HUMBOLDT-UNIVERSITÄT ZU BERLIN
INSTITUT FÜR INFORMATIK


# COMPUTER ARCHITECTURE

**Lecture 1**

# INTRODUCTION

Sommersemester 2002

Leitung: Prof. Dr. Miroslaw Malek

*www.informatik.hu-berlin.de/rok/ca*

# RECHNERARCHITEKTUR SOMMERSEMESTER 2002

Leitung: Prof. Dr. Miroslaw Malek
Lehrstuhl: Rechnerorganisation und Kommunikation,
Rudower Chaussee 25, Haus IV, 2. Stock

| | | | | |
|---|---|---|---|---|
| Vorlesung: | Mo | 16 -18 | UL 6, 3038 | M. Malek |
| | Mi | 10 -12 | UL 6, 3038 | |
| Übungen: | Mo | 12 -14 | DOR 24, 111 | P. Ibach |
| | Mo | 14 -16 | DOR 24, 311 | P. Ibach |
| | Mi | 12 -14 | DOR 24, 311 | K. Wolter |
| | Mi | 12 -14 | DOR 24, 403 | S. Sommer* |
| | Mi | 14 -16 | DOR 24, 311 | K. Wolter |

* (Studierende, die die VL Technische Informatik 1 nicht besucht haben, u. a. Magister 2. HF, schreiben sich bitte in diese Übungsgruppe ein)

| | | |
|---|---|---|
| Termine: | 1. Zwischenklausur | 29.05.02 |
| | 2. Aufgaben | zweiwöchentlich |
| | 3. Projekt-Arbeit | Abgabe 03.07.02 |
| | 4. Projektpresentation | 08-10.7.02 |
| | 5. Abschlussklausur | 22.07.02 |

*weitere Infos unter www.informatik.hu-berlin.de/rok/ca*

# LITERATUR

## English


- V.C. Hamacher, Z.G. Vranesic, S. Zaky, *Computer Organization,* McGr.-Hill/96 4. ed.
- J.L. Hennessy and D. A. Patterson, *Computer Architecture: a Quantitative Approach,* Morgan Kaufmann, 1998, 2. ed., auch in Deutsch: J.L. Hennessy, D. A. Patterson, *Rechnerarchitektur: Analyse, Entwurf, Implementierung, Bewertung,* Vieweg, 1994
- A.S. Tanenbaum, *Computer Organization,* Prentice-Hall 1999 (4. ed.), auch in Deutsch: *Computer Architektur*, Prentice-Hall, 1999
- J.P. Hayes, *Computer Architecture and Organization,* McGraw-Hill, 1998 (3rd ed.)
- M.M. Mano, *Computer Systems Architecture,* Prentice Hall, 1993
- H.S. Stone, *High-Performance Computer Architecture,* Addison-Wesley, 1987
- H.P. Messmer, *The Indispensable Pentium Book*, Addison-Wesley, 3rd ed., 1997
- R.Y. Kasin, *Advanced Computer Architecture, A System Design Approach*, Pr.-Hall, 96
- W. Stallings, *Computer Organization and Architecture,* 1999 (5. ed)
- M.R. Zargham, *Computer Architecture (Simple and Parallel Systems)*, Pr.- Hall, 1995
- J. Y. Hsu, *Computer Architecture: Software Aspects, Coding and Hardware*, CRC 2001


## Deutsch


- W. Giloi, *Rechnerarchitektur, Paperback, 1993*
- H. Liebig, T. Flik: *Rechnerorganisation: Prinzipien, Strukturen, Algorithmen*, Spring. 93

# COURSE OBJECTIVES

***The future of computing is the computer that talks, listens, sees and learns.***

**"Bill Gates".**

- **Introduction to Computer Architecture**
  - Terminology
  - Basic concepts
  - Principles
- **Single Processor Architecture**
  - Specification
  - Designs
  - Implementation
- **Other Concepts**
  - Memory hierarchy
  - Pipelining
  - Parallel processing
- **Brief Introduction to...**
  - Parallel computing
  - Distributed computing
  - Networking

