Chapter 1 Introduction

Jin-Fu Li

Department of Electrical Engineering National Central University Jungli, Taiwan

Outline

- Classes of Computing Applications
- Hierarchical Layers of Hardware and Software
- Contents of the Desktop Computer
- Organization and Architecture
- Structure and Function

Computing Applications

Desktop computers

A computer designed for use by an individual, usually incorporating a graphics display, keyboard, and mouse

Servers

- A computer used for running larger programs for multiple users often simultaneously and typically accessed only via a network
- The modern form of what was once mainframes, minicomputers, supercomputers, and are usually accessed only via a network
- They provide for greater expandability of both computing and input/output capacity than desktop computers

Embedded computers

 A computer inside another device used for running one predetermined application or collection of software

Market Share of Distinct Processors



Advanced Reliable Systems (ARES) Lab.

Applications of Embedded Computers

- > Embedded computers are ubiquitous, yet invisible
 - They are found in our automobiles, appliances, and many other places



[Source: B. Parhami, UCSB]

Embedded Computers in A Car



tor to the brake pedal, the system goes straight into crisis mode. To address the worry about software bugs and electrical snafus, first voiced when by-wire controls appeared in aircraft many years ago, Mercedes also includes a hydraulic backup system for the front wheels, forgoing any savings in weight or cumbersome connections that the system might have provided. The braking system links seamlessly to a stability control system and an active suspension system, which helps keep all parts of the car on the ground when taking a corner. That ride-smoothing savvy comes with a powerful 5-L V8, which is to be followed in about a year by a juiced-up model equipped with a 5.5-L, turbocharged version of the engine. Mercedes says the new engine in its US \$98 000 automobile will be half again as powerful, at around 450 hp (335 kW).

The brake-by-wire system in the SL 500 relies on electronic signals relayed from the brake pedal to the actuator to the electrohydraulic brakes at each wheel.

[Source: IEEE, Spectrum, 2003]

Advanced Reliable Systems (ARES) Lab.

Digital Computer Subsystems



[Source: B. Parhami, UCSB]

Advanced Reliable Systems (ARES) Lab.

Evolution of Digital Computers

First generation

Vacuum tube computers (1945~1953)

Second generation

Transistorized computers (1954~1965)

Third generation

Integrated circuit computers (1965~1980)

Fourth generation

Very large scale integrated (VLSI) computers (1980~2000)

Fifth generation

System-on-chip (SOC) computers (2000~)

IC Production

The manufacturing process for an integrated circuit (IC)



[Source: B. Parhami, UCSB]

Moore's Law

Trends in processor performance and DRAM memory chip capacity



Advanced Reliable Systems (ARES) Lab.

Pitfalls of Computer Technology Forecasting

- "DOS addresses only 1 MB of RAM because we cannot imagine any applications needing more." Microsoft, 1980
- "640K ought to be enough for anybody." Bill Gates, 1981
- "Computers in the future may weigh no more than 1.5 tons." Popular Mechanics
- "I think there is a world market for maybe five computers." Thomas Watson, IBM Chairman, 1943
- "There is no reason anyone would want a computer in their home." Ken Olsen, DEC founder, 1977
- "The 32-bit machine would be an overkill for a personal computer." Sol Libes, *ByteLines*

[Source: B. Parhami, UCSB]

The Computer Level Hierarchy



Hierarchical Layers of HW/SW



System software: Software that provides services that are commonly useful, including operating systems, compilers, and assemblers.

Types of System Software

- There are many types of system software, but two types of systems software are central to every computer system today
 - An operating system and a compiler
- Operating system: supervising program that manages the resources of a computer for the benefit of the programs that run on the machine
 - An operating system interfaces between a user's program and the hardware and provides a variety of services and supervisory functions. For example, among the most important functions are
 - Handling basic input and output operations
 - □ Allocating storage and memory
 - Providing for sharing the computer among multiple applications using it simultaneously

Compiler and Assembler

- Compiler: a program that translates high-level language statements into assembly language statements
- Assembly language: a symbolic representation of machine instructions
- Assembler: a program that translates a symbolic version of instructions into the binary version
 - For example, the programmer would write add, A, B and the assembler would translate this notation into 1000110010100
- High-level programming language: a portable language such as C, Fortran, or Java composed of words and algebraic notation that can be translated by a compiler into assembly language

Relationships among Programs and Languages



Contents of the Desktop Computer

- Motherboard: a plastic board containing packages of integrated circuits or chips, including processor, cache, memory, and connectors for I/O devices such as networks and disks
- Integrated circuit: a device combining dozens to millions of transistors
- Memory: the storage area in which programs are kept when they are running and that contains the data needed by the running programs
- Central processor unit (CPU): also called processor. The active part of the computer, which contains the datapath and control and which adds numbers, tests numbers, signals I/O devices to activate, and so on

Advanced Reliable Systems (ARES) Lab.

Contents of the Desktop Computer

- Datapath: the component of the processor that performs arithmetic operations
- Control: the component of the processor that commands the datapath, memory, and I/O devices according to the instructions of the program
- Dynamic random access memory (DRAM): memory built as an integrated circuit, it provides random access to any location
- Cache memory: a small, fast memory that acts as a buffer for a slower, larger memory

Organization & Architecuture

- 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?
- > All Intel x86 family share the same basic architecture
- This gives code compatibility
 - At least backwards
- Organization differs between different versions

Von Neuman and Harvard Architectures

Von Neumann Architecture

Harvard Architecture



Advanced Reliable Systems (ARES) Lab.

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

Functional View of the Computer



Advanced Reliable Systems (ARES) Lab.

Operations – Data Movement



Operations – Data Storage



Operations – Processing from/to Storage



Operations – Processing from Storage to I/O



Advanced Reliable Systems (ARES) Lab.

Computer Structure – Top Level



Advanced Reliable Systems (ARES) Lab.

Computer Structure – The CPU



Computer Structure – The Control Unit



Why Study Computer Organization



© 2005 IEEE International Solid-State Circuits Conference

[Source: Prof. Wei Huang, NCTU]

Advanced Reliable Systems (ARES) Lab.