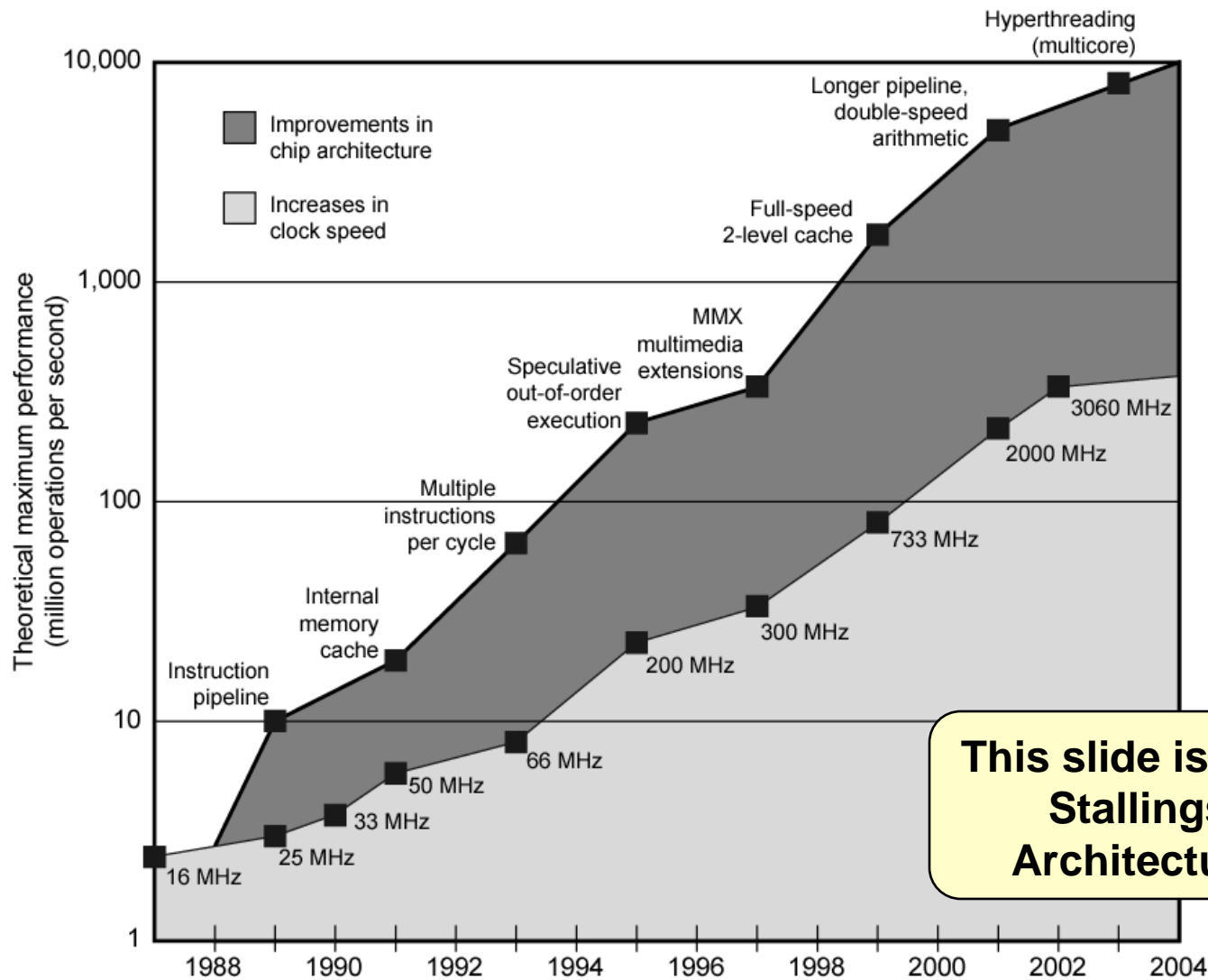
Dark gray is what organization and architecture
accomplished

Both figures are copied from Stallings
architecture book

Logic and Memory Performance Gap



Intel Microprocessor Performance



This slide is from
Stallings
Architecture



Processor structure – then and now

The first slide is the 1946 IAS (institute for advanced studies – Princeton) machine

Actually, Von Neumann wrote a paper based on the ENIAC architecture and got the credit

This is almost the unavoidable basic structure of a stored-program machine

Many copies of the IAS machine were made – some were in service until 1967

The second slide is a modern architecture showing:

