**Theme 1**

# The computer era. Information and computers

**Subjects:**

-Information

-Computers

-Processing of data and basic CPU operations

-Data storaging

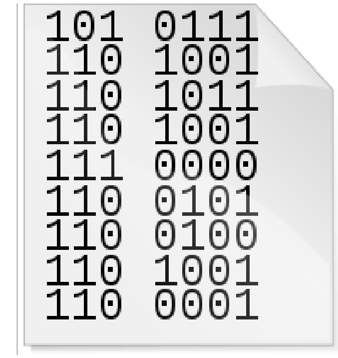
-Networks

-Supercomputers

-Internet

**Duration - 4 ac.h.**

# Information




**Information** as a concept has a diversity of meanings, from everyday usage to technical settings. Generally speaking, the concept of information is closely related to notions of constraint, communication, control, data, form, instruction, knowledge, meaning, mental stimulus, pattern, perception, and representation.

**Information** is the result of processing, gathering, manipulating and organizing data in a way that adds to the knowledge of the receiver.

In other words, it is the context in which data is taken.

**Information** is knowledge about individuals, objects, facts, events, phenomenon's and processes irrespective of their form of representation.

# Message

A **message** in its most general meaning is an object of communication – it is something which provides information; it can also be this information itself. Therefore, its meaning is dependent upon the context in which it is used; the term may apply to both the information and its form.

**More precisely, in communications science**:

A **message** is information which is sent from a source to a receiver.

**Message definition through it properties**:

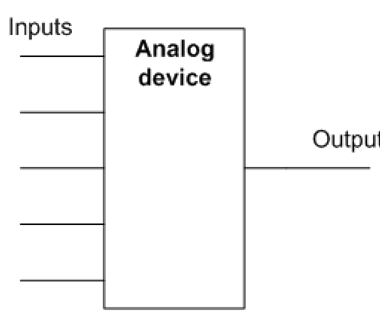
- Any thought or idea expressed in a language, prepared in a form suitable for transmission by any means of communication.
- An arbitrary amount of information whose beginning and end are defined or implied.

# Computer

**Computer** is a device that receives, processes, and presents information according to a set of instructions.

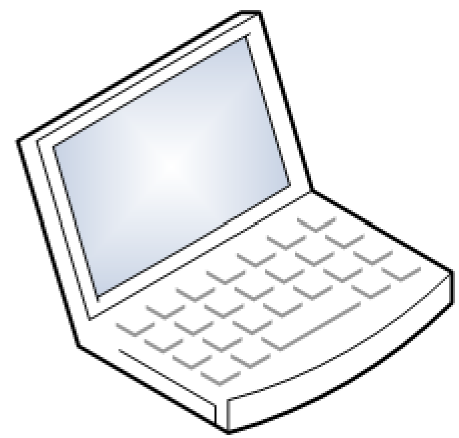
## Analog

An **analog computer** is a form of computer that uses the continuously-changeable aspects of physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved. In contrast, digital computers represent varying quantities incrementally, as their numerical values change.




## Digital

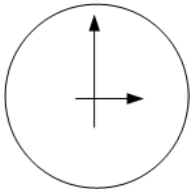
In contrast, a **digital computer** uses symbolic representations of its variables. The arithmetic unit is constructed to follow the rules of one (or more) number systems. Further, the digital computer uses individual discrete states to represent the digits of the number system chosen. A digital computer can easily store and manipulate numbers, letters, images, sounds, or graphical information represented by a symbolic code. Through the use of the stored program, the digital computer achieves a degree of flexibility unequaled by any other computing or data-processing device.



# Processing of data

The operations of a digital computer are carried out by **logic circuits**, which are digital circuits whose single output is determined by the conditions of the inputs, usually two or more.

The various circuits processing data in the computer's interior must operate in **a highly synchronized manner**.



Using of very stable oscillator

Digital computer circuits are capable of performing **thousands** to **trillions** of arithmetic or logic operations per second, thus permitting the rapid solution of problems that would be impossible for a human to solve by hand.


The **Central Processing Unit (CPU)** or **processor** is the portion of a computer system that carries out the instructions of a computer program, and is **the primary element carrying out the computer's functions**.

The fundamental operation of most CPUs, regardless of the physical form they take, is to **execute a sequence of stored instructions** called a **program**.

**The program is represented by a series of numbers that are kept in some kind of computer memory**. There are four steps that nearly all CPUs use in their operation: **fetch**, **decode**, **execute**, and **writeback**.

# Basic CPU operations

1

The first step, **fetch**, involves **retrieving an instruction** (which is represented by a number or sequence of numbers) **from program memory**.

The location in program memory is determined by a **program counter** (PC), which stores a number that identifies the current position in the program. In other words, the program counter keeps track of the CPU's place in the current program.

2

The instruction that the CPU fetches from memory is used to determine what the CPU is to do. In the **decode step**, **the instruction is broken up into parts that have significance to other portions of the CPU**. The way in which the numerical instruction value is interpreted is defined by the CPU's **instruction set architecture** (ISA).

