# Input/Output Systems and Peripheral Devices

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# IOSPD Discipline Information (1)

- General objective
  - Knowledge of operation and performance parameters for I/O interfaces and peripheral devices
- Theoretical objectives
  - Knowledge of the methods for performing I/O transfers
  - Knowledge of various I/O buses
  - Knowledge of the operating principle for various types of displays

# IOSPD Discipline Information (2)

- Knowledge of graphics adapters and digital interfaces for displays
- Knowledge of the recording principle on optical discs and of various types of discs
- Practical objectives
  - Implementing in software protocols for communication with I/O controllers of peripheral devices
  - Implementing applications for controlling I/O interfaces

# IOSPD Discipline Information (3)

- Grading
  - 10% Quizzes at the lectures
  - 40% Laboratory → evaluation during the semester and at the end with a colloquy
  - 50% Exam
  - Minimum grade for each activity: 5
- Web pages
  - http://users.utcluj.ro/~baruch/en/
    Teaching → Input/Output Systems
- Teams: *General* channel, *Files* → *Class Materials* → *Lecture*

# IOSPD Discipline Information (4)

- Lecture
  - Quizzes for testing attention → Teams app
  - The average of grades is used for computing the final grade
  - Students from previous year(s) who did not pass the quizzes have to take them again
- Final Exam
  - Conditions to be accepted: minimum average grade of 5 for the quizzes; laboratory passed
  - Schematics and diagrams must be explained

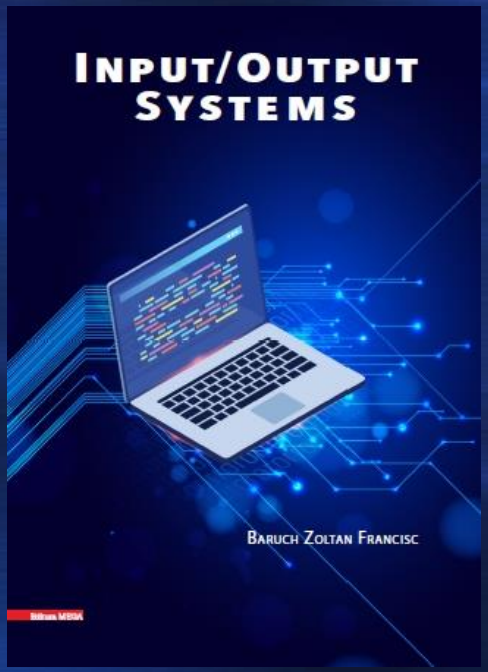
# IOSPD Discipline Information (5)

- Mid-Term Exam
  - Organized only if the majority of students are requesting it
  - Includes questions from Part 1 of the lecture: chapters 1 – 4
  - Recognized only in the summer sessions (regular and recovery), not in the fall session
  - Part 1 and Part 2 (chapters 5 – 7) must be passed separately to pass the final exam
  - Minimum points: 40% of total points

# IOSPD Discipline Information (6)

- Laboratory
  - Assessment:
    - Quizzes with theoretical questions (15%)
    - Three grades for applications (3 x 15%)
    - Colloquy at the end of semester (40%)
  - Laboratory colloquy in the summer recovery session for students who did not pass
  - Recovery: maximum four labs
    - Maximum two labs during the semester
    - Maximum two labs at the end of semester

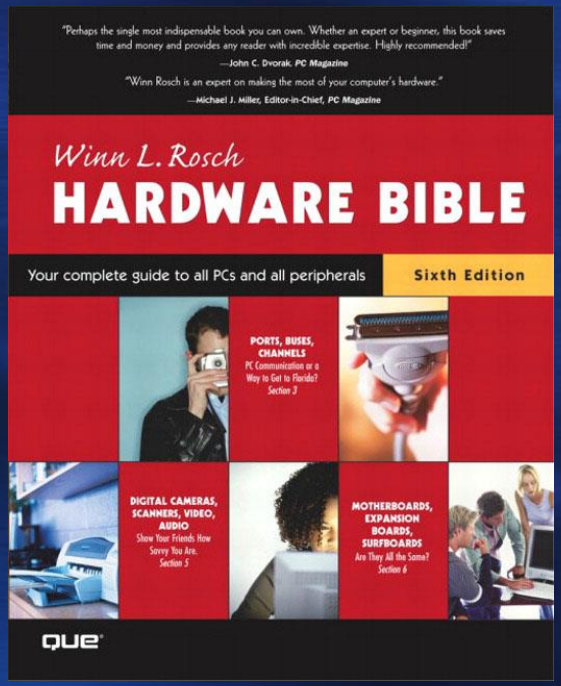
# Bibliography (1)