# COMPUTER ARCHITECTURE

1. **Introduction and Background**
   - World of computers
   - Brief history of digital computers
   - Functional units
   - Basic operational concepts and definitions
   - Performance and cost
2. **Addressing Methods and Machine Programming Concepts**
   - Addresses/Addressing modes
   - Simple I/O programming
   - Pushdown stacks vs. Register organization
3. **Instruction Set Design**
   - Op-codes
   - Minimal instruction sets
   - CISC vs. RISC
4. **The Processing Unit and Microprogrammed Control**
   - Fundamental concepts
   - Sequencing of control signals
   - Concepts of microprogramming
   - Microinstruction formats
   - Hardwired vs. microprogrammed control units

5. **Arithmetic Unit (Unit Operator)**
   - Number representations
   - Addition, subtraction, multiplication, division algorithms
   - Serial, parallel, decimal, floating-point arithmetic units
   - Logic functions
6. **The Memory and its Hierarchy**
   - Processor vs. memory speed
   - Classes of memory systems, memory hierarchies
   - Cost vs. access time
   - Random access memory (RAM)
   - Read-only memory (ROM)
   - Caches/Virtual memories
   - Address translation techniques
7. **Software**
   - System software
   - Languages and translations
   - Loaders/Linkers
8. **Input/Output**
   - I/O problem
   - I/O addressing
   - Data transfer
   - Direct memory access (DMA) channel
   - Selector channel, multiplexor channel and block multiplexor channel

## 9. Computer Communication

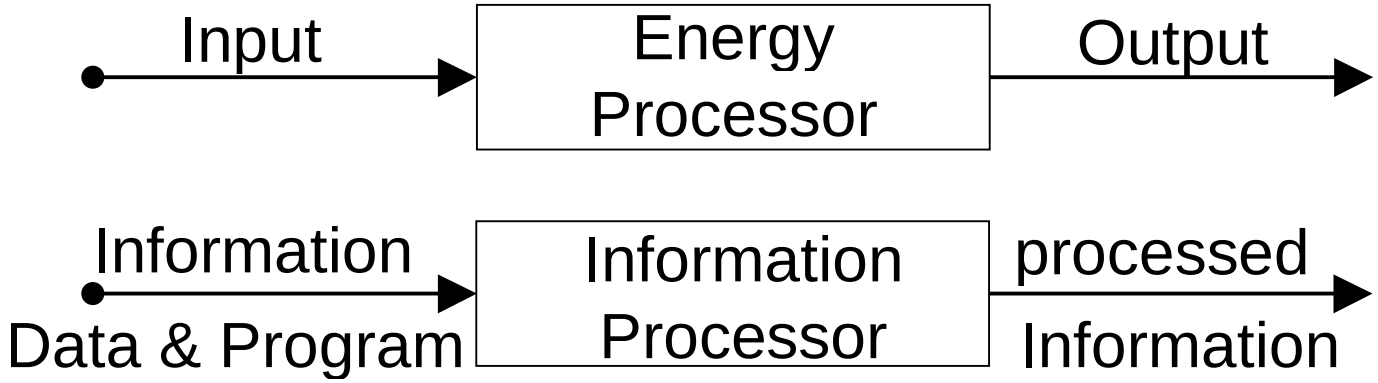
- Parallel computer networks
- Local area networks
- Wide area networks

## 10. Computer Classes, Multicomputer and Special-Purpose Systems

- Supercomputers, mainframes, workstations and PC‘s
- Multiprocessor systems
- Parallel processing
- Distributed systems
- Pipelining
- Real-time systems
- Responsive systems
- Reconfigurable systems
- Fault-tolerant computers
- Computer networks
- Impact of microprocessors on computer organization
- Simulation of computer systems