3

After the fetch and decode steps, the **execute step** is performed. During this step, **various portions of the CPU are connected so they can perform the desired operation**. *If, for instance, an addition operation was requested, an* ***arithmetic logic unit (ALU)*** *will be connected to a set of inputs and a set of outputs. The inputs provide the numbers to be added, and the outputs will contain the final sum.* ***The ALU contains the circuitry to perform simple arithmetic and logical operations on the inputs***.

4

The final step, **writeback**, **simply "writes back" the results of the execute step to some form of memory**. Very often the results are written to some internal CPU register for quick access by subsequent instructions. In other cases results may be written to slower, but cheaper and larger, main memory.

# Basic CPU architecture properties

**Integer range.** **The way a CPU represents numbers is a design choice that affects the most basic ways in which the device functions**. Some early digital computers used an electrical model of the common **decimal** (base ten) numeral system to represent numbers internally. A few other computers have used more exotic numeral systems like **ternary** (base three). **Nearly all modern CPUs represent numbers in binary form, with each digit being represented by some two-valued physical quantity such as a "high" or "low" voltage**.

In the case of a **binary CPU**, **a bit refers to one significant place in the numbers a CPU deals with**. The number of bits (or numeral places) a CPU uses to represent numbers is often called "**word size**", "**bit width**", "**data path width**", or "**integer precision**" when dealing with strictly integer numbers.

| Bits | Number range | Architecture |
|---|---|---|
| 1 bit | 0..1 | Intel internal native |
| 8 bit | 0..255 | Intel 8088 |
| 16 bit | 0..65535 | Intel 80286, Motorola |
| 32 bit | 0.. 4294967295 | Intel 80386 - Intel Pentium 4 |
| 64 bit | 0.. 18446744073709551616 | Intel Itanium, AMD Opteron |

# Basic CPU architecture properties

**Clock rate.** Most CPUs, and indeed most sequential logic devices, are synchronous in nature. That is, they are designed and operate on assumptions about a synchronization signal. This signal, known as a **clock signal**, usually takes the form of a periodic square wave. By calculating the maximum time that electrical signals can move in various branches of a CPU's many circuits, the designers can select an appropriate period for the clock signal.

## Problem

CPU must wait on its slowest elements, even though some portions of it are much faster.

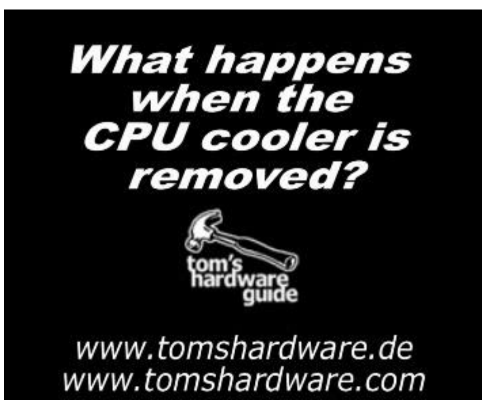
**globally synchronous CPUs**

Solve – in use of many identical oscillators

## Next problem

Solve – turn off unused components

Heating !!!

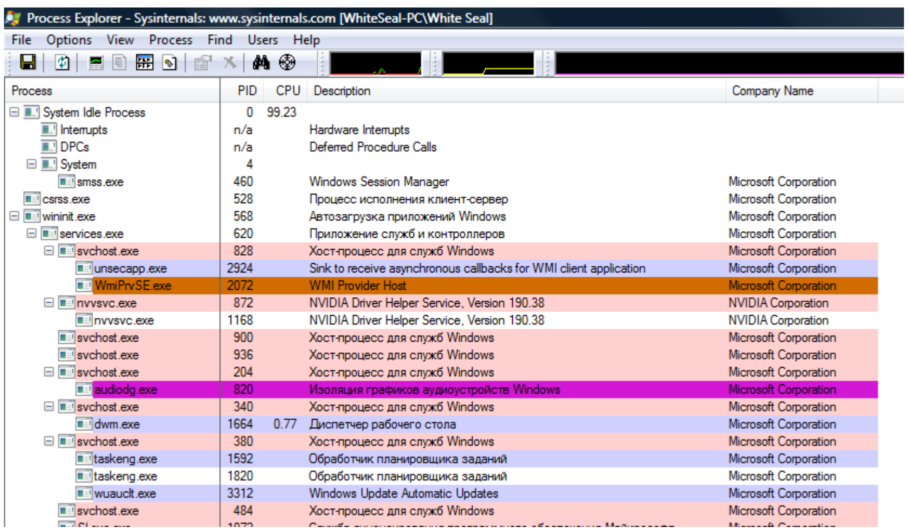



One method of dealing with the switching off unneeded components is called **clock gating**, which involves turning off the clock signal to unneeded components (effectively disabling them).

