Multimedia Technology and Applications

Du Haiqing

Email: duhaiqing@bupt.edu.cn

Tel: 13488794409

Office: Teaching Building 3-511

Who am I?

- Du Haiqing
- 2010 Beijing University of Posts and Telecommunications Ph.D.
- 2013 University of Washington visiting scholar
- Research field: Multimedia Networks, Object Tracking, Visual Positioning.

Course objectives

- 2/32
- This course is a basic course of computer application.
  - Making students master the basic knowledge of multimedia application technology and the basic design method of its application system.
  - To enable students to have certain development and application abilities in the field of multimedia application.

Graduation Requirements for Courses and Support

- **This course is one of the important courses to support the graduation requirements of electronic information (information and communication), which mainly supports the graduation requirement index point 1.5 in its training program.**
- **Support Graduation Requirements Indicator Point 1.5: Master the basic concepts and methods of multimedia processing, and can be applied to complex engineering problems.**

Teaching Content and Arrangement

- **Introduction (6 hours)**
- **Fundamentals of digital audio (4 hours)**
- **Graphics and images data representation (4 hours)**
- **Fundamental concepts in video (4 hours)**
- **Video compression Techniques (4 hours)**
- **Optical storage technology (2 hours)**
- **Lab: Image compression and Wireshark (6 hours)**
- **Flexible hours: 2**

Marking Scheme

- **Attendance 20%**
- **Homework 20%**
- **Final exam---Open-book examination 60% (English)**

Reference Books

- **Teaching Material: 《Fundamentals of Multimedia》, Ze-Nian Li, Mark S.Drew, Prentice Hall，2004**

- **《Fundamentals of Multimedia》，Ze-Nian Li, Mark S.Drew, Jiangchuan Liu, Springer，2014**
- **《多媒体技术教程》，史元春译，机械工业出版社，2007**
- **《多媒体计算机技术基础及应用》，钟玉琢等，高教出版社，2012**

Outline of Chapter 1

- Fundamentals
  - The definition of multimedia
  - The classification of medium
  - The properties of multimedia
- History of multimedia
- Media types in a multimedia system
- Multimedia System Architecture & Computer System Components
- Some Key Techniques in Multimedia Applications
- Multimedia Applications

Fundamentals and History of Multimedia

What is Multimedia?

When different people mention the term **multimedia**, they often have quite different, or even opposing viewpoints.

A PC vendor: a PC that has sound capability, a DVD-ROM drive, and perhaps the superiority of multimedia-enabled microprocessors that understand additional multimedia instructions.

A consumer entertainment vendor: interactive cable TV with hundreds of digital channels available, or a cable TV-like service delivered over a high-speed Internet connection.

A Computer Science (CS) student: applications that use multiple modalities, including text, images, drawings (graphics), animation, video, sound including speech, and **interactivity**.

What is Multimedia? (cont.)

- The term involves many different technologies and applications.

Computers, communication, broadcast and TV

Multimedia is the use of a computer to present and combine text, graphics, audio, and video with links and tools that let the user navigate, create, and communicate.

What is Multimedia? (cont.)

Multi (Latin multus - numerous)

Media, medium (something is transmitted or carried on through an *intervening substance*)

As a means for distribution and presentation of information.

Multiple types of information captured, stored, manipulated, transmitted, and presented.

Specifically: Images, Video, Audio (+Speech) and Text

Medium

- Classification from ITU

  Perception Medium

  Representation Medium

  Presentation Medium

  Storage Medium

  Transmission Medium

Perception Medium

Perception media help human to sense their environment.

How do humans perceive information in a computer environment?

-- through seeing → text,image and video

hearing

↓

sound , music and speech

Image

Video

Representation Medium

Representation media are characterized by internal computer representations of information.

How is the computer information coded?

-- various formats are used to represent media information in a computer.

Representation Dimensions

- Time-independent(or discrete) media:

  text, graphics

- Time-dependent media:

  sound and full-motion video change over time (Information is expressed not only in its individual value, but also by the time of its occurrence).

Presentation Medium

Presentation medium refer to the tools and devices for the input and output of information.

through which medium is information delivered by the computer(output), or introduced into the computer(input)?

Presentation Medium (cont.)

Input media: keyboard, mouse, camera and microphone.

Output Media: used to deliver the information by the computer. screen, speaker etc.

Storage Medium

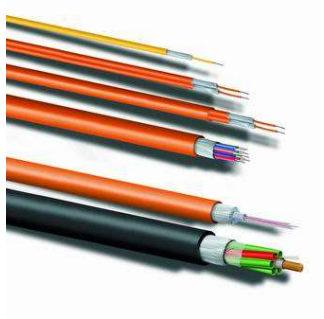
Storage media refer to a data carrier that enables storage of information.

Where will the information be stored?

—Microfilm, floppy disk, hard disk, CD-ROM.

Transmission Medium

Transmission medium enable continuous data transmission.



Over what will the information be transmitted?

Information is transmitted over networks that use wire and wireless transmission. Such as coaxial cable, fiber optics and free air space.

Main Properties of a Multimedia System

A multimedia system distinguishes itself from other system through several properties.

- **Combination of media**
- **Computer-supported integration**
- **Communication system**

Main Properties of a Multimedia System (cont.)

- **Combination of media**

  At least a continuous (time-dependent) and a discrete (time-independent) medium combination justifies the usage of the term multimedia.

  A text processing program with incorporated images is not a multimedia application.

Main Properties of a Multimedia System(cont.)

- **Computer-supported integration**

  The system should be capable of computer-controlled media processing. Moreover, the system should be programmable by a system programmer or even a user.

  Computer-controlled data of independent media can be integrated to accomplish certain function.

Main Properties of a Multimedia System(cont.)

- **Communication system**

  Communication–capable multimedia systems must be approached.

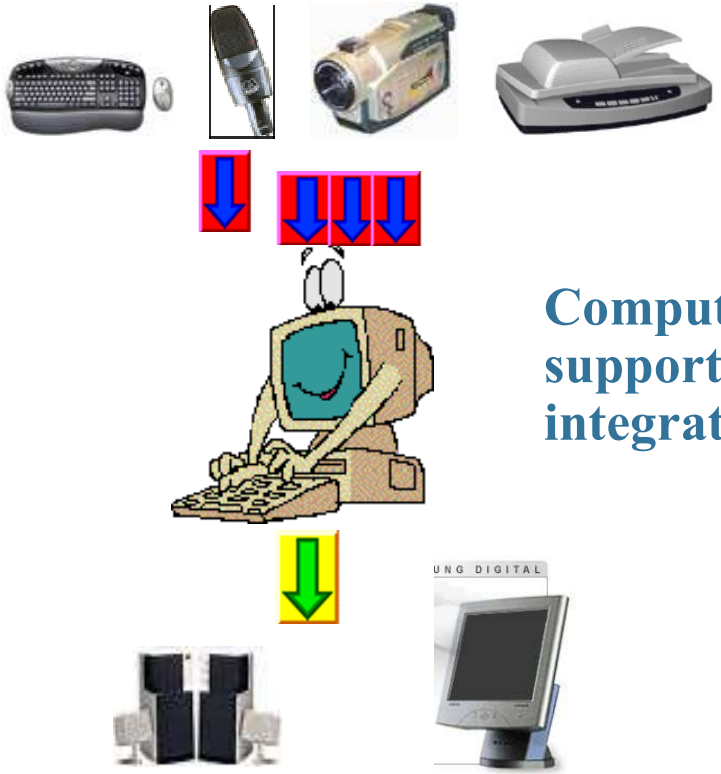
  (1) Most of today's computers are interconnected;

  (2) Distributed environment enables particularly interesting multimedia applications.

Main Properties of a Multimedia System(cont.)

single media:text,voice,video,

animation, graphics, image…



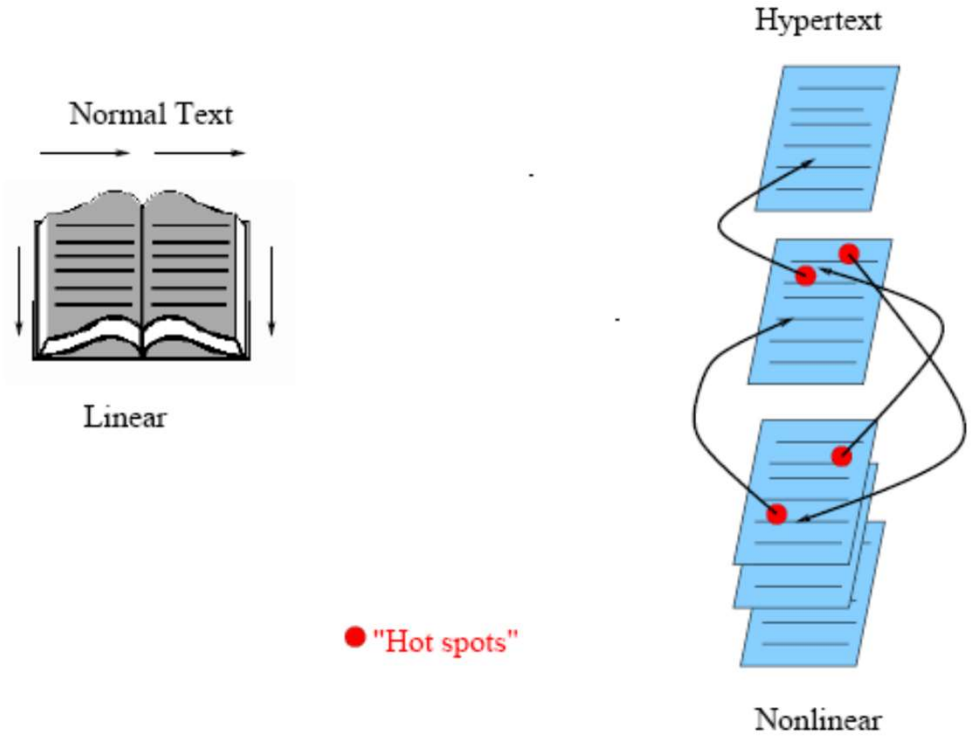
- **Combination of media**
- **Computer-supported integration**
- **Communication system**

Multimedia System

- **A multimedia system is characterized by computer-controlled, integrated production, manipulation, presentation, storage and communication of independent information, which is encoded at least through a continuous (time-dependent) and a discrete (time-independent) medium.**

Hypermedia and Multimedia

- A **hypertext system**: meant to be read nonlinearly, by following links that point to other parts of the document, or to other documents.



Hypertext is nonlinear

Hypermedia and Multimedia (cont.)

- **Hypermedia**: not constrained to be text-based, can include other media, e.g., graphics, images, and especially the continuous media—sound and video.

  -------The World Wide Web (WWW) is the best example of a hypermedia application.

- **Multimedia** means that computer information can be represented through audio, graphics, images, video, and animation in addition to traditional media.

History of Multimedia

1. **Newspaper**: perhaps the first mass communication medium, uses text, graphics, and images.
2. **Motion pictures**: conceived of in 1830's in order to observe motion too rapid for perception by the human eye.
3. **Wireless radio transmission**: Guglielmo Marconi, at Pontecchio, Italy, in 1895.
4. **Television**: the new medium for the 20th century, established video as a commonly available medium and has since changed the world of mass communications.

Multimedia Timeline

The **connection** between **computers** and ideas about **multimedia** covers what is actually only a short period:

1967 – Nicholas Negroponte formed MIT Architecture Machine Group
(later in 1985 MIT Media Lab opens)

1984 – Apple, Bitmap,Windows and Icon

1986 – Philips & Sony, CD-I（Compact Disc Interactive）

1987 – RCA's David Sarnoff Labs' announce Digital Video Interactive,
the first multimedia computer

1988 – Apple "Knowledge Navigator" vision

1989 – IBM, AVC system(Audio Visual Connection) ,editing
http://www.audiovisualconnection.com/

1990 – Philips and other companies, MPC standard MPC1

1993 – MPC standard MPC2

1995 – MPC standard MPC3

Multimedia Timeline (cont.)

1991 – Moving Picture Experts Group

1994 – Netscape; creation of World Wide Web Consortium (W3C)

1995 – JAVA for platform-independent application development

1996 – PNG (Portable Network Graphics)

1997 – HTML 4.0

1998 – XML 1.0

2001 – MPEG-7, JPEG 2000,

2002 – Intellectual property

2004 – DVB-H

2005 – T-DMB

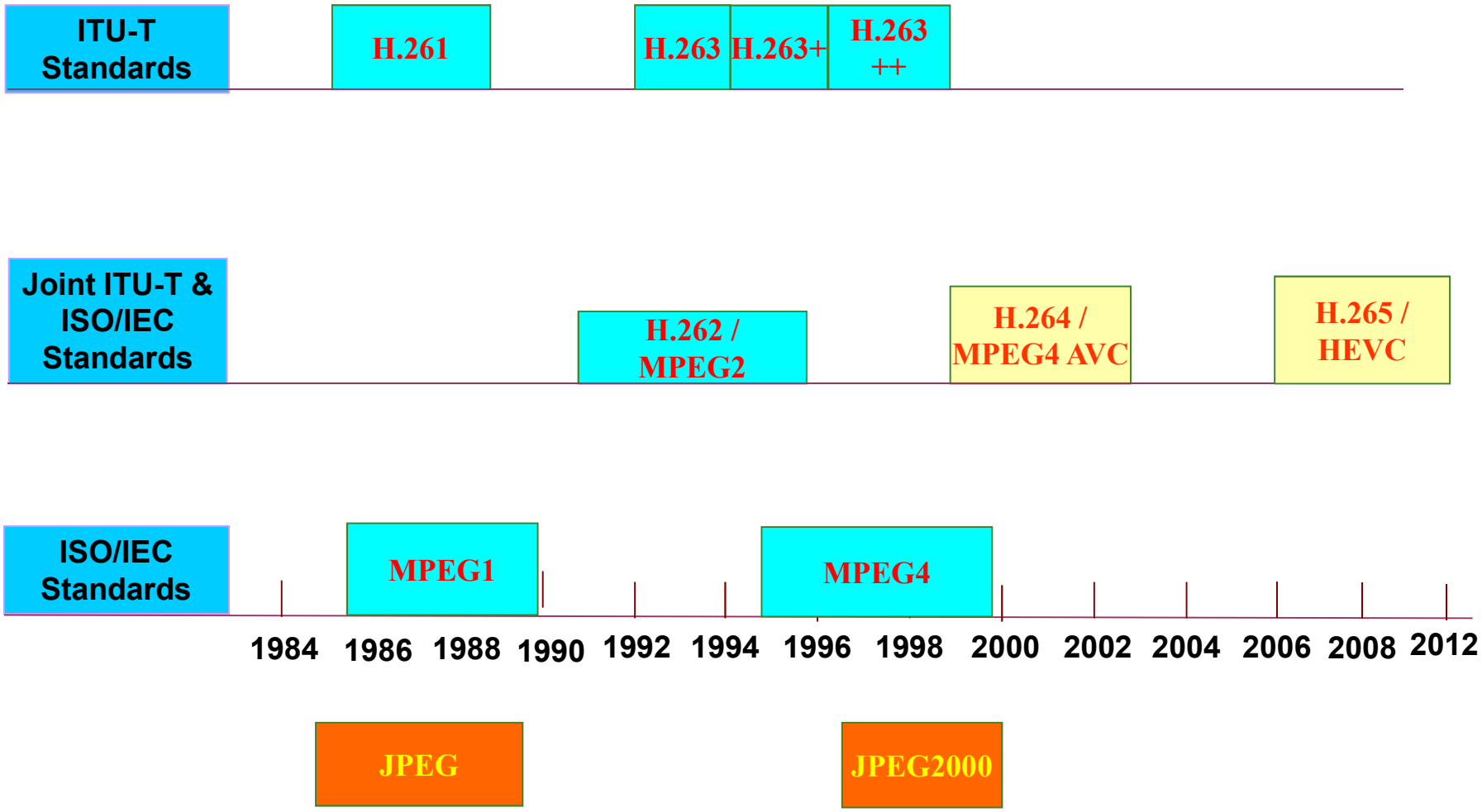
2010~ – Triple play, HDTV, etc.

- **Two Main Organizations for video compression：**
  - **ITU　International Telecommunication Union**
  - **ISO/IEC　International Standard Organization /International Electro-technical Commission**
  - **ITU：**
    - **CCITT（International Telephone and Telegraph Consultative Committee) 1956~1992**
    - **CCIR （International Radio Consultative Committee) 1927~1992**
  - **1992 Regroup**
    - **CCITT → ITU-T　Wire**
    - **CCIR　→ ITU-R　Radio-Wireless**

ISO/IEC

- **IEC - International Electrotechnical Commission**
  - Est. 1906
  - Swiss land non-profitable private
- **ISO - International Organization for Standardization**
  - Est. 1947
  - Swiss land non-profitable private
- **ISO/IEC （ISO/IEC Joint Technical Committee 1, JTC1)**
  - Joint to all activities for standards related to computers
  - Take 30% of all the ISO & IEC standards

History of Video Encoding Standard



MPC level 1

The first MPC minimum standard set in 1990 was:

- **CPU(386sx): 16 MHz**
- **RAM: 2 MB**
- **Hard disk: 30 MB**
- **Video card: 256-color, 640x480(VGA).**
- **Sound card: outputting 22KHz, 8-bit sound, and inputting 11KHz, 8-bit sound.**
- **1x CD-ROM: <1s seek time**
- **System: windows 3.0**

MPC level 2

Announced in 1993, the MPC level 2 minimum standard was:

- **CPU(486sx): 25 MHz**
- **RAM: 4 MB**
- **Hard disk: 160 MB**
- **Video card: 16-bit color, 640x480(VGA)**
- **Sound card: 16-bit CD quality**
- **2x CD-ROM: <400 ms seek time**
- **System: windows 3.0, or windows 3.1**

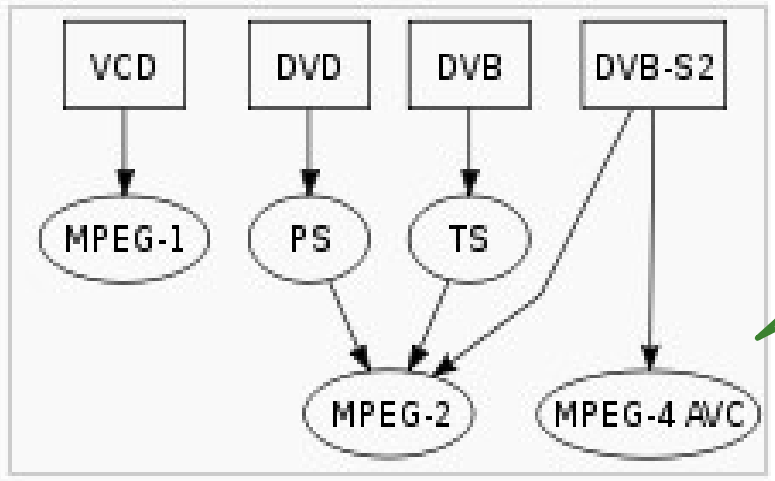
MPC level 3

In 1995, MPC level 3 was announced:

- **75 MHz Pentium CPU**
- **8 MB RAM**
- **540 MB hard disk**
- **Video system use 16-bit color that can show 352x240 at 30 frames per second**
- **4x CD-ROM drive, with <250 ms seek time**
- **Sound card outputting 44KHz, 16-bit CD quality sound**
- **Using system windows 3.11 or windows 95**

Moving Picture Experts Group

- **MPEG was formed by ISO and IEC to set standers for audio and video compression and transmission. The MPEG standards consist of different parts, each part convers a certain aspect of the whole specification.**
- **MPEG groups of standard mainly include MPEG-1, MPEG-2, MPEG-4, MPEG-7, MPEG-21.**



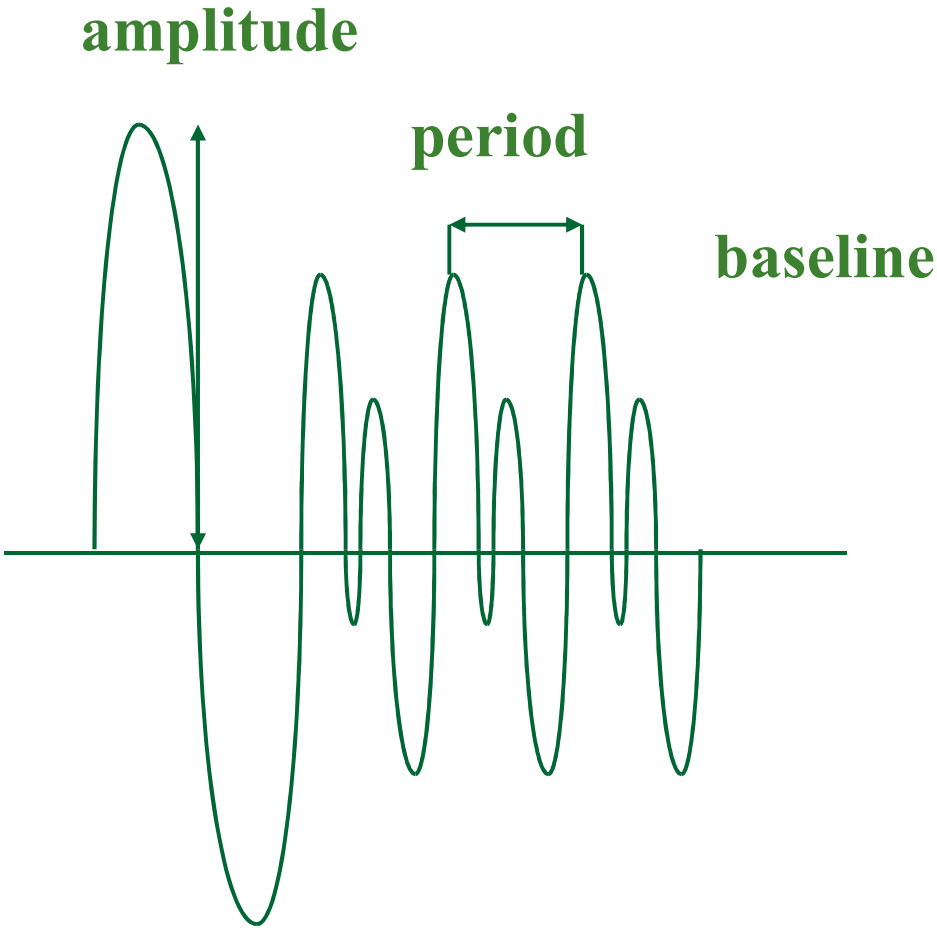
This picture relates some of the most known media to the MPEG Format version and container format used.

Media Types in a Multimedia Systems

- Text
- Sound/Audio
- Image and Graphics
- Video
- Animation

Sound/Audio

Sound is produced by the vibration of matter. During the vibration, pressure variation are created in the air surrounding it. The pattern of the oscillation is called a waveform.



Sound/Audio (cont.)

- **Frequency**
  - **Infra- sound from 0 to 20Hz(Hertz)**
  - **Human hearing frequency from 20Hz to 20kHz**
  - **Ultra-sound from 20kHz to 1GHz**
  - **Hyper-sound from 1GHz to 10THz**
- **Amplitude(loudness)**
  - **the measure of the displacement of the air pressure wave from its mean.**

Sound/Audio (cont.)

- **The sound within the human hearing range is called *audio* and the waves in this frequency range is called *acoustic signals*.**
- **Speech is an acoustic signal produced by humans; music signals have a frequency range between 20Hz and 20kHz. Besides speech and music, we denote any other audio signal as noise.**

Image and Graphics

Graphics(Vector images): each component in the image is defined mathematically, the definitions are stored, and the image is redrawn from these. Vector images are compact smaller files.

- Vector graphics have the following extensions

  .wmf .dxf .mgx .cgm

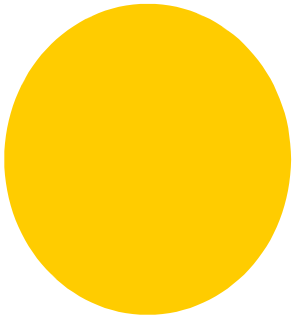


Image and Graphics (cont.)

Graphics are Scaleable

- Scaleable means that the image stays in the same proportion as the browser window grows and shrinks in size
- Allows the designer to maintain control of how the Web site looks when the viewer resizes the window
- The same image may be resized, moved or rotated while maintaining its origin quality and proportions
- 3D-graphics, maps(which may be readily enlarged to view more detail), CAD/CAM and design work(an object or structure can be rotated to display different views)

Image and Graphics (cont.)

Graphics

Image

Image

- **An image is just a matrix of light intensity**
- **Below is an example of a 6×10 L-shaped image**

0	255	0	0	0	0	0	0	0	0
0	255	0	0	0	0	0	0	0	0
0	255	0	0	0	0	0	0	0	0
0	255	0	0	0	0	0	0	0	0
0	255	0	0	0	0	0	0	0	0
0	255	255	255	255	255	255	255	255	0

Pixel - a picture element, containing the colour or the hue and relative brightness of that point in the image.

Image (cont.)

$$\begin{bmatrix} a_{00} & \cdots & a_{0n} & \cdots \\ a_{10} & \cdots & a_{1n} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ a_{m0} & \cdots & a_{mn} & \cdots \\ \vdots & \vdots & \vdots & \vdots \end{bmatrix}$$

1. **Monochrome Image**

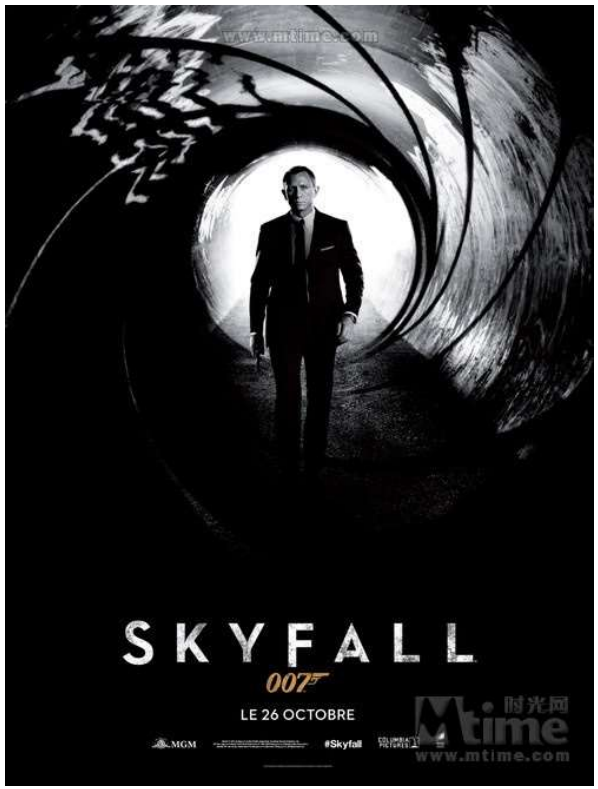
   - Each pixel contains a single bit of information, indicating whether the pixel is white or dark.

2. **Gray-scale Images**

   - Each pixel is stored as a byte, indicating the degree of brightness of the point. Normally interpreted as the brightness from black to white.

