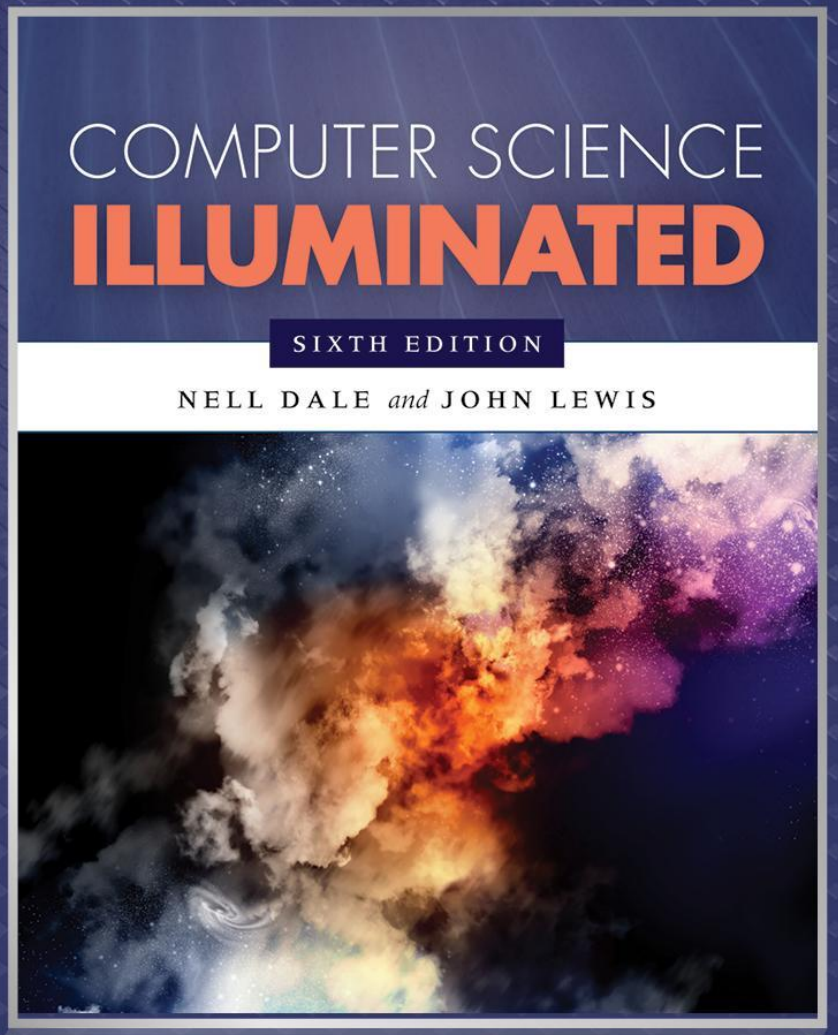
The Big Picture



Chapter Goals

- Describe the layers of a computer system
- Describe the concept of abstraction and its relationship to computing
- Describe the history of computer hardware and software
- Describe the changing role of the computer user
- Distinguish between systems programmers and applications programmers
- Distinguish between computing as a tool and computing as a discipline

Computing Systems

Computing systems are dynamic!

What is the difference between hardware and software?

Computing Systems

Hardware The physical elements of a computing system (printer, circuit boards, wires, keyboard…)