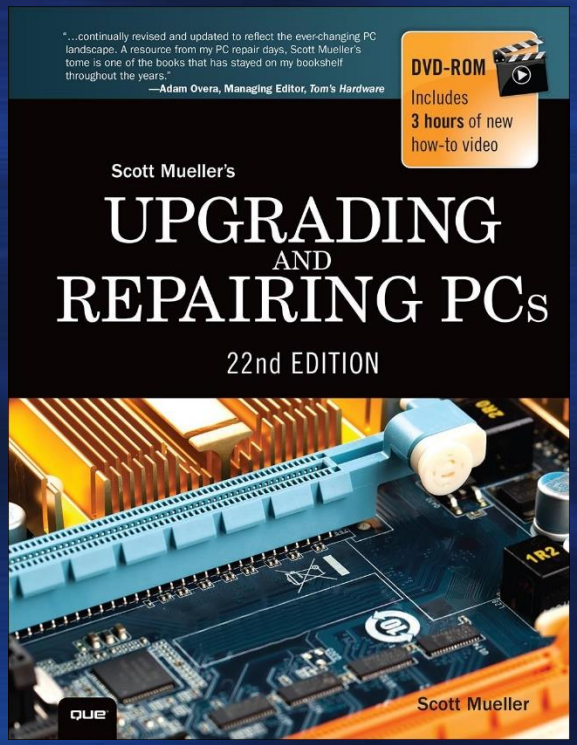
- Baruch, Z. F., *Input/Output Systems*, MEGA, Cluj-Napoca, 2020, ISBN 978-606-020-242-4

# Bibliography (2)




- Rosch, Winn L., *Hardware Bible*, Sixth Edition, Que Publishing, 2003, ISBN 0-7897-2859-1

# Bibliography (3)





- Mueller, Scott, *Upgrading and Repairing PCs*, 22nd Edition, Que Publishing, 2015, ISBN 0-13-405774-0

# Contents of the Lecture

- 1. Introduction
- 2. Methods for I/O Operations
- 3. Computer Buses
- 4. Expansion Modules for Embedded Systems
- 5. Computer Displays
- 6. Graphics Adapters
- 7. Optical Discs

# 1. Introduction

- I/O Systems
- Structure of an I/O System
- I/O Modules

# I/O Systems (1)

- I/O System (IOS): performs the transfer of information between the main memory and the external environment of the computer system
  - External information media
  - Other computer systems
- The computer system's performance depends on the relationship between:
  - Processor and memory
  - Processor and I/O devices

# I/O Systems (2)

- The *access time* and *transfer rate* of I/O devices affect the overall performance of the system
- *CPU execution time* – does not include the time waiting for I/O operations or running other tasks
  - Ignores I/O operations
- A more appropriate performance metric: *response time*