3. **24-Bit Colour Image**

   - Each pixel is represented by three bytes, RGB



24-Bit Colour Image

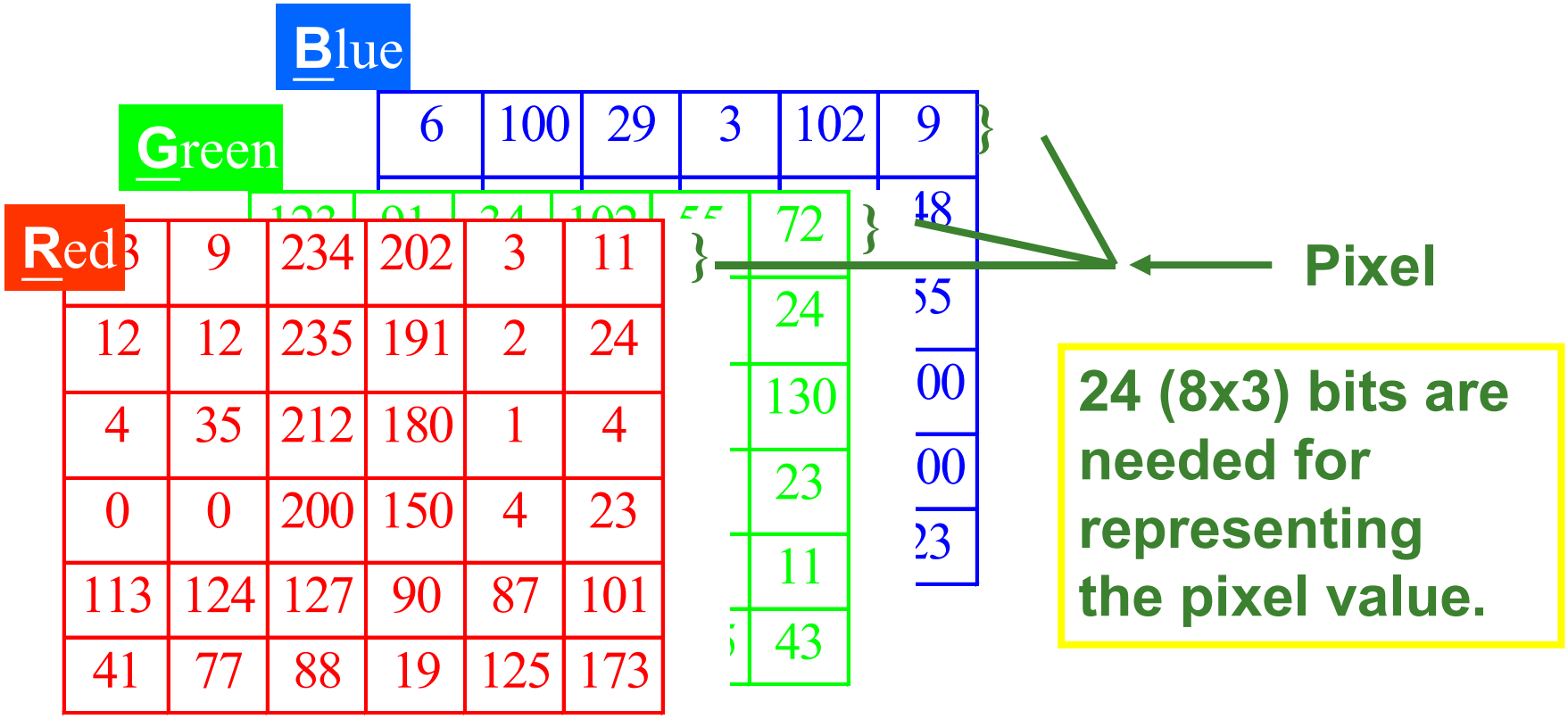
Gray-scale Images

Monochrome Image

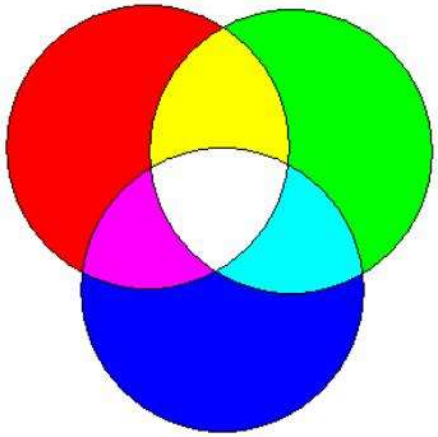
Monochrome Image

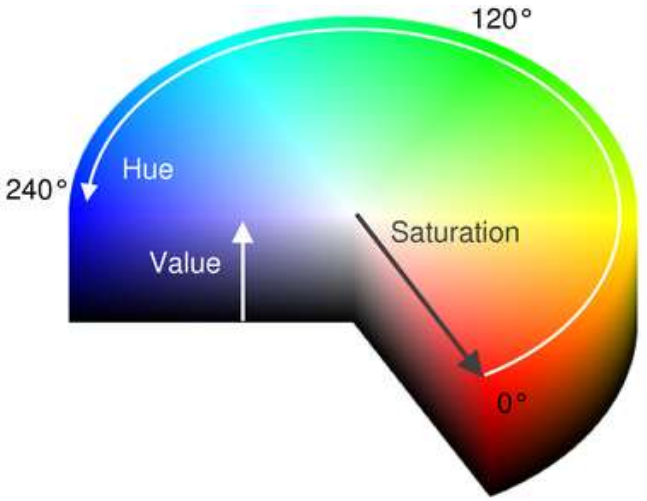
Image (cont.)

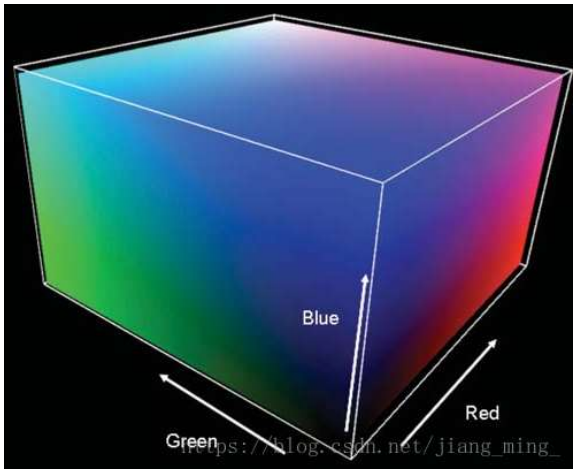
- **Color image**

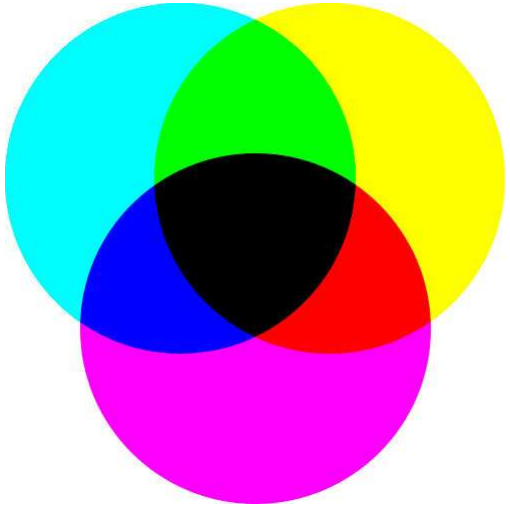


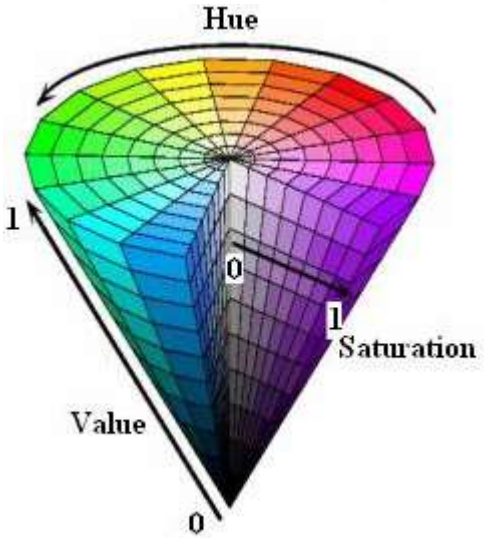
Color Spaces





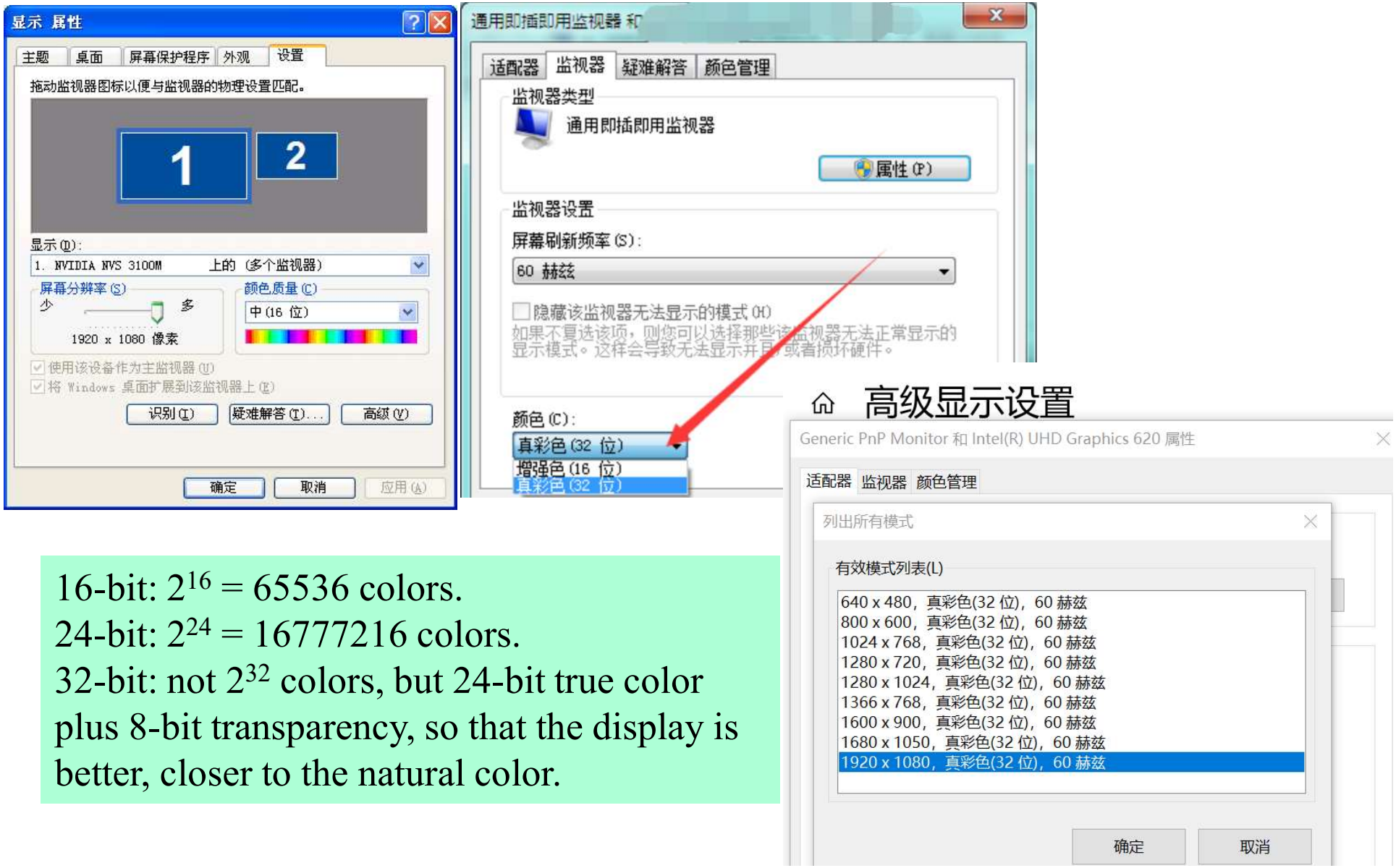






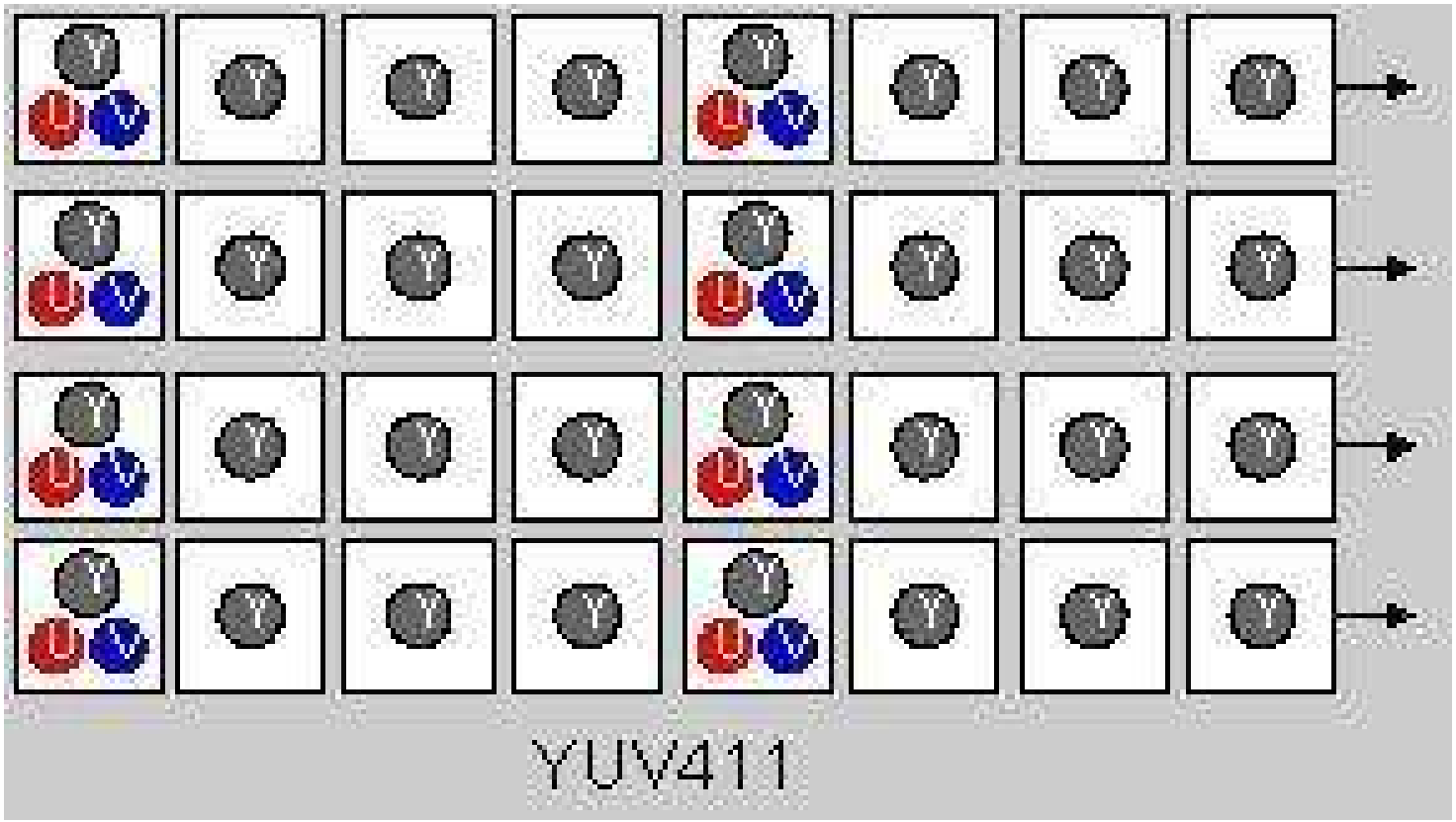
RGB **CMYK** **HSV**

24 bit True Color



16-bit: $2^{16} = 65536$ colors.
24-bit: $2^{24} = 16777216$ colors.
32-bit: not 2^{32} colors, but 24-bit true color plus 8-bit transparency, so that the display is better, closer to the natural color.

YUV



RGB to YUV

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.148 & -0.289 & -0.437 \\ 0.615 & 0.515 & -0.100 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Image (cont.)

- **Image Resolution**

  - The number of pixels in the image.

- **Image File Format**

  ***.GIF (Graphics Interchange Format)**

  ***.JPEG (Joint Photographic Exports Group)**

  ***.PNG (Portable Network Graphics)**

  ***.TIFF (Tag Image File Format)**

Video

- **Video is made up of frames**

  Sequences of recorded image frames

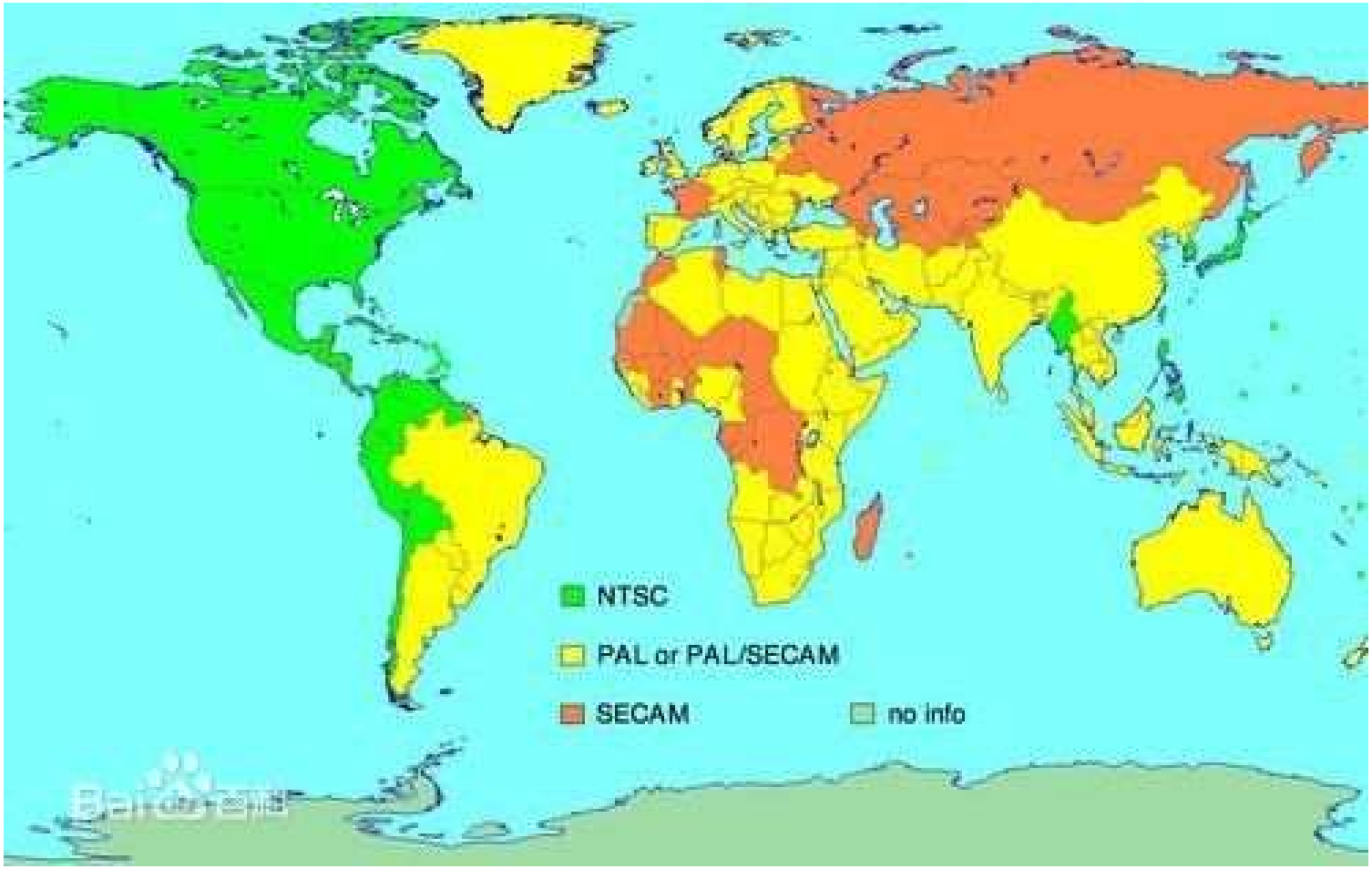
  - **Frame rate = delay between successive frames**
  - **Sequencing creates the illusion of movement**
    - **16 frames per second (fps) is "smooth"**
    - **Standards: NTSC 29.97 fps, PAL 25fps**

Video (cont.)

- Analog video is represented as a continuous (time-varying) signal.
  - **NTSC(U.S. Japan. S.Korean)**
  - **PAL(West Europe, P.R.C)**
  - **SECAM(France, East Europe, Soviet Union)**

- Digital video is represented as a sequence of digital images.

Video (cont.)



Animation

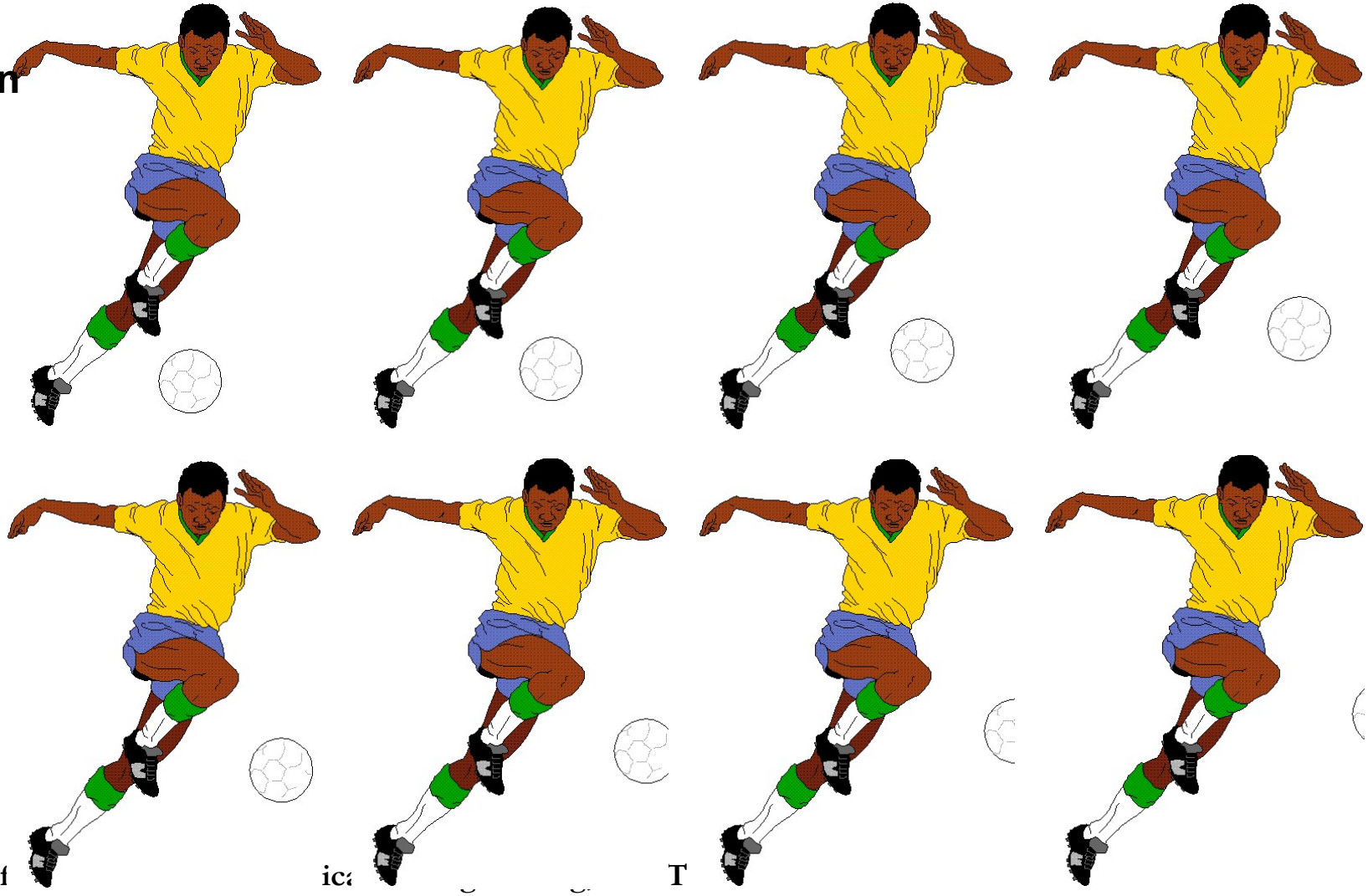
- **Animation**

  — the process of creating a series of images, each slightly different from the previous one, so that when viewed in rapid sequence an impression of motion is achieved.

- Animation development software should include algorithms for rotating, translating, and blurring objects in various directions and planes, and at various speeds
- Software may also include morphing and gait synthesis

