



CS10003: Programming & Data Structures

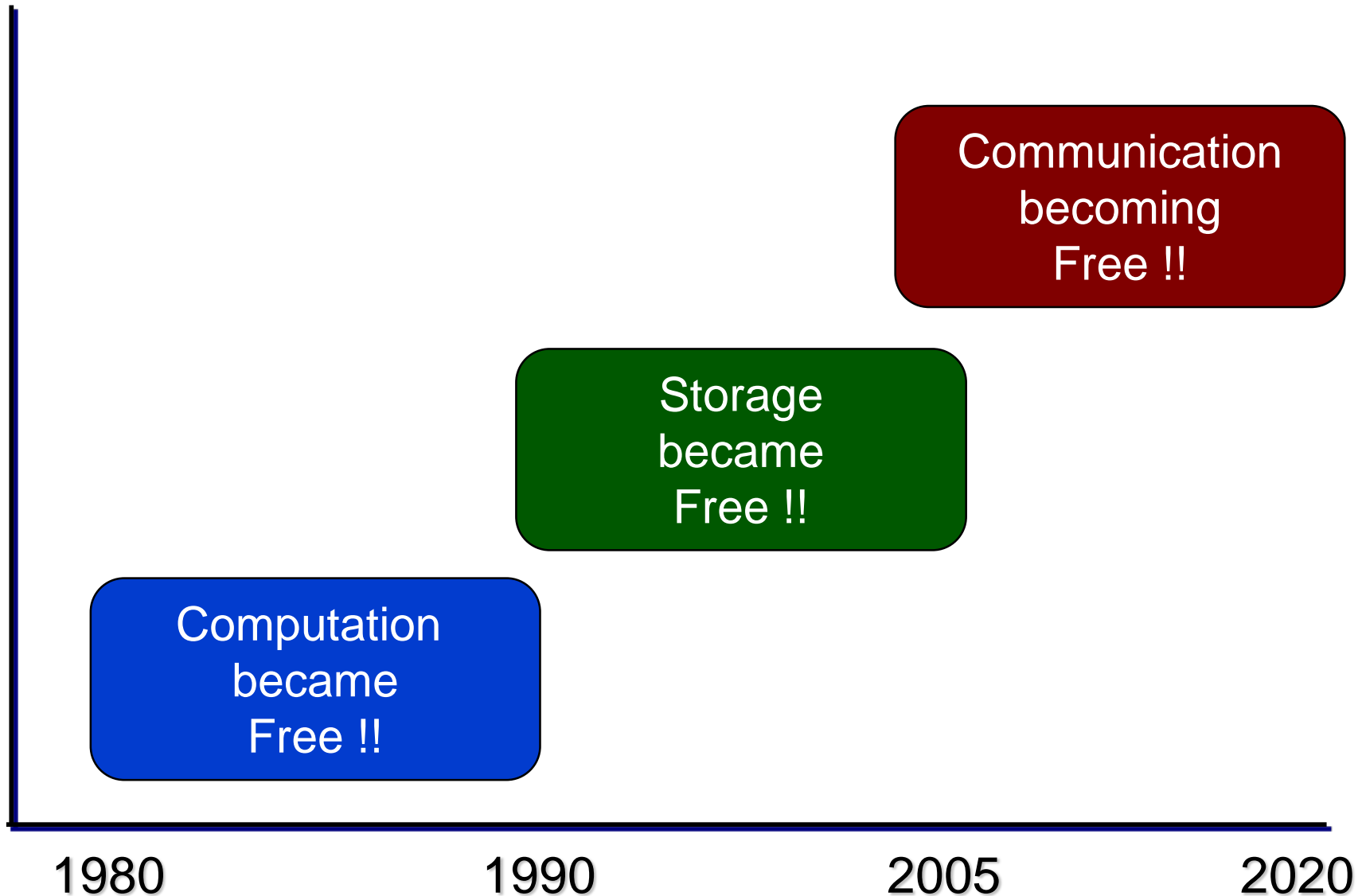
Dept. of Computer Science & Engineering
Indian Institute of Technology Kharagpur