## 11. Latest Developments and Trends in Computer Organization: The 21st Century Computing

# COMPUTER




HUMAN BEING

⇩

ABACUS

⇩

MECHANICAL COMPUTER

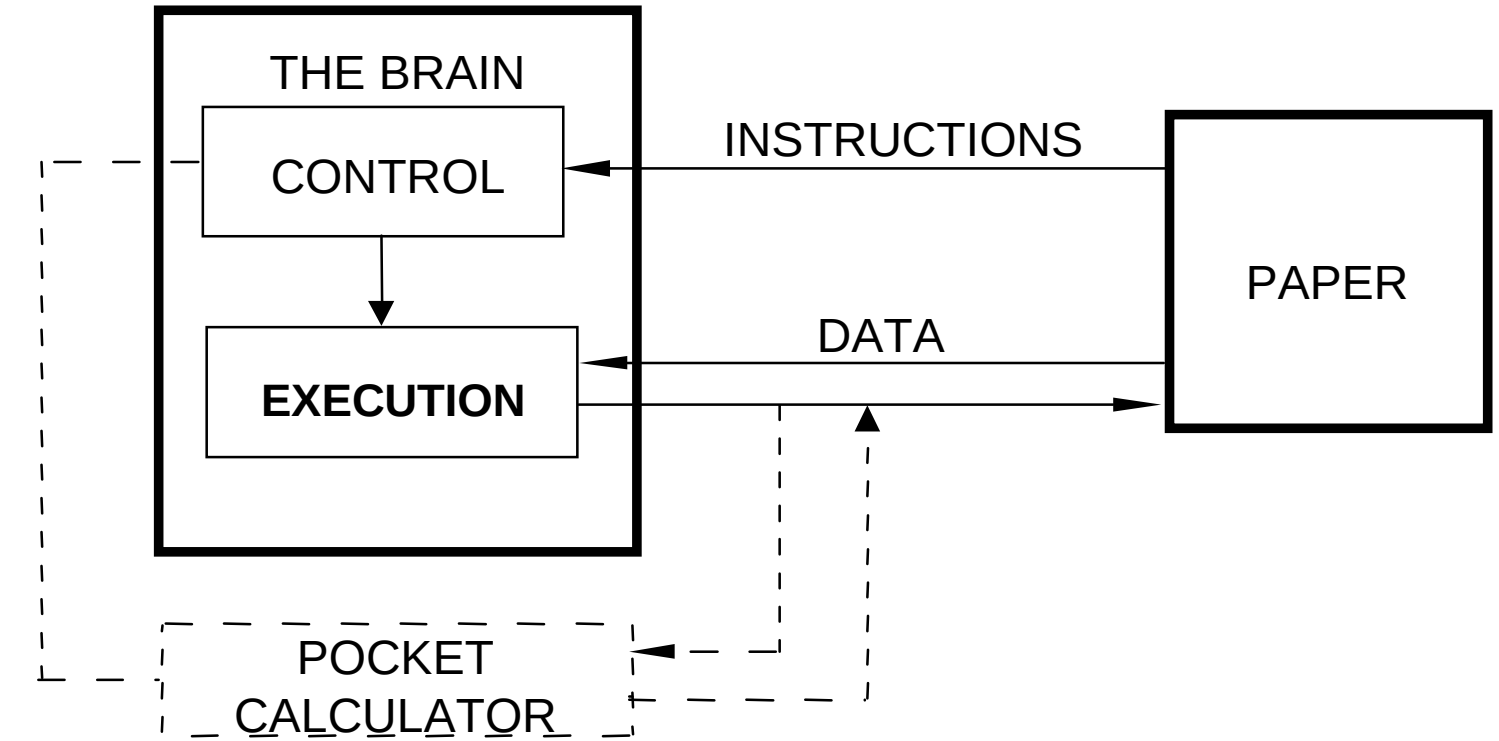
⇩

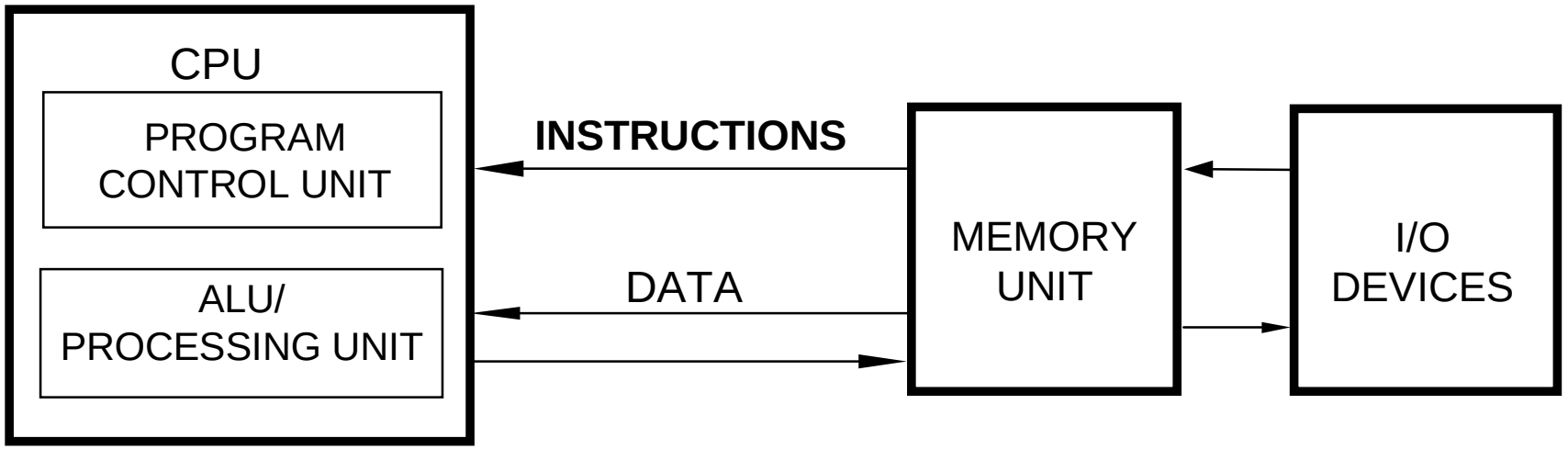