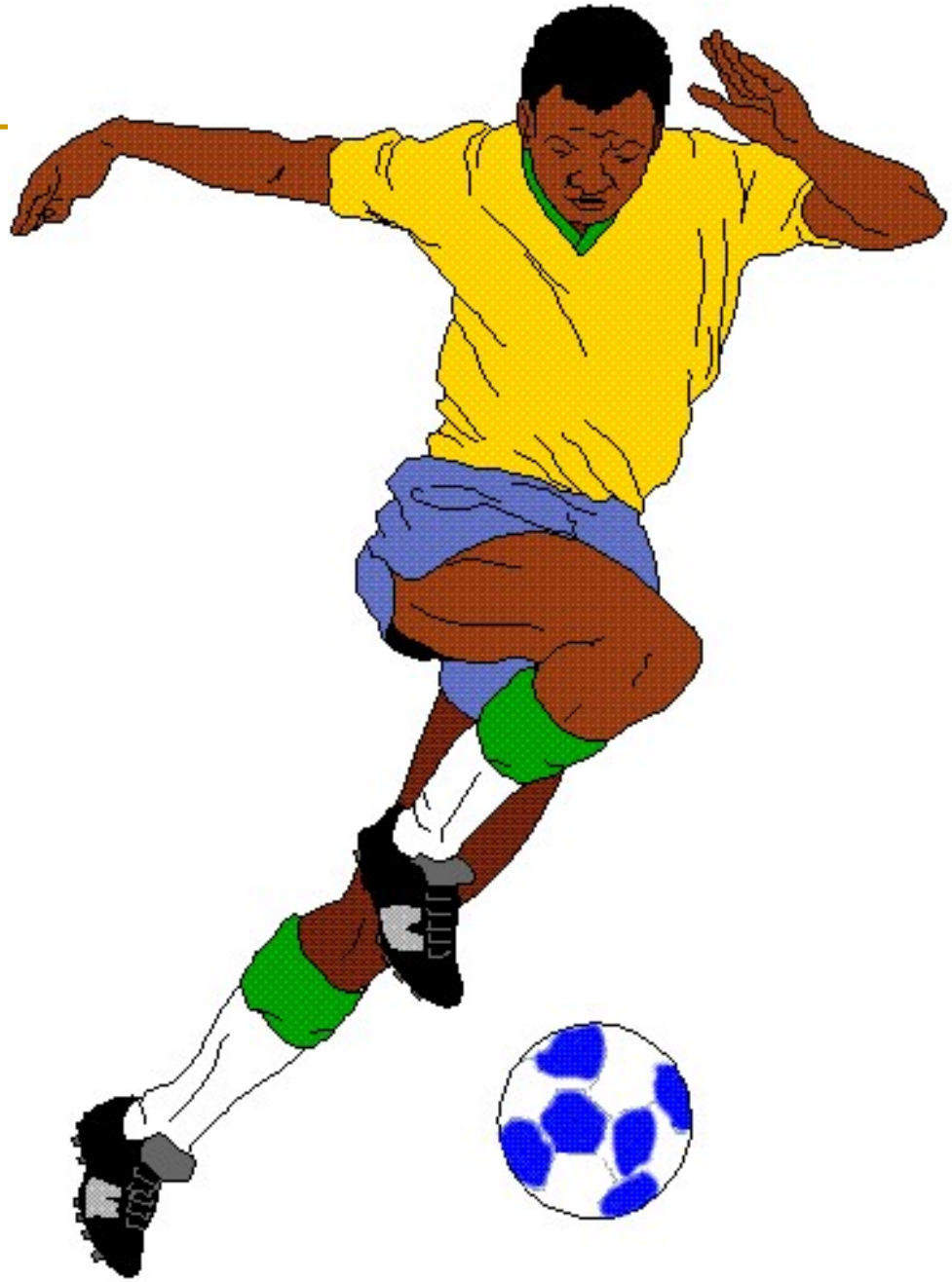
Animation

Simple Translation Animation

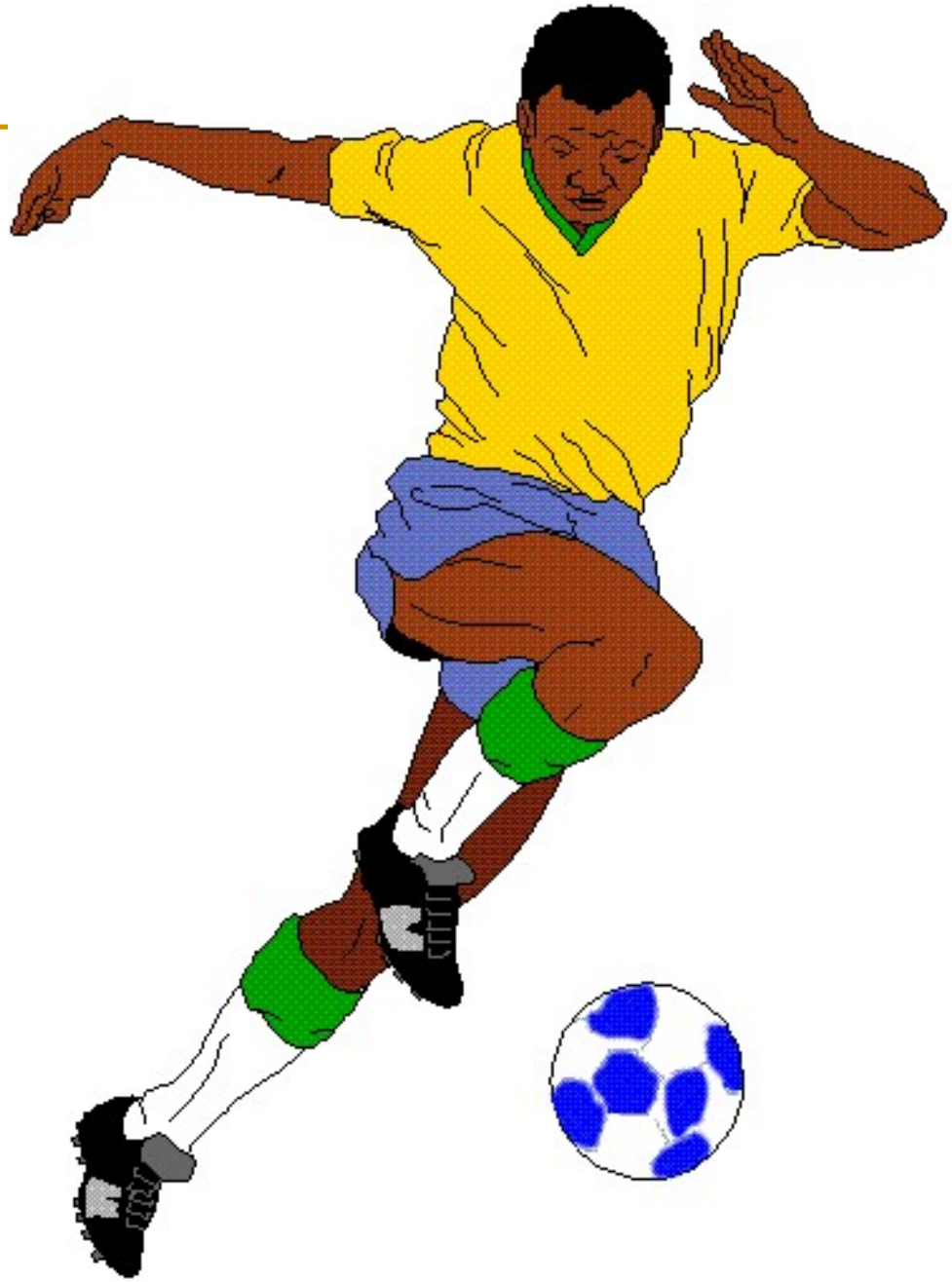


Simple
Translation
Animation

Simple
Translation
Animation

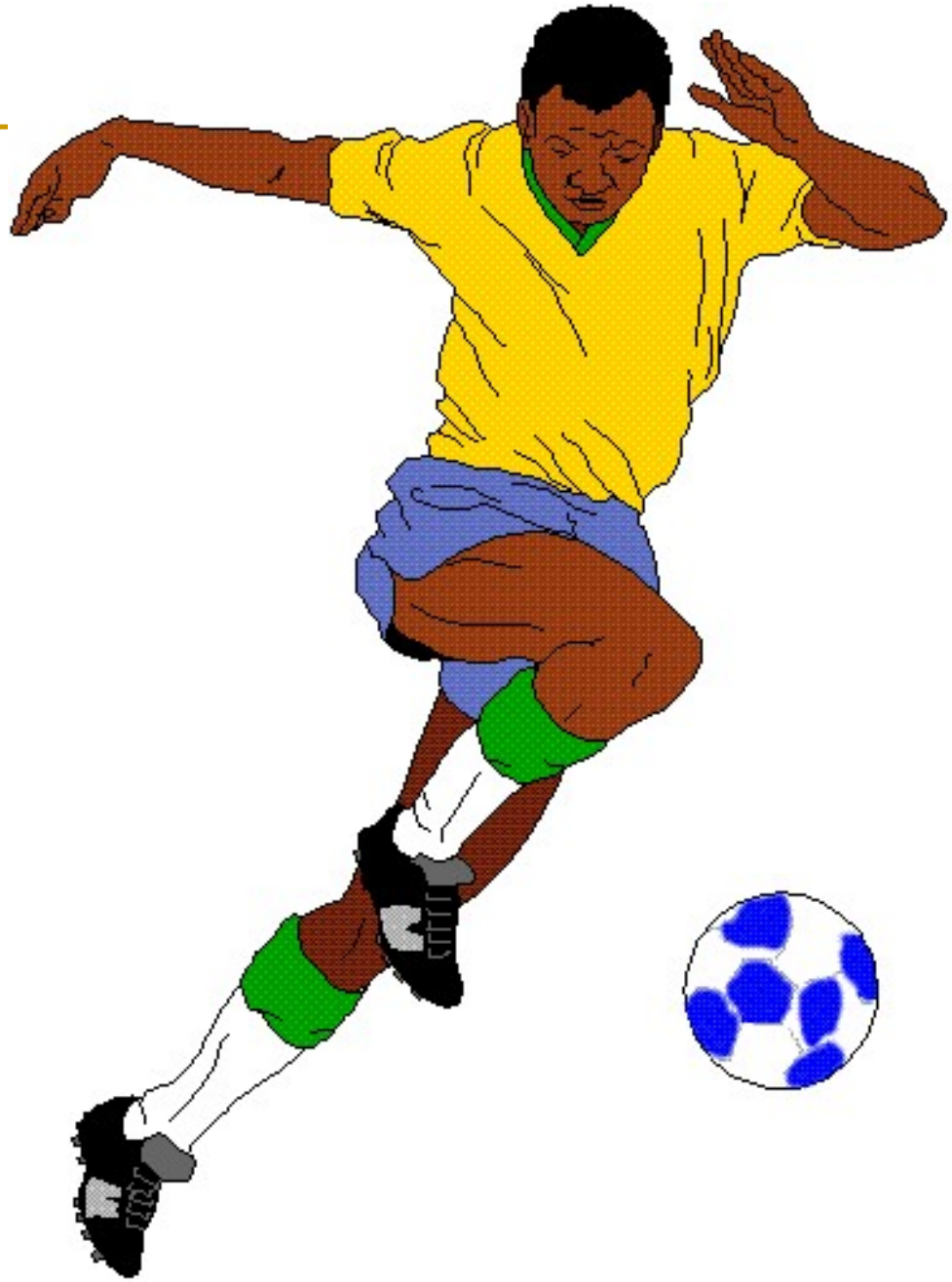


Simple Translation Animation



Simple Translation Animation

Simple Translation Animation



Simple Translation Animation

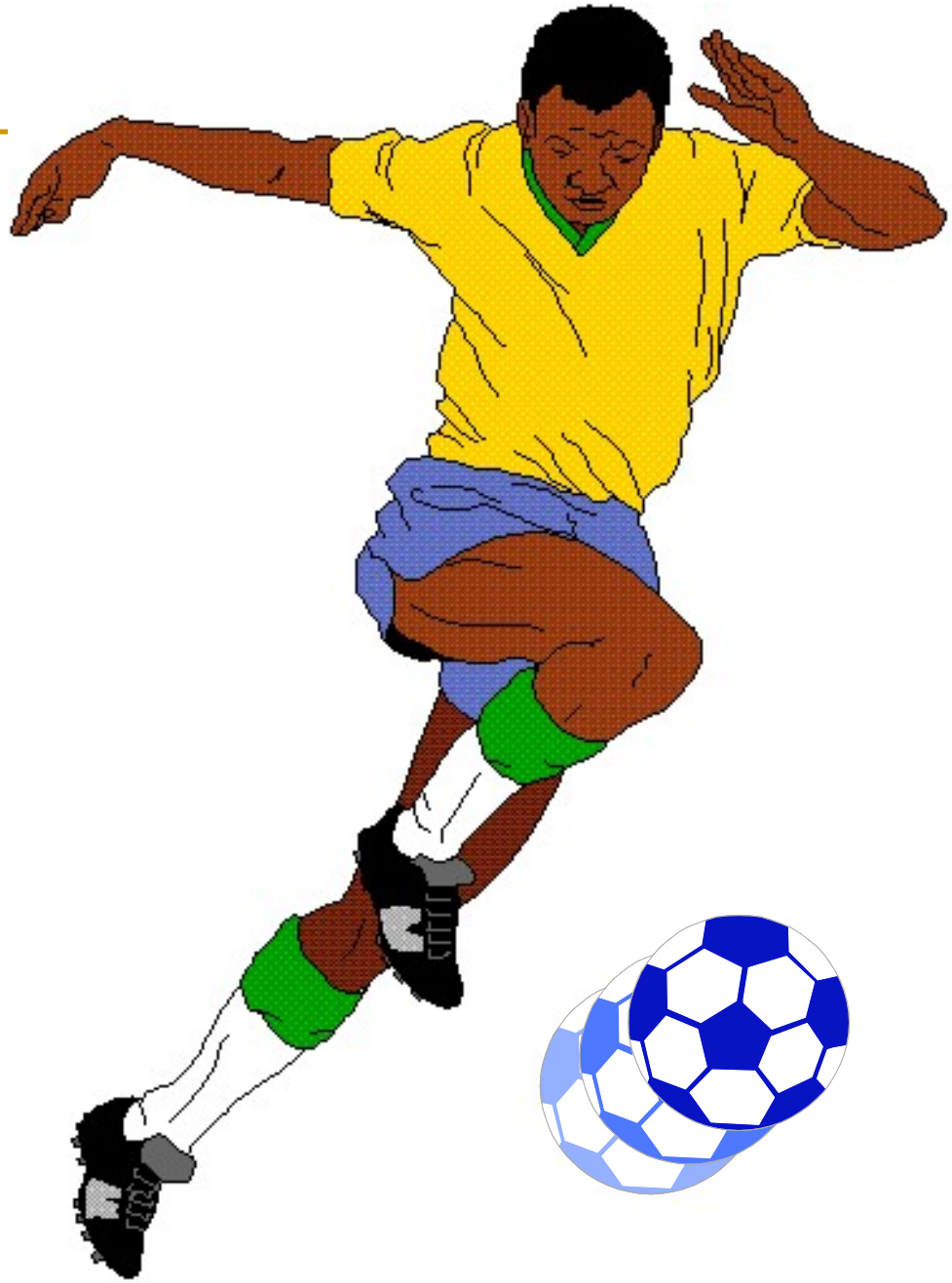
Simple Translation Animation

Simple Translation Animation

Simple Translation Animation with Blurring

Simple Translation Animation with Blurring

Simple Translation Animation with Blurring



Simple Translation Animation with Blurring

Simple Translation Animation with Blurring

Simple Translation Animation with Blurring

Simple Translation Animation with Blurring

Simple Translation Animation with Blurring

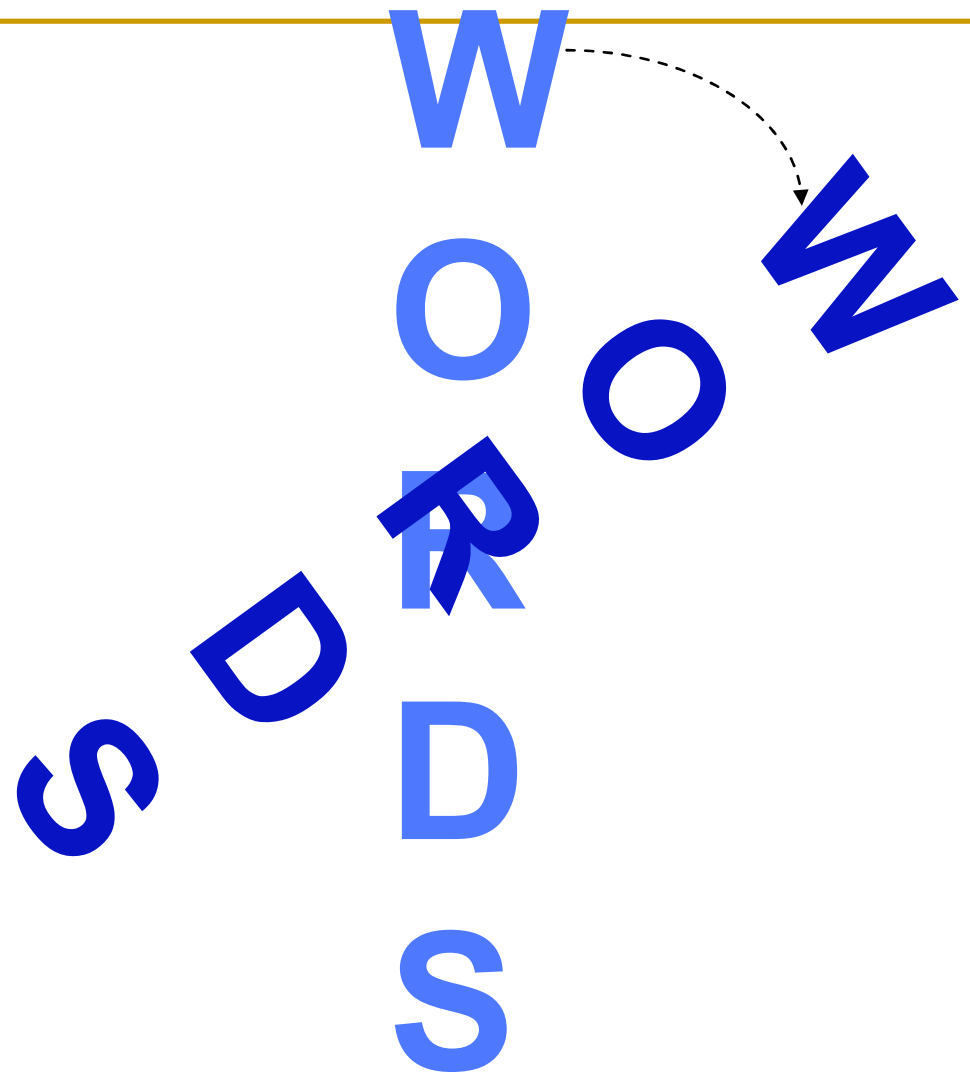
Simple Translation Animation with Blurring

Simple Translation Animation with Blurring

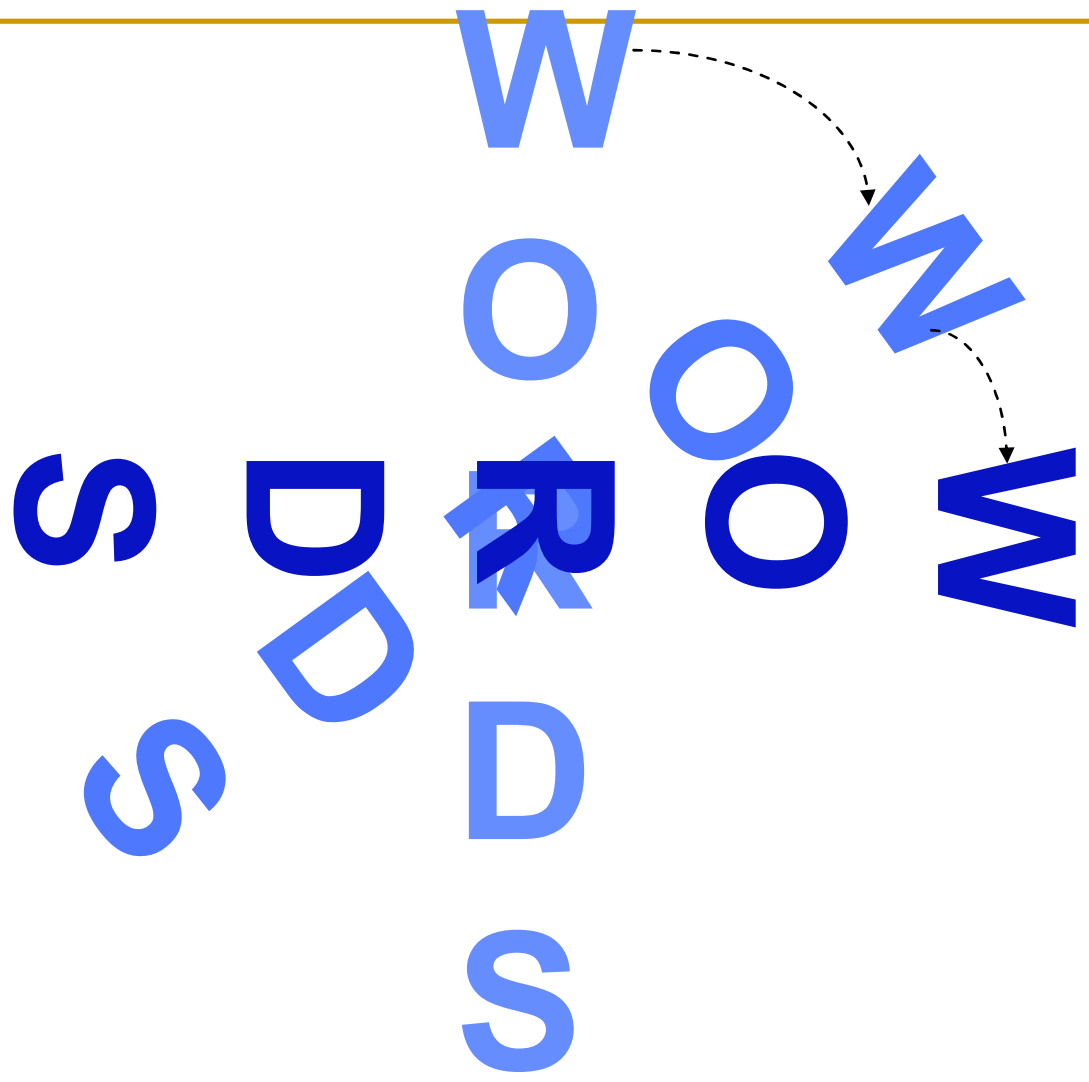
Simple Rotational Animation

W O R D S

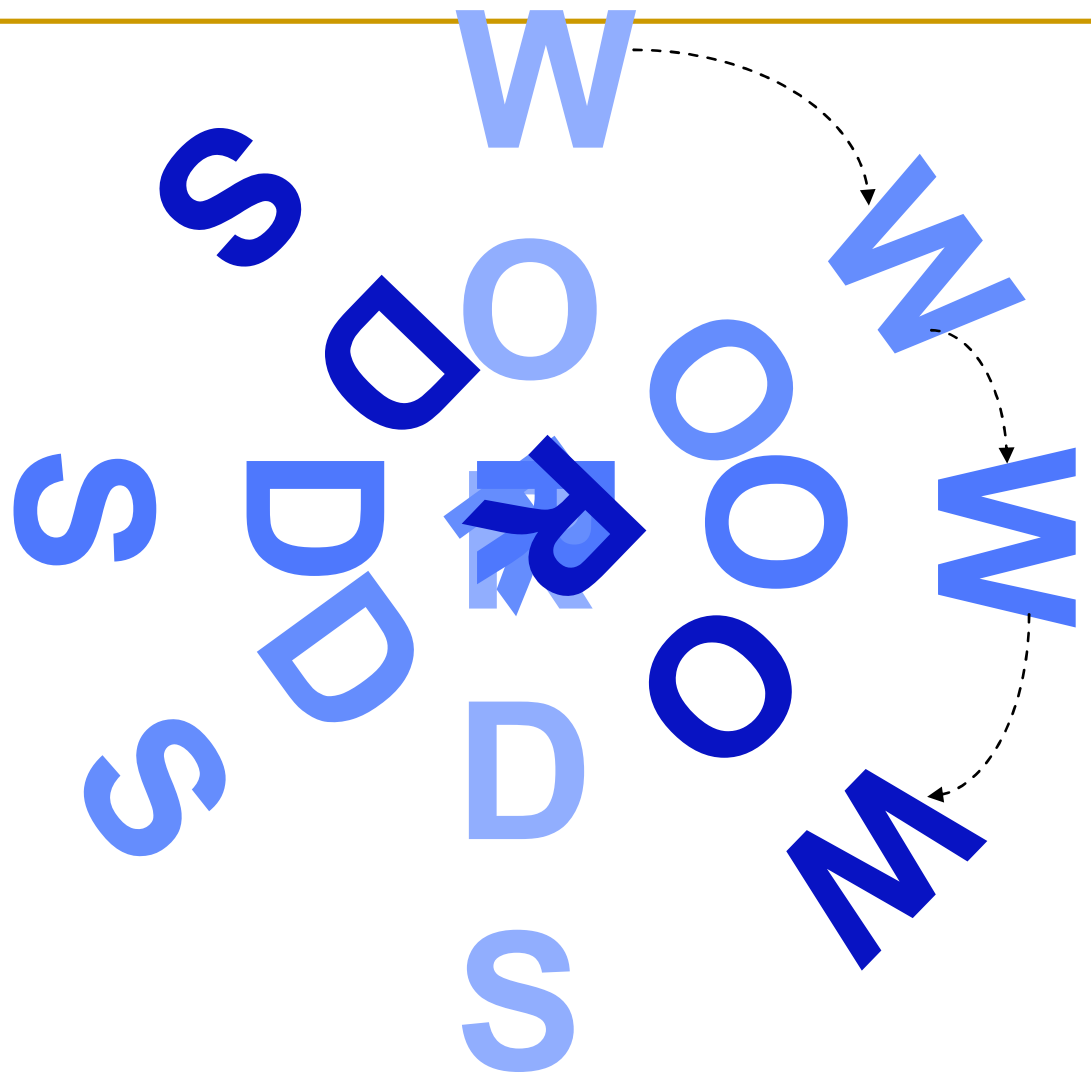
Simple Rotational Animation



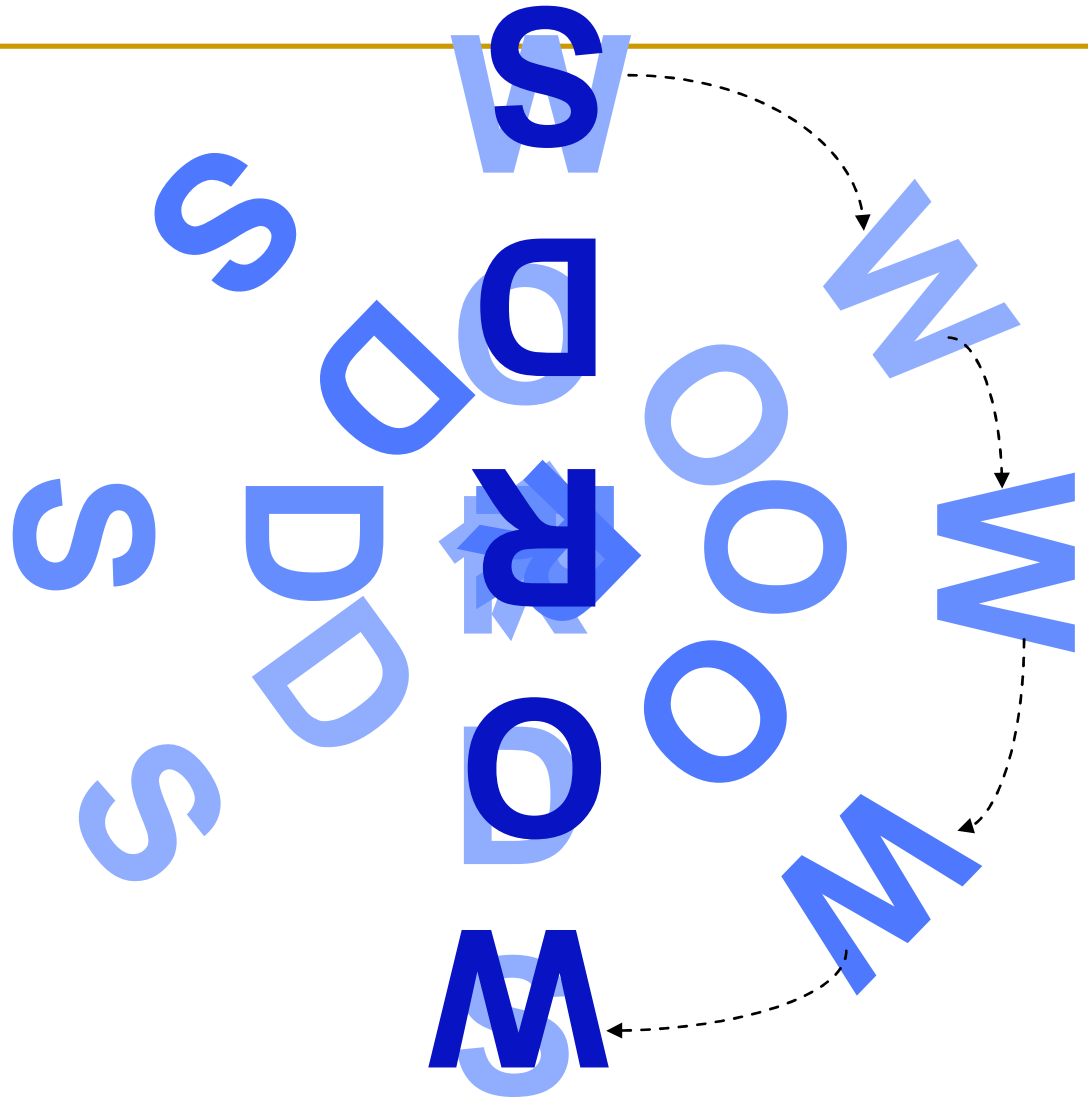
Simple Rotational Animation



Simple Rotational Animation



Simple Rotational Animation



Animation: Morphing

- **Morphing — an effect that makes one image appear to transform itself into another over a brief time span**
- **The fundamental lines and colors of each portion of the original image are gradually changed into the lines and colors of the corresponding portion of the second image.**
- **It is a powerful tool and has widespread use for achieving special visual effect in the entertainment industry.**

Animation: Morphing

Animation:Morphing

In the Titanic

Animation:Gait Synthesis

- When a biped or other animal moves, many different parts of the body are in motion in complex combinations of directions
- Creating all of these motions, given a starting figure and a destination, known as “gait synthesis,” is a complex form of animation

Exercise

1. State and explain the classification of medium by ITU.
2. Explain the meaning of the terms “luminance” and “ chrominance”.
3. Please state the difference between images and graphics.

Exercise

2. **Explain the meaning of the terms “luminance” and “ chrominance”.**

Luminance: the brightness of light, or gray value

Chrominance: the property of a color, independent of brightness. It reflects the hue (the type of color, such as red, yellow) and saturation (color intensity, purity) of a color.

Examples, such as YUV or HSV.