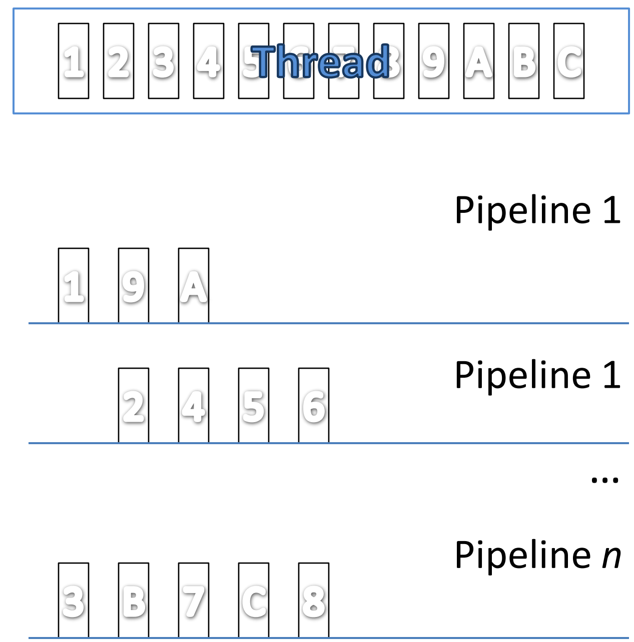
# Basic CPU architecture properties

**Parallelism.** The description of the basic operations describes the simplest form that a CPU can take. This type of CPU, usually referred to as subscalar, operates on and executes one instruction on one or two pieces of data at a time.

Thread-level parallelism




Instruction-level parallelism

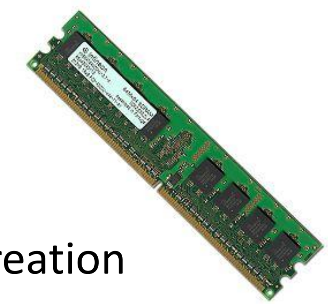


# Dynamic storage

Storage

RAM ROM EAROM Flash PROM EPROM EEPROM

**Random-access memory** (usually known by its acronym, **RAM**) is a form of computer data storage. Today, it takes the form of integrated circuits that allow stored data to be accessed in any order (i.e., at random). The word random thus refers to the fact that any piece of data can be returned in a constant time, regardless of its physical location and whether or not it is related to the previous piece of data. The word RAM is often associated with **volatile types of memory** (such as DRAM memory modules), where the **information is lost after the power is switched off**.



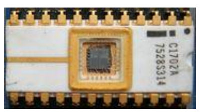
## Realization of RAM based on creation of memory chips

Similar to a microprocessor, a **memory chip** is an integrated circuit (IC) made of millions of transistors and capacitors. In the most common form of computer memory, dynamic random access memory (DRAM), a transistor and a capacitor are paired to create a memory cell, which represents a single bit of data. The capacitor holds the bit of information—a 0 or a 1 . The transistor acts as a switch that lets the control circuitry on the memory chip read the capacitor or change its state.

# Dynamic storage

Storage

RAM · ROM · EAROM · Flash · PROM · EPROM · EEPROM



**Read-only memory** (usually known by its acronym, **ROM**) is a class of storage media used in computers and other electronic devices. Because data stored in ROM cannot be modified (at least not very quickly or easily), it is mainly used to distribute firmware (software that is very closely tied to specific hardware, and unlikely to require frequent updates). Classic mask-programmed ROM chips are integrated circuits that physically encode the data to be stored, and thus it is impossible to change their contents after fabrication.

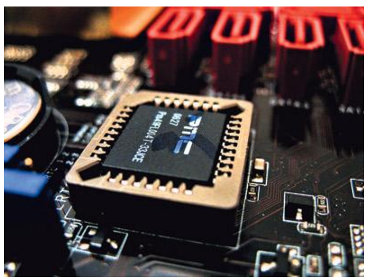
**Programmable read-only memory (PROM)**, or one-time programmable ROM (OTP), can be written to or programmed via a special device called a PROM programmer. Typically, this device uses high voltages to permanently destroy or create internal links (fuses or antifuses) within the chip. Consequently, a PROM can only be programmed once.

**Erasable programmable read-only memory (EPROM)** can be erased by exposure to strong ultraviolet light (typically for 10 minutes or longer), then rewritten with a process that again requires application of higher than usual voltage. Repeated exposure to UV light will eventually wear out an EPROM, but the endurance of most EPROM chips exceeds 1000 cycles of erasing and reprogramming. EPROM chip packages can often be identified by the prominent quartz "window" which allows UV light to enter. After programming, the window is typically covered with a label to prevent accidental erasure. Some EPROM chips are factory-erased before they are packaged, and include no window; these are effectively PROM.

# Dynamic storage

Storage

- RAM
- ROM
- EAROM
- Flash
- PROM
- EPROM
- EEPROM



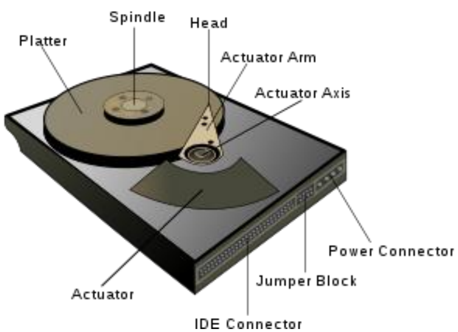
**Electrically erasable programmable read-only memory (EEPROM)** is based on a similar semiconductor structure to EPROM, but allows its entire contents (or selected banks) to be electrically erased, then rewritten electrically, so that they need not be removed from the computer (or camera, MP3 player, etc.). Writing or flashing an EEPROM is much slower (milliseconds per bit) than reading from a ROM or writing to a RAM (nanoseconds in both cases).