Autumn 2020

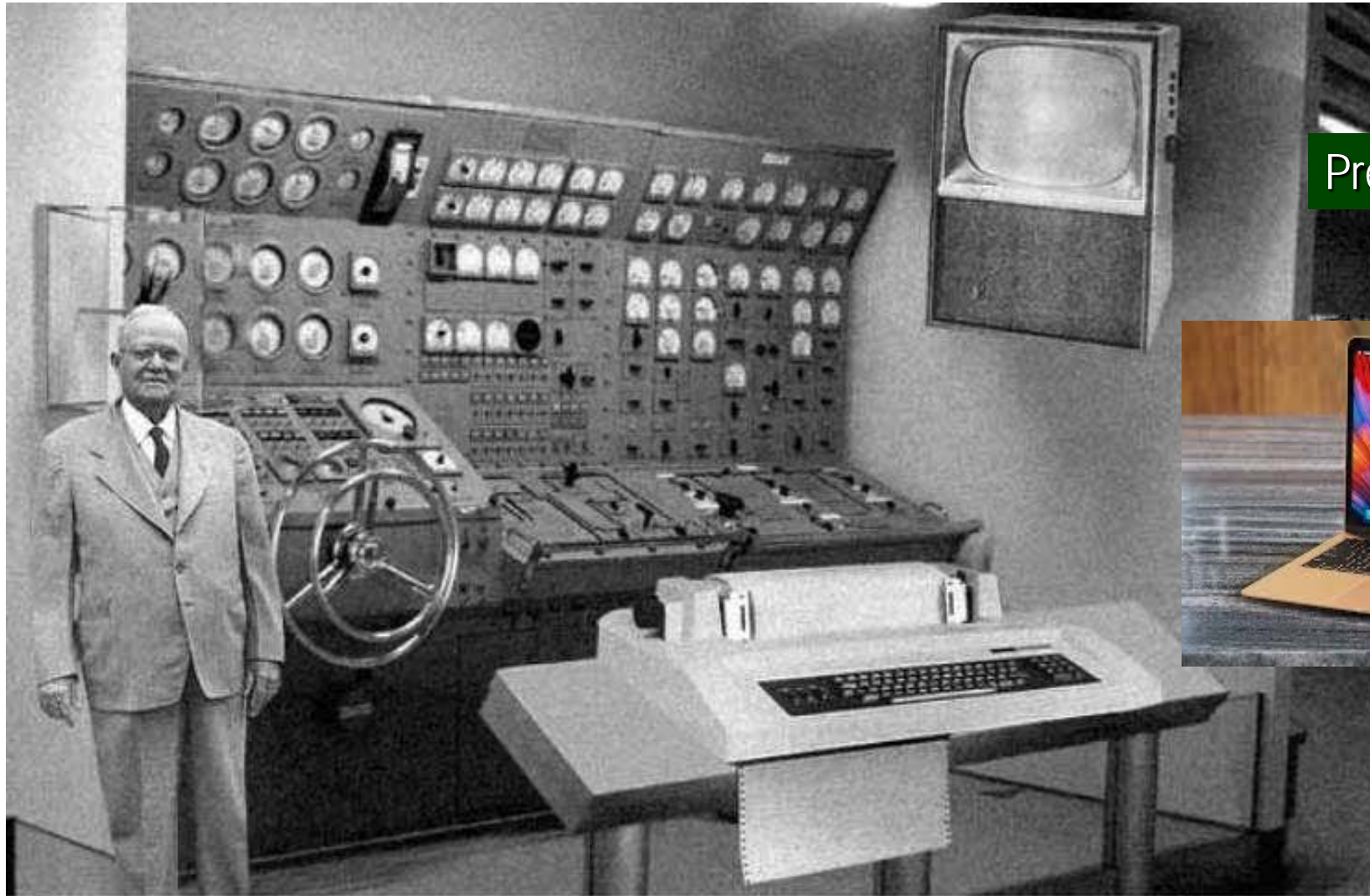


Introduction

The Evolution of Electronic Computing



Home Computer @ 2004: *Predicted versus Real*



Predicted in 1954



Reality

Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.

Storage has become free!!