3. **Please state the difference between images and graphics.**

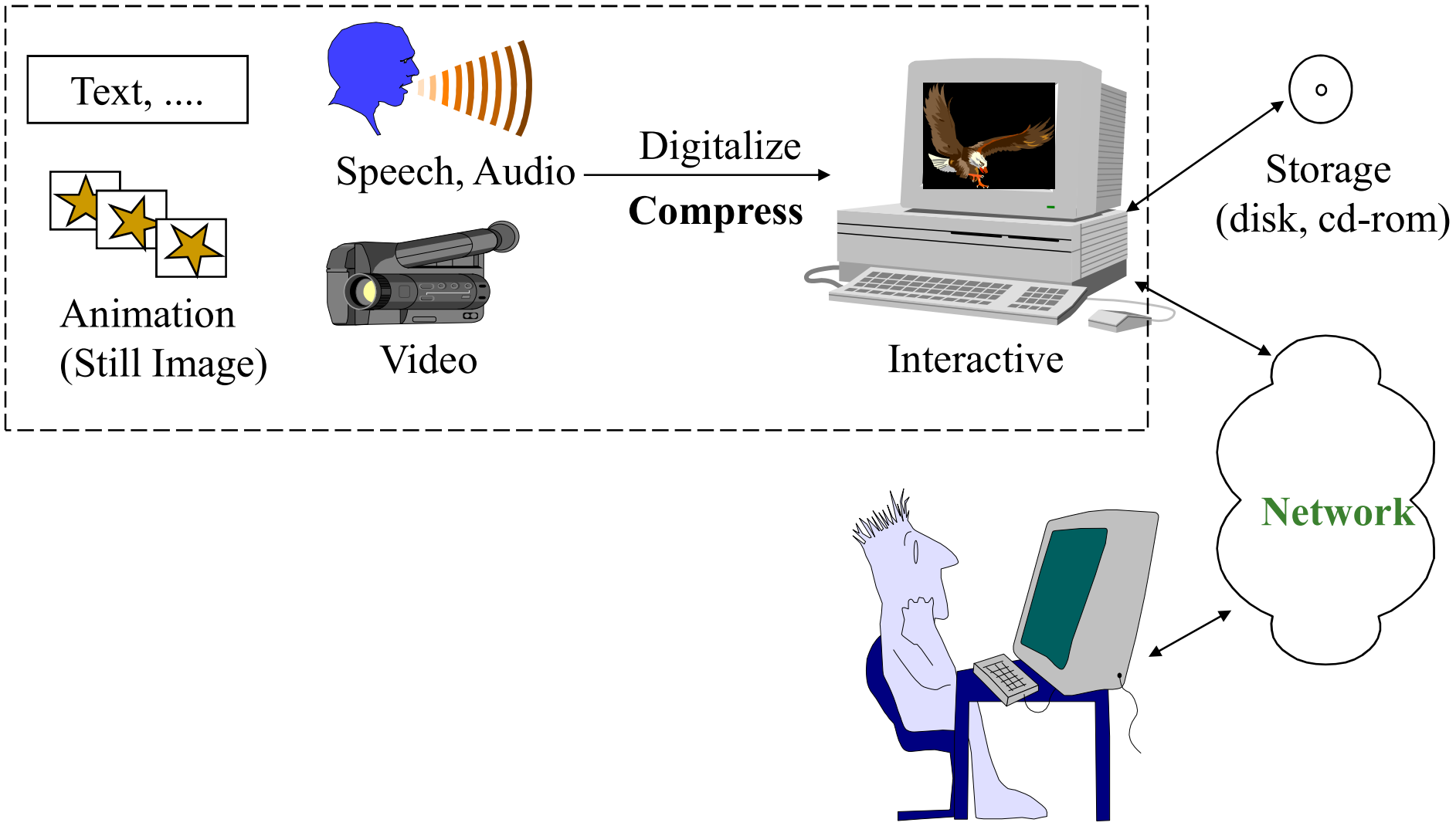
Source: Input through camera or scanner /Designed by computer

Structure: Bitmaps, pixels /Parametric graph, vector graph

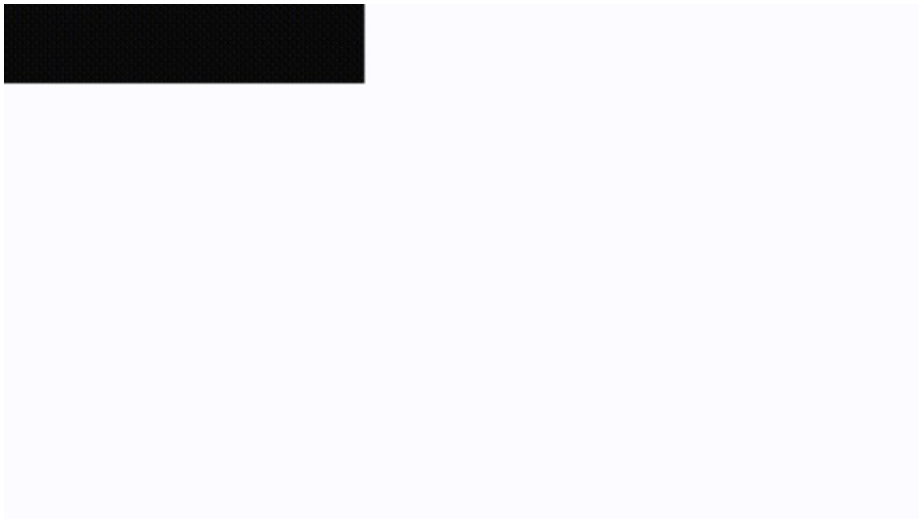
Data Description: Large storage, sawtooth during scaling /small, scaleable file format

Multimedia System Architecture & Computer System Components

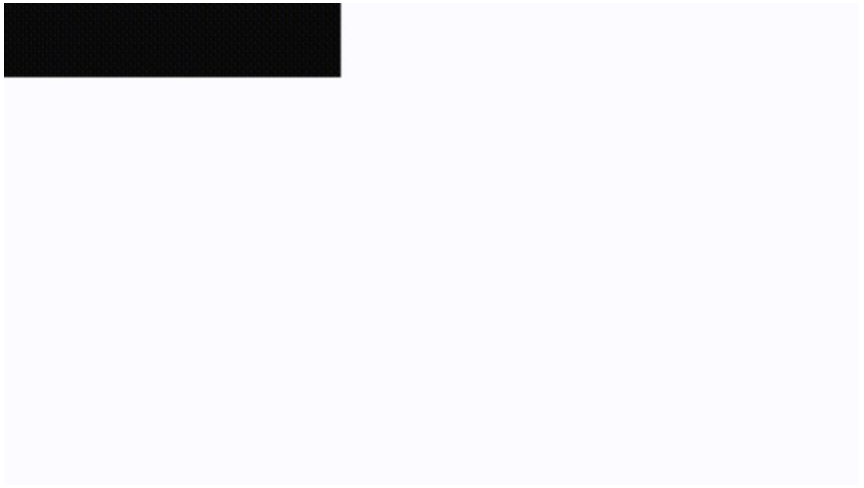
Multimedia System Architecture



逐行扫描和隔行扫描

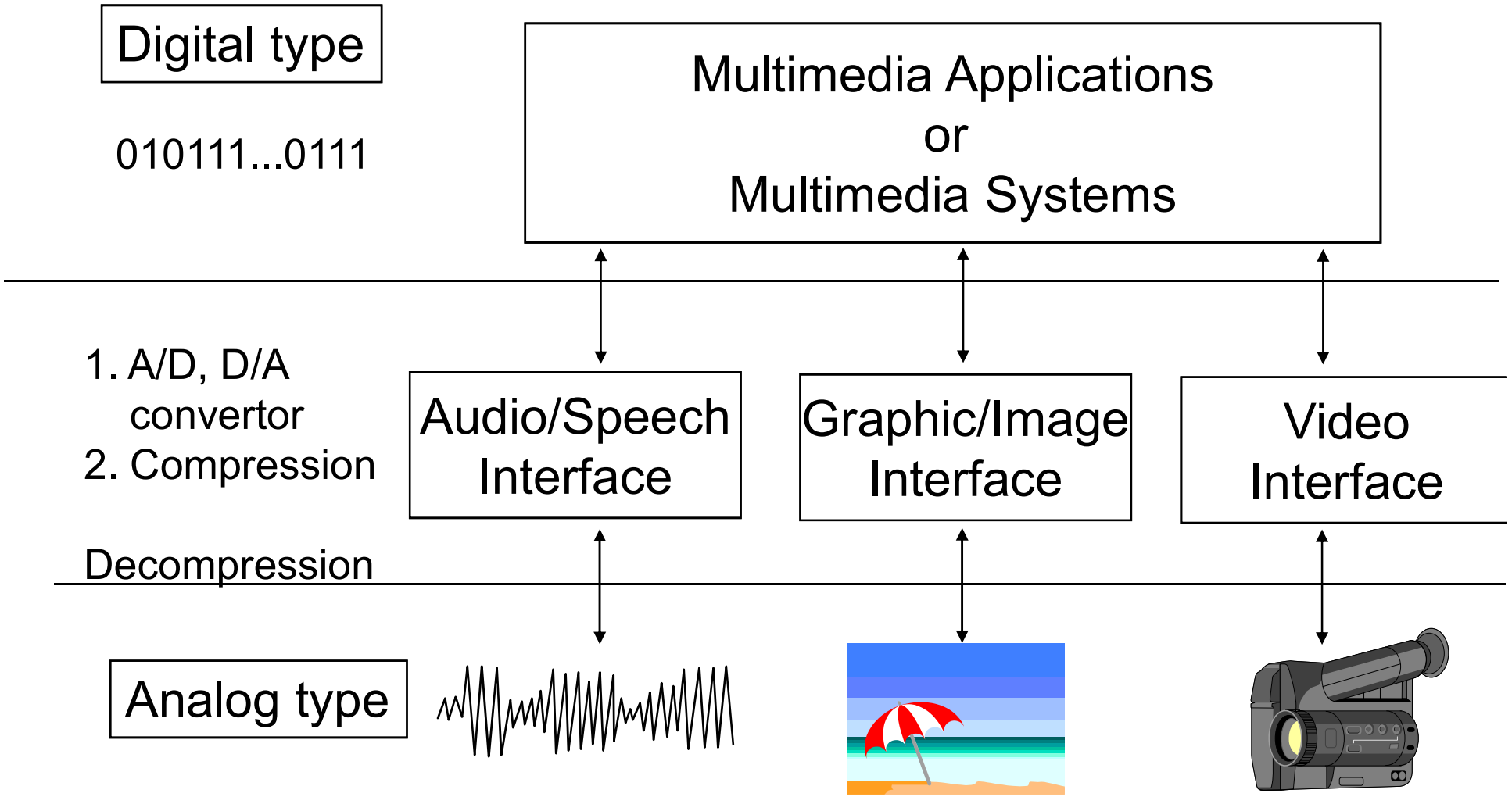


1080P

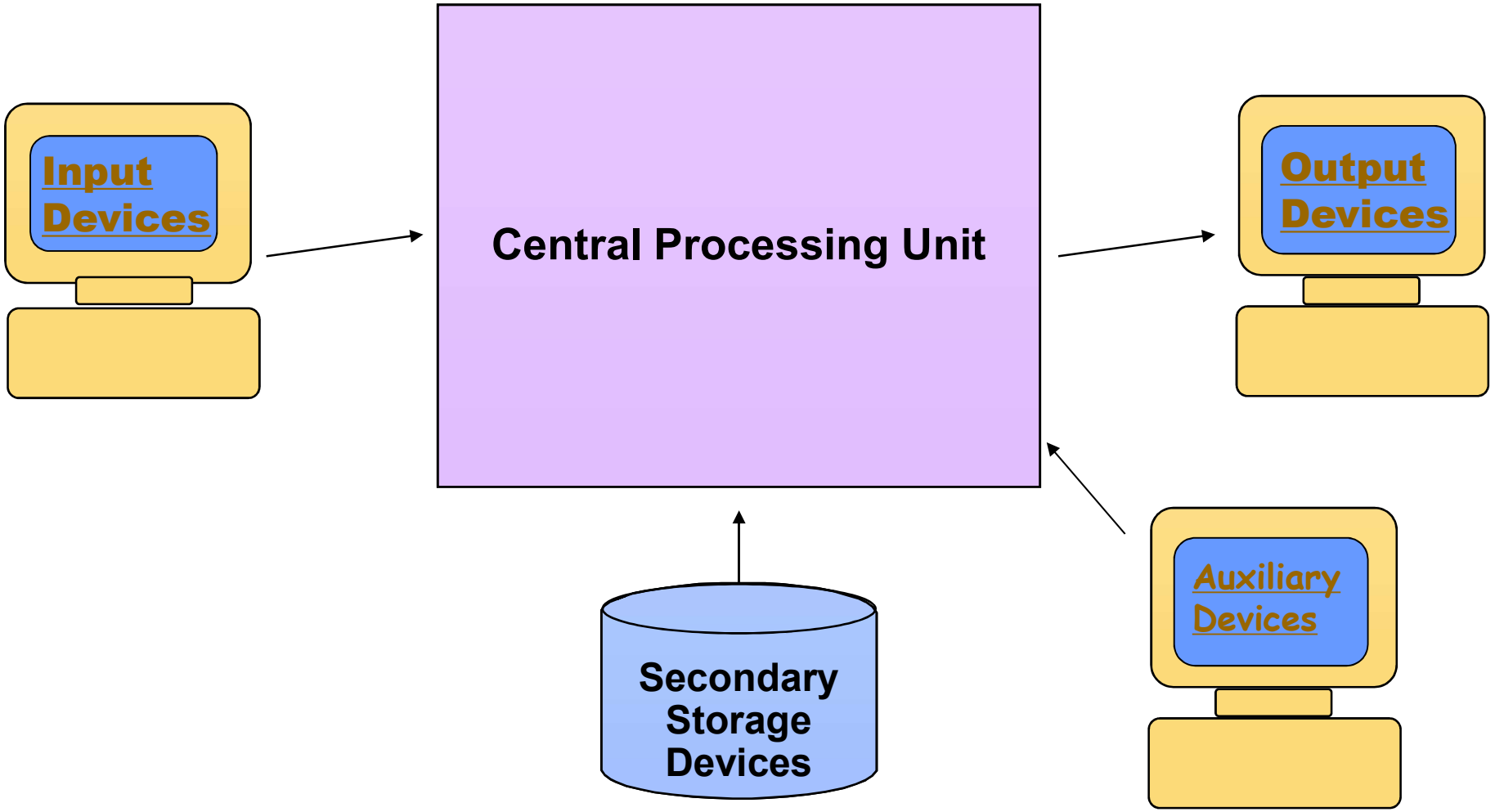


1080i

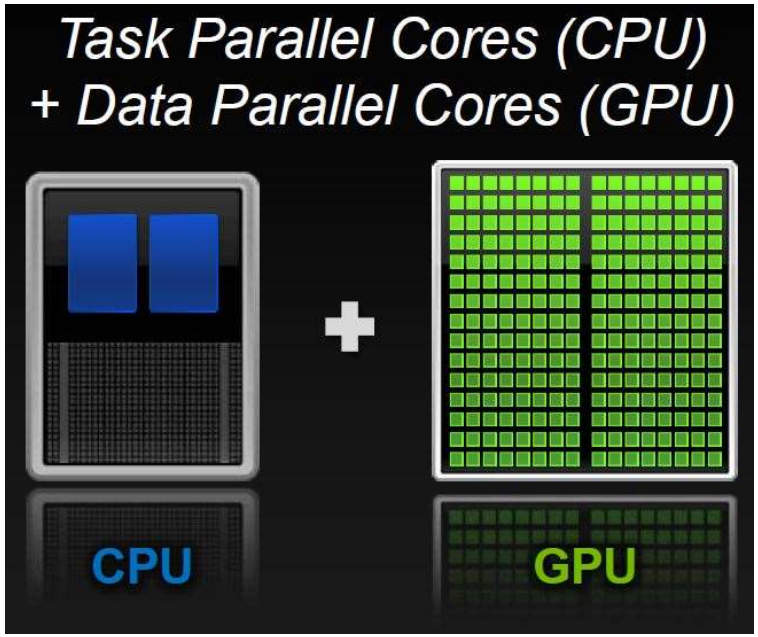
Basic Multimedia System Architecture

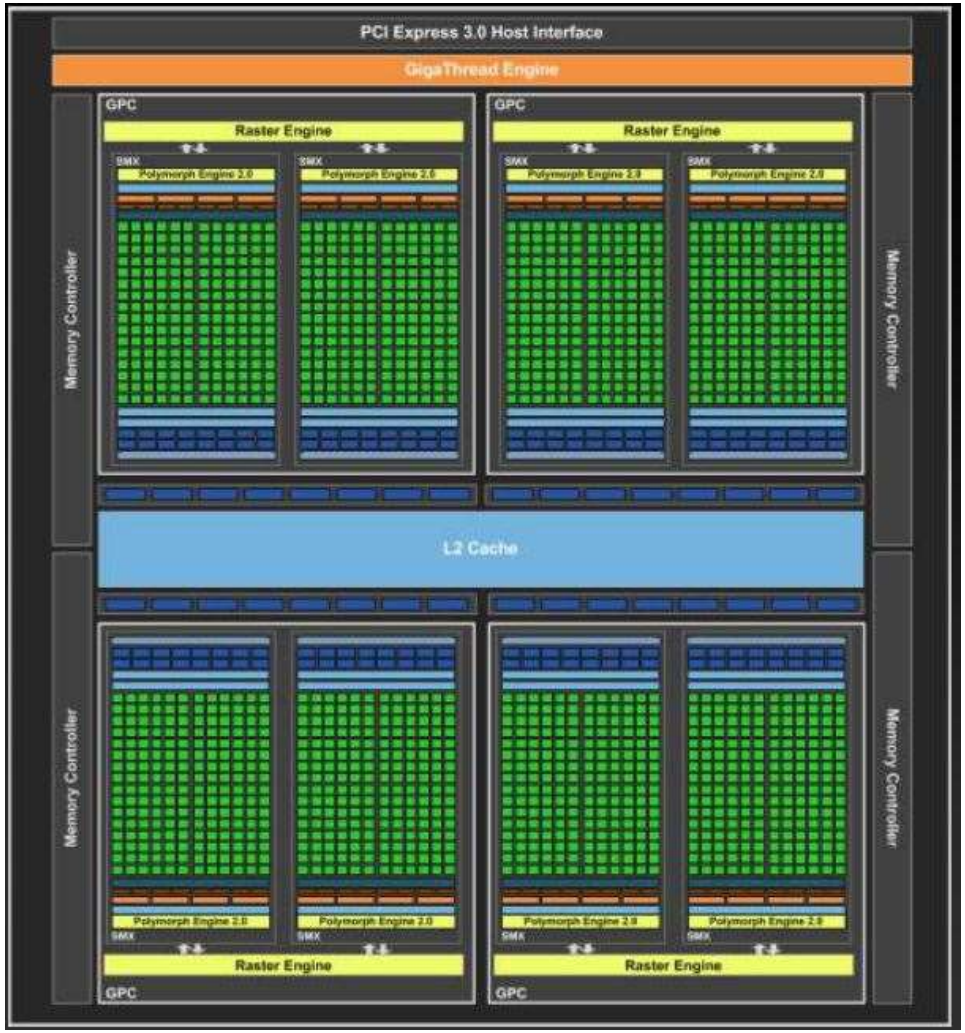


Computer System Components



CPU + GPU





Green: data parallel processors
Light-Blue/Gray: cache/memory
Yellow/Orange/Dark-Blue: function

Input Devices

- **Input: put the data into the computer for processing**
- **Input devices:**

Keyboard

Mouse

Scanner

Microphone

PC Camera

Digital Camera

Scanner

A **scanner** is a device that optically scans images, printed text, handwriting, or an object, and converts it to a digital image.

Scanner characteristics

- Scanner Resolution
- Color shades and grayscale
- Speed

Scanner

Scanner Resolution

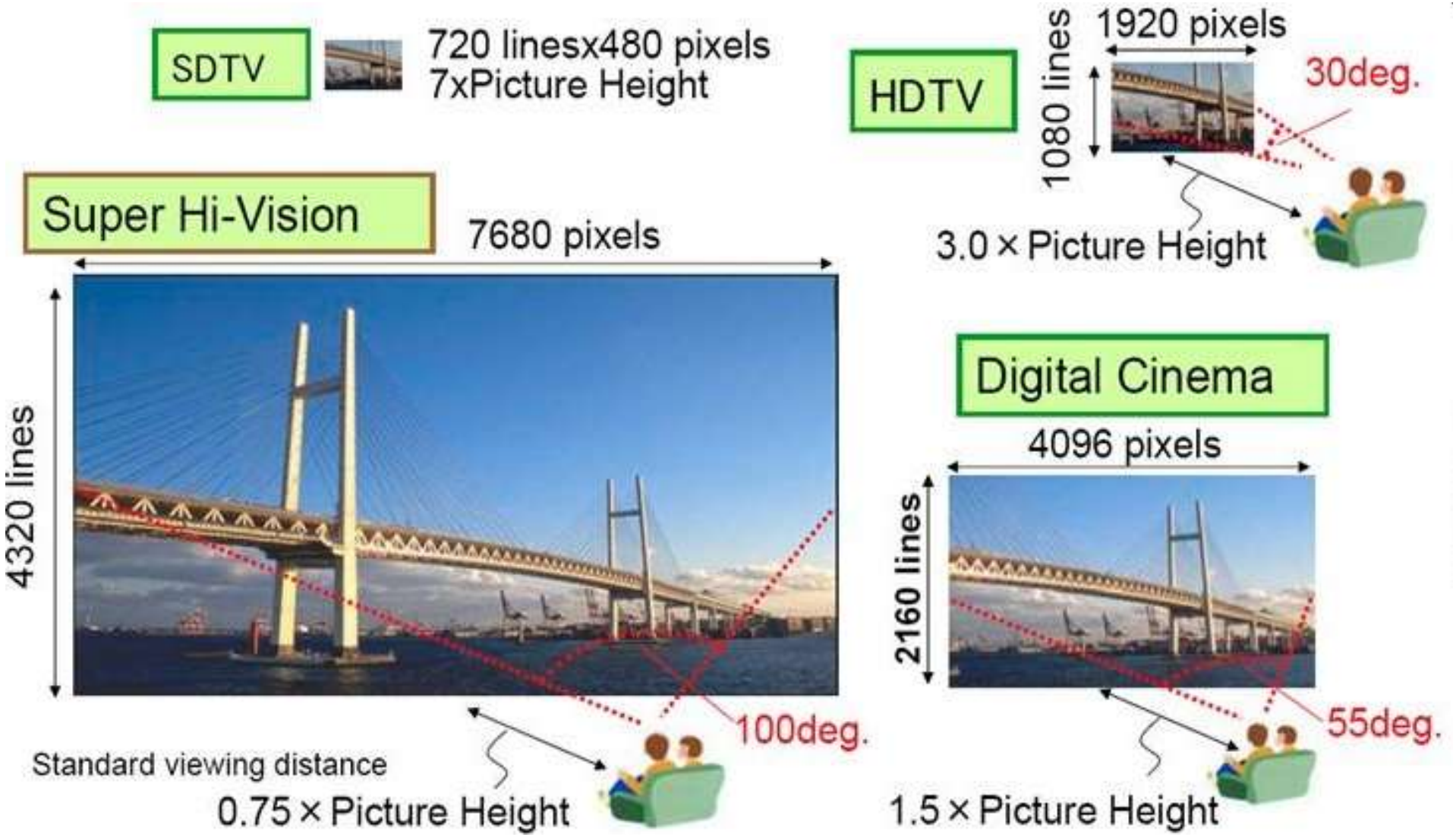
Generally the definition of the scanner resolution is given in dpi. Dpi, or dots per inch, is one factor in measuring the detail, or optical resolution of the image.

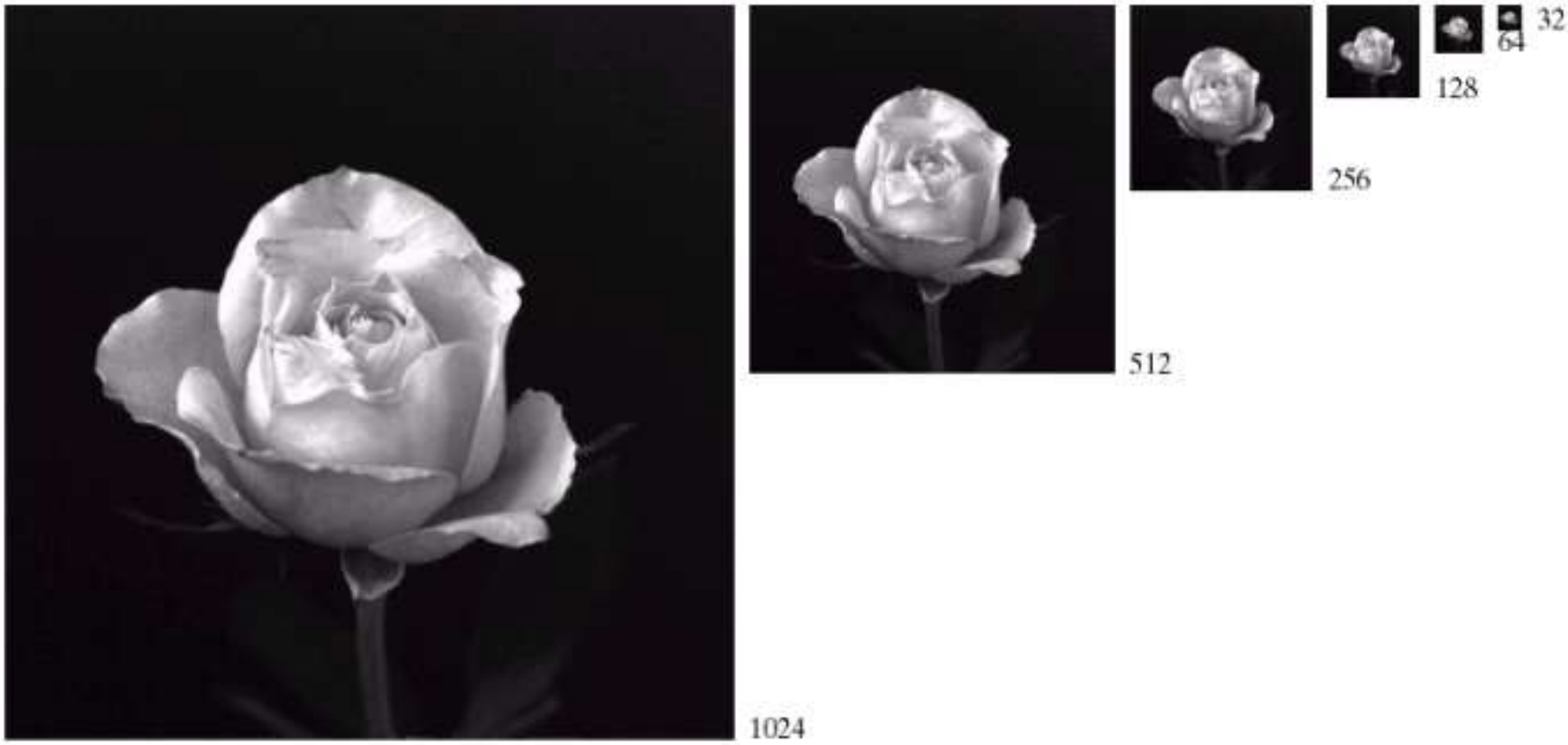
Color shades and grayscale

The scanners capture a number of colors or a number of bits per pixel. The more bits a scanner works with, the greater variety of colors it can read.