**Electrically alterable read-only memory (EAROM)** is a type of EEPROM that can be modified one bit at a time. Writing is a very slow process and again requires higher voltage (usually around 12 V) than is used for read access. EAROMs are intended for applications that require infrequent and only partial rewriting. EAROM may be used as non-volatile storage for critical system setup information; in many applications, EAROM has been supplanted by CMOS RAM supplied by mains power and backed-up with a lithium battery.

**Flash memory** (or simply flash) is a modern type of EEPROM invented in 1984. Flash memory can be erased and rewritten faster than ordinary EEPROM, and newer designs feature **very high endurance** (exceeding 1,000,000 cycles). Modern NAND flash makes efficient use of silicon chip area, resulting in individual ICs with a capacity as high as 128 Gb; this feature, along with its endurance and physical durability, has allowed NAND flash to replace magnetic in some applications (such as USB flash drives). **Flash memory is sometimes called flash ROM or flash EEPROM** when used as a replacement for older ROM types, but not in applications that take advantage of its ability to be modified quickly and frequently.


# Off-line storage

A **hard disk drive** is a non-volatile storage device that stores digitally encoded data on rapidly rotating platters with magnetic surfaces. Strictly speaking, "drive" refers to the motorized mechanical aspect that is distinct from its medium, such as a tape drive and its tape, or a floppy disk drive and its floppy disk.




HDDs record data by **magnetizing ferromagnetic material directionally**, to represent either a 0 or a 1 binary digit. They read the data back by detecting the magnetization of the material. A typical HDD design consists of a spindle that holds one or more flat circular disks called platters, onto which the data are recorded. The **platters** are made from a **non-magnetic material**, usually aluminum alloy or glass, and are coated with a **thin layer of magnetic material**, typically 10-20 nm in thickness with an outer layer of carbon for protection. Older disks **used iron(III) oxide** as the magnetic material, but current disks use a **cobalt-based alloy**.

The **platters** are spun at very high speeds. Information is written to a platter as it rotates past devices called **read-and-write heads** that operate very close (tens of nanometers in new drives) over the magnetic surface. The read-and-write head is used to detect and modify the magnetization of the material immediately under it. There is **one head** for each **magnetic platter surface** on the **spindle**, mounted on a common arm. An actuator arm (or access arm) moves the heads on an arc (roughly radially) across the platters as they spin, allowing each head to access almost the entire surface of the platter as it spins. The arm is moved using a voice coil actuator or in some older designs a stepper motor.

HD heads are kept from contacting the platter surface by the air that is extremely close to the platter; that air moves at, or close to, the platter speed. The record and playback head are mounted on a block called a **slider**, and the surface next to the platter is shaped to keep it just barely out of contact. It's a type of air bearing.

# Off-line storage

**CD-ROM** ("compact disc read-only memory") is a pre-pressed compact disc that contains data accessible to, but not writable by, a computer for data storage and music playback, the 1985 “Yellow Book” standard developed by Sony and Philips adapted the format to hold any form of binary data.

A **CD-ROM sector** contains 2352 bytes, divided into 98 24-byte frames. Unlike a music CD, a CD-ROM cannot rely on error concealment by interpolation, and therefore requires a higher reliability of the retrieved data. In order to achieve improved error correction and detection, a CD-ROM has a third layer of Reed-Solomon error correction.

A **Mode-1 CD-ROM**, which has the full three layers of error correction data, contains a net 2048 bytes of the available 2352 per sector. In a Mode-2 CD-ROM, which is mostly used for video files, there are 2336 user-available bytes per sector. The net byte rate of a Mode-1 CD-ROM, based on comparison to CDDA audio standards, is 44.1k/s×4B×2048/2352 = 153.6 kB/s. The playing time is 74 minutes, or 4440 seconds, so that the net capacity of a Mode-1 CD-ROM is 682 MB or, equivalently, **650 MB**.

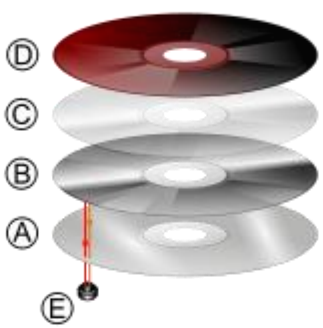



**Diagram of CD layers.**
A. A polycarbonate disc layer has the data encoded by using bumps.
B. A reflective layer reflects the laser back.
D. Artwork is screen printed on the top of the disc.
E. A laser beam reads the polycarbonate disc, is reflected back, and read by the player.

# Off-line storage


**DVD**, also known as Digital Versatile Disc or Digital Video Disc, is an optical disc storage media format, and was founded in 1995. Its main uses are video and data storage. DVDs are of the same dimensions as compact discs (CDs), but store more than six times as much data.

Variations of the **term DVD** often describe the way data is stored on the discs: DVD-ROM (read only memory) has data that can only be read and not written; DVD-R and DVD+R (recordable) can record data only once, and then function as a DVD-ROM; DVD-RW (re-writable), DVD+RW, and DVD-RAM (random access memory) can both record and erase data multiple times. The wavelength used by standard DVD lasers is 650 nm; thus, the light has a red color.