Magnetic Tape Drive

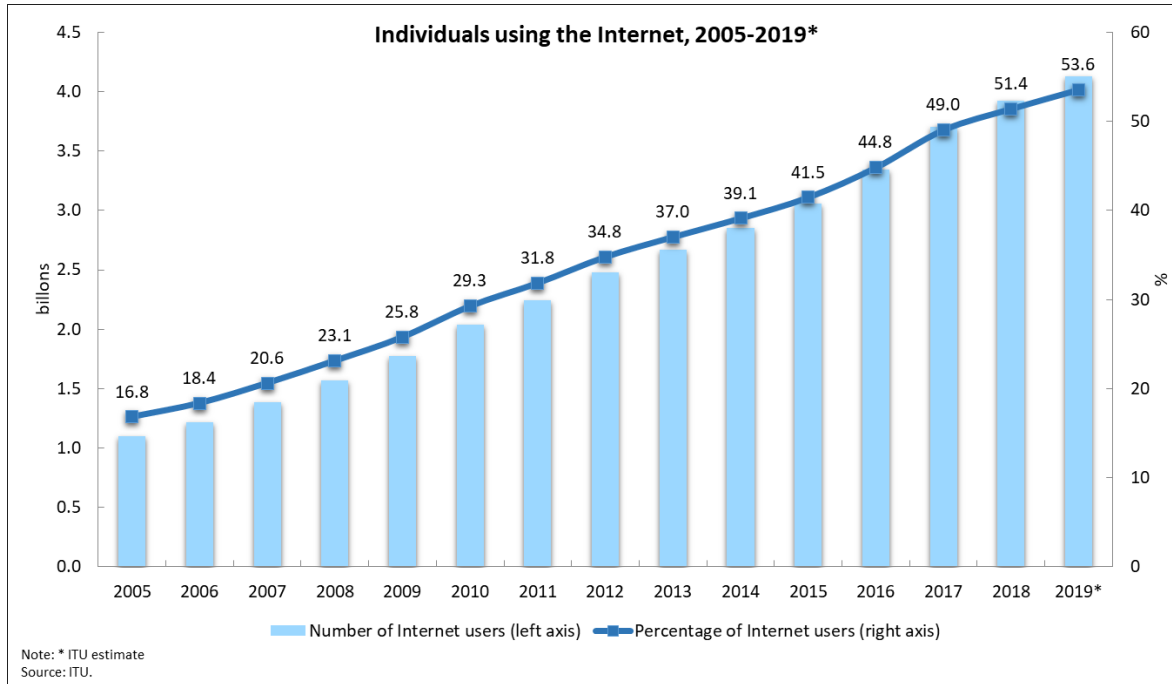


5 MB Hard Disk [1956]

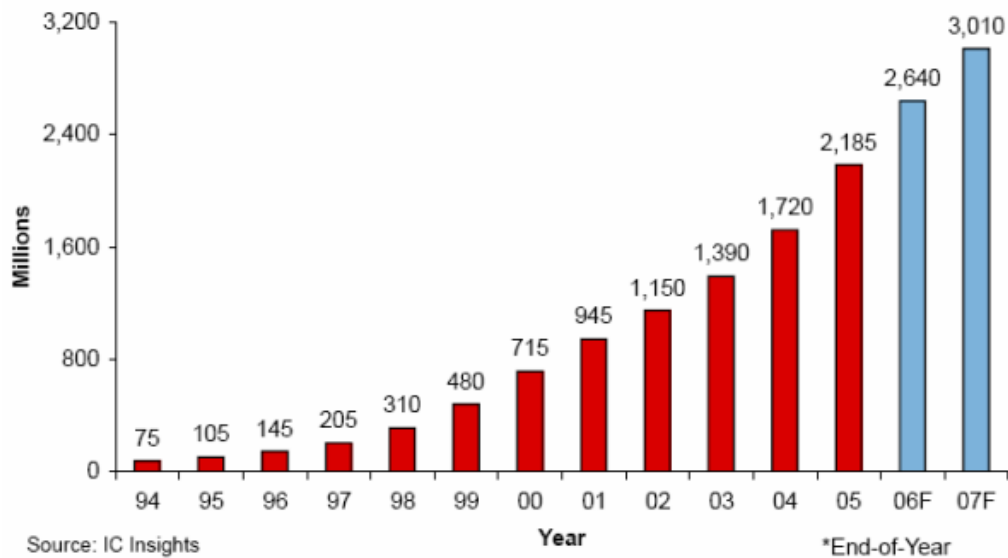


128 GB Pen Drive

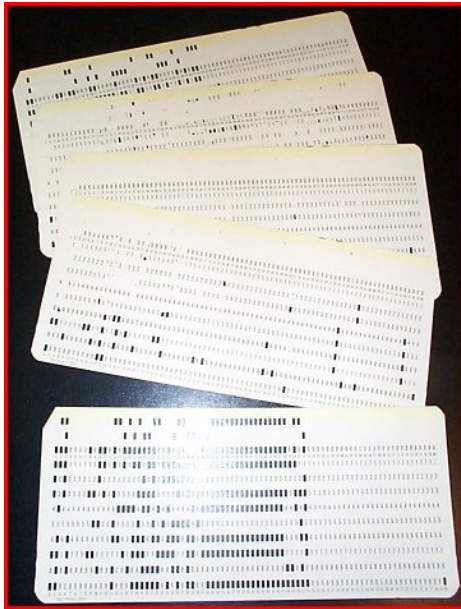
Communication



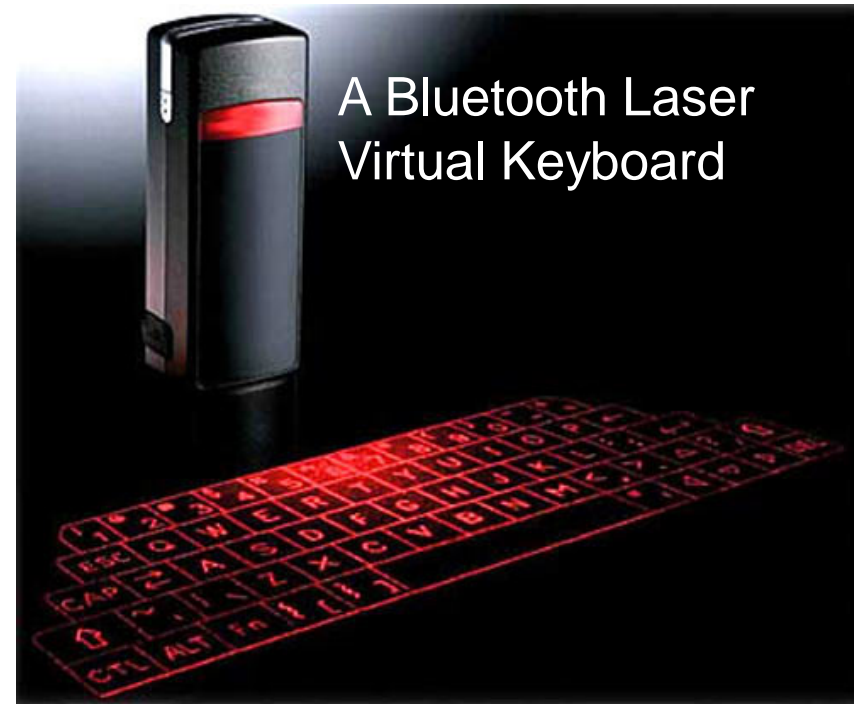
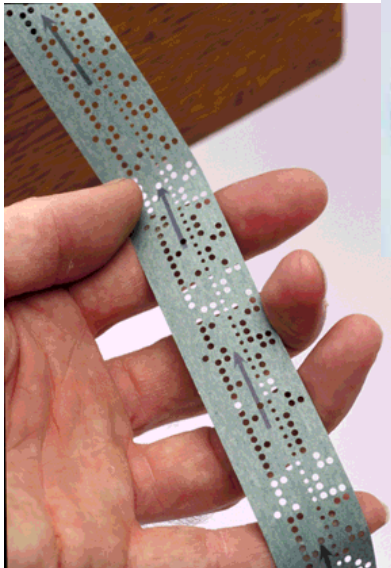
Total Worldwide Cellular/PCS Subscriber Base* (1994-2007)