Multiple cores

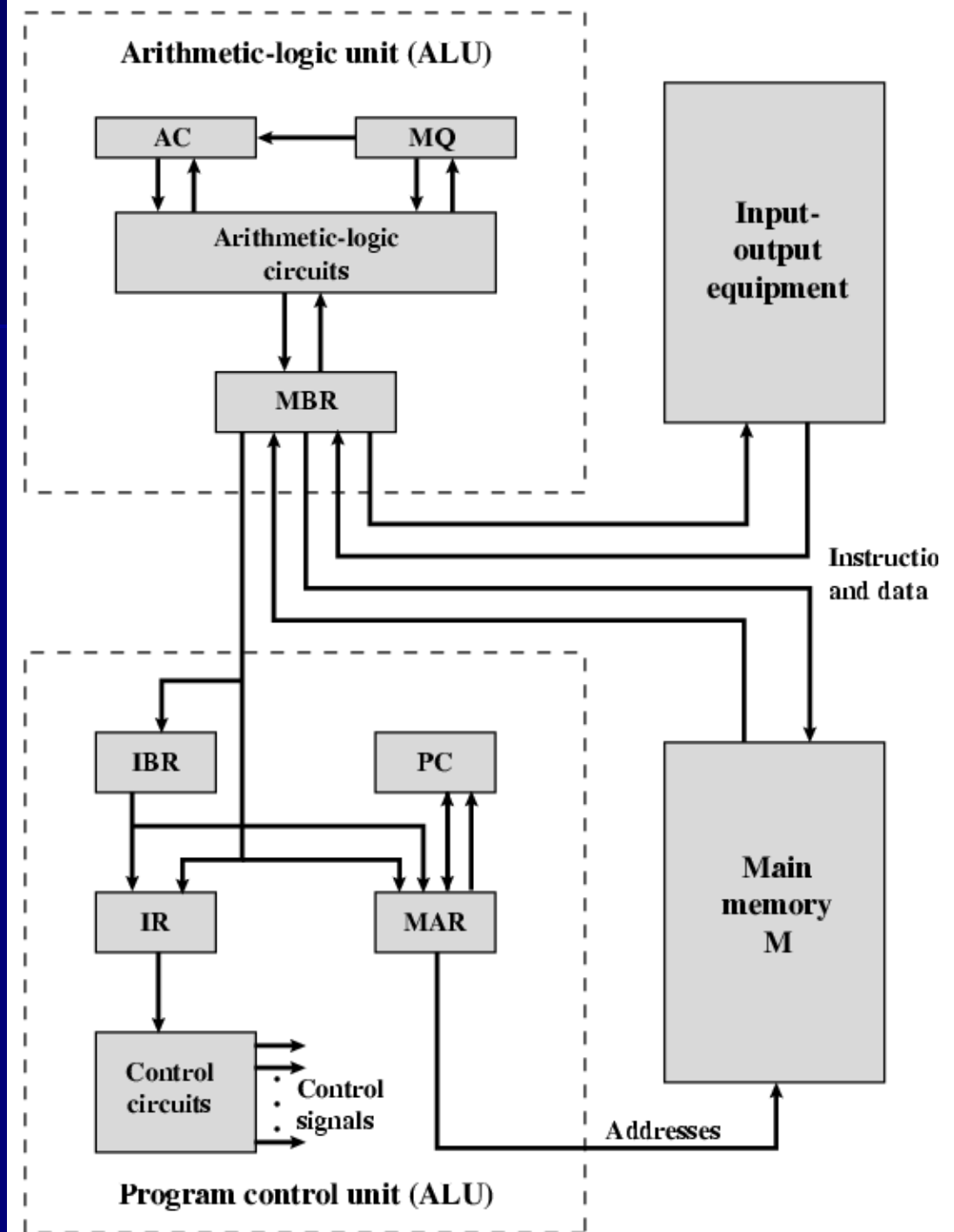
Caches

Interconnect

Note that the original IAS ideas are still there

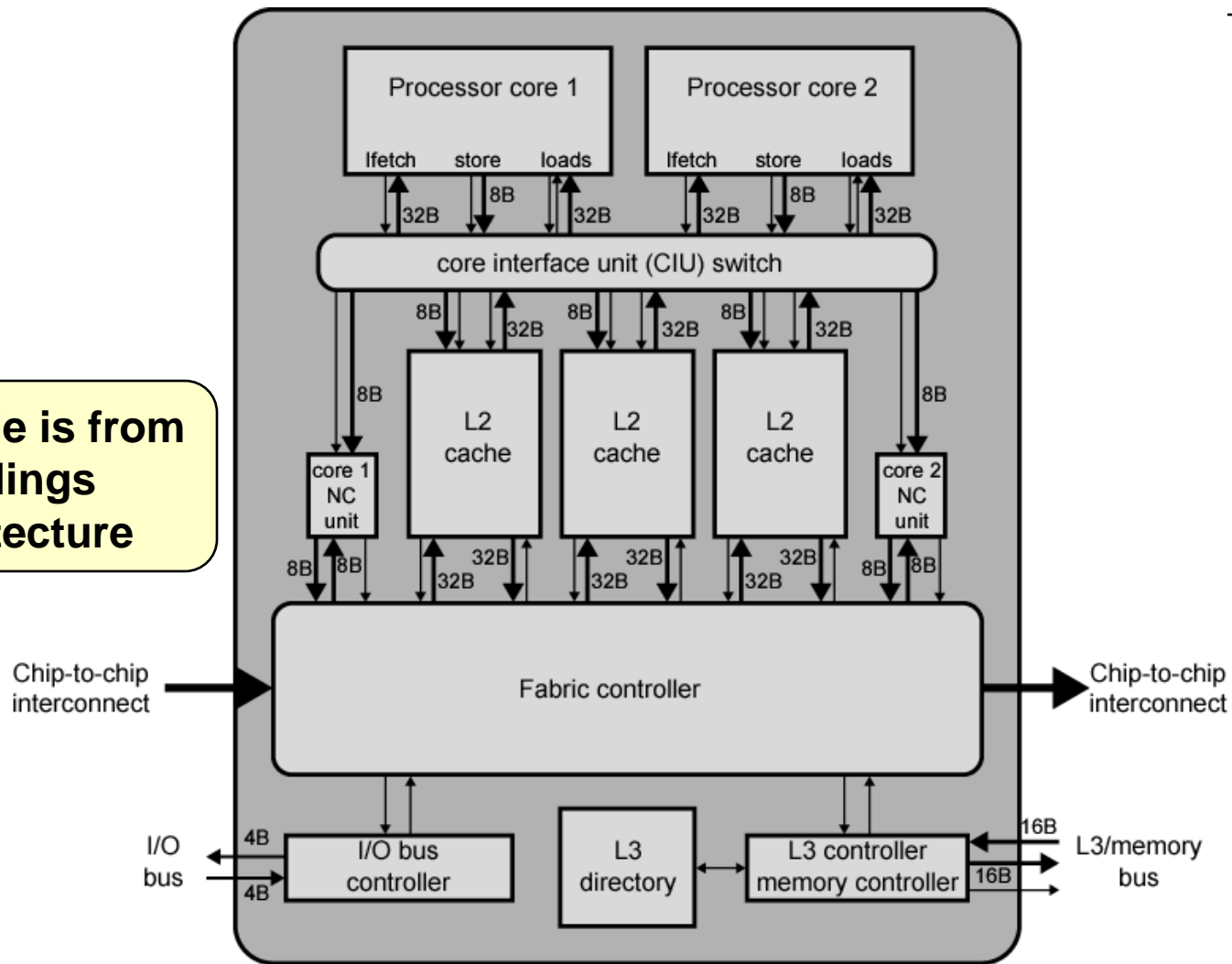
Structure of IAS (1946) – detail

This slide is from
Stallings
Architecture




POWER4 Chip Organization

This slide is from
Stallings
Architecture



NC = noncacheable



Course Goals: Understanding Structure and Function of Digital Computer at 3 Levels

This course

Multiple levels of computer operation

Application level

High Level Language(s), HLL, level(s)

Assembly/machine language level: instruction set

System architecture level: subsystems & connections

Digital logic level: gates, memory elements, buses

Electronic design level

Semiconductor physics level

Interactions and relations between levels

View of machine at each level

Tasks and tools at each level

Historical perspective

Trends and research activities

**This slide is from
Heuring and
Jordan**



Prerequisites

Experience with a high level language

Java

C, etc.

Assembly language programming

Digital logic circuits

Appendix A summarizes logic design in sufficient detail so the text can be used in courses without digital logic circuits as a prerequisite.

**This slide is from
Heuring and Jordan**



Text Overview

- 1: The General Purpose Machine
- 2: Machines, Machine Languages, and Digital Logic
- 3: Some Real Machines
- 4: Processor Design at the Gate Level
- 5: Processor Design - Advanced Topics
- 6: Computer Arithmetic and the Arithmetic Unit
- 7: Memory System Design
- 8: Input and Output
