Introduction and Course Overview

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CS 502: Computers and Communications

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Introduction

- What do we mean by a computer?
  - Different types: desktop, servers, embedded devices
  - Different uses: automobiles, graphics, finance, genomics…
  - Different manufacturers: Intel, Apple, IBM, Microsoft, Sun…
  - Different underlying technologies and different costs!
- Analogy: Consider a course on “automotive vehicles”
  - Many similarities from vehicle to vehicle (e.g., wheels)
  - Huge differences from vehicle to vehicle (e.g., gas vs. electric)
- Best way to learn:
  - Focus on a specific instance and learn how it works
  - While learning general principles and historical perspectives

Components of Computing Systems

- Hardware: Circuit boards, chips, disk drives, peripherals, wires, etc.
- Software: Programs (sequences of instructions for the computer to carry out)
- Data (information in its digital form)

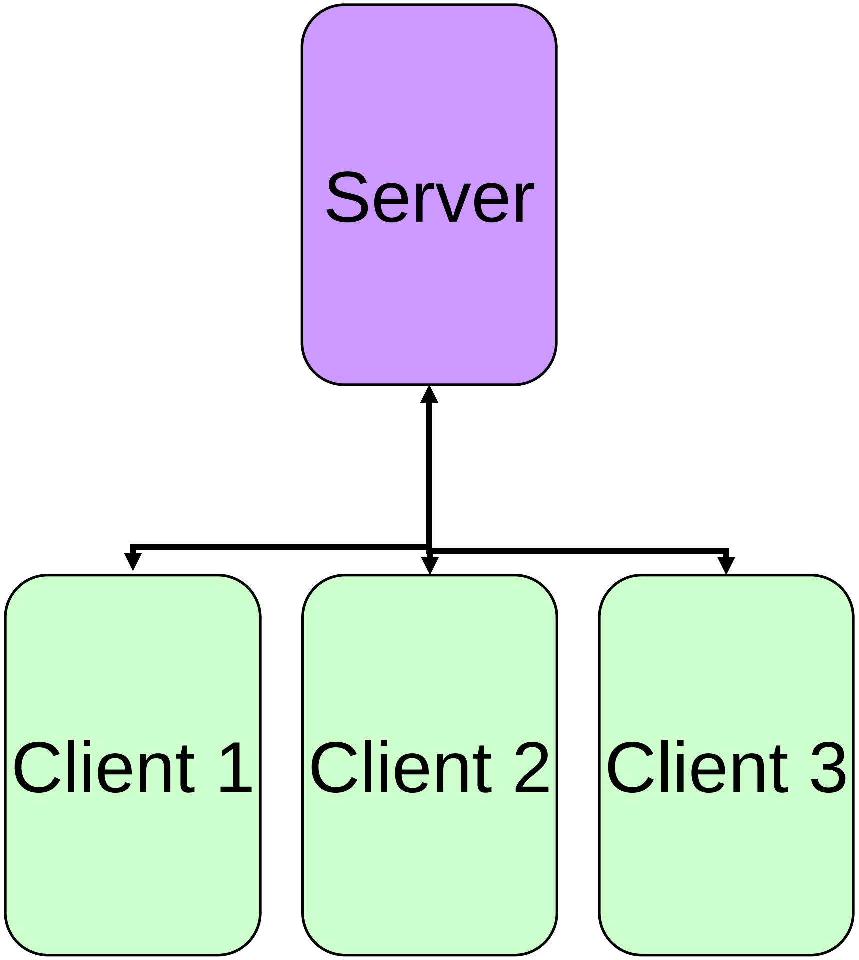
The Processor

Our primary focus in the first half of the course: The processor (datapath and control)