Interfaces



From punch cards
to paper tapes
to keyboards

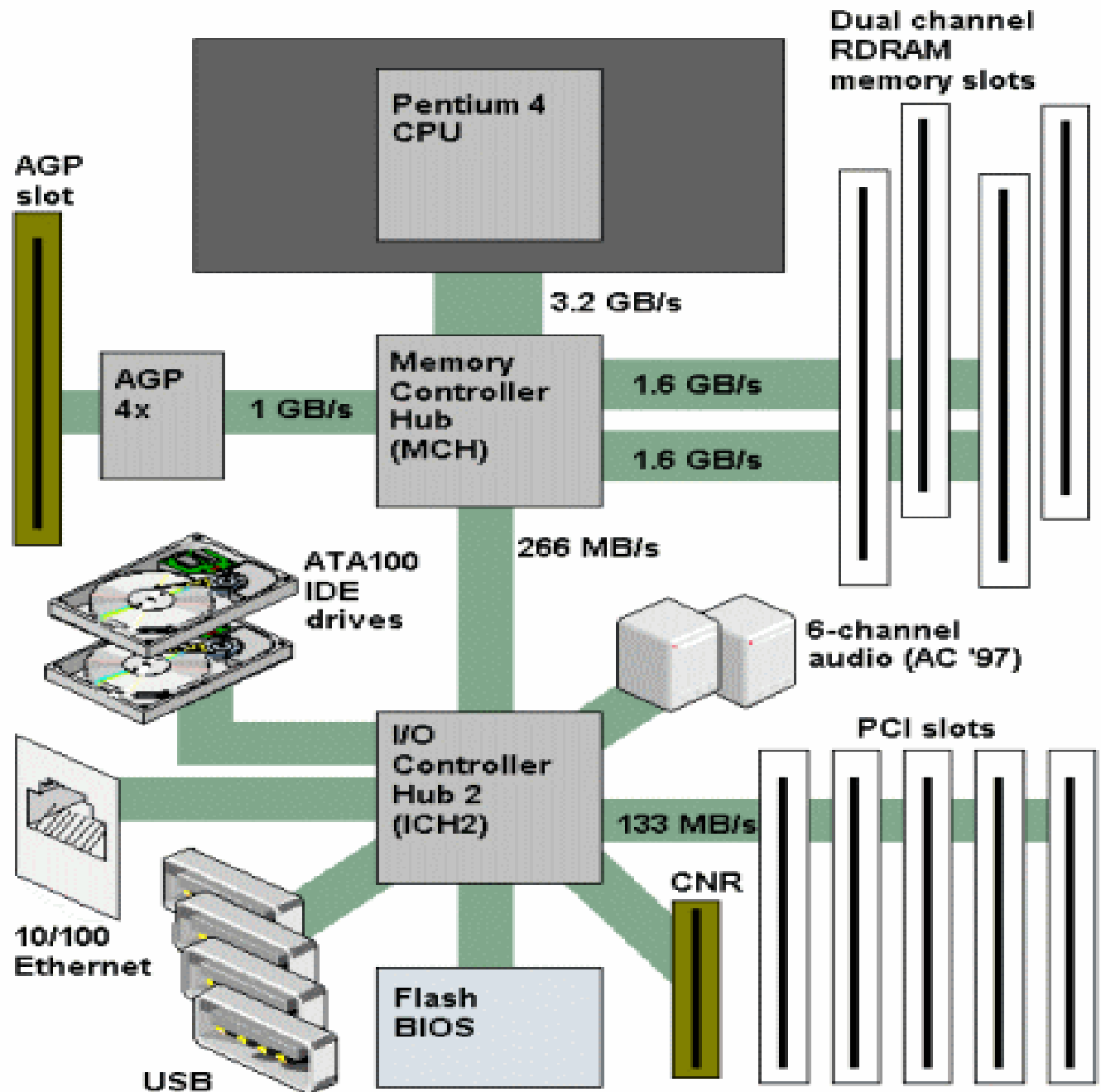


A Bluetooth Laser
Virtual Keyboard



Architecture

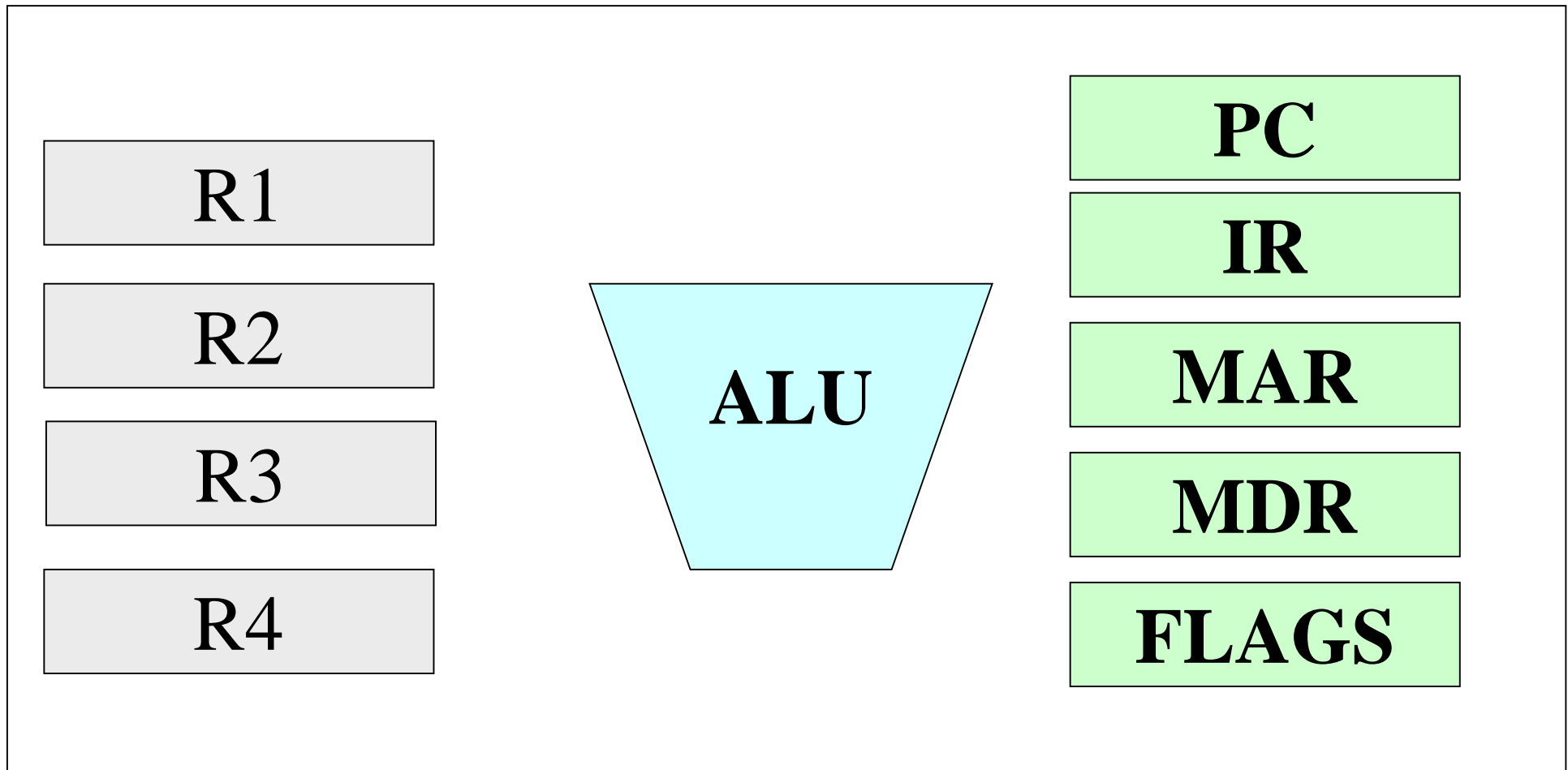
Typical system architecture for a desktop PC