Speed

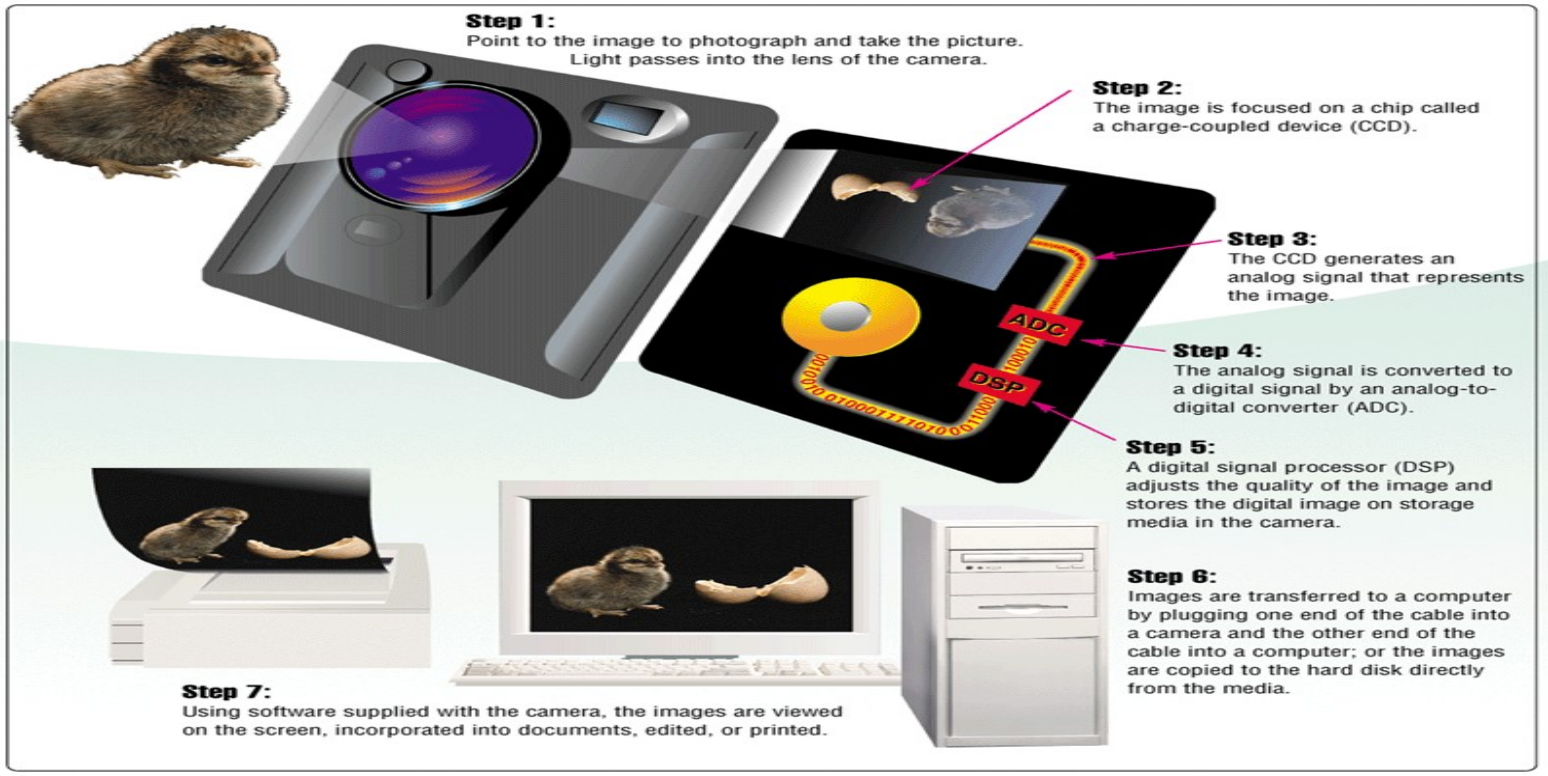
Generally the speed is given for an A4 document scanned with a resolution of 200 dpi and in black and white.


SDTV
720 linesx480 pixels
7xPicture Height
HDTV
1920 pixels
1080 lines
30deg.
3.0 × Picture Height
Super Hi-Vision
7680 pixels
4320 lines
100deg.
Standard viewing distance
0.75 × Picture Height
Digital Cinema
4096 pixels
2160 lines
55deg.
1.5 × Picture Height


1024
512
256
128
64
32

Digital Camera

- **A digital camera is a camera that takes video or still photographs, or both, digitally by recording images via an electronic image sensor.**



Digital Cameras and Scanners

Image quality depends on the:

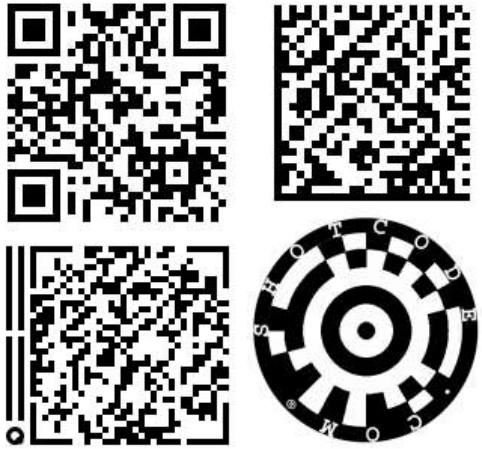
- Quality of the optics and the scanning mechanism, which determines focus
- Precision of the photosensitive cells, which determines the accuracy of the encoding of intensity and wavelength data
- Resolution of the instrument in dots per inch, which determines graininess
- Amount of storage available, which determines the total size of an image that can be digitized

Optical Character Recognition (OCR)

- **With OCR software and a scanner, you can convert paper documents into a word processing document.**
- **Software — systematically checks the entire image for patterns of light and dark that it recognizes as alphabetic, numeric, or punctuation characters.**
- **OCR software entails pattern recognition, a sophisticated logic problem.**

Barcode Readers

- A barcode is an optical machine-readable representation of data, which shows certain data on certain products. Originally, barcodes represented data in the widths (lines) and the spacings of parallel lines, and may be referred to as linear or 1D barcodes. They also come in patterns of squares, dots, hexagons and other geometric patterns within images termed 2D matrix codes.



Barcode Readers (cont.)

- **A barcode reader (or barcode scanner) is an electronic device for reading printed barcodes. It consists of a light source, a lens and a light sensor translating optical impulses into electrical ones. Additionally, nearly all barcode readers contain *decoder* circuitry analyzing the barcode's image data provided by the sensor and sending the barcode's content to the scanner's output port.**

Barcode Readers (cont.)

- A barcode reader works by directing a beam of light across the bar code and measuring the amount of light that is reflected back.
- The dark bars on a barcode reflect less light than the white spaces between them. The scanner converts the light energy into electrical energy, which is then converted into data by the decoder and forwarded to a computer.

Touch Screen

- **A touchscreen is an electronic visual display that the user can control through simple or multi-touch gestures by touching the screen with a special stylus/pen and-or one or more fingers. Touch input is suitable for a wide variety of multimedia applications**

Microphone

Microphones just convert a real sound wave into an electrical audio signal. In order to do so, they have a small, light material in them called the **diaphragm**. When the sound vibrations through the air reach the diaphragm, they cause the diaphragm to vibrate.

Output Devices

- **Output: the result produced by the CPU**
- **Output devices:**

Printer

Monitor

Speaker

Printer

The quality of a print is largely determined by how many dot-per-inch(dpi) it can print.

Printers that print at 300DPI produce acceptable graphics,but 600DPI looks a lot better.

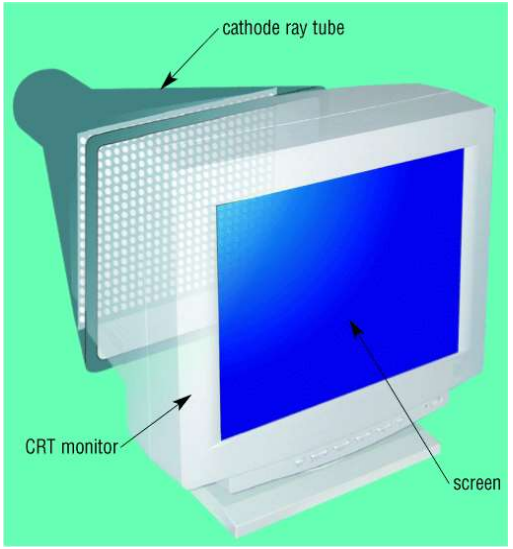
- **Dot Matrix Printer**
- **Laser Jet Printers:the best and fastest prints**
- **Ink Jet Printer**

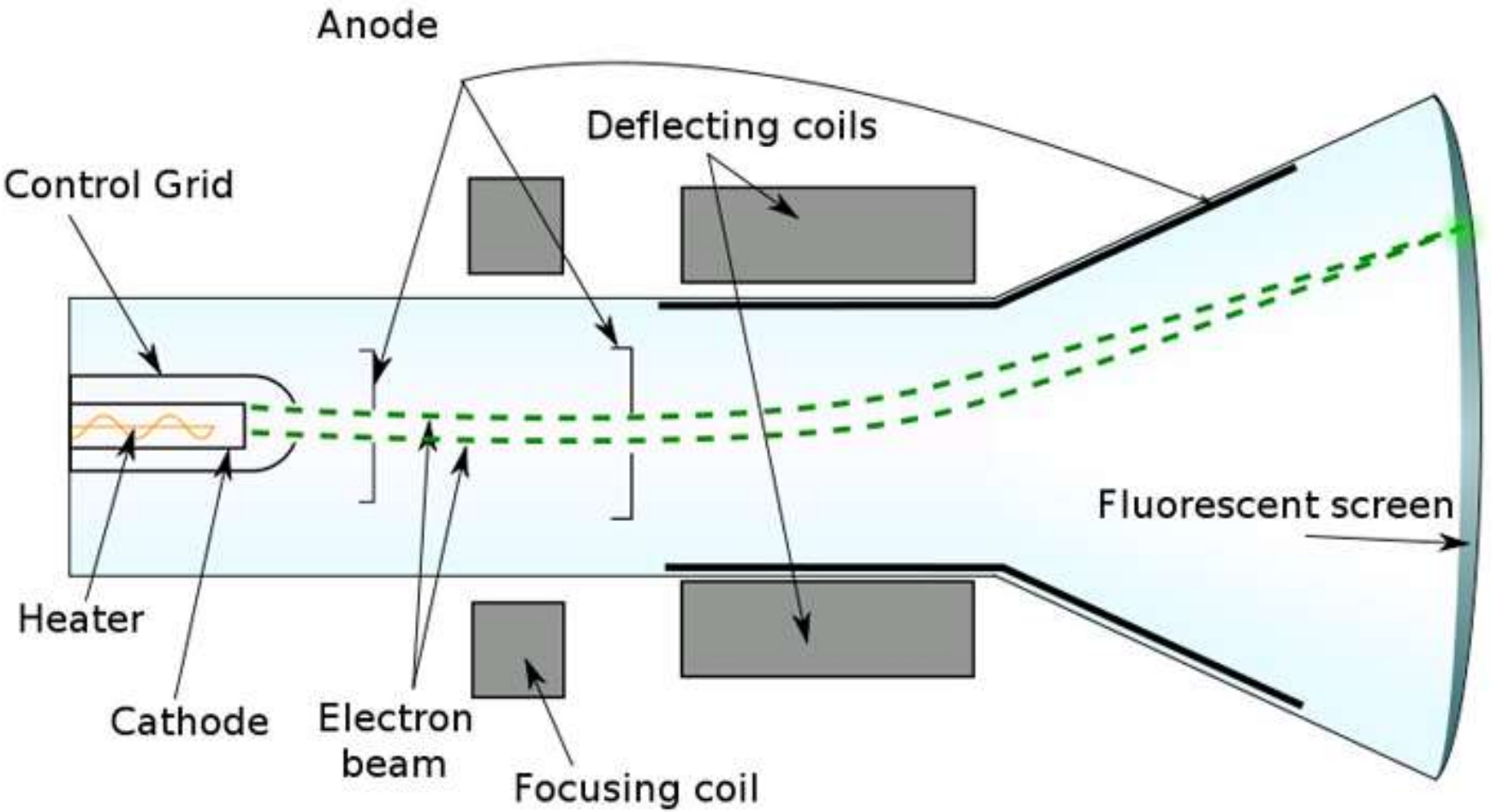
Display Monitors

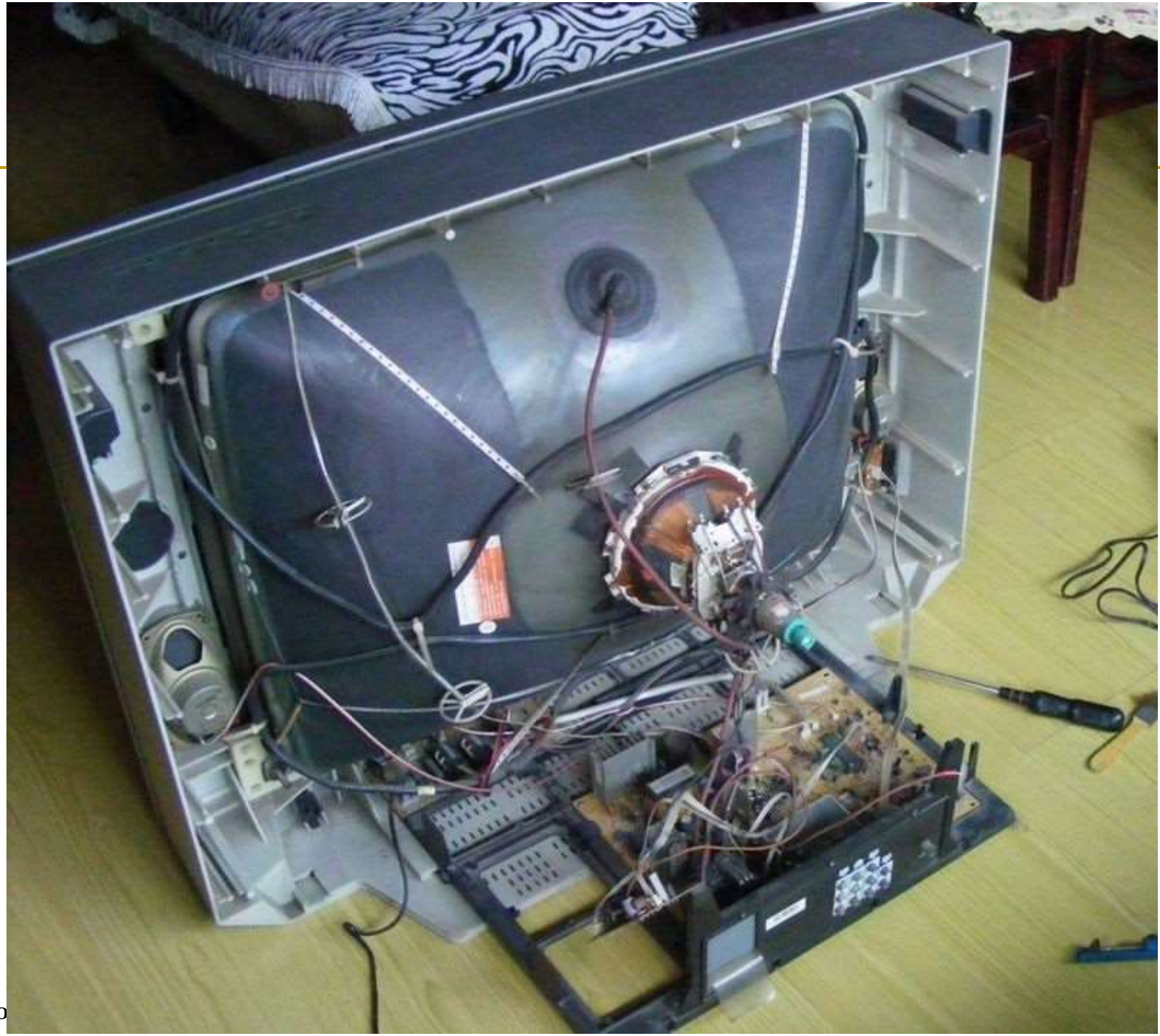
CRT Monitors

cathode ray tube

- Raster scan technology
- An electron beam moves back and forward across the back of the screen, this causes dots on the front of the screen to glow, producing an image
- Available in various sizes 15 – 22 inches
- Flat and curved screens




Anode
Deflecting coils
Control Grid
Fluorescent screen
Heater
Cathode
Electron
beam
Focusing coil



Display Monitors (cont.)

CRT Monitors

Standard	Suggested Resolution	Possible Simultaneous Colors
Monochrome Display Adapter (MDA)	720 x 350	1 for text
Video Graphics Array (VGA)	640 x 480	16
	320 x 200	256
Extended Graphics Array (XGA)	1024 x 768	256
	640 x 480	65,536
Super Video Graphics Array (SVGA)	800 x 600	16.7 million
	1024 x 768	16.7 million
	1280 x 1024	16.7 million
	1600 x 1200	16.7 million
Beyond SVGA	1920 x 1440	16.7 million
	2048 x 1536	16.7 million

Display Monitors (cont.)

Liquid Crystal Display

LCD Monitors

- Contains liquid crystals between 2 sheets of material
- An electric current passes through the crystals causing them to twist, block light waves and create an image.
- Uses less than one third the power of a CRT monitor

Plasma Display Panel

•A layer of gas instead of liquid crystals

•Larger screens

Speakers

- A loudspeaker (or "speaker", or in the early days of radio "loud-speaker") is an electroacoustic transducer that produces sound in response to an electrical audio signal input.
- Speakers convert electrical signals into audible signals.

Devices for Communication

- **Modem**
- **NIC (network interface card)**

Modem

- **A modem (*modulator-demodulator*) is a device that modulates an analog carrier signal to encode digital information, and also demodulates such a carrier signal to decode the transmitted information. The goal is to produce a signal that can be transmitted easily and decoded to reproduce the original digital data. Modems can be used over any means of transmitting analog signals, from driven diodes to radio.**

Modem (cont.)

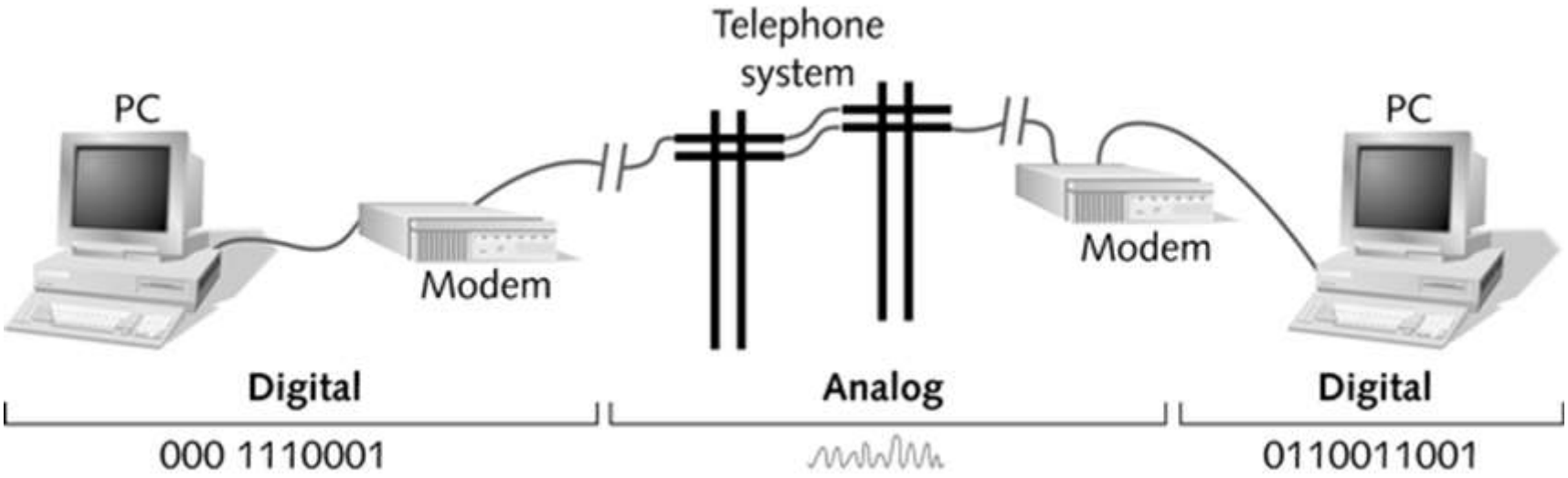
- **The most familiar type is a voice band modem that turns the digital data of a computer into modulated electrical signals in the voice frequency range of a telephone channel. These signals can be transmitted over telephone lines and demodulated by another modem at the receiver side to recover the digital data.**

Modem Speed

- **normally measured in bits per second (bit/s, or bps).**

Modem (cont.)

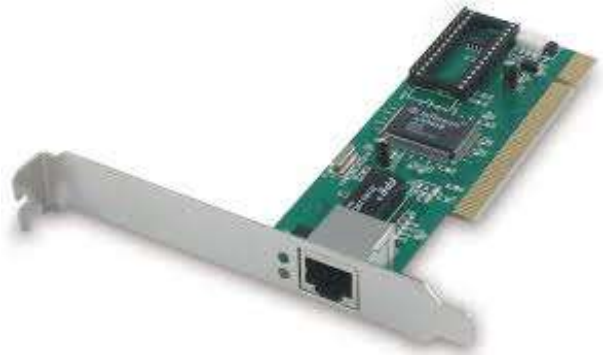
Modulation/Demodulation



Modems convert a digital signal to analog and then back to digital

NIC（Network Interface Card）

- **A** network interface card **(also called network adapter, network card) is a piece of computer hardware designed to provide for computer communication over a computer network.**



Network Interface Card

- In accordance with a certain protocol such as Ethernet or token ring among small groups of computers on the same LAN, and through a routable protocol, such as IP, for large-scale network communications.
- Every network has a unique 48-bit serial number called a Media Access Control (MAC) address, which is stored in read-only memory.
- Every computer on an Ethernet network must have at least one controller. It assumes that no two network controllers will share the same address, because controller vendors purchase blocks of addresses from the Institute of Electrical and Electronics Engineers (IEEE) and assign a unique address to each controller at the time of manufacture.

应用举例

沙河校区

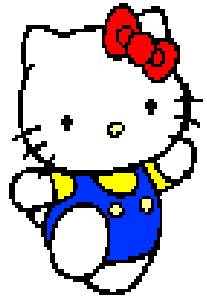
- 9月16日晚，在北京邮电大学西土城校区和沙河校区，通过“5G+全息投影”技术首次实现了跨校区远程互动教学。
  - 三维全息投影人像清晰呈现

西土城校区

Some Key Techniques in Multimedia Applications

Technologies Support Multimedia

- **Computer Science & Electronic Engineering**
  - **DSP technology (Digital Signal Processing)**
  - **Network technology**
  - **Computer Graphics**
  - **Database**



Technologies Support Multimedia (cont.)

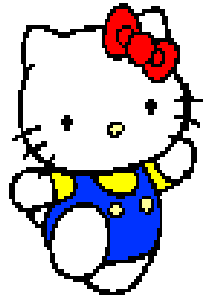
- **Hardware**
  - **VLSI advance**
    - fast CPU power
    - high bandwidth bus
  - **Large media storage support**
    - SCSI
    - Disk array
    - CD-ROM, VCD,DVD

Very Large Scale Integration

Small Computer Systems Interface

Research Topics in Multimedia Applications

- **Multimedia coding and processing**
  - ✓ compression
  - ✓ multimedia content analysis
  - ✓ content-based multimedia retrieval
  - ✓ multimedia security
  - ✓ audio/image/video processing
  - ✓ etc.



Data Compression

Why need data compression?

- **Storing or transmitting multimedia data requires large space or bandwidth.**
- **The size of one hour 44K sample/sec 16-bit stereo (two channels) audio is**

$$3600 \times 44000 \times 16 \times 2 \div 8 = 633.6\text{MB}$$

which can be recorded on one CD (650 MB).

- **MP3 compression can reduce this number by factor of 10.**

Data Compression (cont.)

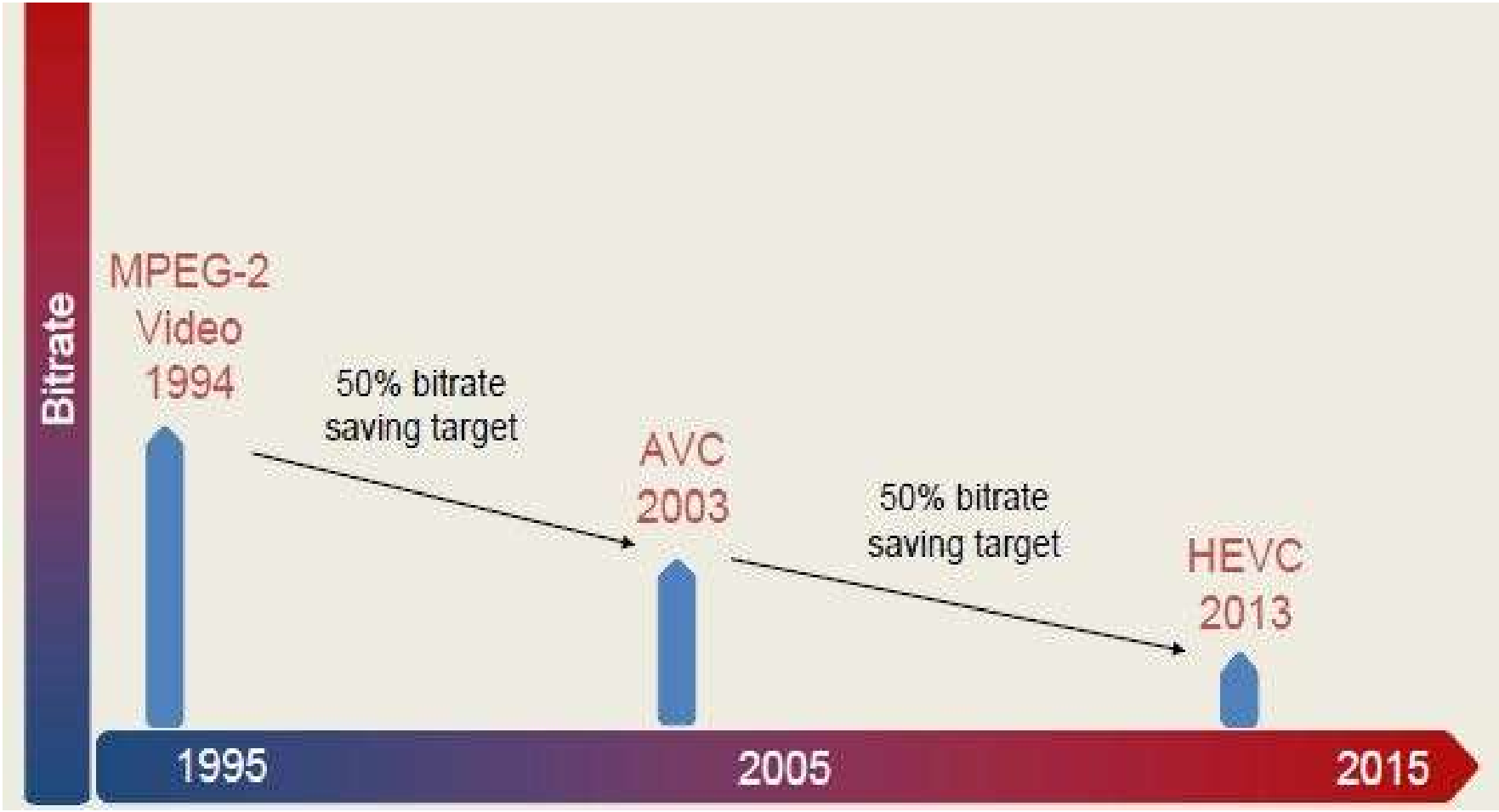
- **The size of a 500×500 color image is 750KB without compression (JPEG can reduced this by a factor of 10 to 20)**
- **The size of one minute real-time, full size, color video clip is** 60×30×640×480×3= 1.659GB**. A two-hour movie requires 200GB.**
- **MPEG2 compression can bring this number down to** 4.7 GB **(DVD)**

Data Compression (cont.)

Compression reduces the size of a file

- To save ***TIME*** when transmitting it.
- To save ***SPACE*** when storing it.
- Most files have lots of redundancy.

Video Coding Standards



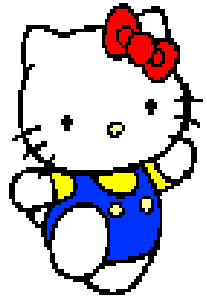
Even Higher in VR/AR

Device	Screen Size	FOV	Screen Resolution	ppi	360 Video Res.
TV	40” diag. (16:9)	~32°	1920 × 1080	48	7680 × 3840
Smartphone	5.5” diag. (16:9)	~32°	1920 × 1080	400	7680 × 3840[1]
HMD	2.5” × 2.5” / eye (1:1)	~90°	5400 × 5400	2160	21600 × 10800 / eye

Assumption is that 90° of content is displayed on the screen horizontally.