- 9: Peripheral Devices
- 10: Communications, Networking and the Internet

**This slide is from
Heuring and
Jordan**



Course Overview – Basic aspects

1: The General Purpose Machine

ISA (Instruction Set Architecture)

The architect's view

The Logic designers view

2: Machines, Machine Languages, and Digital Logic

SRC (Simple RISC Computer) an example for the entire course

RTN (Register Transfer Notation) – a simple language that describes from ISA to logic

3: Some Real Machines



Speedup methods – pipelining and parallelism

4: Processor Design at the Gate Level

This introduces

Stages of an instruction – Fetch, Decode, Operand Fetch, Execution, Writeback

The LogicWorks version of the SRC will be the primary example

5: Processor Design - Advanced Topics

The crux chapter – this introduces

Pipelining

Instruction-level parallelism

Microcoded control units

A processor within a processor



Components – arithmetic and memory

6: Computer Arithmetic and the Arithmetic Unit

Arithmetic operations and types

Integer

Floating point

Specialized – logic operations and bit fiddling

Design of arithmetic units

7: Memory System Design

Memory cells – static/dynamic, RAM/ROM variants

Memory organization – SDRAM and DDR RAM examples

Cache memory organization



Components again – I/O and peripherals

8: Input and Output

Primarily how the processor handles interrupts, exceptions and DMA

9: Peripheral Devices

Just background information

10: Communications, Networking and the Internet

Not covered in this course – others cover it well