Software The programs that provide the instructions for a computer to execute

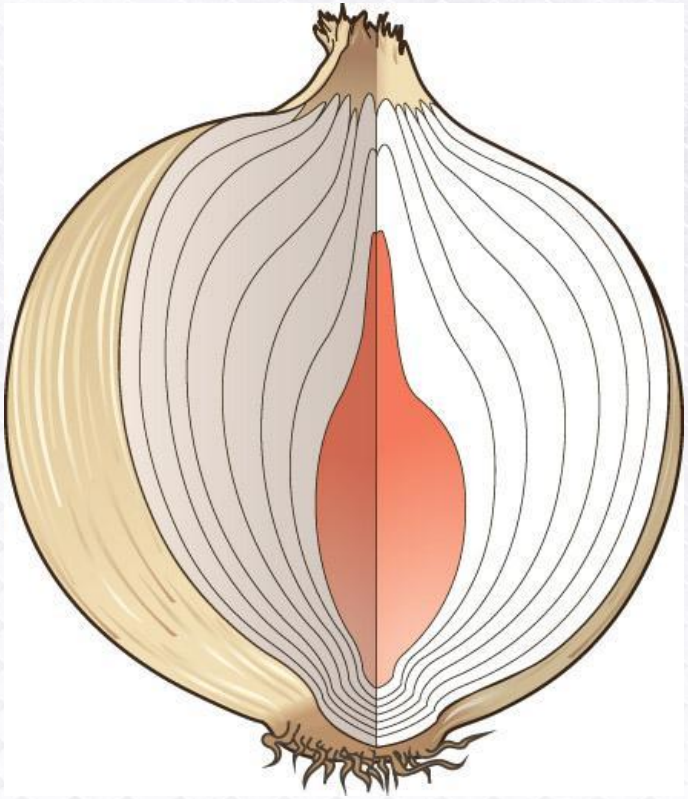


FIGURE 01.UN02: Computer Science Illuminated

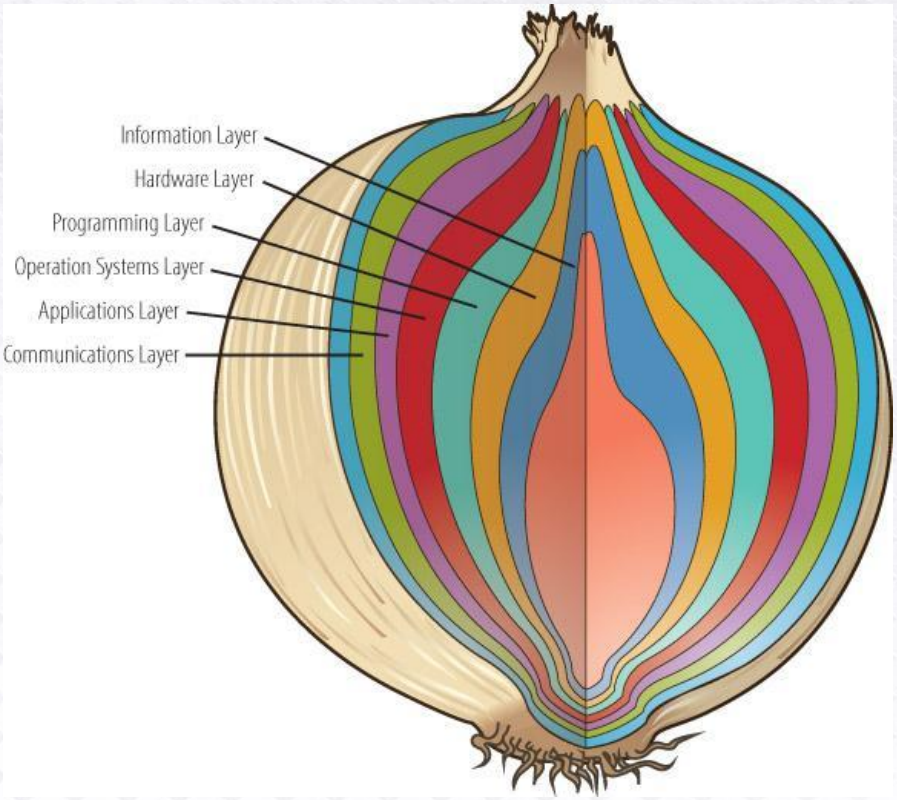


FIGURE 01.UN10: Computer Science Illuminated

Layers of a Computing System

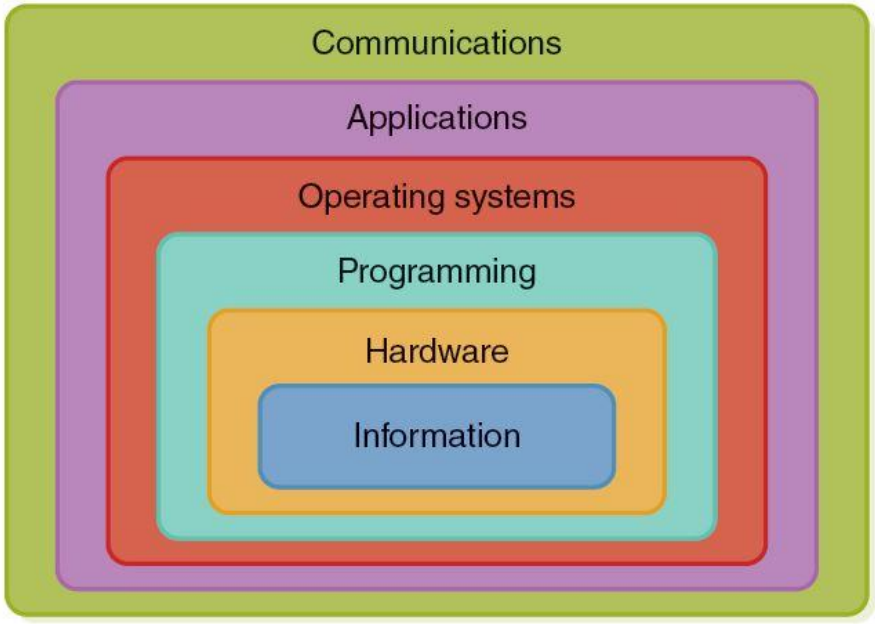
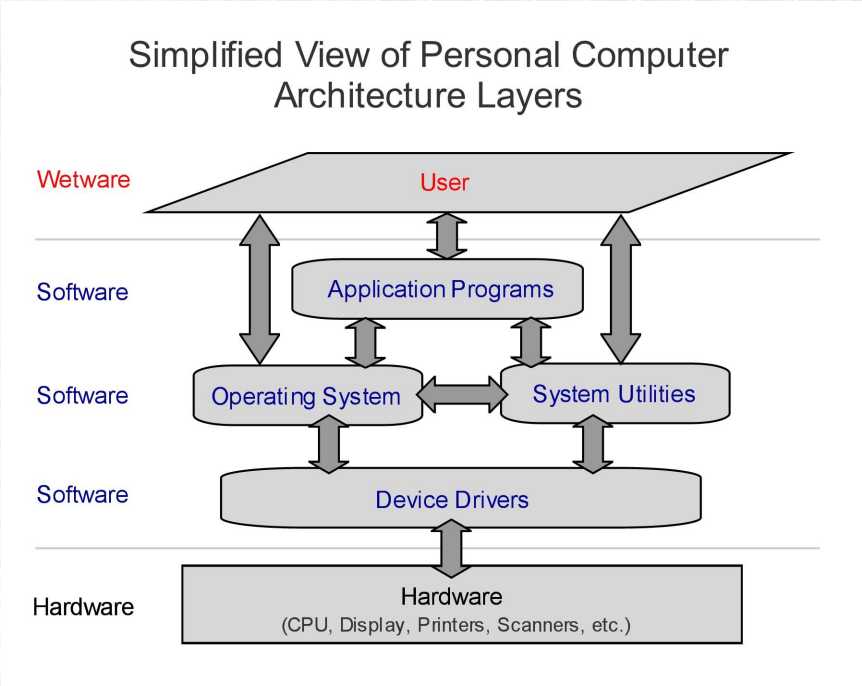