Research Topics in Multimedia Applications

- **Multimedia system support and networking**
  - ✓ network protocols (such as Internet)
  - ✓ quality of service (QoS)
  - ✓ databases
  - ✓ operating systems
  - ✓ servers and clients
  - ✓ etc.



Computer Networks

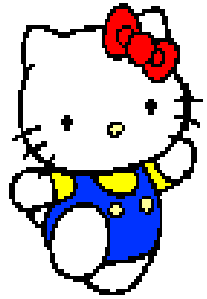
Goal: Communication between computers

treats collection of computers as if

one big computer, distributed resource sharing

Theme: Different computers must agree on many things

– Overriding importance of standards and protocols



Computer Networks (cont.)

Facets people talk a lot about:

- **topology (e.g., bus, ring)**
- **routing algorithms**
- **switching (including multiplexing)**
- **wiring (e.g., choice of media, copper, coax, fiber)**

Computer Networks (cont.)

Definition: A computer network is an interconnected collection of autonomous computers

- **Interconnected meaning two computers have the ability to exchange information using copper cable, fiber optics, or radio**
- **Autonomous meaning where no one computer controls any other computer (i.e. no computer can forcibly start or stop another computer)**
- **Computers can be PC's, workstations and other "specialized" computers such as hubs, switches and routers**

Computer Networks (cont.)

- **A NETWORK ENABLES**
  - **Resource Sharing**

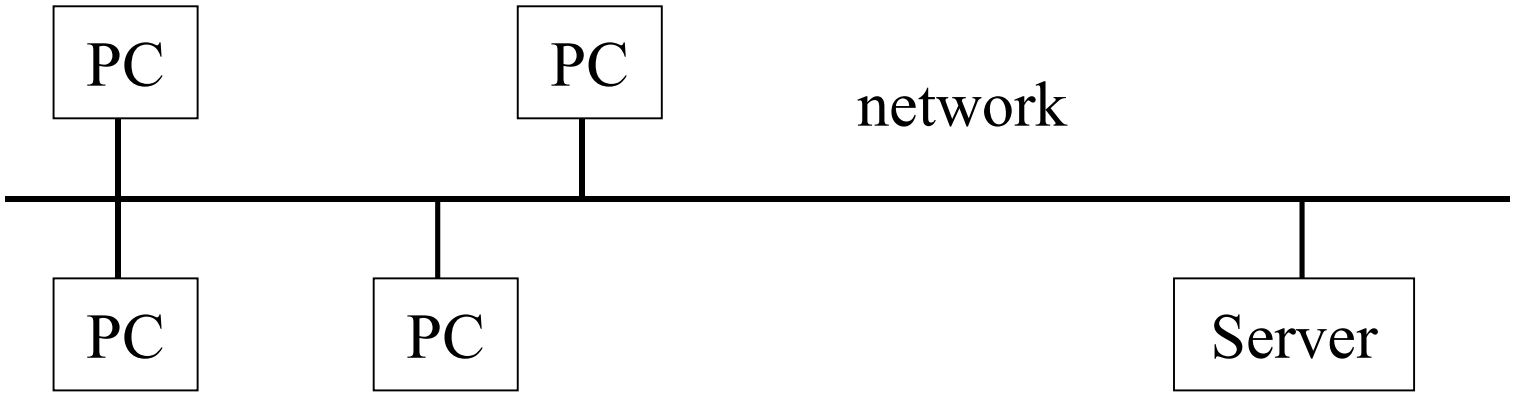
    Data can be shared with a computer in the next room or on a different continent (e.g. the Internet)
  - **Reliability**

    The presence of multiple computers means that if one computer becomes unavailable on the network (due to failure) another can be used to take over that computer's work.
  - **Saving Money**

    Mainframe computers are 10 times faster but 100 times more expensive than PCs. Hence groups of PCs networked together can reduce costs (client-server model).

Client/ Server Model

- **The Client Server model is most commonly used to connect two or more computers together**
- **Computers are now cheaper and interconnected to exchange information**
- **the concept and usefulness of a big machine called a server still exists. Cheaper machines access this shared server.**



Types of networks

- **LAN (Local Area Network)**
- **MAN(Metropolitan Area Network)**
- **WAN (Wide Area Network)**

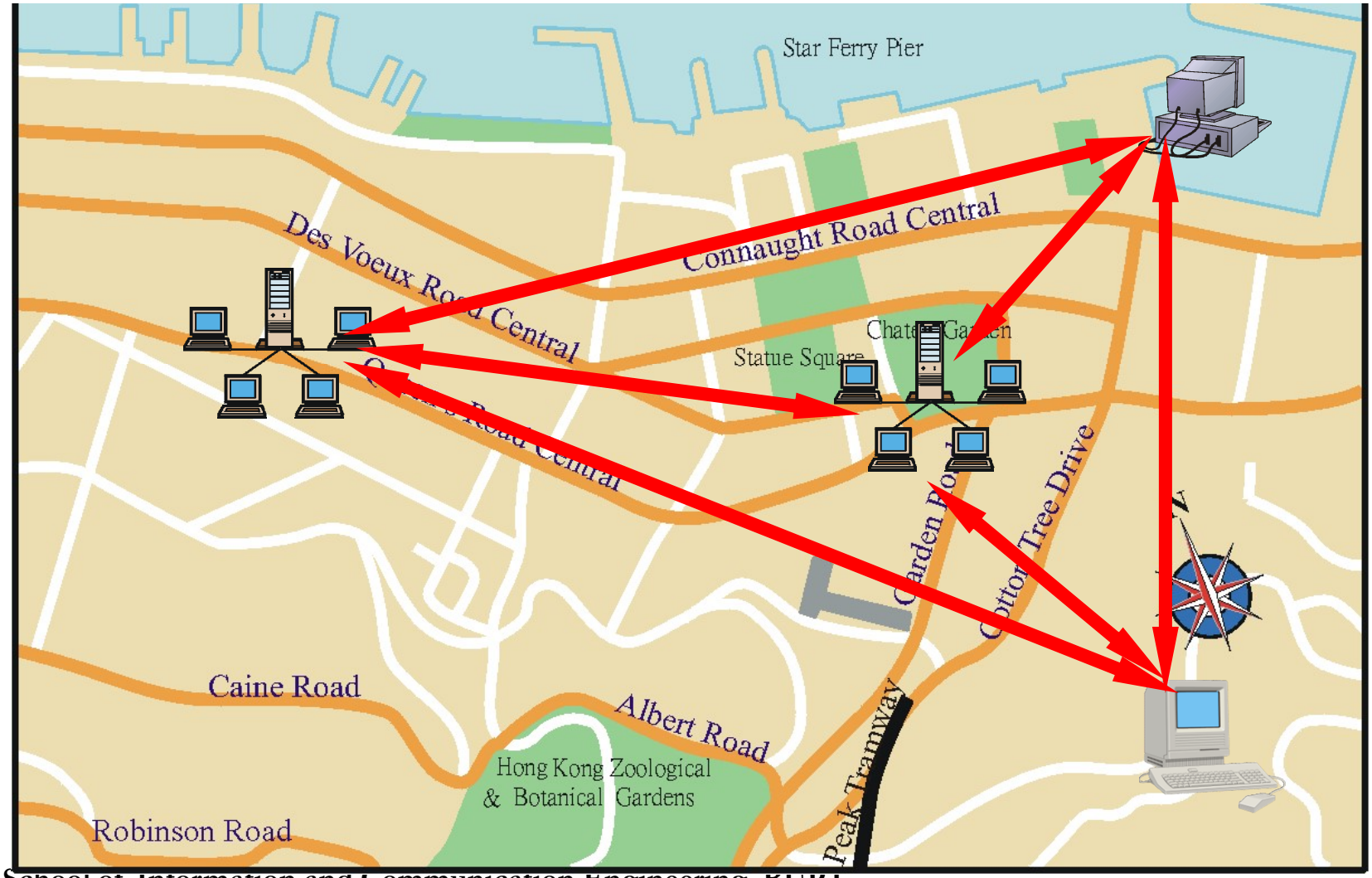
Local Area Network （LAN）

- Within a room, floor or building

Metropolitan Area Network

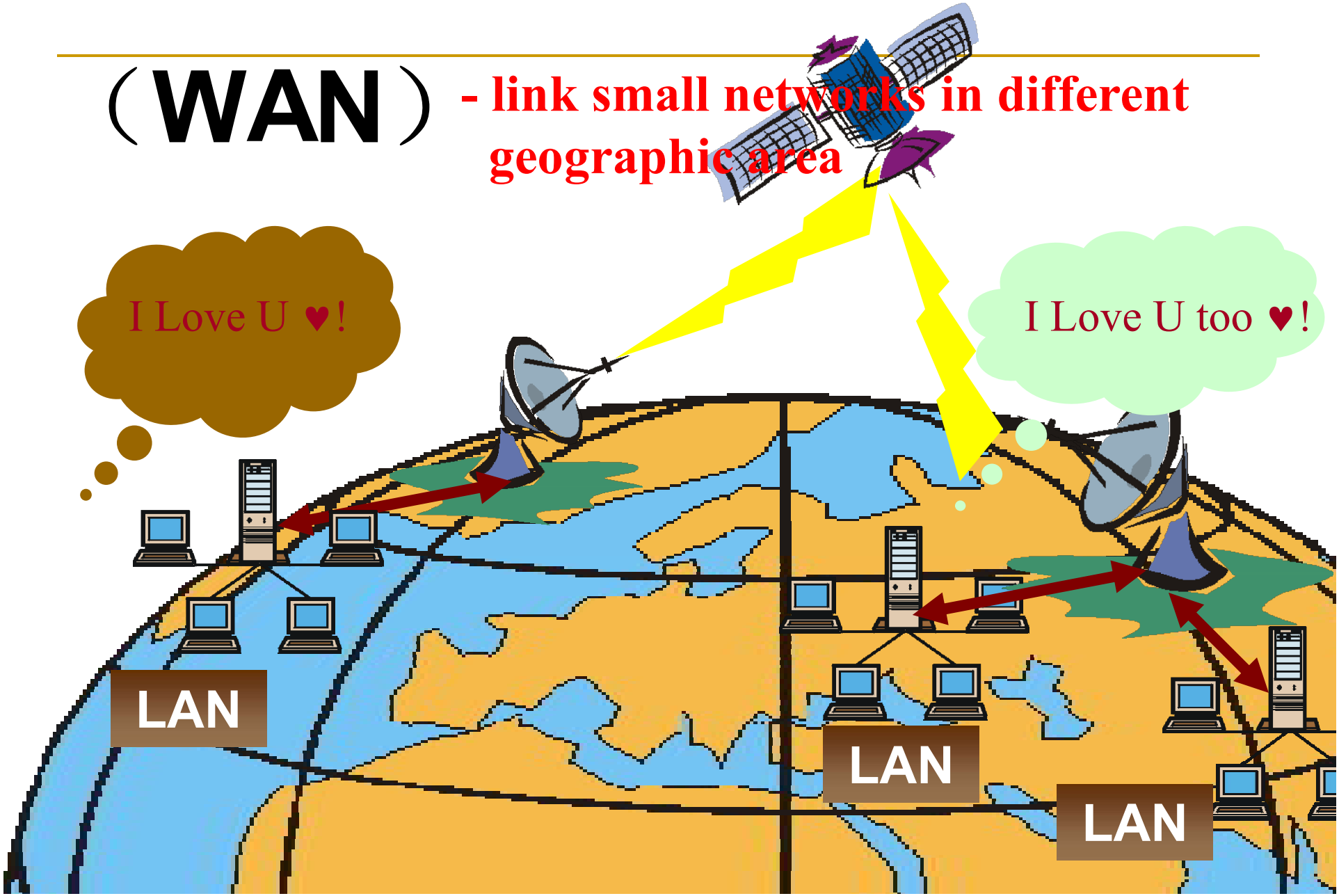
（MAN）

- Within a large city
- Optical fibers as media

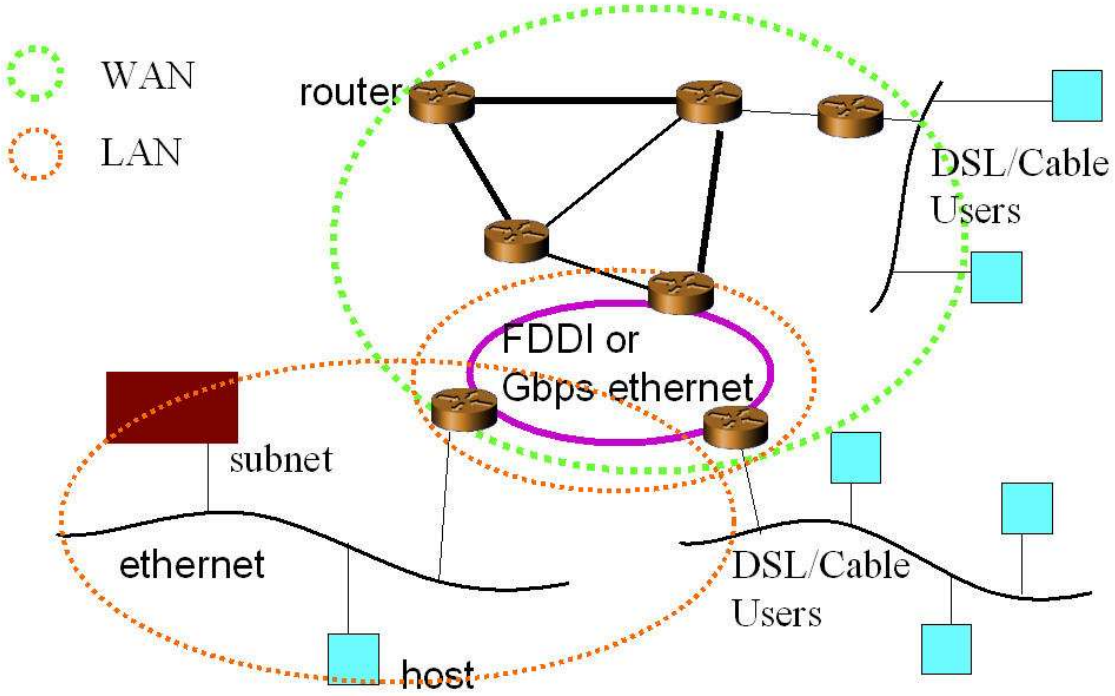


Wide Area Network

（WAN） - link small networks in different geographic area



Internet: A Collection of Local Area Networks

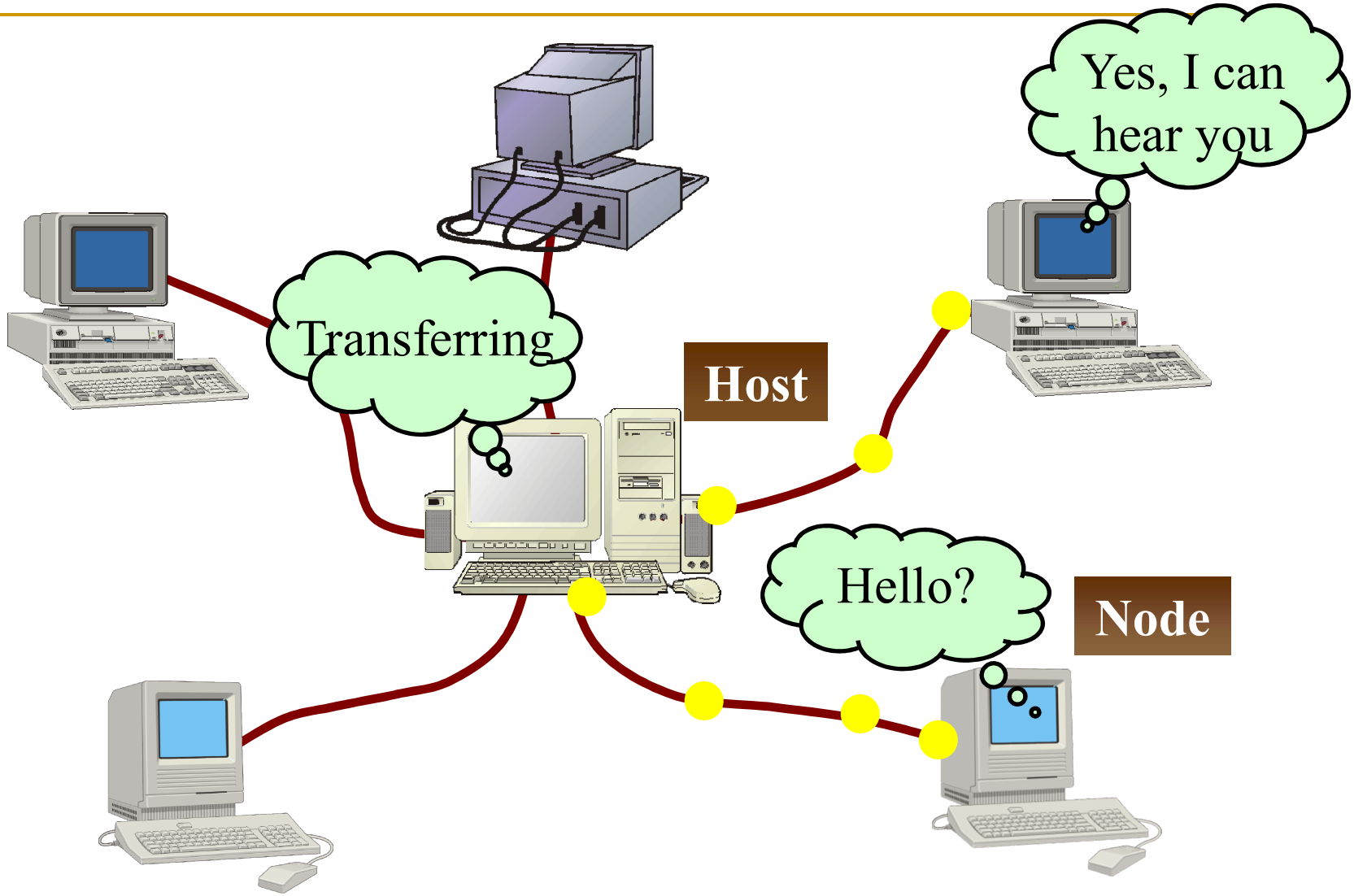


Services/Networks	Data Rates
POTS	28.8-56 Kbps
ISDN	64-128 Kbps
ADSL	1.544-8.448 Mbps (DL) 16-640 Kbps (UL)
VDSL	12.96-55.2 Mbps
CATV	20-40 Mbps
OC-N/STS-N	Nx51.84 Mbps
Ethernet	10 Mbps
Fast Ethernet	100 Mbps
Gigabit Ethernet	1000 Mbps
FDDI	100 Mbps
802.11b	1, 2, 5.5, and 11 Mbps
802.11a/g	6-54 Mbps

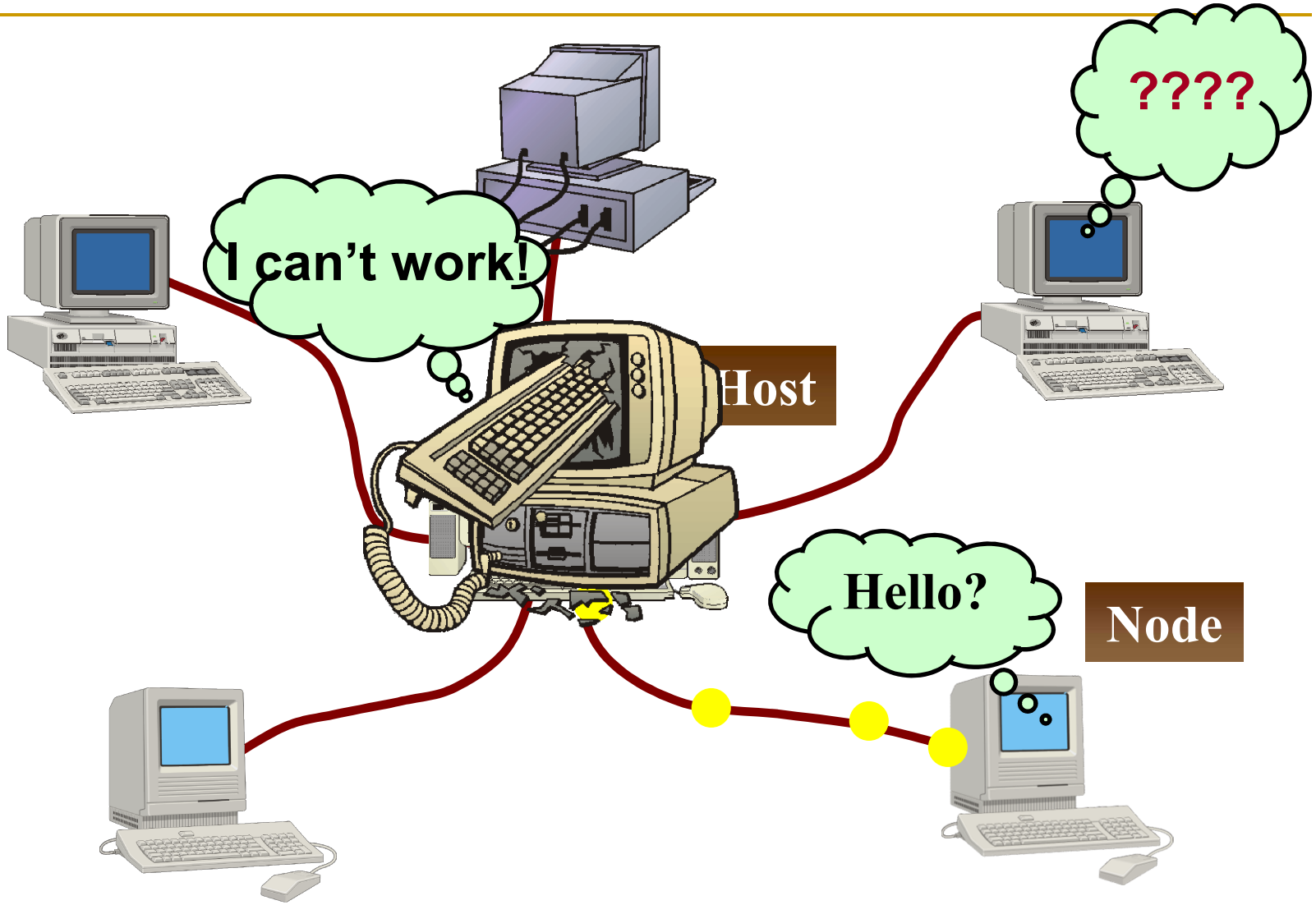
Network Topology

- It refers to the way by which the network hardware (called nodes) are arranged and the means if data flow.

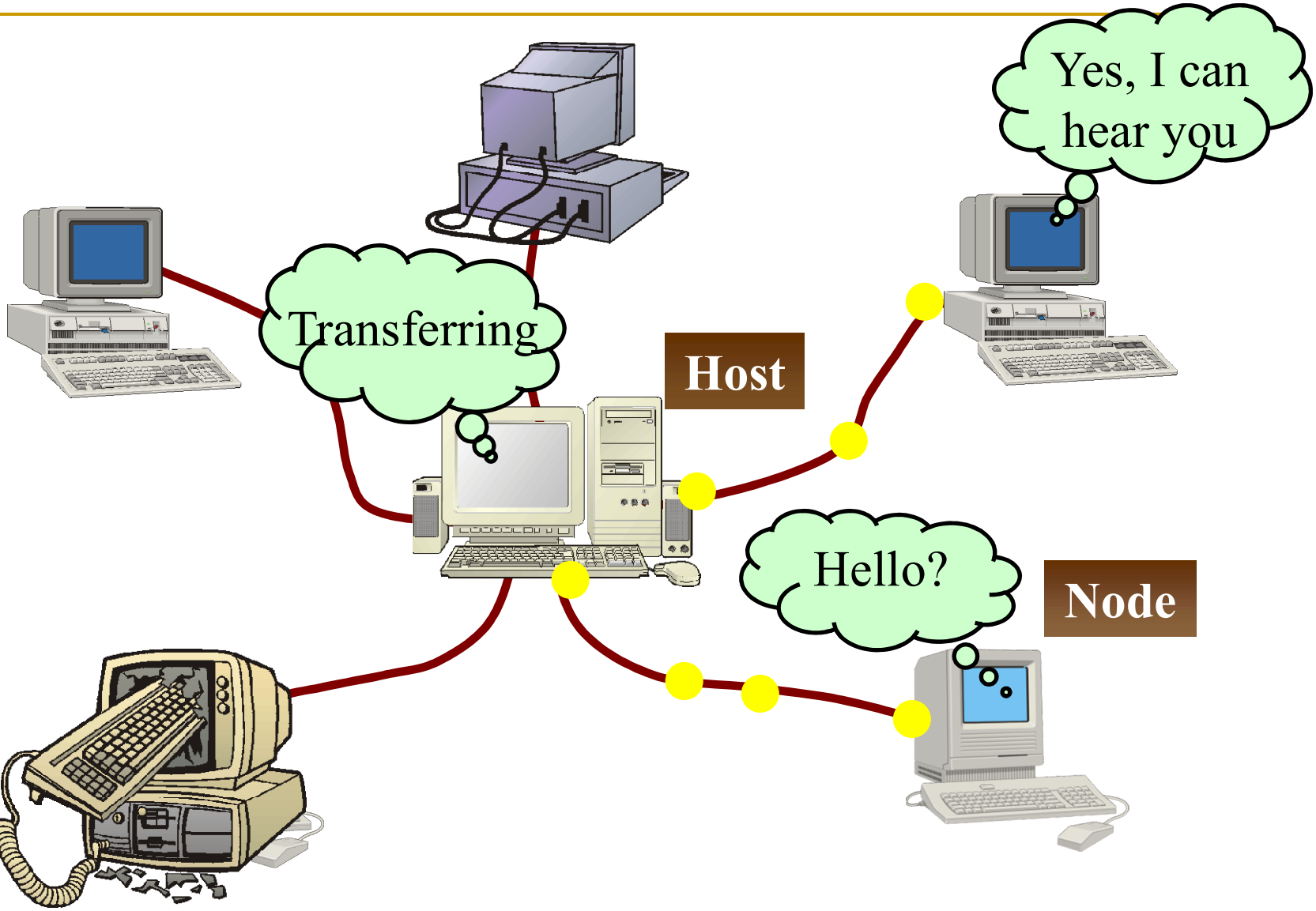
Star Architecture



Star Architecture (cont.)