CPU (Central Processing Unit)

- Computations take place to perform a designated task.
 - Large number of registers to temporarily store data and programs (instructions).
 - Functional units (circuitry) to carry out arithmetic and logic operations
- Retrieves instructions from the memory, interprets (decodes) them, and performs the requested operation
 - Fetch → Decode → Execute cycle
- CPU is also referred to as the processor
 - Computers may have multiple processors
 - Modern processors are multi-core (multiple processors in one chip)

CPU: A first cut



Main Memory

- Uses semiconductor technology
 - Allows direct access
- Memory sizes in the range of 256 MegaBytes (MB) to 8 GigaBytes (GB) are typical today.
- Some measures to be remembered
 - 1 K = 2^{10} (= 1024)
 - 1 M = 2^{20} (= one million approx.)
 - 1 G = 2^{30} (= one billion approx.)

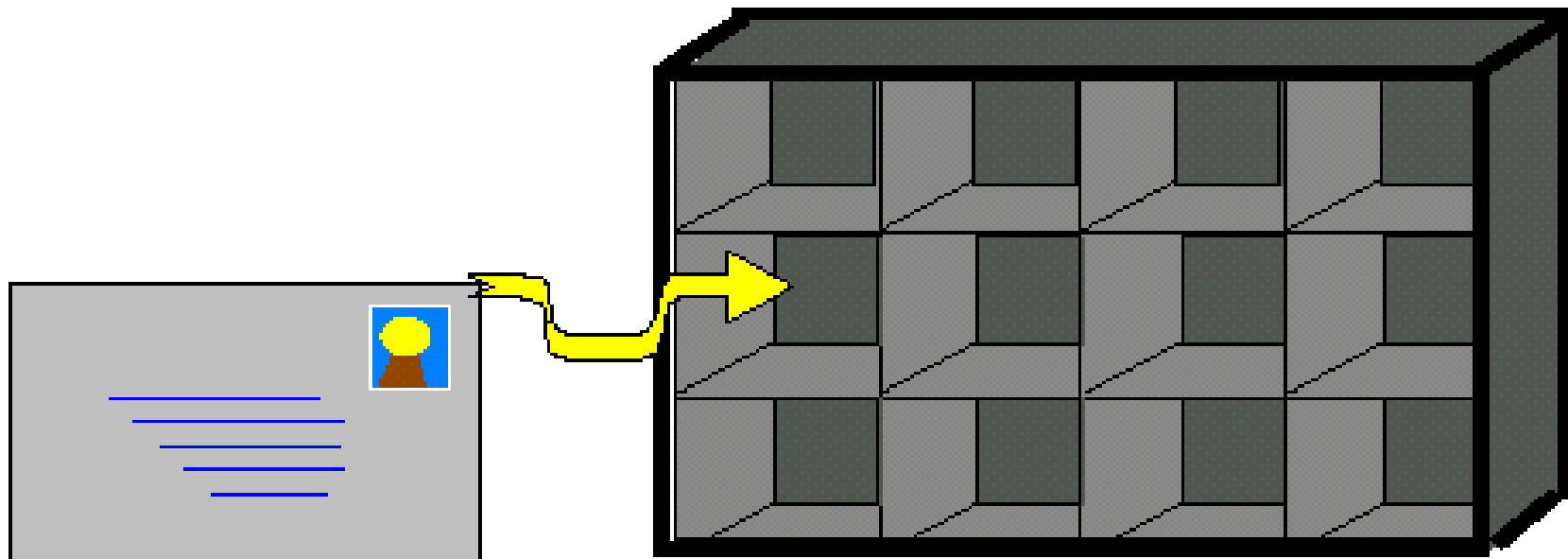
Memory: Address and Values

Every memory location has a **unique** address

0	0
1	11
2	5
3	23
4	12
5	62

Address of byte

Value of byte (0...255)



I/O and Peripherals

- **Input Device**
 - Keyboard, Mouse, Scanner, Digital Camera
- **Output Device**
 - Monitor, Printer
- **Storage Peripherals**
 - **Magnetic Disks: hard disk, floppy disk**
 - Allows direct (semi-random) access
 - **Optical Disks: CDROM, CD-RW, DVD**
 - Allows direct (semi-random) access
 - **Flash Memory: pen drives**
 - Allows direct access
 - **Magnetic Tape: DAT**
 - Only sequential access

How does a computer work?

- **Stored program concept.**
 - Main difference from a calculator.
- **What is a program?**
 - Set of instructions for carrying out a specific task.
- **Where are programs stored?**
 - In secondary memory, when first created.
 - Brought into main memory, during execution.

Number System – *The Basics*

- We are accustomed to using the so-called *decimal number system*.

- Ten digits :: 0,1,2,3,4,5,6,7,8,9
- Every digit position has a weight which is a power of 10.

- Examples:

$$234 = 2 \times 10^2 + 3 \times 10^1 + 4 \times 10^0$$

$$250.67 = 2 \times 10^2 + 5 \times 10^1 + 0 \times 10^0 + 6 \times 10^{-1} + 7 \times 10^{-2}$$

Computer works with Binary Numbers

- *Binary number system:*
 - Two digits :: 0,1
 - Every digit position has a weight which is a power of 2.

- **Examples:**

$$101 \text{ (Binary)} = 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 5 \text{ (Decimal)}$$

$$11001 \text{ (Binary)}$$

$$= 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

$$= 25 \text{ (Decimal)}$$

Bits and Bytes

- **Bit**
 - A single binary digit (0 or 1).
- **Nibble**
 - A collection of four bits (say, 0110).
- **Byte**
 - A collection of eight bits (say, 01000111).
- **Word**
 - Depends on the computer.
 - Typically 4 or 8 bytes (that is, 32 or 64 bits).