ELECTRONICAL COMPUTER

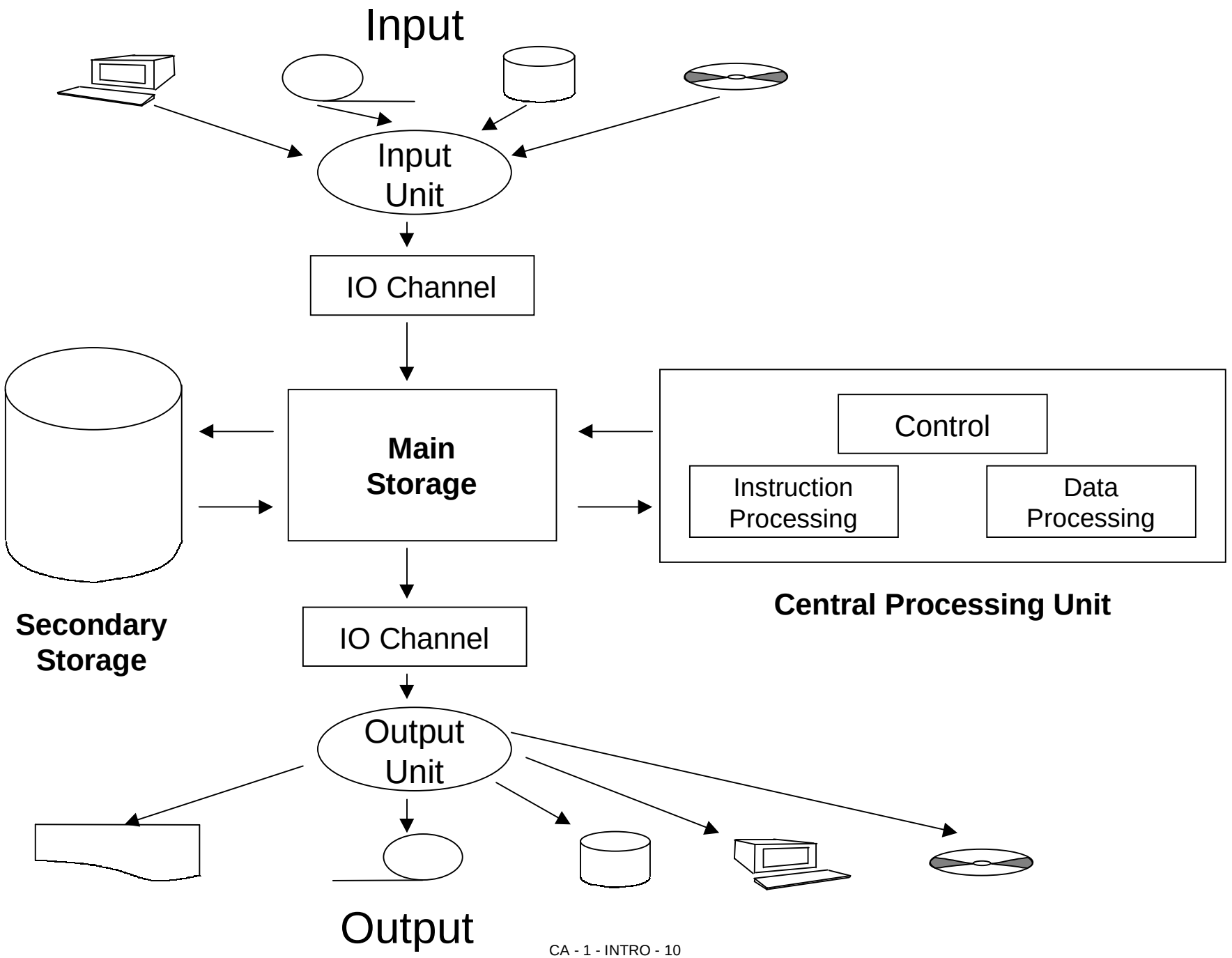
⇩

COMPUTER

TWO GOALS: 1. SPEED, 2. ACCURACY


THE BRAIN
CONTROL
EXECUTION
INSTRUCTIONS
DATA
PAPER
POCKET
CALCULATOR


CPU
PROGRAM
CONTROL UNIT
ALU/
PROCESSING UNIT
INSTRUCTIONS
DATA
MEMORY
UNIT
I/O
DEVICES


Input
Input Unit
IO Channel
Main Storage
Control
Instruction Processing
Data Processing
Central Processing Unit
Secondary Storage
IO Channel
Output Unit
Output