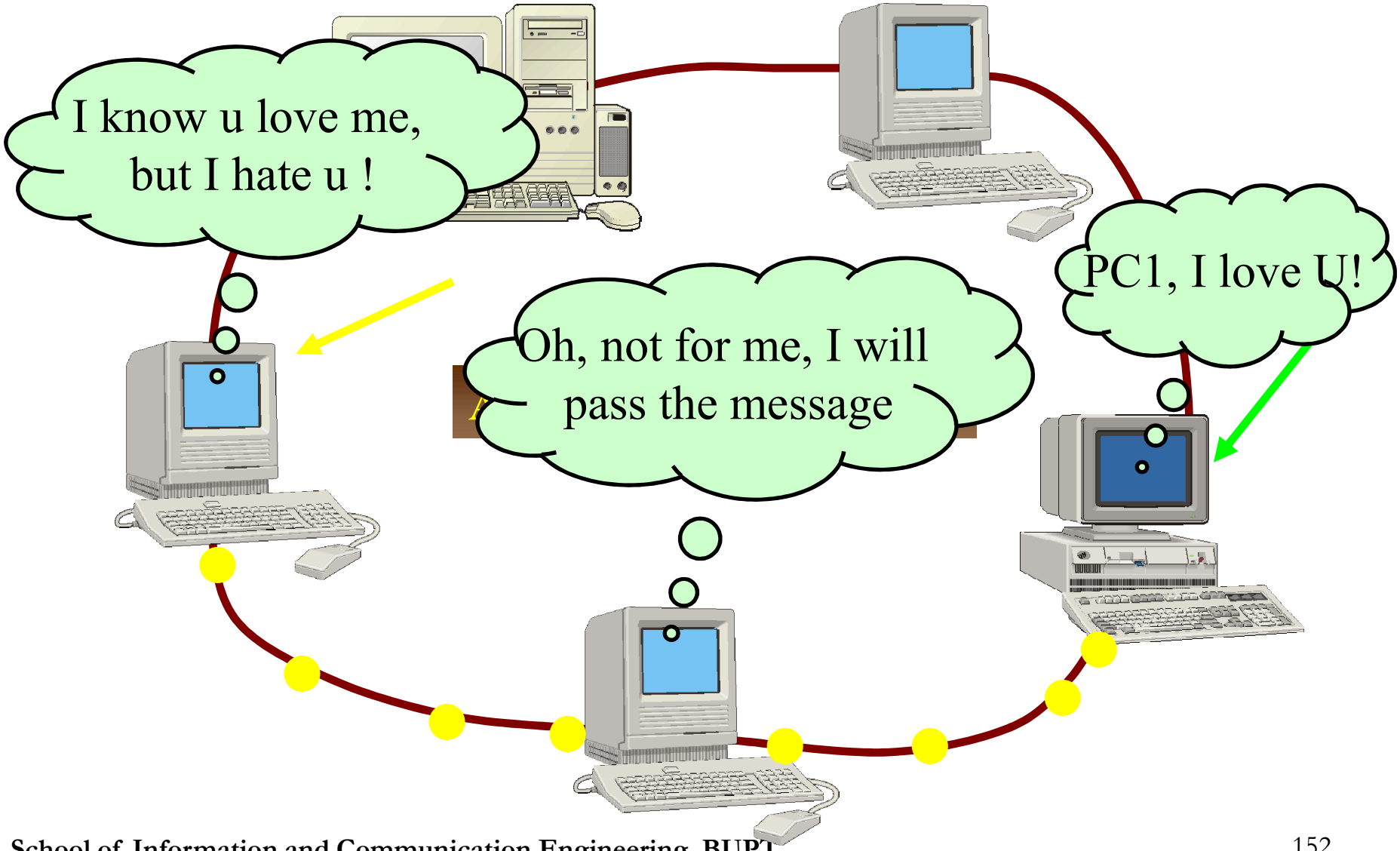
Star Architecture (cont.)



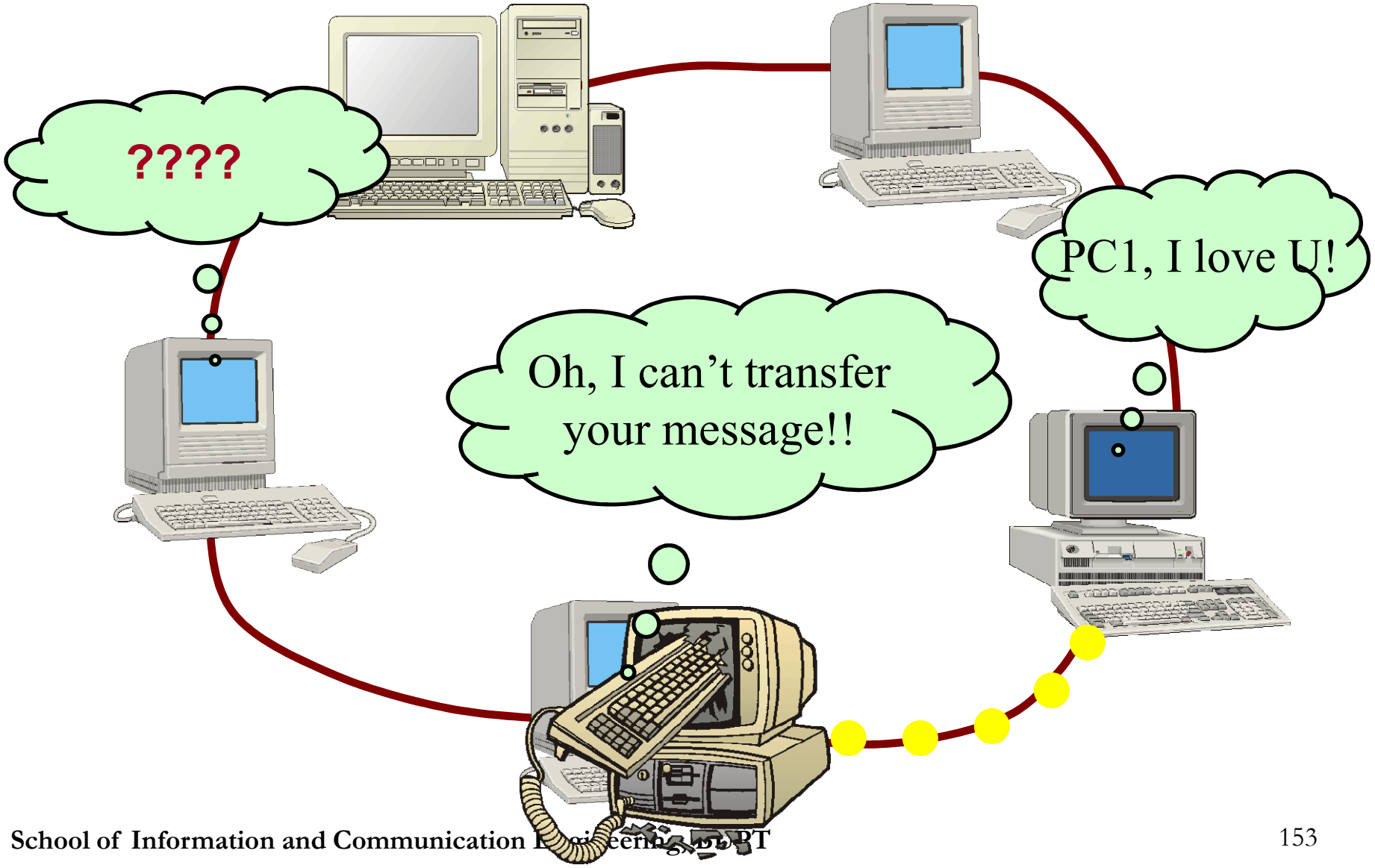
Star Architecture (cont.)

- Host fails,
  - whole network breaks down
- Node fails,
  - network not affected
- Configuration is simple

Ring Architecture

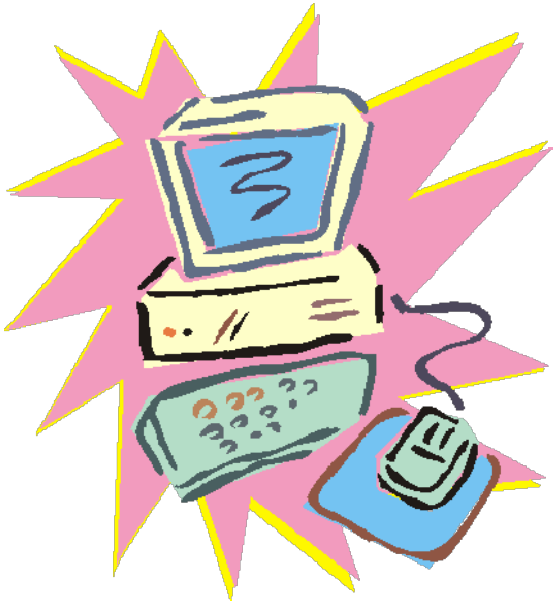


Ring Architecture (cont.)

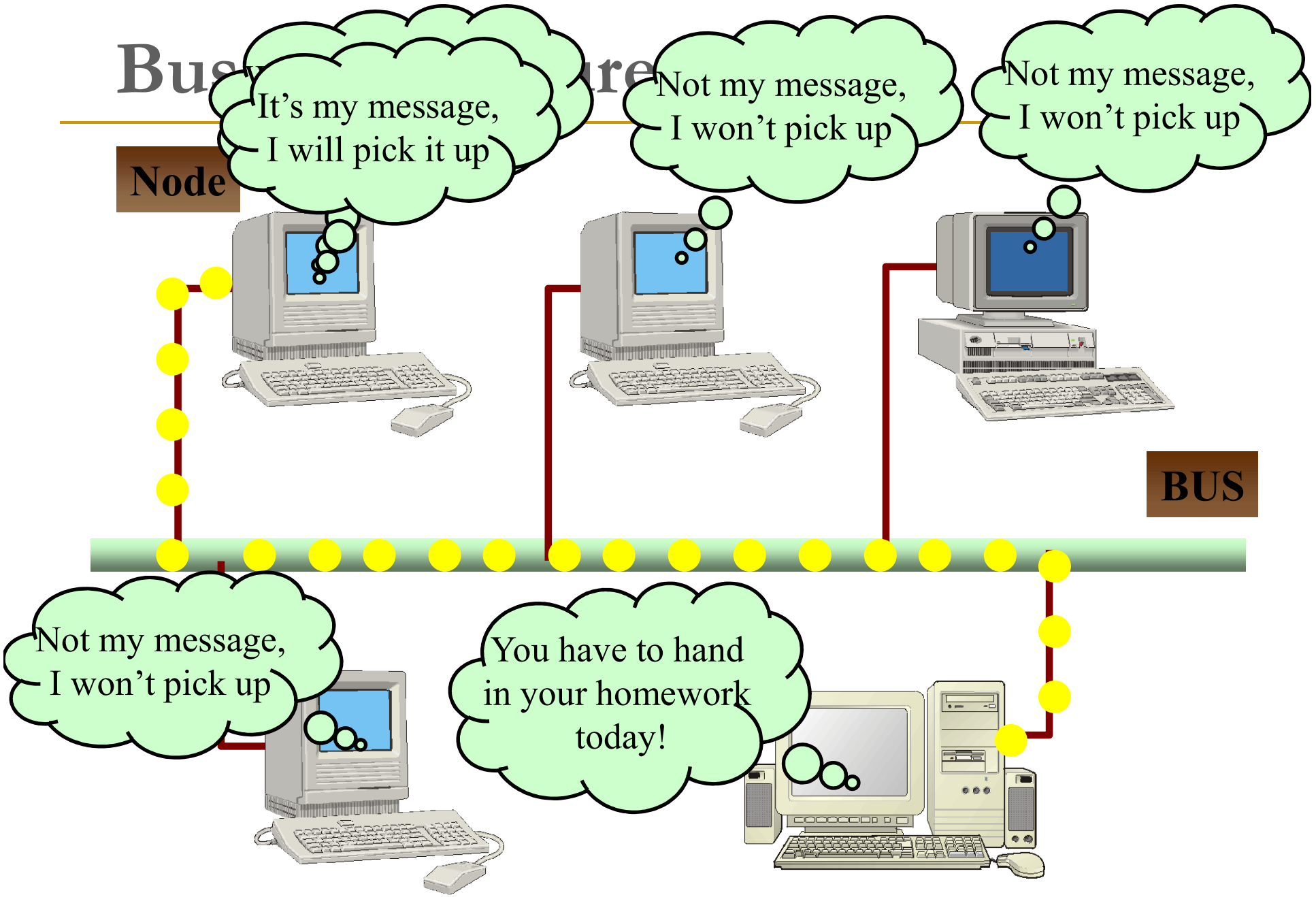


Ring Architecture (cont.)

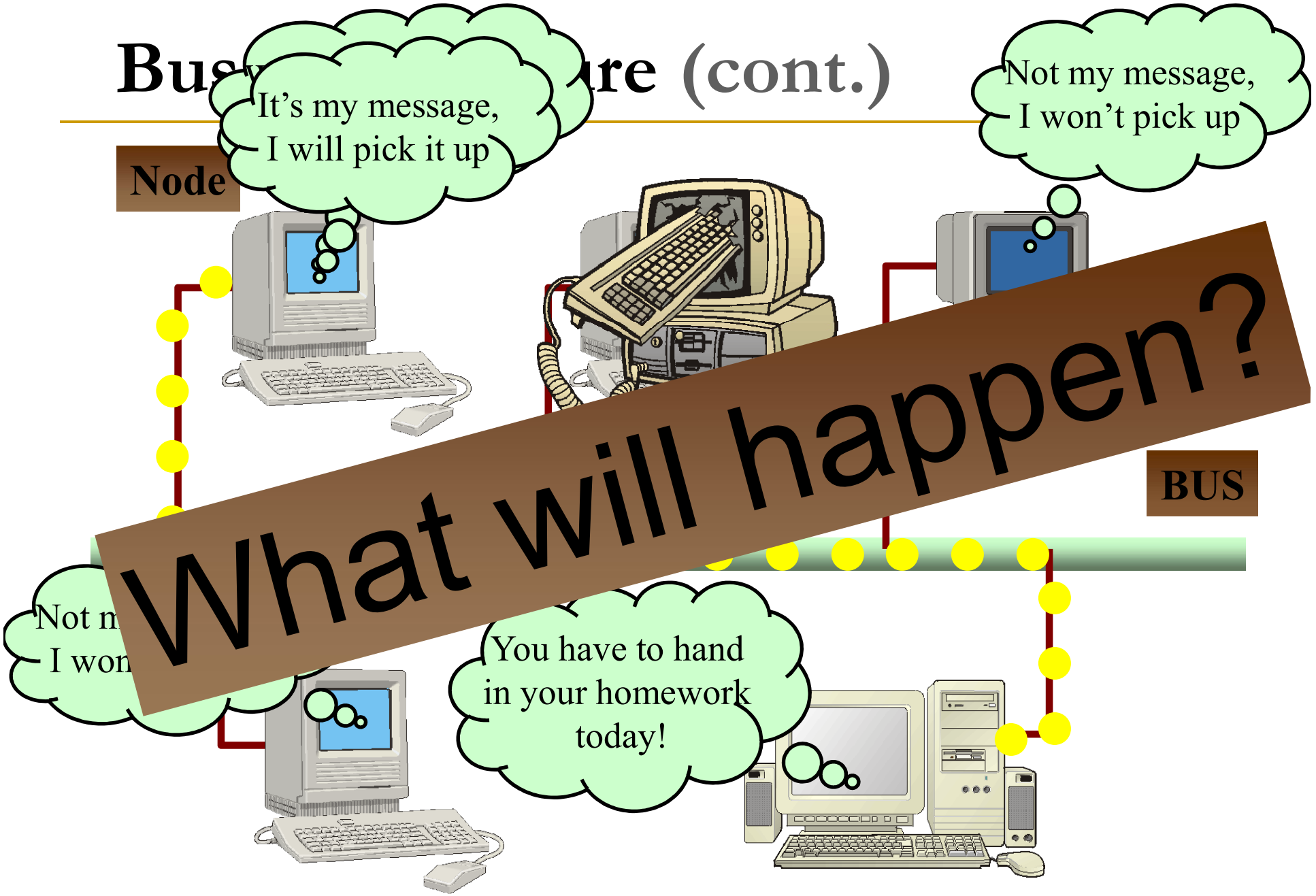
- All computers are
  - Nodes
- If any node fails,
  - whole network break down



Bus


It's my message,
I will pick it up
Not my message,
I won't pick up
Not my message,
I won't pick up
Node
BUS
Not my message,
I won't pick up
You have to hand
in your homework
today!

Bus… …re (cont.)


It's my message,
I will pick it up
Not my message,
I won't pick up
Node
BUS
What will happen?
You have to hand
in your homework
today!

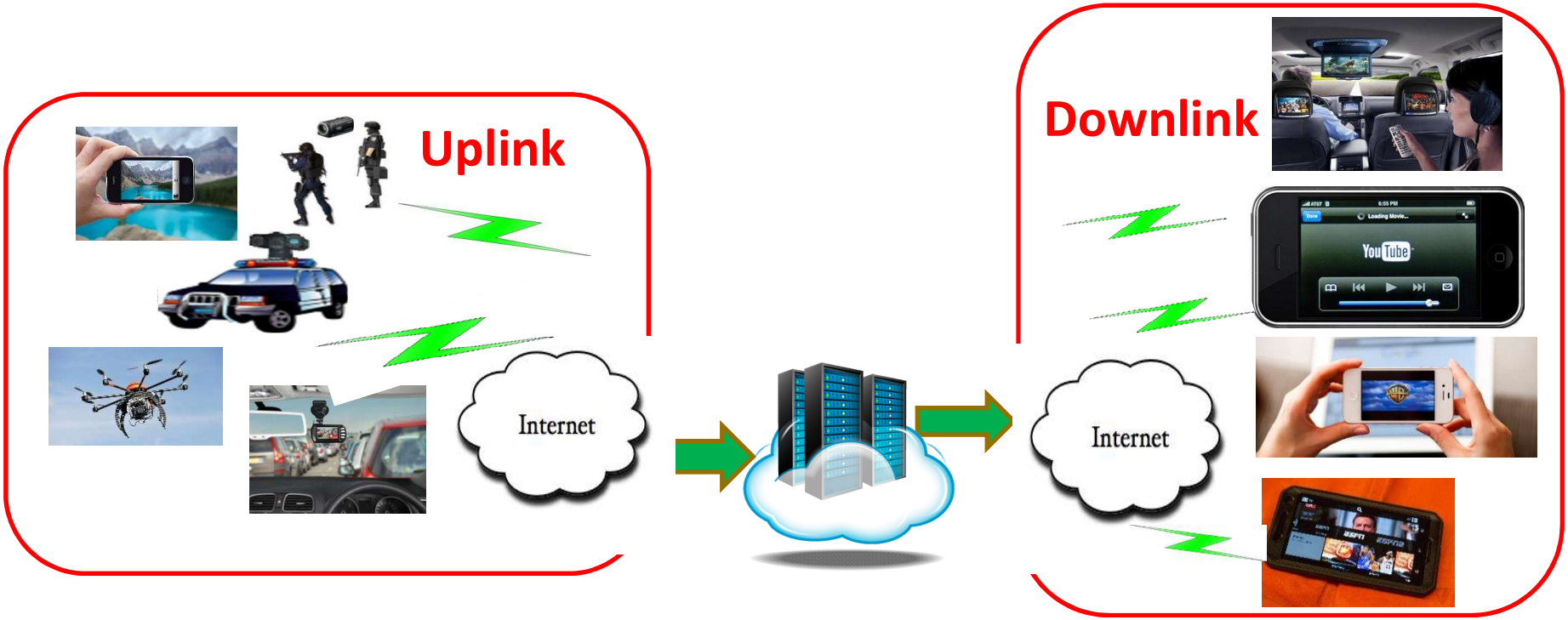
Bus Architecture (cont.)

- All Nodes connected to
  - BUS
- If any node fails,
  - network not affected

Communication Standards (Protocols)

- protocol - a set of rules for the exchange of data
- communicating systems must agree on
  - transmission method, speed, duplex setting, etc.
- TCP/IP - Transmission Control Protocol/Internet Protocol - standard set of rules for Internet communication

Media Streaming over IP



- From one-way media streaming (couple seconds pre-buffering or re-buffering) to "two-way" real-time interactive (skype, facetime..)
- Best effort packet networks – limited bandwidth, limited buffer, variable quality of service (QoS)

Quality of Service (QoS) for Multimedia Networking

- ITU-T one-way VoIP delay recommendations
  - < 150 ms: good quality
  - > 250 ms: intolerable
- Delay Jitter:
  - < 40 ms: best quality
  - > 75 ms: unacceptable

- 1~2% audio packet loss for good quality
- 3~5% video packet loss is acceptable (intra or inter-coded frame)

G.729 (8Kbps), no loss

G.729, 2% loss

G.729, 10% loss

Multimedia Database

Not all data stored in a database is text based.

- Video
- Audio
- Images
- Hybrid Documents

Problem: How do we store, retrieve and manage multiple types of media?

Multimedia Database (cont.)

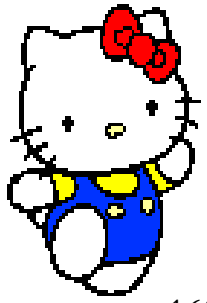
Multimedia Database Management Systems

- **Database software that can manage a wide variety of data types**
- **Requirements**
  - **Must be able to query different formats uniformly**
  - **Must know how to merge and relate the results**
  - **Needs to be able to retrieve large amounts of data smoothly and quickly**
  - **Has to present the results of queries in a way that makes sense to the user**

Multimedia Database (cont.)

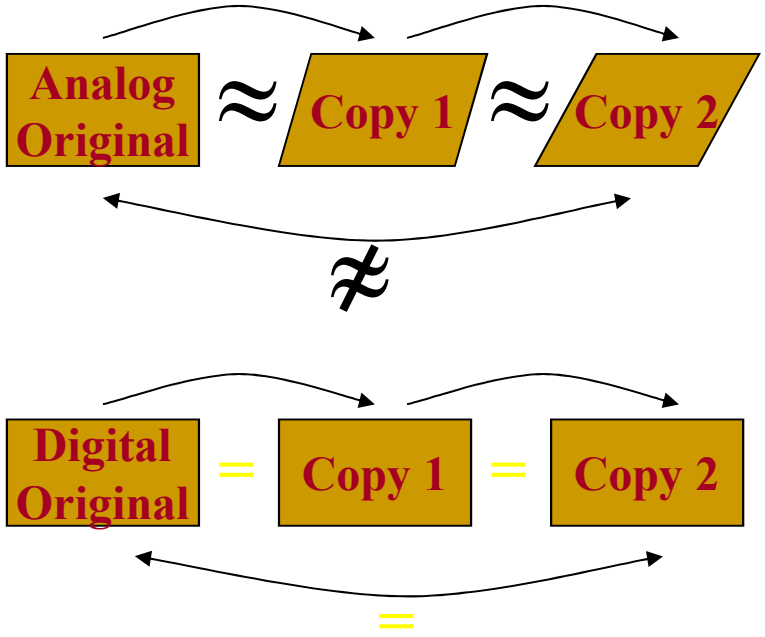
Examples

- Movies on Demand
- Expert advice and technical support
- Travel guides and planning sites
- Home shopping
- Content-based Retrieval



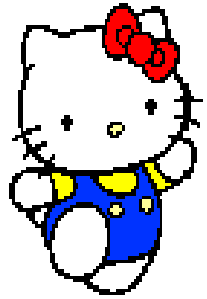
Piracy of Digital Media

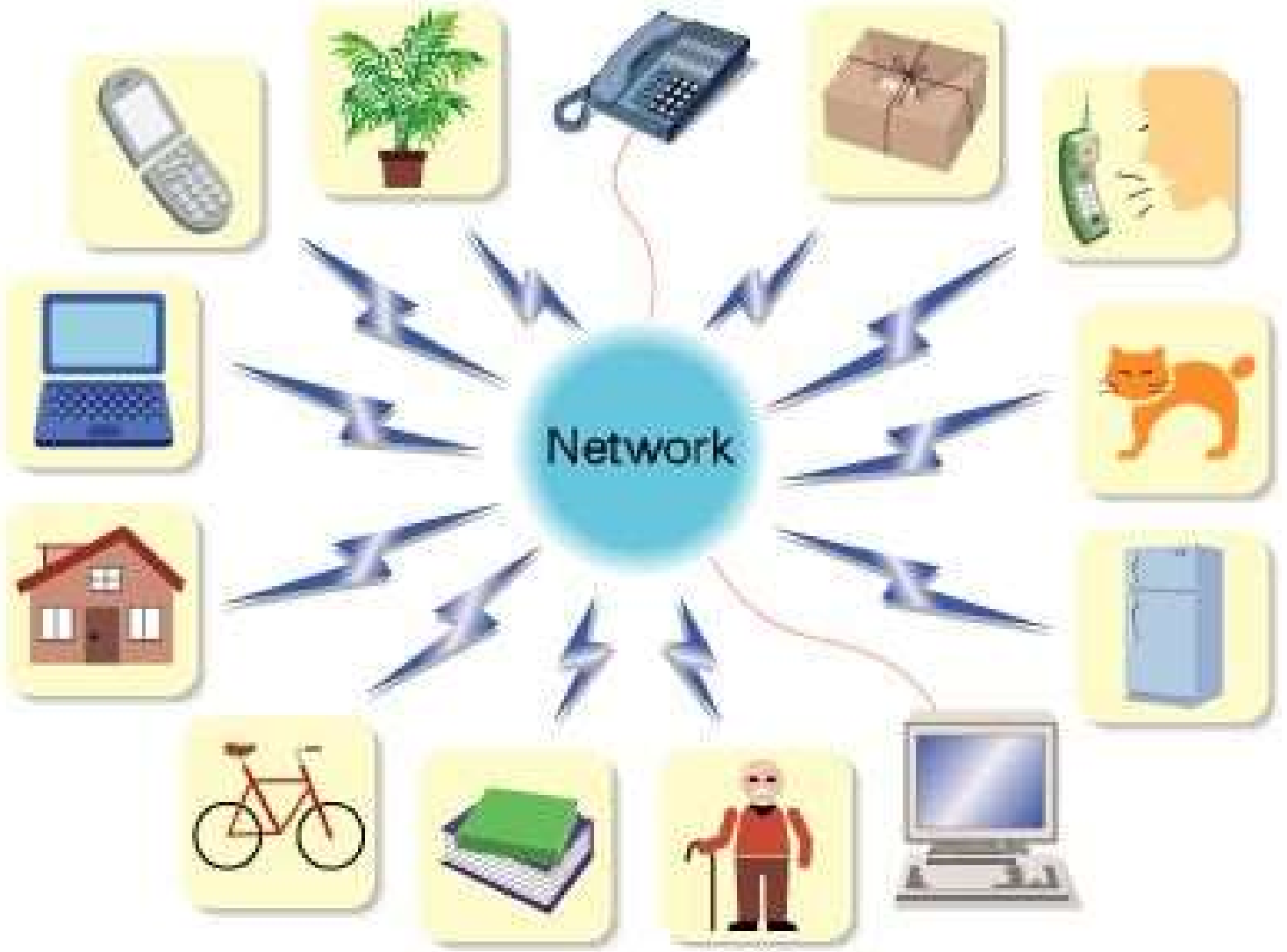
- **The proliferation of digitized media**
  - **E-Book, internet TV, Image, Video, MP3**
- **Growing Need for Digital Rights Management, (DRM) due to**
  - **Illegal Copying**
  - **Falsification**
  - **No Copyright Protection**
  - **No Ownership Identification**



Research Topics in Multimedia Applications (cont.)

- **Multimedia tools, end-systems and applications**: hypermedia systems, user interfaces, authoring systems.
- **Multi-modal interaction and integration**: “ubiquity”--web-everywhere devices, multimedia education including Computer Supported Collaborative Learning, and design and applications of virtual environments.



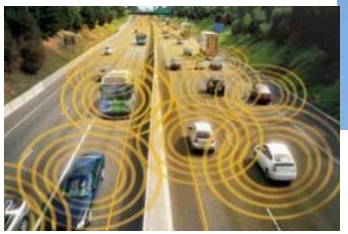


Ubiquitous computing will enable diverse wireless applications, including monitoring of pets and houseplants, operation of appliances, keeping track of books and bicycles, and much more.

Multimedia Applications

Multimedia Applications

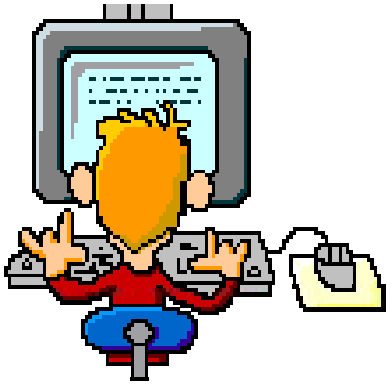
- Multimedia communication system
- Home entertainment
- Multimedia training, education
- Phone over IP
- Audio/video conferencing
- Virtual worlds
- Video Surveillance
- Audio/video postproduction
- Professional video services
- ……



Multimedia Communication System

A system that handles more than one media stream in a synchronized way from the user's point of view.

The system may allow interconnection of multiple parties, multiple connections, and the addition or deletion of resources and users within a single communication session.



Multimedia Communication Applications

Three categories:

-- Interpersonal Communications

-- Interactive application over the Internet

-- Entertainment applications

Interpersonal Communications

Interpersonal communication may involve speech, image, text, or video.

- Text only: email
- Image only: fax
- Speech only
- Speech and Video

Interpersonal Communications (cont.)

Speech only

- Voice-mail

used in the event of the called party being unavailable. A spoken message can then be left in the voice mailbox.