FIGURE 1.1 The layers of a computing system

Layers of a Computing System



*Taken from https://computerbasicsforluddites.wordpress.com/2013/10/13/pc-software-and-hardware-video/

Abstraction

A mental model that removes complex details

Or

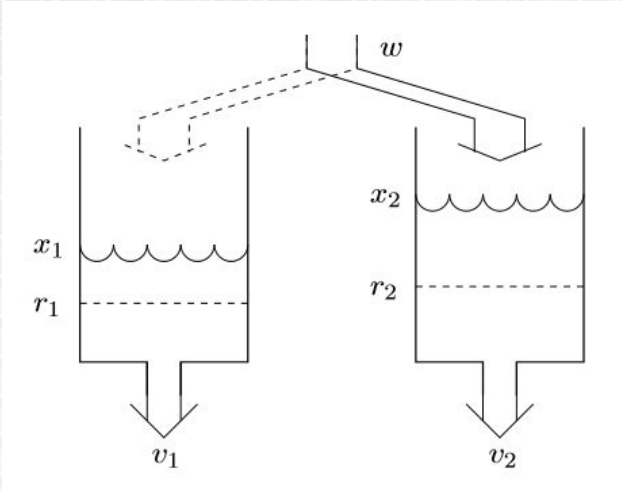
"The act or process of leaving out of consideration one or more properties of a complex object so as to attend to others."