**DVD-Video** and **DVD-Audio discs** refer to properly formatted and structured video and audio content, respectively. Other types of DVDs, including those with video content, may be referred to as DVD Data discs.

# Off-line storage

**Blu-ray Disc** (also known as **Blu-ray** or **BD**) is an optical disc storage medium designed to supersede the standard DVD format. Its main uses are **for storing high-definition video**, PlayStation 3 games, and other data, with up to 25 GB per single layered, and 50 GB per dual layered disc. The disc has the same physical dimensions as standard DVDs and CDs.

Blu-ray Disc™

The name **Blu-ray Disc** derives from the blue-violet laser used to read the disc. While a standard DVD uses a 650 nanometre red laser, Blu-ray uses a shorter wavelength, a 405 nm blue-violet laser, and allows for almost six times more data storage than a DVD.

| Drive speed | Data rate | | Write time for Blu-ray Disc (min) | |
|---|---|---|---|---|
| | Mbit/s | MB/s | Single-Layer | Dual-Layer |
| 1x | 36 | 4.5 | 90 | 180 |
| 2x | 72 | 9 | 45 | 90 |
| 4x | 144 | 18 | 23 | 45 |
| 6x | 216 | 27 | 15 | 30 |
| 8x | 288 | 36 | 12 | 23 |
| 12x | 432 | 54 | 8 | 15 |

# Networks

A **computer network** is a group of interconnected computers. Networks may be classified according to a wide variety of characteristics.

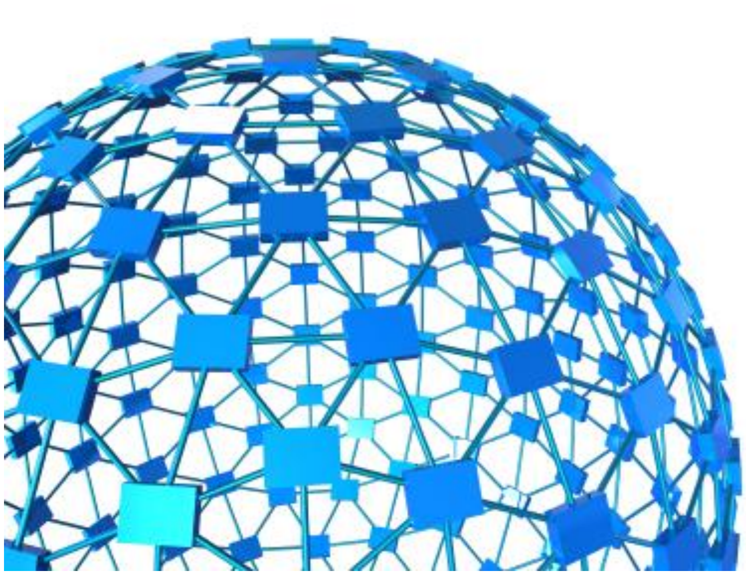
Classification

Connection method

Scaling

Architecture

Topology



# Networks connection methods

## Connection

### Wired technologies

**Twisted-Pair Wire** - This is the most widely used medium for telecommunication. Twisted-pair wires are ordinary telephone wires which consist of two insulated copper wires twisted into pairs and are used for both voice and data transmission. The use of two wires twisted together helps to reduce crosstalk and electromagnetic induction. The transmission speed range from 2 million bits per second to 100 million bits per second.

**Coaxial Cable -** These cables are widely used for cable television systems, office buildings, and other worksites for local area networks. The cables consist of copper or aluminum wire wrapped with insulating layer typically of a flexible material with a high dielectric constant, all of which are surrounded by a conductive layer. The layers of insulation help minimize interference and distortion. Transmission speed range from 200 million to more than 500 million bits per second.

**Fiber Optics** – These cables consist of one or more thin filaments of glass fiber wrapped in a protective layer. It transmits light which can travel over long distance and higher bandwidths. Fiber-optic cables are not affected by electromagnetic radiation. Transmission speed could go up to as high as trillions of bits per second. The speed of fiber optics is hundreds of times faster than coaxial cables and thousands of times faster than twisted-pair wire.

### Wireless technologies

**Terrestrial Microwave** – Terrestrial microwaves use Earth-based transmitter and receiver. The equipment look similar to satellite dishes. Terrestrial microwaves use low-gigahertz range, which limits all communications to line-of-sight. Path between relay stations spaced approx. 30 miles apart. Microwave antennas are usually placed on top of buildings, towers, hills, and mountain peaks.

**Communications Satellites** – The satellites use microwave radio as their telecommunications medium which are not deflected by the Earth's atmosphere. The satellites are stationed in space, typically 22,000 miles above the equator. These Earth-orbiting systems are capable of receiving and relaying voice, data, and TV signals.