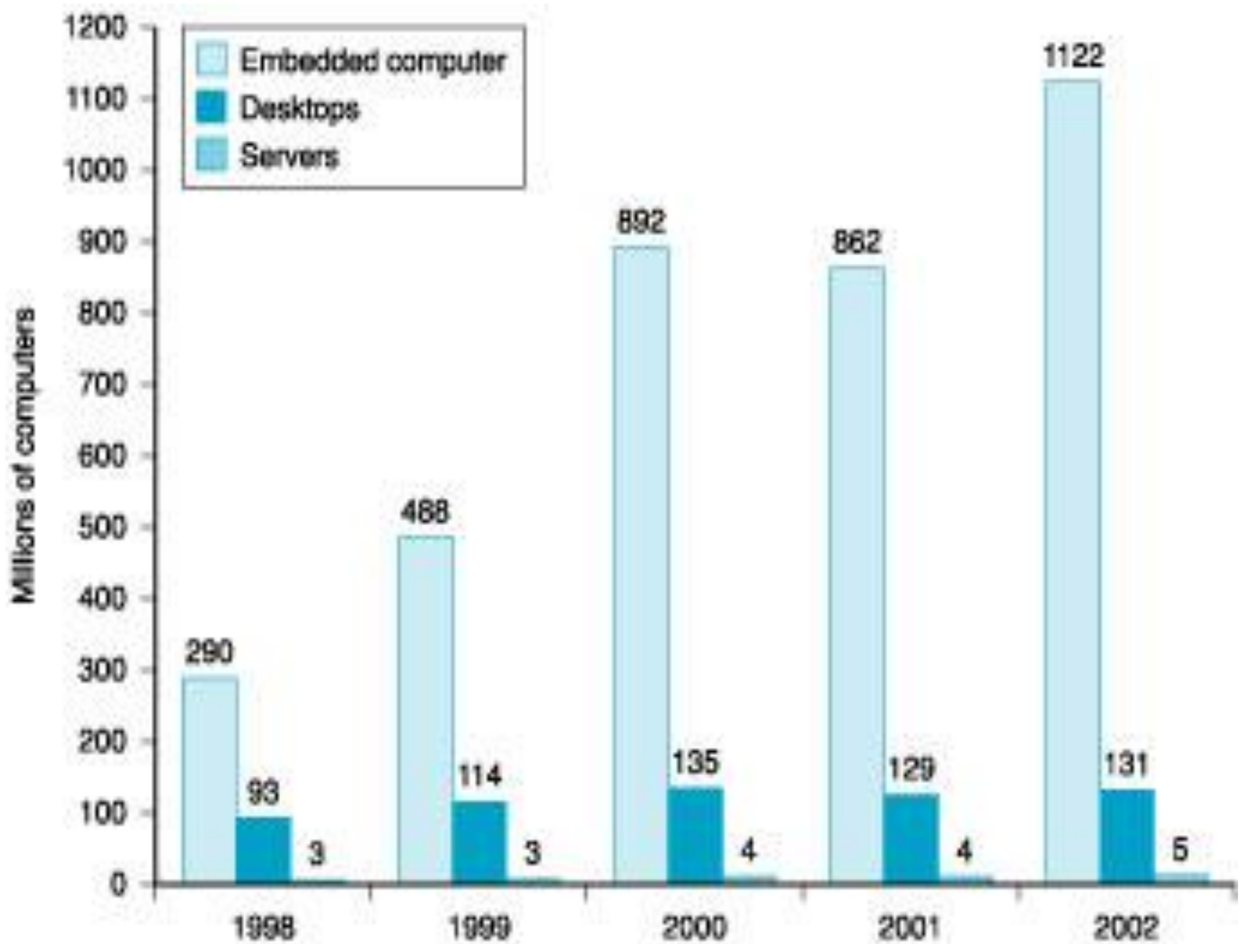
- implemented using millions of transistors
- Impossible to understand by looking at each transistor
- We need...

Abstraction…

…removes or hides complex details.



Distinct Processors Sold



How do computers work?

- Need to understand abstractions such as:
  - Applications software
  - Systems software
  - Assembly Language
  - Machine Language
  - Architectural Issues: i.e., Caches, Virtual Memory, Pipelining
  - Sequential logic, finite state machines
  - Combinational logic, arithmetic circuits
  - Boolean logic, 1s and 0s
  - Transistors used to build logic gates (CMOS)
  - Semiconductors/Silicon used to build transistors
  - Properties of atoms, electrons, and quantum dynamics

- So much to learn!