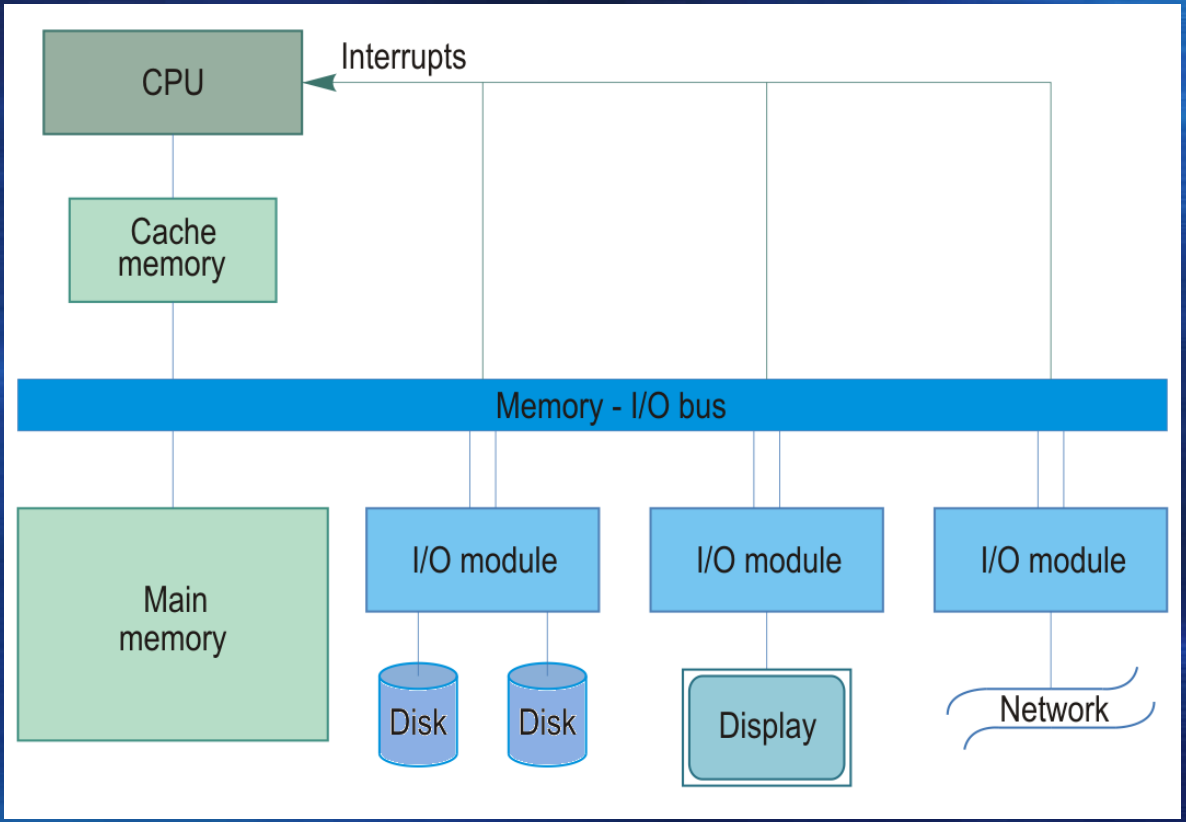
# I/O Systems (3)

- Ignoring the IOS reduces the system's global performance
- Example:
  - Assume a difference of 10% between the CPU execution time and response time
  - The CPU speed increases by a factor of 10, neglecting the I/O system
  - Amdahl's Law: a speedup of only 5 times is achieved

# 1. Introduction

- I/O Systems
- Structure of an I/O System
- I/O Modules

# Structure of an I/O System (1)




Structure of a computer system and a typical I/O system

# Structure of an I/O System (2)

- Peripheral devices are not connected directly to the system bus for the following reasons:
  - There are many types of peripherals, with various methods of operation
  - The data transfer rate of peripherals can be much lower than that of memory and CPU
  - Peripherals use different data formats and word lengths than the CPU

# 1. Introduction

- I/O Systems
- Structure of an I/O System
- I/O Modules

# I/O Modules (1)

- An I/O module (I/O controller) performs the following:
  - Controls the external devices
  - Transfers data between those devices and main memory and/or CPU registers
- An internal interface: to the CPU and main memory
- An external interface: to the peripheral device

# I/O Modules (2)

- Functions and main requirements for an I/O module:
  - Control and timing
  - Communication with the CPU
  - Communication with the external devices
  - Data buffering
  - Error detection

# I/O Modules (3)

- Control and timing
  - During any period of time, the CPU may communicate with one or more external devices
  - Internal resources must be shared among several activities
  - Function to coordinate the flow of data between internal resources and external devices

# I/O Modules (4)

- Communication with the CPU includes:
  - Command decoding
    - Commands → signals on the control bus
    - Parameters → on the data bus
  - Data transfer between the CPU and the I/O module over the data bus
  - Status reporting
    - An I/O module may be busy with the execution of the previous command → *BUSY* signal
  - Address recognition for each peripheral

# I/O Modules (5)

- Communication with the external devices
  - Performed using control, status, and data signals
- Data buffering
  - For most peripheral devices, the transfer rate is low compared to that between main memory and CPU
  - Data transferred from main memory are buffered by the I/O module and sent to the peripheral device at its data rate

# I/O Modules (6)

- Error detection
  - Errors should be reported to the CPU
  - Mechanical and electrical malfunctions
  - Accidental changes of the data transmitted between the device and I/O module
  - Error-detecting and error-correcting codes
    - Parity bit
    - CRC (*Cyclic Redundancy Check*)
    - ECC (*Error Correcting Code*)

# Summary

- For users, response time is a more appropriate performance metric than CPU execution time
- The performance of IOS significantly affects the global performance of the computer system
- Peripheral devices are connected to the system bus via I/O modules

# Concepts, Knowledge

- Input/output system
- CPU execution time
- Response time
- I/O module (I/O controller)
- Functions of an I/O module
- CRC, ECC codes