Number System (Contd.)

- A k-bit decimal number
 - Can express unsigned integers in the range
 - 0 to $10^k - 1$
 - For k=3, from 0 to 999.
- A k-bit binary number
 - Can express unsigned integers in the range
 - 0 to $2^k - 1$
 - For k=8, from 0 to 255.
 - For k=10, from 0 to 1023.

Classification of Software

Two categories:

1. Application Software

- Used to solve a particular problem.
- Editor, financial accounting, weather forecasting, etc.

2. System Software

- Helps in running other programs.
- Compiler, operating system, etc.

Computer Languages

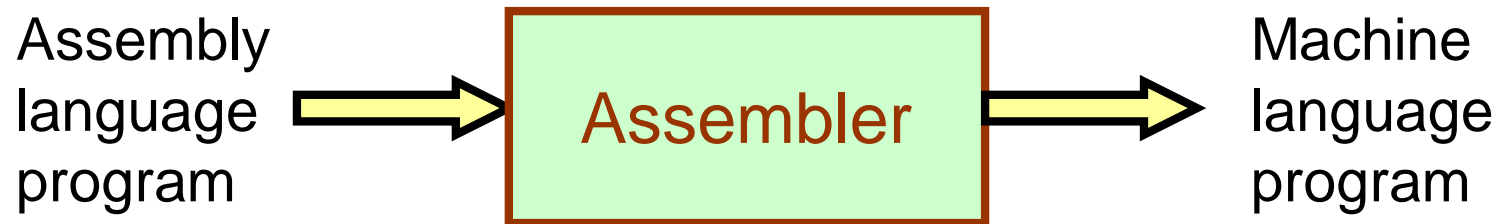
- **Machine Language**

- Expressed in binary and directly understood by the computer.
- Not portable; varies from one machine type to another.
 - Program written for one type of machine will not run on another type of machine.
- Difficult to use in writing programs.

- **Assembly Language**

- Mnemonic form of machine language.
- Easier to use as compared to machine language.
 - For example, use “ADD” instead of “10110100”.
- Not portable (like machine language) and requires a translator program called *assembler*.

Computer Languages (Contd.)



- Assembly language is difficult to use in writing programs.
- Requires many instructions to solve a problem.
- **Example:** Find the average of three numbers.

```
MOV    A,X    ; A = X
ADD    A,Y    ; A = A + Y
ADD    A,Z    ; A = A + Z
DIV    A,3    ; A = A / 3
MOV    RES,A ; RES = A
```

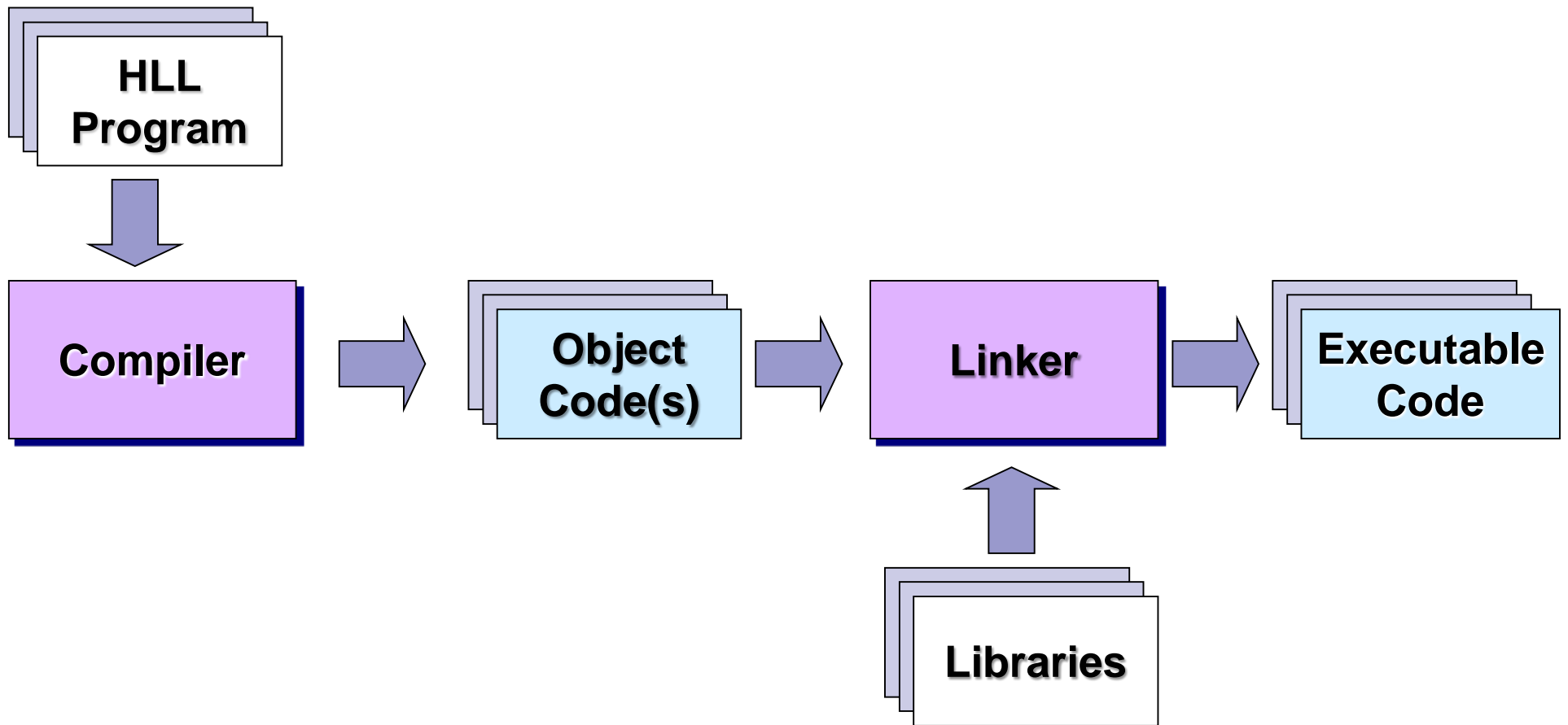
In C,

```
RES = (X + Y + Z) / 3
```

High-Level Language

- Machine language and assembly language are called low-level languages.
 - They are closer to the machine.
 - Difficult to use.
- High-level languages are easier to use.
 - They are closer to the programmer.
 - Examples: Fortran, Cobol, C, C++, Java.
 - Requires an elaborate process of translation.
 - Using a software called *compiler*.
 - They are portable across platforms.