## DEFINITIONS

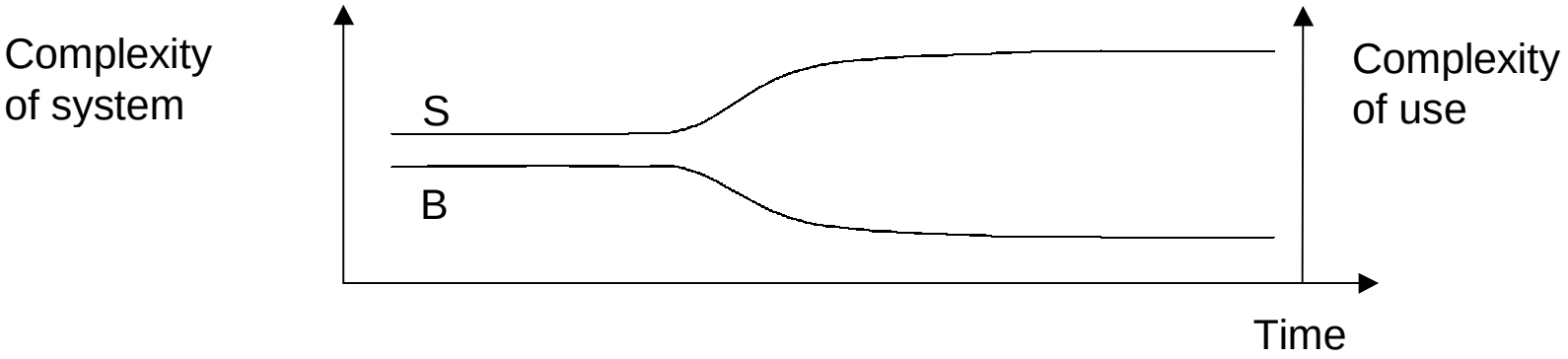
COMPUTER ARCHITECTURE IS:

- the Art - to fulfill needs of users
- Structuretheorie - how to build computer systems
- the Art - to form the design to provide a useful interface

**ARCHITECTURE and ORGANIZATION**

| the perspective of Programmers | the perspective of the Ingenieurs |
|---|---|

**THE PARADOX OF COMPLEXITY**



# COMPUTER ARCHITECTURE - DEFINITIONS

- Art of determining the needs of the user of a structure and then designing to meet those as effectively as possible within economic and technological constraints. Includes engineering considerations so that the design will be economical and feasible; the emphasis is upon the needs of the user, whereas in engineering the emphasis is upon the needs of the fabricator. (Planning a Computer System, W. Buchholz ed., McGraw-Hill, 1962, p. 5)

- To describe the attributes of a system as seen by the programmer, i.e. The conceptual structure and functional behavior as distinct from the organization of the data flow and controls, the logical design and the physical implementation. (Architecture of IBM System/360, IBM J.R.&D., April 1964, pp.87-101, G. M. Amdahl, G. A. Blaauw, F. P. Brooks)

- The art of designing a machine that will be a pleasure to work with. This art, one cannot call it a science, is one step more abstract than that of a logical designer, which in turn is abstracted from the study of electronic circuits. (Computer Architecture, C. C. Foster van Nostrand Reingold, 1970)

# COMPUTER ARCHITECTURE – DEFINITIONS (2)

- The study of Computer Architecture is the study of the organization and interconnection of components of computer systems. Computer architects construct computers from basic buildings blocks such as memories, arithmetic units and buses. From those building blocks the Computer Architecture can construct any number of different types of computers. (Introduction to Computer Architecture, H. S. Stone ed., SRA, Chicago, 1975, p.3)

- The overall design of the system level, the kinds of instructions available, the kinds of data used, the mechanics available for altering the flow of control, the memory organization and addressing, the relationship between instruction set and memory organization, the method by which the virtual machine is implemented - the topics are sometimes loosely grouped together under the imprecise labels of Computer Organization or Computer Architecture. (Structured Computer Organization, A. S. Tanenbaum, P-H, 1976, p.15)

- The study of the structure, behavior and design of computers. (Computer Architecture and Organization, J. P. Hayes, McGraw-Hill, 1978, p.XI)

# COMPUTER ARCHITECTURE – DEFINITIONS (3)

- Computer Architecture is a term commonly used to denote the organization and design of digital computers. (Computer System Architecture, M. M. Mano, P-H, 1976, p.XI)

- The design of the system specifications at a general or subsystem level is called Computer Architecture. (Principles of Digital Computer Design, Vol. 1, A. M. Abd-Alla, A. C. Meltzer, P-H, 1976, p. 187)