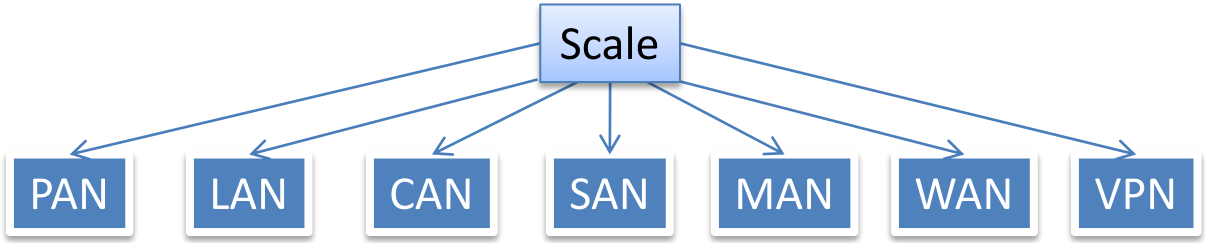
**Cellular and PCS Systems** – Use several radio communications technologies. The systems are divided to different geographic area. Each area has low-power transmitter or radio relay antenna device to relay calls from one area to the next area.

**Wireless LANs** – Wireless local area network use a high-frequency radio technology similar to digital cellular and a low-frequency radio technology. Wireless LANS use spread spectrum technology to enable communication between multiple devices in a limited area. Example of open-standard wireless radio-wave technology is IEEE 802.11b.

**Bluetooth** – A short range wireless technology. Operate at approx. 1Mbps with range from 10 to 100 meters. Bluetooth is an open wireless protocol for data exchange over short distances.

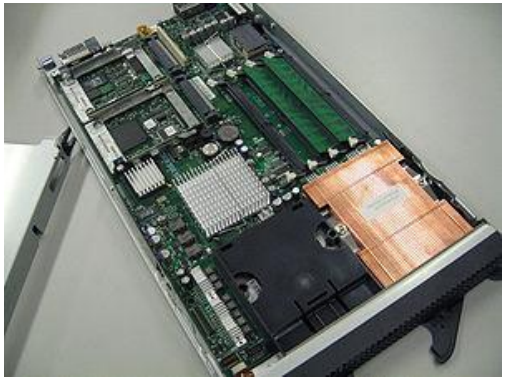
**The Wireless Web** – The wireless web refers to the use of the World Wide Web through equipments like cellular phones, pagers, PDAs, and other portable communications devices. The wireless web service offers anytime/anywhere connection.

# Networks classification




| Abbr. | Description | Distance | Speed |
|---|---|---|---|
| PAN | Personal Area Network | meters | 1-100 Mbit/s |
| LAN | Local Area Network | hundreds of meters | 10-1000 Mbit/s |
| CAN | Campus Area Network | kilometers | 100 Mbit/s |
| SAN | Storage Area Network | tens of meters | 1-10 Gbit/s |
| MAN | Metropolitan Area Network | tens of kilometers | 10-100 Mbit/s |
| WAN | Wide Area Network | Earth-distance and above | 1-10 Mbit/s, Gigabits |
| VPN | Virtual Private Network | not restricted | depends on base technology |

# Blade servers



**Blade servers are stripped down computer servers with a modular design optimized to minimize the use of physical space**. Whereas a standard rack-mount server can function with (at least) a power cord and network cable, blade servers have many components removed to save space, minimize power consumption and other considerations, while still having all the functional components to be considered a computer.

A **blade enclosure**, which can hold multiple blade servers, provides services such as power, cooling, networking, various interconnects and management - though different blade providers have differing principles around what to include in the blade itself (and sometimes in the enclosure altogether). Together, blades and the blade enclosure form the **blade system (blade center)**.

In a **standard server-rack configuration**, 1RU (one rack unit, 19" [48 cm] wide and 1.75" [4.45 cm] tall) defines the minimum possible size of any equipment. The principal benefit and justification of blade computing relate to lifting this restriction as to minimum size requirements. The most common computer rack form-factor is 42U high, which limits the number of discrete computer devices directly mountable in a rack to 42 components. **Blades do not have this limitation**; As of 2009, densities of up to 128 discrete servers per rack are achievable with the current generation of blade systems.

# Using of supercomputers


**Supercomputer** – integrated data processing device with number of processors greater than digit capacity of single processor, which is part of device.

Supercomputers are used for **highly calculation-intensive tasks** such as problems involving quantum mechanical physics, weather forecasting, climate research, molecular modeling (computing the structures and properties of chemical compounds, biological macromolecules, polymers, and crystals), physical simulations (such as simulation of airplanes in wind tunnels, simulation of the detonation of nuclear weapons, and research into nuclear fusion), cryptanalysis, and many others. Major universities, military agencies and scientific research laboratories are heavy users.

**Basic restrictions in supercomputer development are:**

- **A supercomputer generates large amounts of heat** and must be cooled. Cooling most supercomputers is a major problem.
- **Information cannot move faster than the speed of light** between two parts of a supercomputer. For this reason, a supercomputer that is many metres across must have latencies between its components measured at least in the tens of nanoseconds.
- **Supercomputers consume and produce massive amounts of data** in a very short period of time. According to Ken Batcher, "A supercomputer is a device for turning compute-bound problems into I/O-bound problems." Much work on external storage bandwidth is needed to ensure that this information can be transferred quickly and stored/retrieved correctly.