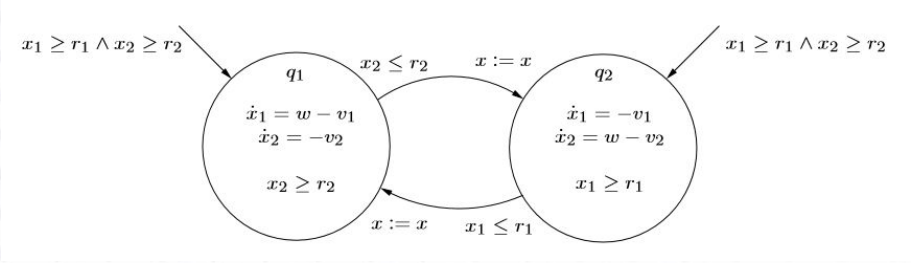
This is a key concept.

Internal and Abstract View

FIGURE 1.2 A car engine and the abstraction that allows us to use it

Internal and Abstract View





***From Lecture Notes on Hybrid Systems by John Lygeros**

History

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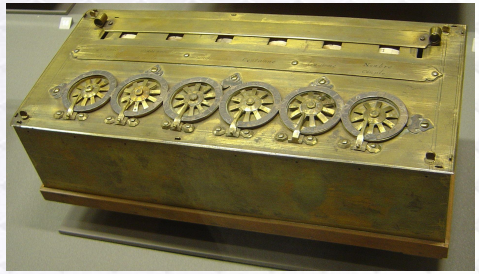
Early History of Computing

Abacus, ~2700BC

An early device to record numeric values

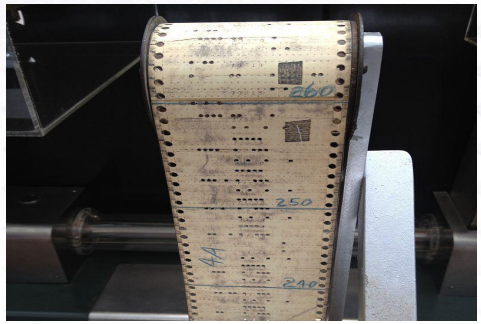
Blaise Pascal, 1645

Mechanical device to add, subtract, divide & multiply



Joseph Jacquard, 1801

Jacquard's Loom, the punched card



Charles Babbage, 1837

Analytical Engine (concept)

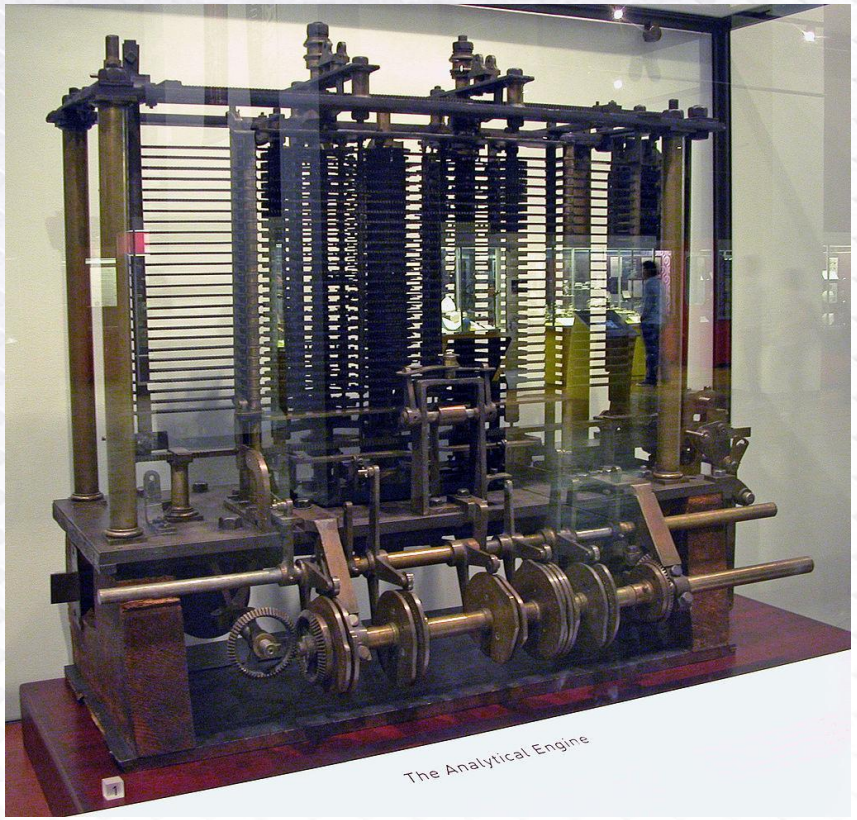
Early History of Computing

Charles Babbage, 1837

Analytical Engine (concept)