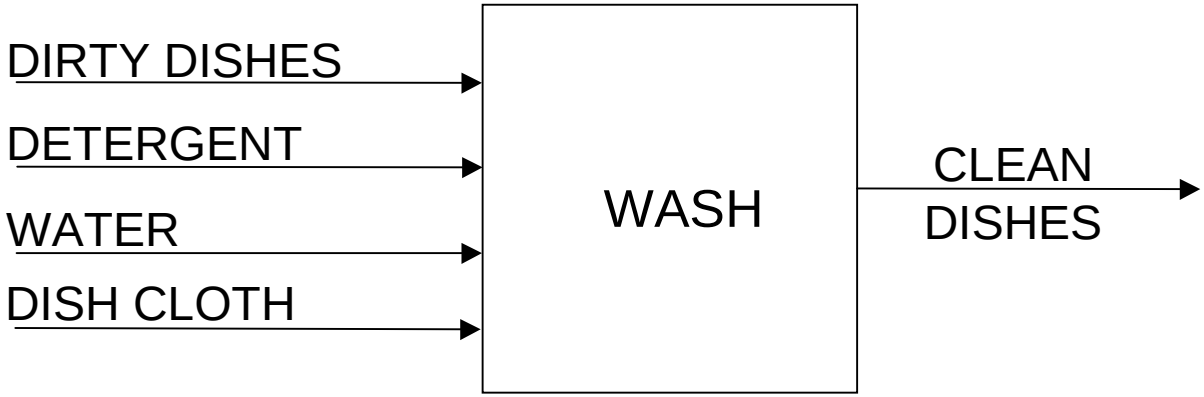
- The “blue-print“ used to build the machine. It is the instruction set and the I/O connection capabilities. Machines with the same architecture can execute the same programs and can have the same I/O devices connected to them. The organization of a machine is usually shown by a block diagram. (Developments and Directions in Computer Architecture, Computer, Aug. 1978, pp. 54-67, G. J. Lipovski, K. L. Doty)

- Art, science and/or engineering of computer structure, organization, implementation and performance evaluation. (Computer Systems Architecture, J. C. Baer, Computer Science Press, 1980, p. VII)

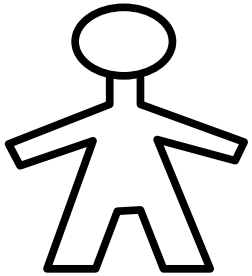
- Summary by W. Stallings: Computer architecture refers to those attributes of a system visible to a programmer, or put another way, those attributes that have a direct impact on the logical execution of a program. Computer organization refers to the operational units and their interconnections that realize the architectural specifications. (Computer Organization and Architecture, 4. ed., 1996, p.3)