# Most powerful supercomputers

The XT common external login nodes provide a single system external to each XT partition that allows users to access data, compile, and submit batch jobs regardless of the target partition's state.


The XT5 partition contains 18,688 compute nodes in addition to dedicated login/service nodes. Each compute node contains dual hex-core AMD Opteron 2435 (Istanbul) processors running at 2.6GHz, 16GB of DDR2-800 memory, and a SeaStar 2+ router. The resulting partition contains 224,256 processing cores, 300TB of memory, and a peak performance of 2.3 petaflop/s (2.3 quadrillion floating point operations per second).

| | |
|---|---|
| System name | Jaguar |
| Site | Oak Ridge National Laboratory |
| System family | Cray XT |
| System model | Cray XT5-HE |
| Computer | Cray XT5-HE Opteron Six Core 2.6 GHz |
| Vendor | Cray Inc. |
| Application area | Not Specified |
| Installation year | 2009 |
| Operation system | Linux |
| Interconnect | Proprietary |
| Processor | AMD x86_64 Opteron Six Core 2600 MHz (10.4 GFlops) |

Hybrid supercomputer propels performance to
**1,700 trillion calculations per second**.

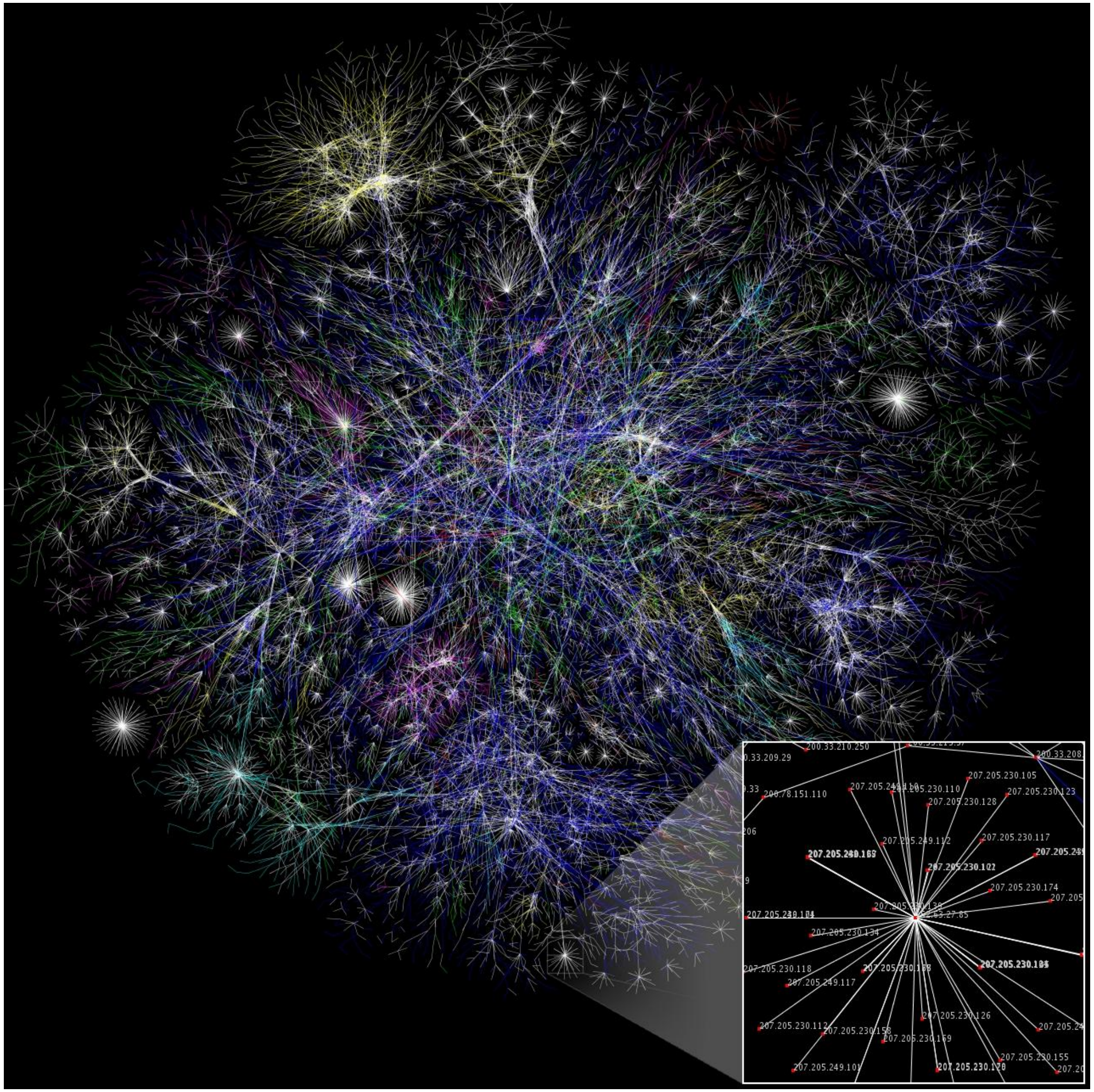
# Most powerful supercomputers

**IBM Sequoia** is a petascale Blue Gene/Q supercomputer constructed by IBM for the National Nuclear Security Administration as part of the Advanced Simulation and Computing Program (ASC). It was delivered to the Lawrence Livermore National Laboratory (LLNL) in 2011 and was fully deployed in June 2012.