From HLL to executable



Operating Systems

- Makes the computer easy to use.
 - Basically the computer is very difficult to use.
 - Understands only machine language.
- Categories of operating systems:
 - Single user
 - Multi user: Time sharing, Multitasking, Real time
- Popular operating systems:
 - Windows 10: **single-user multitasking**
 - Unix: **multi-user**
 - Linux: **a free version of Unix**
- Question:
 - How multiple users can work on the same computer?

Some Terminologies

- **Algorithm / Flowchart**
 - A step-by-step procedure for solving a particular problem.
 - Independent of the programming language.
- **Program**
 - A translation of the algorithm/flowchart into a form that can be processed by a computer.
 - Typically written in a high-level language like C, C++, Java, Python, etc.

Programming and Software

- Computer needs to be **programmed** to do such tasks
- **Programming** is the process of writing instructions in a **language** that can be understood by the computer so that a desired task can be performed by it
- **Program**: sequence of instructions to do a task, computer processes the instructions sequentially one after the other
- **Software**: programs for doing tasks on computers



Three steps in writing programs

Step 1: Write program in a high-level language
(in your case, C)

Step 2: Compile the program using a C compiler

Step 3: Run the program
(as the computer to execute it)

First C Program: first.c

- Type in the following C program exactly as it is in the file, and then save it

```
/* The first C program */  
  
#include <stdio.h>  
int main( )  
{  
    printf("Welcome to IITKGP\n");  
    printf("\tYou are doing PDS Theory.");  
    return 0;  
}
```

Structure of a C program

- A collection of **functions** (we will see what they are later)
- Exactly one special function named **main** must be present. Program always starts from there
- Each function has statements (instructions) for declaration, assignment, condition check, looping etc.
- Statements are executed one by one

Making a Mistake

- Remove the) (right bracket) after main

```
/* The first C program */
```

```
#include <stdio.h>
```

```
int main(  
{
```

```
{
```

```
    printf("Welcome to IITKGP\n");
```

```
    printf("\tYou are doing PDS Theory.");
```

```
    return 0;
```

```
}
```

!! ... To Bug is Human, To Debug Divine ... !!

Configuring and Executing the Program

- Save the file
- Compile the file
- You will see an error printed out:
first.c:4 : error: Syntax error
- Go back and correct the error
- Save the file **again**
- Compile the file **again**
- *Should show no errors this time*
- Run the file and verify that **Welcome to IITKGP** is printed in a line and in the next line some (tab) space is left and **You are doing PDS Theory.** is printed.

Reading values from keyboard

```
#include <stdio.h>
int main()
{
    int num ;
    printf("Enter How many Students: ");
    scanf("%d", &num);
    printf("No. of students is %d.\n", num);
    return 0;
}
```

Output:

```
Enter How Many Students: 180
No. of students is 180.
```


The C Character and Keyword Set

- The C language alphabet
 - Uppercase letters 'A' to 'Z'
 - Lowercase letters 'a' to 'z'
 - Digits '0' to '9'
 - Certain special characters:

!	#	%	^	&	*	()
-	_	+	=	~	[]	\
	;	:	'	"	{	}	,
.	<	>	/	?	blank		

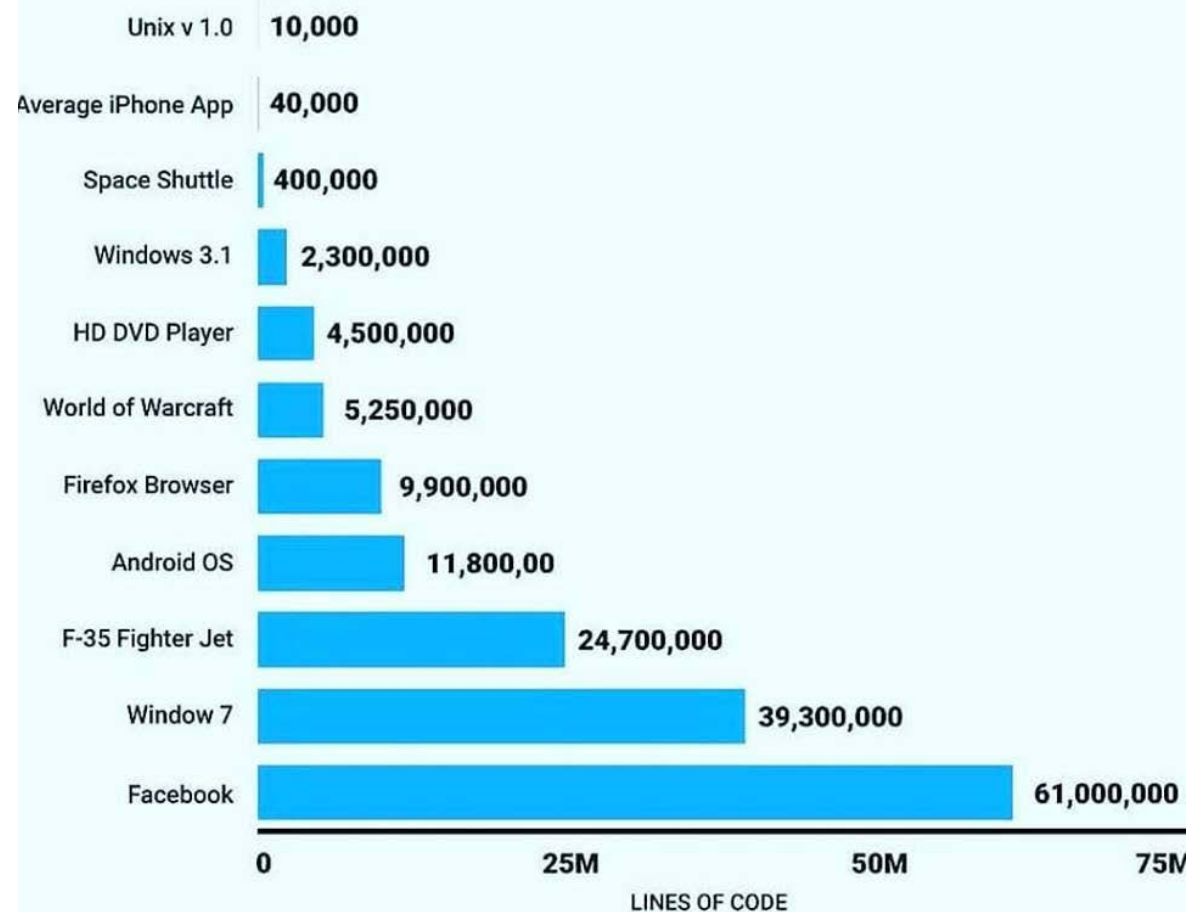
C program should not contain anything else!