Integrated memory
Arithmetic and Logic Unit
Branches and Loops

Input via punch card
Output via printer



BOX 01.BOXUN02: Ada Lovelace, the First Programmer?

Courtesy of U.S. Army.

Early History of Computing

Ada Lovelace, 1840

First Programmer, the loop

Alan Turing, 1948

Turing Machine, Artificial Intelligence Testing

Harvard Mark I, ENIAC, UNIVAC I

Early computers launch new era in mathematics, physics, engineering and economics

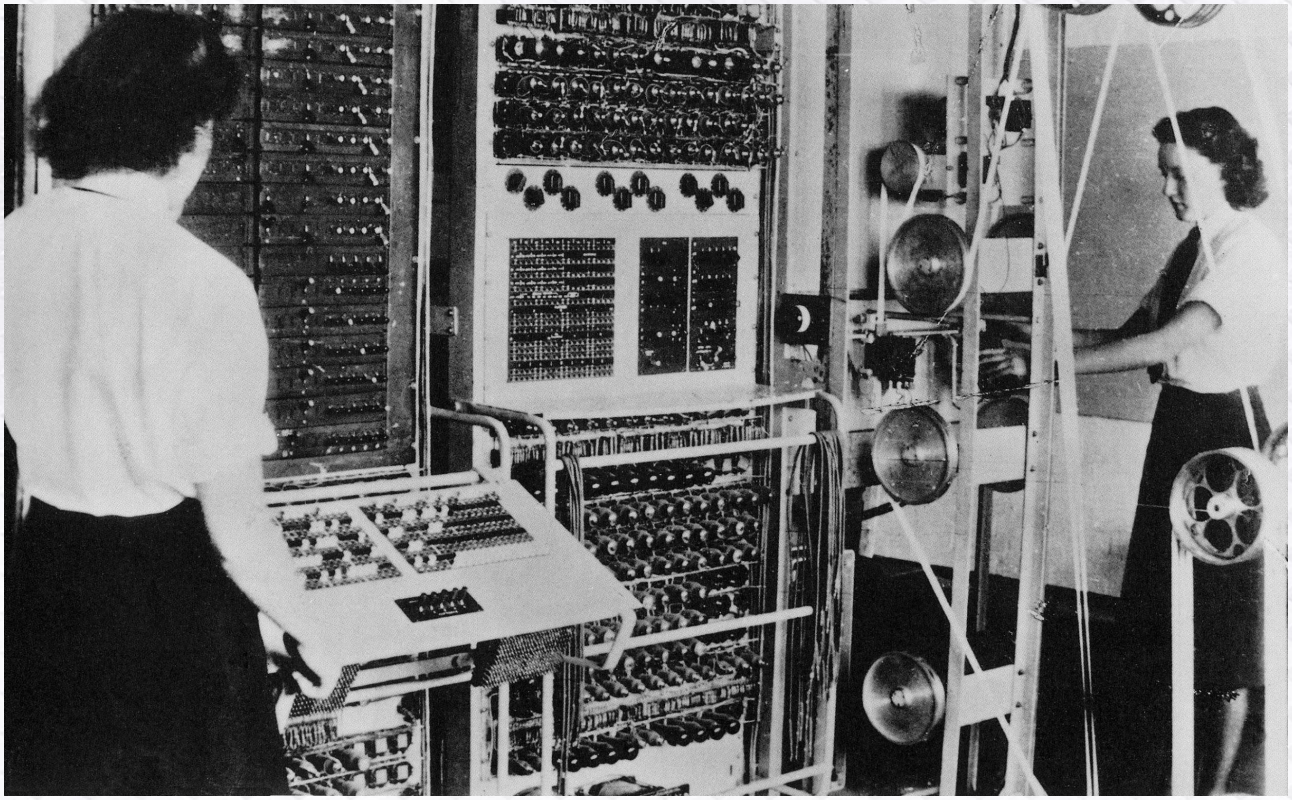


FIGURE 01.F04: The Colossus, the first all-programmable digital computer

© CBS/Landov

First Generation Hardware (1951-1959)