# UNDERSTANDING OF PROCESSES AND SYSTEMS

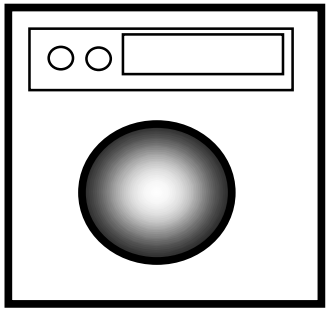
## A PROCESS ABSTRACTION

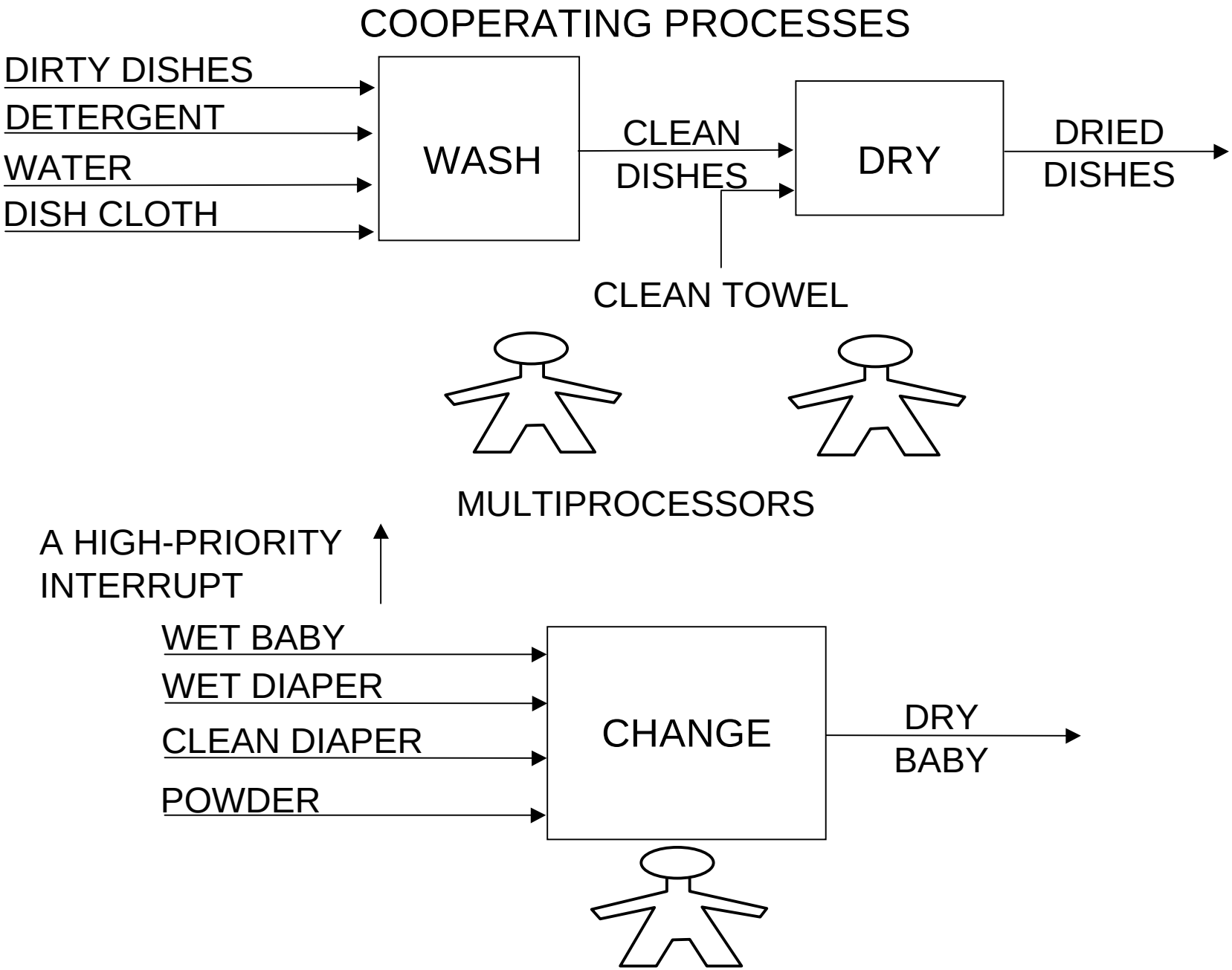



## A PROCESSOR



OR




COOPERATING PROCESSES
DIRTY DISHES
DETERGENT
WATER
DISH CLOTH
WASH
CLEAN
DISHES
DRY
DRIED
DISHES
CLEAN TOWEL
MULTIPROCESSORS
A HIGH-PRIORITY
INTERRUPT
WET BABY
WET DIAPER
CLEAN DIAPER
POWDER
CHANGE
DRY
BABY

# NEW CONCEPTS

PROCESS (TASK)
PROCESS INPUTS
PROCESS OUTPUTS
PROCESS EXECUTION
PROCESS INITIATION
PROCESS SUSPENSION
PROCESS TERMINATION

COOPERATING PROCESSES
CONCURRENT PROCESSES
PARALLEL PROCESSES
INTERRUPT
PROCESS PRIORITY
PROCESS RESUMPTION

PROCESSOR

SYSTEM

UNIPROCESSOR

MULTIPROCESSOR

PROCESSOR ASIGNMENT