| Year | Supercomputer | Location |
|---|---|---|
| 2008 | IBM Roadrunner | New Mexico, USA |
| 2009 | Cray Jaguar | Oak Ridge, USA |
| 2010 | Tianhe-IA | Tianjin, China |
| 2011 | Fujitsu K computer | Kobe, Japan |
| 2012 | IBM Sequoia | Livermore, USA |

# Internet

**The Internet** is a global system of interconnected computer networks that use the standardized Internet Protocol Suite (TCP/IP) to serve billions of users worldwide.



It is a network of networks that consists of **millions** of private and public, academic, business, and government networks of local to global scope that are linked by copper wires, fiber-optic cables, wireless connections, and other technologies. The Internet carries a vast array of information resources and services, most notably the inter-linked hypertext documents of the **World Wide Web** (WWW) and the infrastructure to support electronic mail.

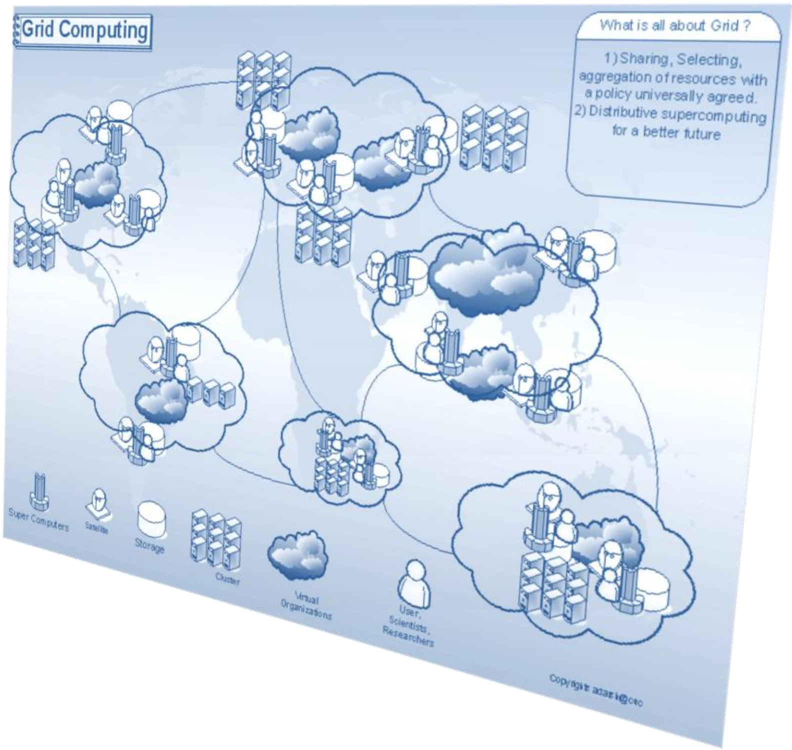
In addition it supports popular services such as online chat, file transfer and file sharing, gaming, commerce, social networking, publishing, video on demand, and teleconferencing and telecommunications. Voice over Internet Protocol (VoIP) applications allow person-to-person communication via voice and video.

# GRID Computing

**Grid computing** (or the **use of computational grids**) is the combination of computer resources from multiple administrative domains applied to a common task, usually to a scientific, technical or business problem that requires a great number of computer processing cycles or the need to process large amounts of data.

It is a form of distributed computing whereby a “super and virtual computer” is composed of a cluster of networked loosely coupled computers acting in concert **to perform very large tasks**. This technology has been applied to computationally intensive scientific, mathematical, and academic problems through volunteer computing, and it is used in commercial enterprises for such diverse applications as drug discovery, economic forecasting, seismic analysis, and back-office data processing in support of e-commerce and Web services.

One of the main strategies of grid computing is using software to **divide and apportion** pieces of a program among several computers, sometimes up to many thousands. Grid computing is distributed, large-scale cluster computing, as well as a form of network-distributed parallel processing. The size of grid computing may vary from being small – confined to a network of computer workstations within a corporation, for example – to being large, public collaboration across many companies and networks. "The notion of a confined grid may also be known as an intra-nodes cooperation whilst the notion of a larger, wider grid may thus refer to an inter-nodes cooperation". This inter-/intra-nodes cooperation "across cyber-based collaborative organizations are also known as **Virtual Organizations**".



# Cloud Computing

**Cloud computing** is a paradigm of computing in which dynamically scalable and often **virtualized resources are provided as a service over the Internet**. Users need not have knowledge of, expertise in, or control over the technology infrastructure in the "cloud" that supports them.

The concept generally incorporates combinations of the following:

- Infrastructure as a service (IaaS).
- Platform as a service (PaaS).
- Software as a service (SaaS).

Cloud computing customers do not generally own the physical infrastructure serving as host to the software platform in question. Instead, they avoid capital expenditure by renting usage from a third-party provider. **They consume resources as a service and pay only for resources that they use**.

Thanks for attention