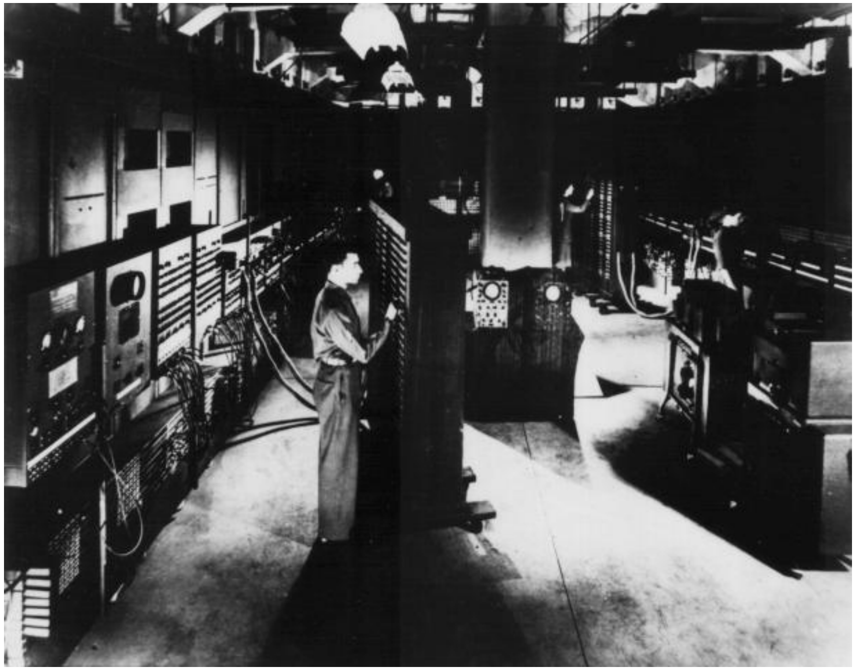
Instruction Set Architecture

- A very important abstraction
  - interface between hardware and low-level software
  - standardizes instructions, machine language bit patterns, etc.
  - advantage: *different implementations of the same architecture*
  - disadvantage: *sometimes prevents using new innovations*

- Modern instruction set architectures:
  - IA-32, PowerPC, MIPS, SPARC, ARM, and others

Historical Perspective

- ENIAC built in World War II was the first general purpose computer
  - Used for computing artillery firing tables
  - 80 feet long by 8.5 feet high and several feet wide
  - Each of the twenty 10 digit registers was 2 feet long
  - Used 18,000 vacuum tubes, weighed 30 tons
  - Performed 1900 additions per second

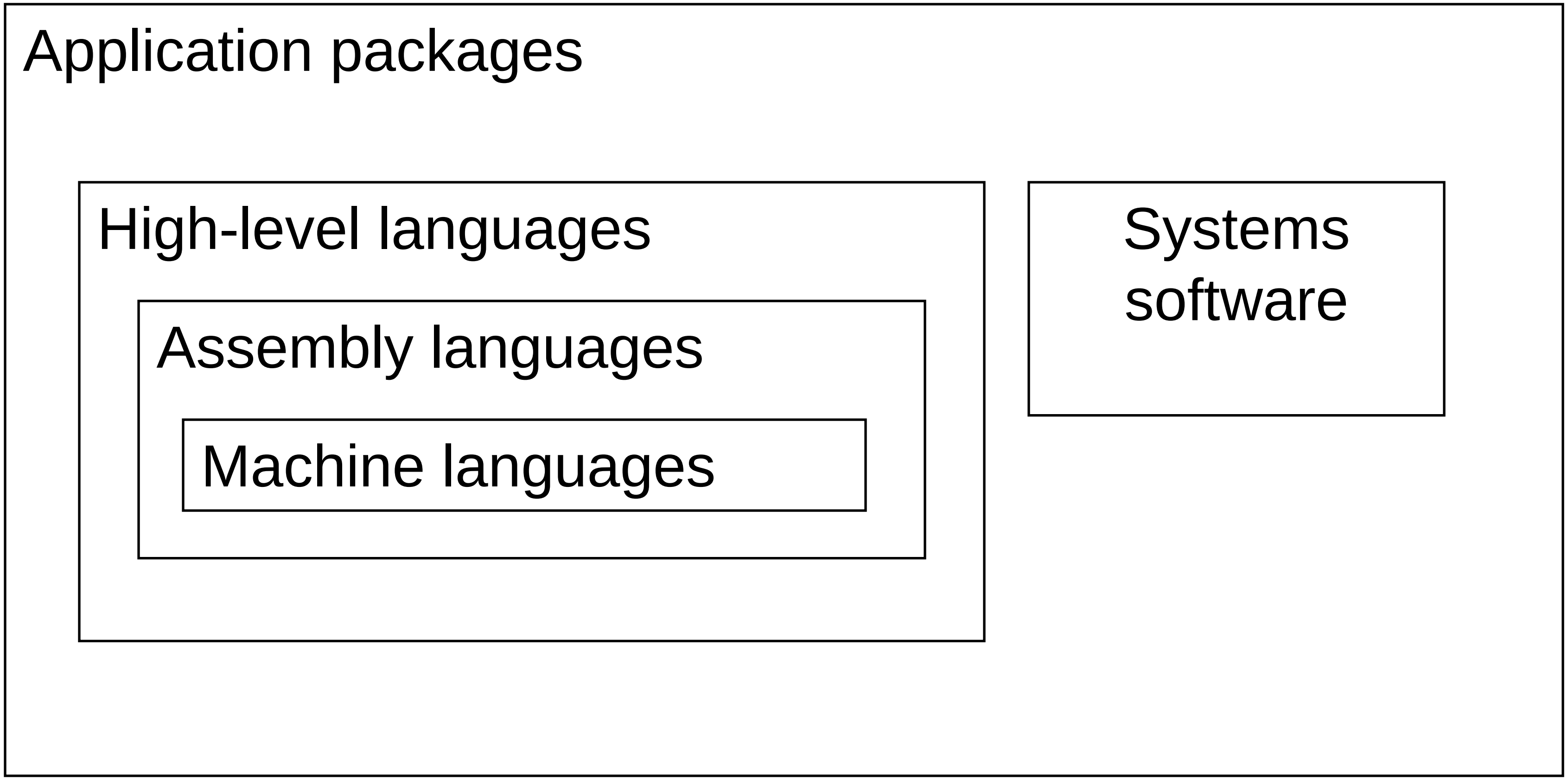


–**Since then:**

Moore's Law:

transistor capacity doubles every 18-24 months

Layers of Software



Memory

- *Volatile/primary/main (DRAM: Dynamic Random Access Memory)*
- *Nonvolatile/secondary (magnetic/hard disk)*