Vacuum Tubes

Large, not very reliable, generated a lot of heat

Magnetic Drum

Memory device that rotated under a read/write head

Card Readers and Magnetic Tape Drives

Sequential auxiliary storage devices

FIGURE 1.6 A vacuum tube

Second Generation Hardware (1959-1965)

Transistor

Replaced vacuum tube, fast, small, durable, cheap

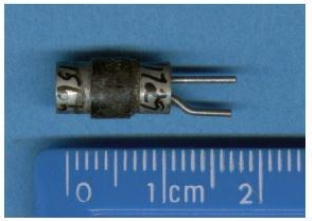


FIGURE 1.7 A transistor, which replaced the vacuum tube

Courtesy of Dr. Andrew Wylie

Magnetic Cores

Replaced magnetic drums, information available instantly

Magnetic Disks

Replaced magnetic tape, data can be accessed directly

Third Generation Hardware (1965-1971)

Integrated Circuits

Replaced circuit boards, smaller, cheaper, faster, more reliable

Transistors

Now used for memory construction

Terminal

An input/output device with a keyboard and screen

Fourth Generation Hardware (1971-?)

Large-scale Integration

Great advances in chip technology

PCs, the Commercial Market, Workstations

Personal Computers and Workstations emerge
New companies emerge: Apple, Sun, Dell …

Laptops, Tablet Computers, and Smart Phones

Everyone has his/her own portable computer

Parallel Computing and Networking

Parallel Computing

Computers rely on interconnected central processing and/or memory units that increase processing speed

Networking

Ethernet connects small computers to share resources
File servers connect PCs in the late 1980s

ARPANET, LANs and Internet

What's Next?

Quantum Computing

Utilising Quantum Mechanics to develop a computer which used quantum-bits (qubits)

Qubits

Replacing traditional bits which can either be 0 or 1 a qubit can represent both a zero and a one at the same time!

(Schrödinger's cat)

First Generation Software (1951-1959)

Machine Language

Computer programs written in binary (1s and 0s)

Assembly Languages and Translators

Programs written using mnemonics, which were translated into machine language

Programmer Changes

Programmers divide into two groups: application programmers and systems programmers

Assembly/Machine

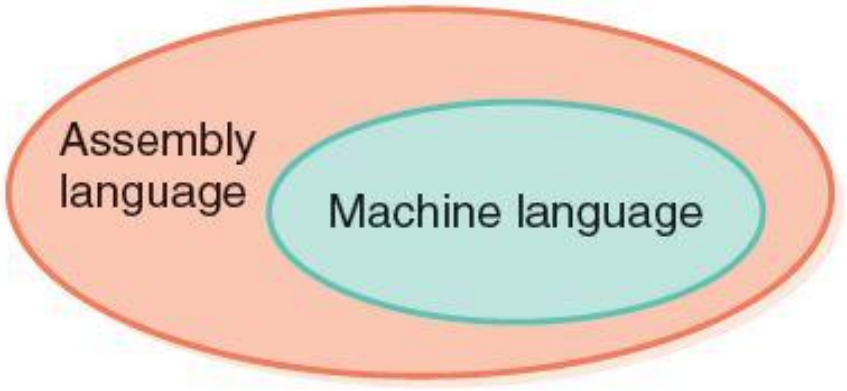


FIGURE 1.8 Layers of languages at the end of the first generation

Second Generation Software (1959-1965)

High-level Languages

English-like statements made programming easier: Fortran, COBOL, Lisp

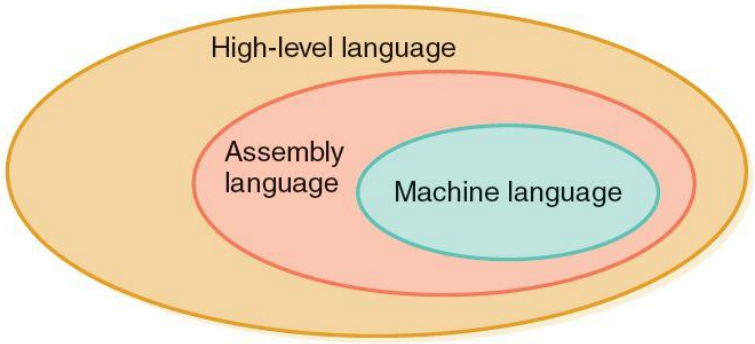


FIGURE 1.9 Layers of language at the end of the second generation

Third Generation Software (1965-1971)