- Teleconferencing call (audio conferencing call)

involve multiple interconnected telephones/PCs.

Each person can hear and talk to all of the others involved in the call.

Interpersonal Communications (cont.)

Speech and Video

- Video telephony

(1) Technology which enable the exchange of real time video and audio signal between two (or more) geographically separated parties via phone lines or computer network.

(2) Allow people in different locations to meet face-to-face as if they are in the same room.

Video Telephony

Peripheral Device

- **Cameras**

  to capture and send video from your local endpoint

- **Video displays**

  to display video received from remote endpoints

- **Microphones**

  to capture and send audio from your local endpoint

- **Speakers**

  to play audio received from remote endpoints

Interactive Application over the Internet

- WWW (World Wide Web)

The W3C has listed the following goals for the WWW.

1. Universal access of web resources (by everyone every-where).
2. Effectiveness of navigating available information.
3. Responsible use of posted material.

HTTP--HyperText Transfer Protocol

The **URI** (Uniform Resource Identifier): an identifier for the resource accessed, e.g. the host name, always preceded by the token “http://”.

HTTP--HyperText Transfer Protocol (cont.)

- The basic response format:

  Version Status-Code Status-Phrase

  Additional-Headers

  Message-body

- Two commonly seen **status codes**

  1. **200 OK----** the request was processed successfully.
  2. **404 Not Found---** the URI does not exist.

HTML (HyperText Markup Language)

HTML: a language for publishing Hypermedia on the World Wide Web-defined using SGML:

1. HTML uses ASCII, it is portable to all different (possibly binary incompatible) computer hardware.
2. The current version of HTML is version 4.01.
3. The next generation of HTML is XHTML---- a reformulation of HTML using XML.

- HTML uses **tags** to describe document elements:

  ---- <token params> ------ defining a starting point

  ---- </token>------ the ending point of the element

  ---- Some elements have no ending tags

HTML (HyperText Markup Language) (cont.)

- A very simple HTML page is as follows:

```
<HTML> <HEAD>
<TITLE>
A sample web page.
 </TITLE>
 <META NAME = "Author" CONTENT = "Cranky Professor">
</HEAD> <BODY>
<P>
We can put any text we like here, since this is a paragraph element.
</P>
</BODY> </HTML>
```

- Naturally, HTML has more complex structures and can be mixed in with other standards.

XML (Extensible Markup Language)

XML: a markup language for the WWW in which there is modularity of data, structure and view so that user or application can be able to define the tags (structure).

Example of using XML to retrieve stock information from a database according to a user query:

1. First use a global Document Type Definition (**DTD**) that is already defined.
2. The server side script will abide by the DTD rules to generate an XML document according to the query using data from your database.
3. Finally send user the ***XML Style Sheet*** **(XSL)** depending on the type of device used to display the information.

XML (Extensible Markup Language) (cont.)

- The current XML version is XML 1.0, approved by the W3C in Feb. 1998.
- XML syntax looks like HTML syntax, although it is much more strict:
  - ---All tags are in lower case, and a tag that has only inline data has to terminate itself, i.e., <token params />.
  - ---Uses name spaces so that multiple DTDs declaring different elements but with similar tag names can have their elements distinguished.
  - ---DTDs can be imported from URIs as well.

XML (Extensible Markup Language) (cont.)

An example of an XML document structure-- the definition for a small XHTML document:

```
<?xml version="1.0" encoding="iso-8859-1"?> <!DOCTYPE html
PUBLIC "-//W3C//DTD XHTML 1.0"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-
                                        transition.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
... [html that follows
    the above mentioned
    XML rules]
</html>
```

Entertainment Applications

Video on Demand (VOD) is the technology which allows simultaneous access of viewers to the video content with the following basic functionalities:

- Every viewer has a dedicated video and audio channel.
- Every viewer can navigate and explore the audiovisual content in order to decide the material to be seen.
- Every user has complete video cassette recorder(VCR)-like control over the content he is viewing.

VOD

Implemented using standard inexpensive networks infrastructure like IP, Ethernet, switches, etc, making the use of VOD more affordable and easy.

What are the parts of a VOD system?

1.The video server
2.The application server
3. On line encoders
4.The network

Video Server

- It stores the audiovisual content.
- It includes an additional software which manages the resources, monitors, the use of the bandwidth, the CPU, the storage, and shows which part of them are available.

Application Server

- The application server includes the user application and the management application.
- Users connect to it in order to explore the audiovisual content.
- The system administrator connects to it in order to manage the content and the use of the system.
- It stores the logs and historical data for billing or to generate statistics.

OnLine Encoders

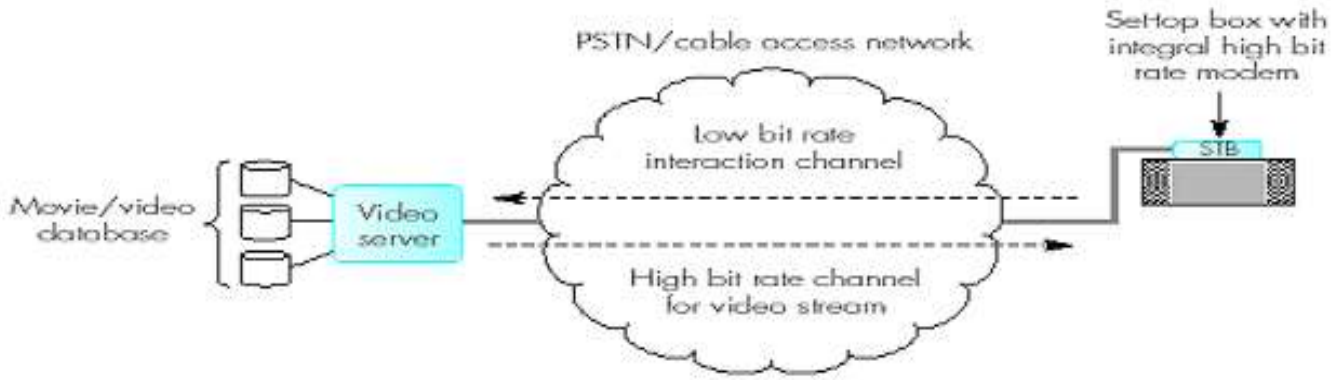
VOD system may offer not only prerecorded material but also live video signals.

A real time video encoder compresses the video and packages it so that it could be received on the terminals as an additional signal.

The Network

While a few years ago using IP networks to transmit video seemed to be impossible, nowadays the modern IP networks allow the transmission of video with quality and safety.

VOD Networking Schematic



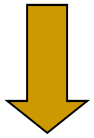
In addition to select a movie, the subscriber can control the showing of the movie by using similar controls to those used on a conventional VCR.

pause, fast-forward and so on.

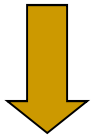
VOD and N-VOD

VOD

A subscriber can initiate the showing of a movie selected from a large library of movies at any time.



The server must be capable of playing a large number of video streams equal to the number of subscribers currently watching a movie simultaneously.



The information flow from the server to be extremely high since it must support not just the transmission of a possibly large number of different movies, but also multiple copies of each movie.

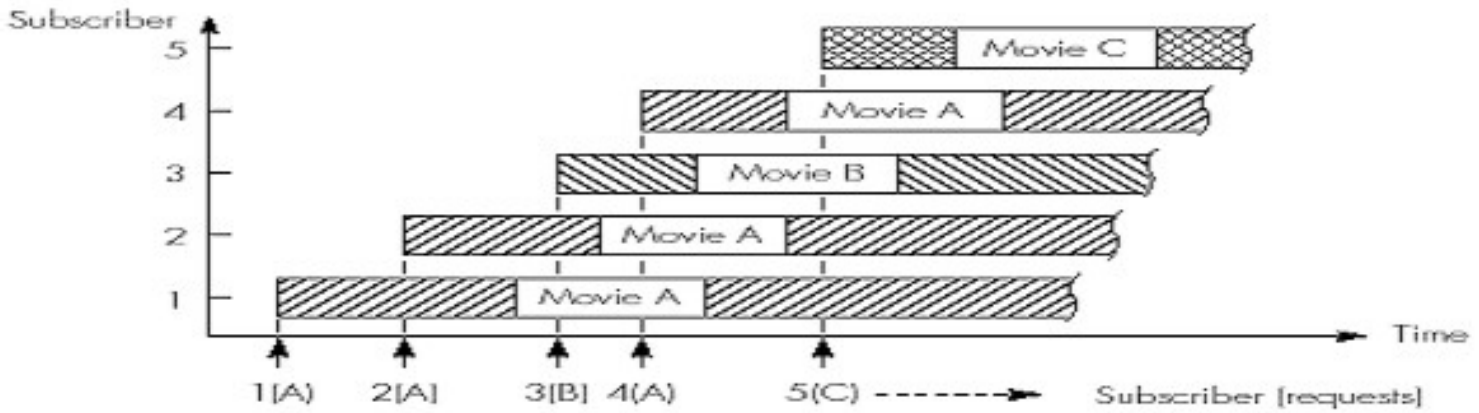
VOD and N-VOD (cont.)

N-VOD

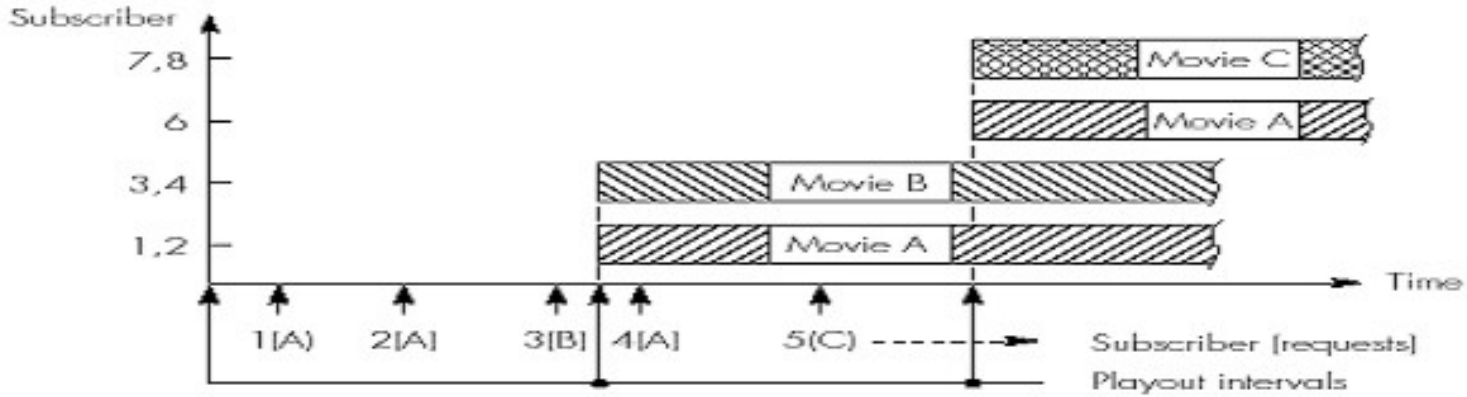
A particular movie is not played out immediately but instead are queued until the start of the next playout time of that movie .

All requests for the same movie which are made during the period up to the next playout time are satisfied simultaneously by the server outputting a single video stream. The viewer is unable to control the playout of the movie.

VOD and N-VOD (cont.)



VOD



N-VOD

Communication Mode

1. Simplex

   The information associated with the application flows in one direction only.

2. half-duplex

   Information flows in both directions but alternately.

3. duplex

   Information flows in both directions simultaneously.

The bit rate associated with the flow of information in each direction can be either equal or difference.

- equal → **symmetric**
- difference → **asymmetric**

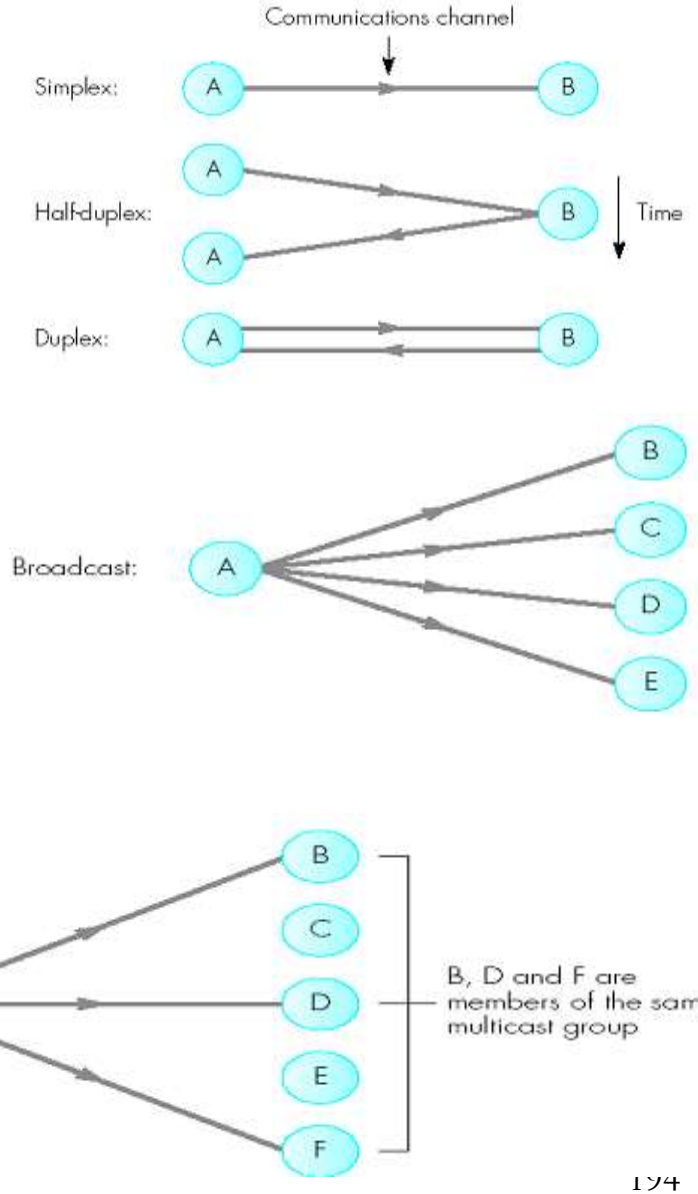
Communication Mode (cont.)

4. Broadcast

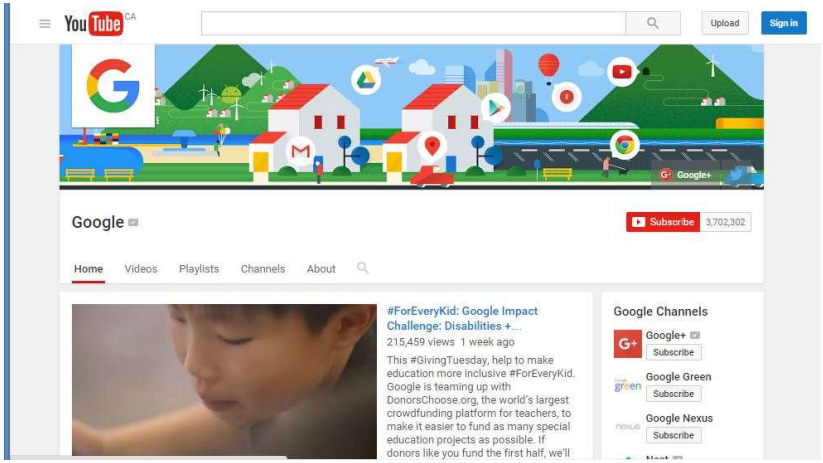
Information output by a single source node is received by all the other nodes.

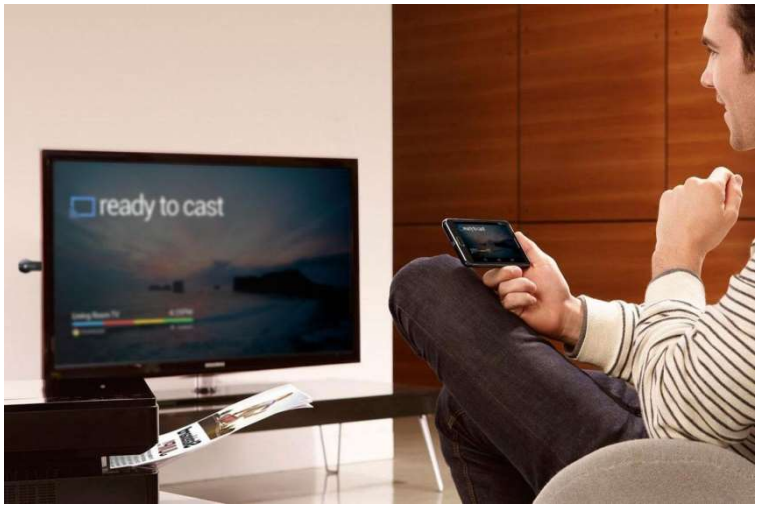
5. Multicast

Information output by a single source node is received by only a specific subset of the nodes that are connected to a network.

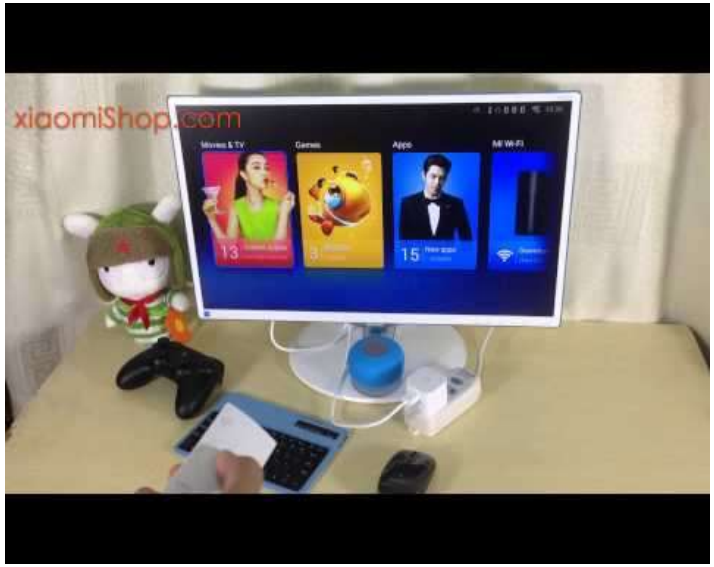


Google TV, YouTube & Chromecast





Xiaomi TV and Xiaomi Mini



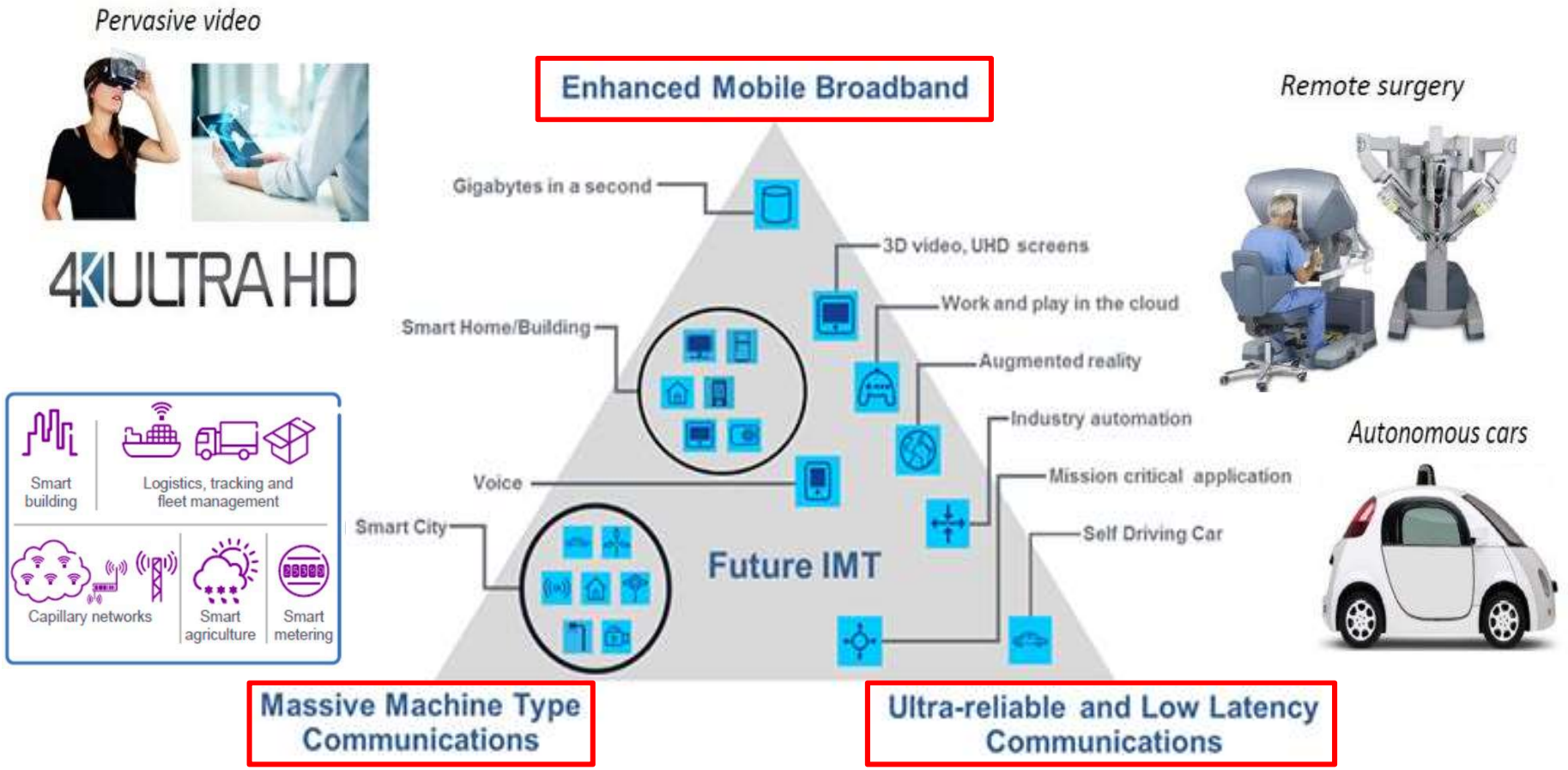
IPTV = IP+TV+Interactivity

- An emerging technology that delivers video, audio or TV broadcasts over (IP) based networks with the required level of QoS/QoE, security, interactivity, and reliability.
- In Conclusion: IPTV it means:
  - Television you fully control
  - Any content, any time, any place
  - Television that can take you anywhere
  - Unlimited visual interactive applications
- It is the IP in IPTV that's important!

IPTV: More Than Just TV or Video over IP Networks

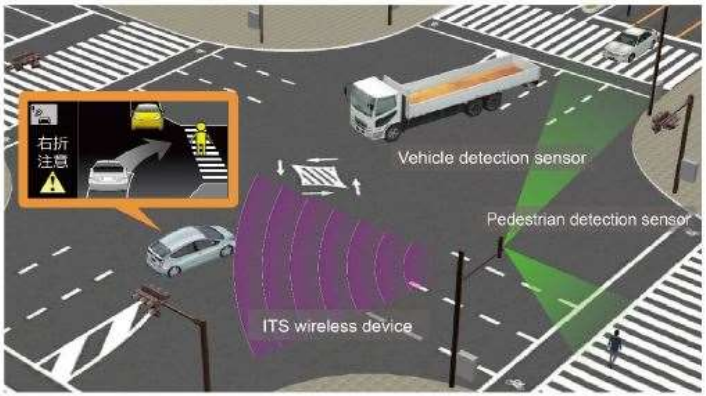
(SBB licensed from www.im.tv of ERA Digital Media, Taiwan)

Three Main Objectives of 5G



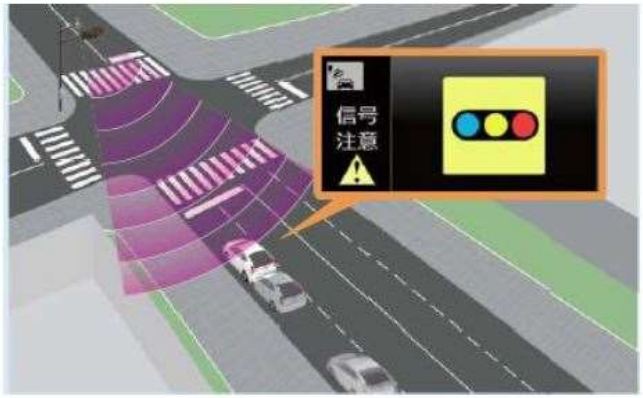
Intelligent Transportation

Right Turn Collision Warning



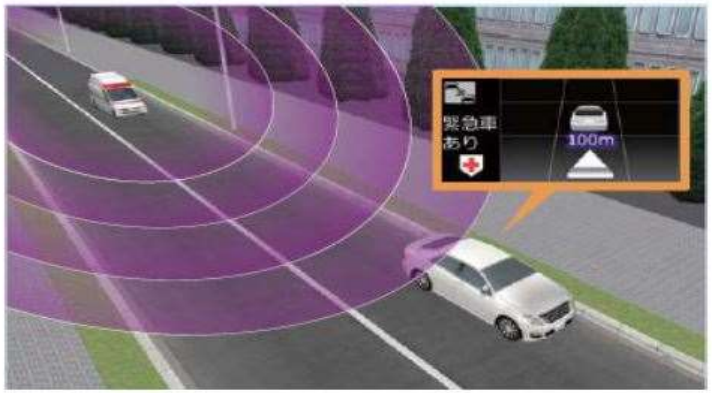
Alerts the driver of oncoming vehicles that can be difficult to see and pedestrians crossing the road

Red Light Warning



Alerts the driver when the light ahead has changed or is about to change

Emergency Vehicle Notification



Driver is notified when an emergency vehicle approaches

Cooperative-adaptive Cruise Control

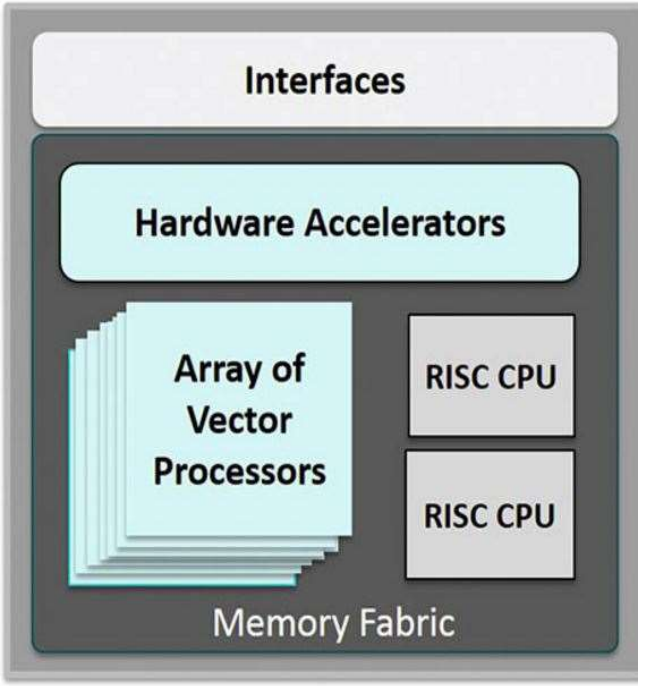
Cars share information on speed changes in real-time.

Machine Learning & AI

- **Siri, Cortana, Alexa, Viv, and other artificial assistants are data-based machine-learning wonders – language and image understanding**
- **Google's own photo-sorting app, which mines your photos' data and sorts them in appropriate categories.**
- **Google's pact with Movidius on developing vision processor unit (VPU) is such a big deal.**

Vision Processing Unit (VPU)

- **Movidius MA2450, a vision processing unit (VPU) designed to perform the neutral network calculations at low power, in future mobile devices.**
- **A VPU is similar in concept to a graphics processing unit (GPU), silicon tuned to make graphics computation efficient.**
- **The distinction is that the Movidius processor is designed specifically for computer vision applications, like image recognition and text translation.**



Myriad 2 Vision Processor Unit (VPU)

Exercise

1. State and explain the MAC address.
2. State and explain the importance of multimedia compression.
3. Explain the difference between BUS-LAN and RING-LAN.