Communicating with Other Computers

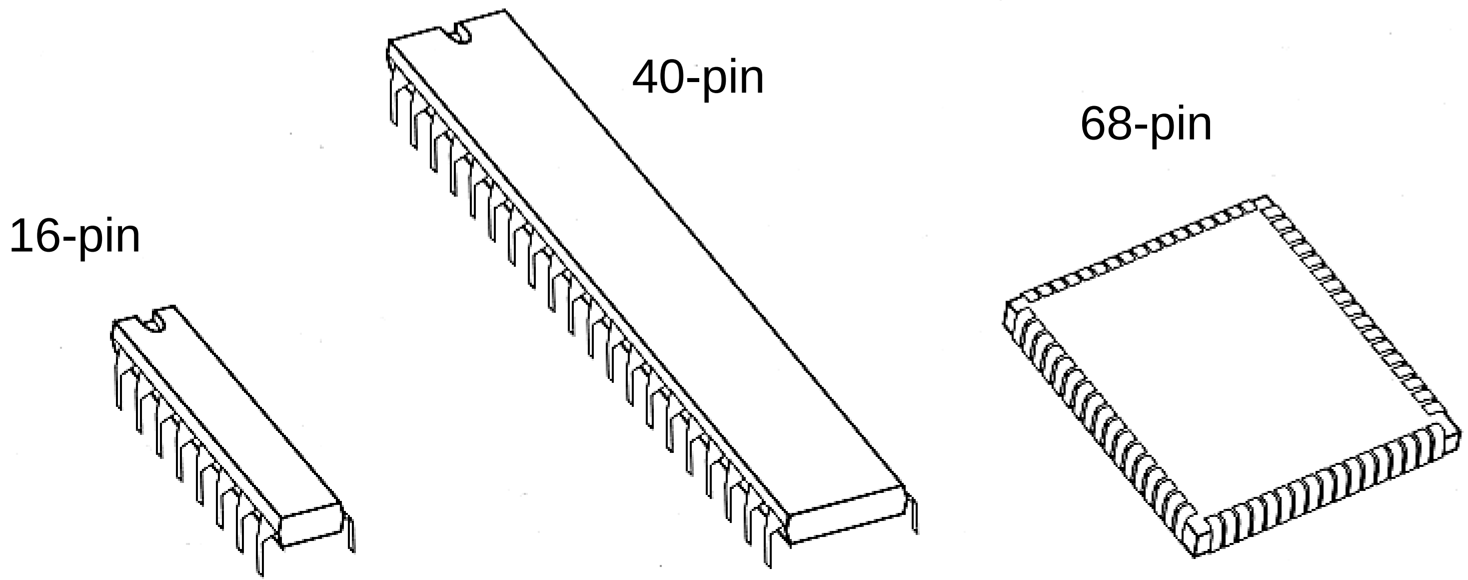
- *Resource sharing*
- *Nonlocal (remote) access*

- Local area network (LAN)
- Wide area network (WAN)

Technologies for Building Processors and Memory

- **Transistor**: An on/off switch controlled by an electric signal
- **Vacuum tube**: Consists of a hollow glass tube about 5 to 10 cm long from which as much air has been removed as possible; Uses an electron beam to transfer data
- **Very large scale integrated (VLSI) circuit**: A device containing hundreds of thousands to millions of transistors

Integrated Circuits (Chips)



SSI: 1 to 10 gates   LSI: 100 to 100,000 gates   VLSI: more than 100,000 gates
MSI: 10 to 100 gates

SSI: Small-Scale Integration
MSI: Medium-Scale Integration
LSI: Large-Scale Integration
VLSI: Very-Large-Scale Integration

Manufacturing Chips

- **Silicon crystal ingot**: A rod composed of a silicon crystal that is between 8 and 12 inches in diameter and about 12 to 24 inches long
- **Wafer**: A slice from a silicon ingot no more than 0.1 inch thick, used to create chips
- **Dies**: The individual rectangular sections that are cut from a wafer, more informally known as chips
- **Yield**: The percentage of good dies from the total number of dies on the wafer
- **Bonding**: The process of connecting dies to I/O pins
- **CMOS** (complementary metal oxide semiconductor): Does not directly consume power when idle