Systems Software

Utility programs

Language translators

Operating system, which decides which programs to run and when

Separation between Users and Hardware

Computer programmers write programs to be used by general public (i.e., nonprogrammers)

Third Generation Software (1965-1971)

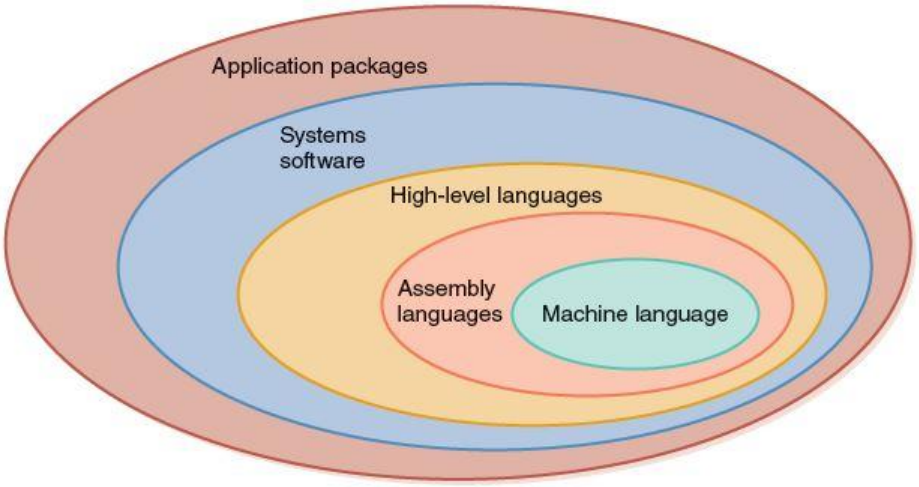


FIGURE 1.10 The layers of software surrounding the hardware continue to grow

Fourth Generation Software (1971-1989)

Structured Programming

Pascal

C++

New Application Software for Users

Spreadsheets

Word processors

Database management systems

Fifth Generation Software (1990- present)

Microsoft

Windows operating system and other Microsoft application programs dominate the market

Object-Oriented Design

Based on a hierarchy of data objects (i.e. Java)

World Wide Web

Allows easy global communication through the Internet

New Users

Today's user needs no computer knowledge

Predictions

“I think there is a world market for maybe five computers” – Thomas Watson, chair of IBM, 1943.

“There is no reason anyone would want a computer in their home” – Ken Olsen, 1977.

“I predict that the Internet … will go spectacularly supernova and in 1996 catastrophically collapse” – Bob Metcalfe, 1995.

“Remote shopping, while entirely feasible, will flop.” - Time Magazine, 1966.