- Used Keywords by the C language, cannot be used as variable names
 - Examples:
int, float, char, double, main, if, else, for, while, do, struct, union, typedef, enum, void, return, signed, unsigned, case, break, sizeof, ...
 - There are others, see textbook ...

Computer Program is Everywhere!

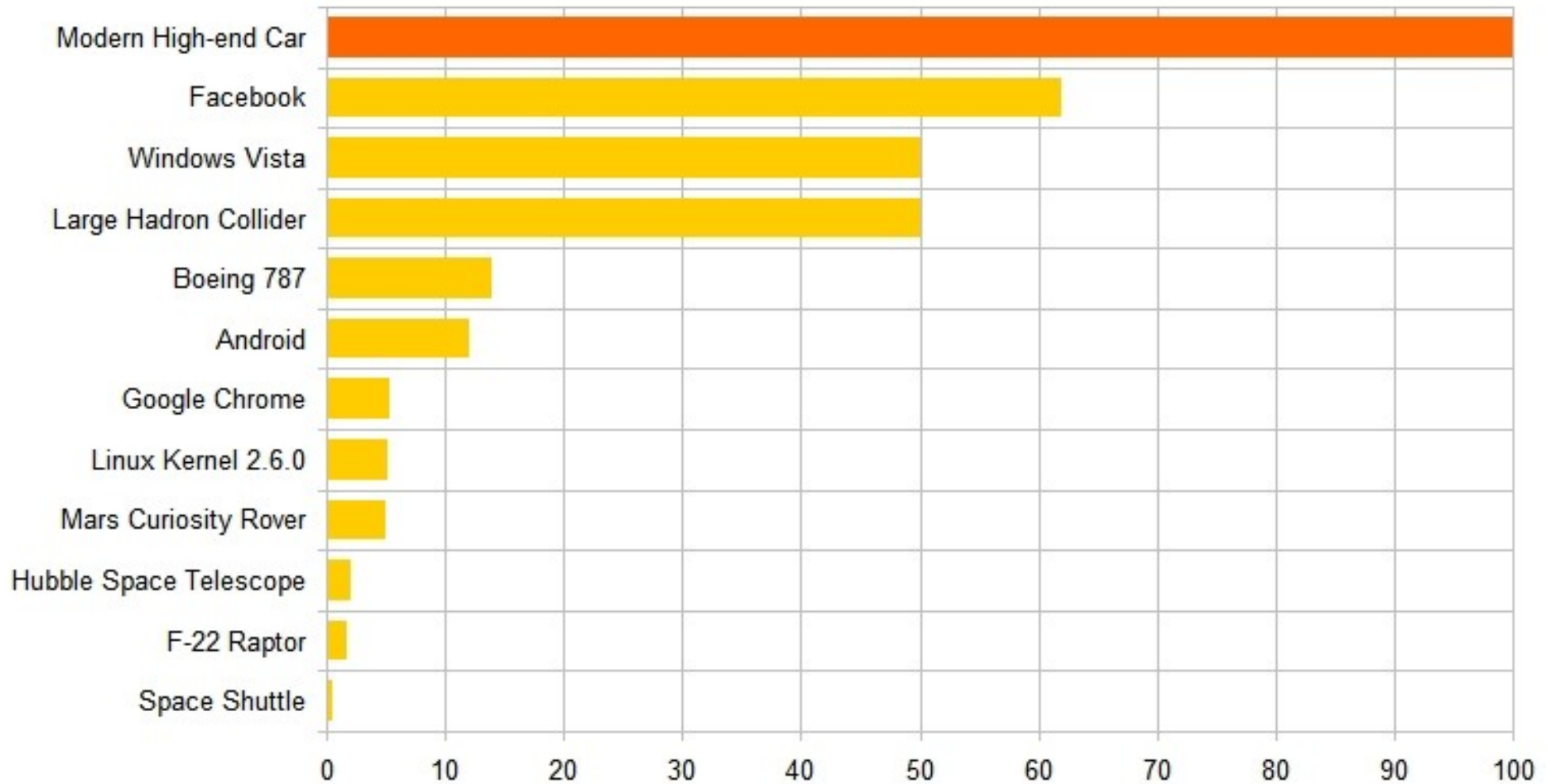
- Determining if a given integer is a prime number
- A Palindrome recognizer
- Airline Reservation System
- Journey Route Determination
- Telephone pole placement
- Patriot Missile Control
- Autonomous vehicles
- Finger-print recognition
- Chess Player
- Speech Recognition
- Language Recognition
- Discovering New Laws
- Automatic drug discovery
- ...
- ...

HOW MANY LINES OF CODE MAKE UP THESE POPULAR TECHNOLOGIES



Increasing Program Size!

Software Size (million Lines of Code)



Thank You!