Predictions

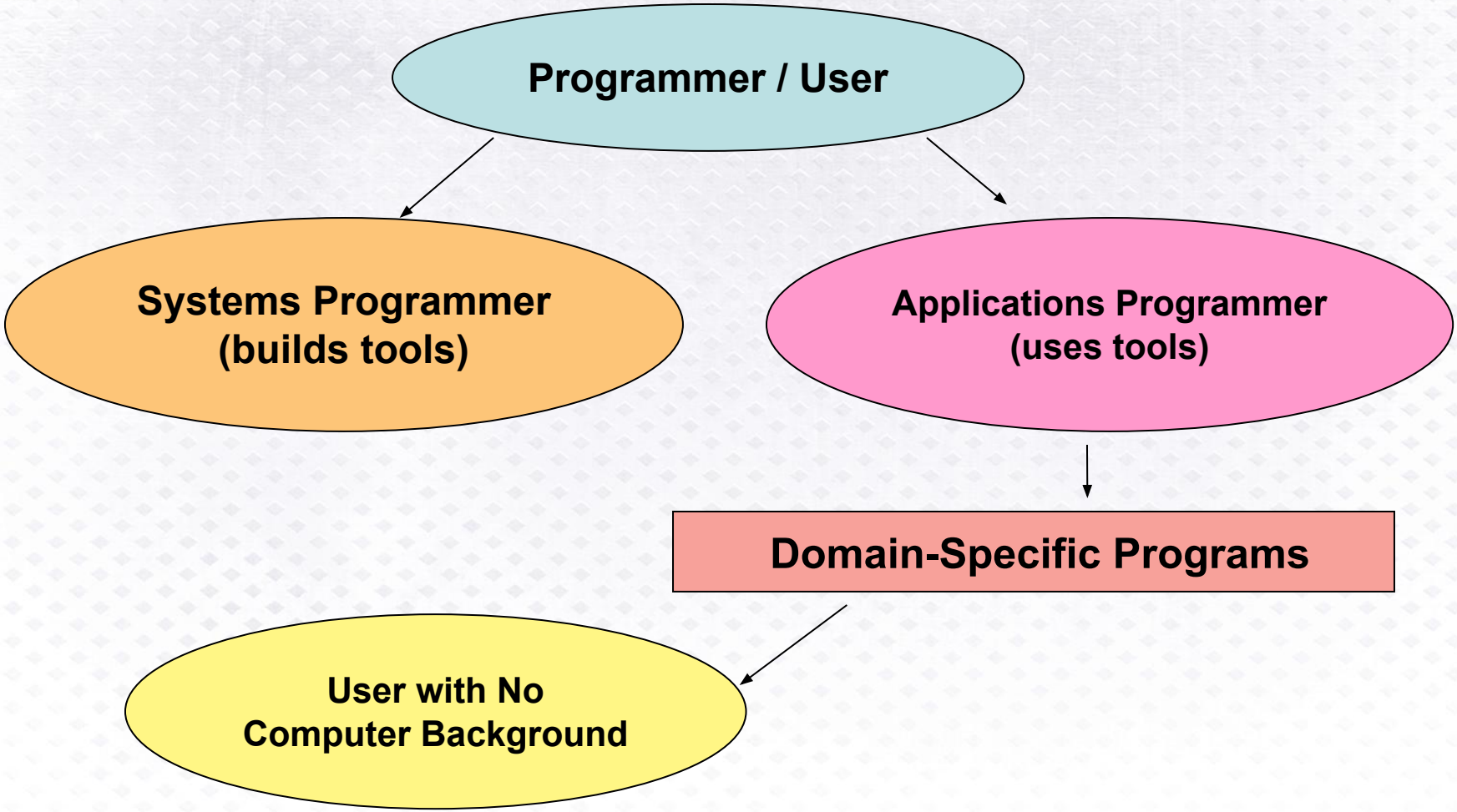
“There’s just not that many videos I want to watch.” - Steve Chen, co-founder of YouTube, 2005.

“Everyone’s always asking me when Apple will come out with a cell phone. My answer is, ‘Probably never.’” - The New York Times, 2006.

iPhone is released

“There’s no chance that the iPhone is going to get any significant market share.” - Steve Ballmer, Microsoft CEO, 2007.

Computing as a Tool



Computing as a Discipline

What can be (efficiently) automated?

Four Necessary Skills

- **Algorithmic Thinking**
- **Representation**
- **Programming**
- **Design**

Computing as a Discipline

What do you think?

Is Computer Science a mathematical, scientific, or engineering discipline?

Examples of Systems Areas

- Algorithms and Data Structures
- Programming Languages
- Architecture
- Operating Systems
- Software Engineering
- Human-Computer Communication

Examples of Application Areas

- Numerical and Symbolic Computation
- Databases and Information Retrieval
- Intelligent Systems
- Graphics and Visual Computing
- Net-Centric Computing
- Computational Science

Who am I?

Can you list three items on my resume?

Ethical Issues

Digital Divide

What disparity does the term "digital divide" describe?

What is the E-Rate program?

What is the One-Laptop-Per-Child program?

What additional challenge must developing nations face?

Do you know?

Who said the Analytical Engine "weaves algebraic patterns"?

Where did scientists build the first nanotube computer?

What computer company was launched in a garage?

What companies turned Jobs and Wozniak away?

Where is the Computer History Museum?

What is Room to Read?

When and where were the first CS Departments formed?