Multimedia Systems

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Definition and terms

- Srandard **ISO/IEC JTC1 SC29/WG12**, multimedia represents the ability to deal with different types of presentation media that constitute a data type with the task of defining the nature of information in its encoded format.

- Before the advent of computers, means of mass communication: newspapers, radio, cinema and television.

- A medium is a medium (air, water) through which something is transmitted.

- "multi" represents multiple, multimedia refers to means of communication with more than one medium.

Definition and terms

- Classification according to criteria:
- **perception** (hearing, vision, touch...),
- **presentation** (text, audio, video...),
- **display** (output: newspaper, screen, speakers; input: mouse, keyboard, microphone)
- **storage** (newspaper, microfilm, magnetic and optical discs),
- **transmission** (cables, free space)
- II classification:
- **Diskette media** - time independent
- **Continuous medi**a-time dependent

Defintion and terms

Discrete and continuous media

Definition and terms

- The convergence of telecommunications and computers:

- **Applications:** a set of functions that meet user requirements (e-mail, telephony, database access, file transfer, video conferencing).

- **The middleware layer** serves to create multimedia applications in a fast and robust way.

- **The transport layer** provides reliable transparent transmission of multimedia data between endpoints in the network.

Definition and terms
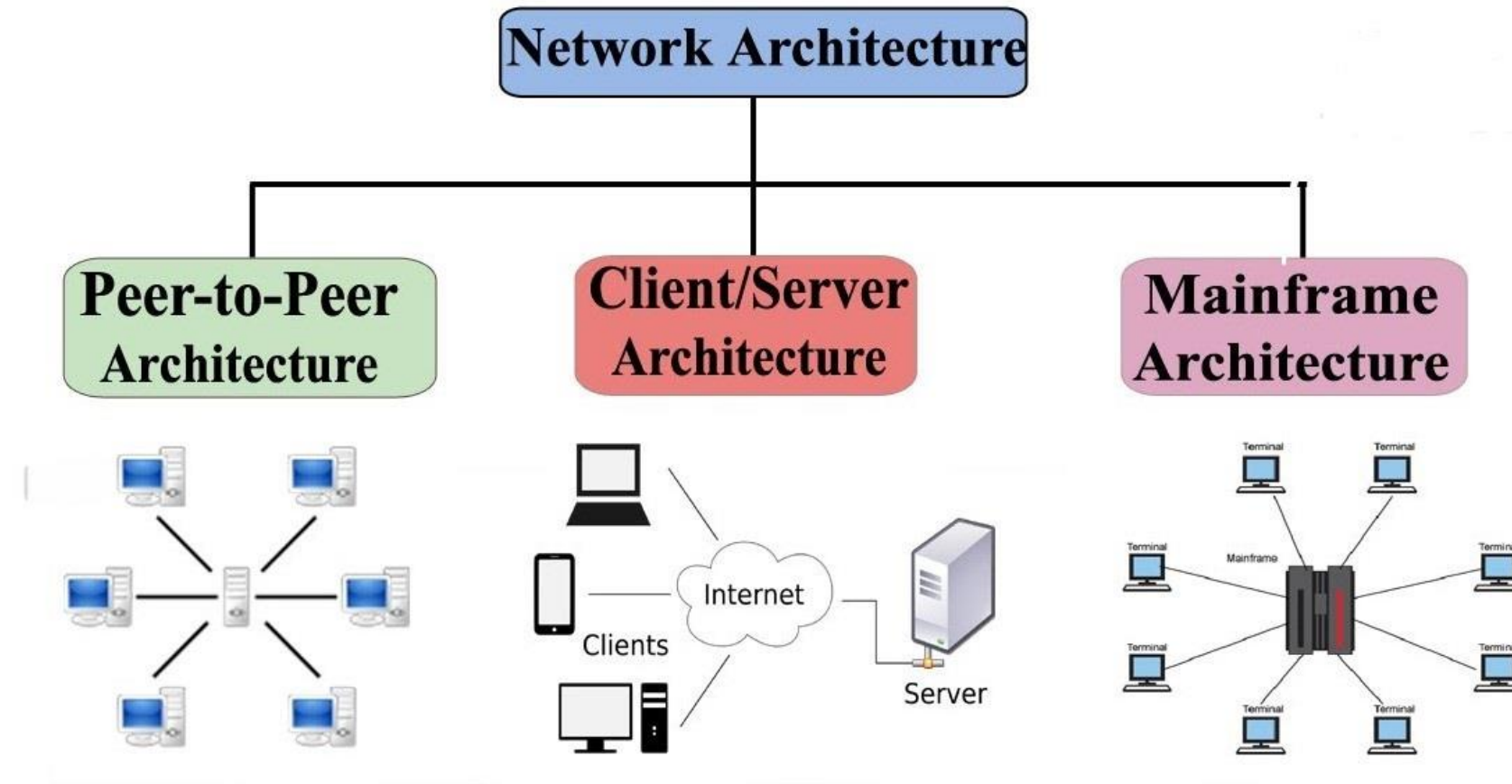
Types of network architecture

Definition and terms

- The multimedia communication model implies:

- **Division of objects** according to different types of information (data, audio, video) for easier communication, memorization and processing,

- **Standardization** of service components

- **Creating a platform for two levels**: a network service platform and a multimedia communication platform,

- **Defining general applications** for multiple purposes in different multimedia environments,

- **Specific applications**: electronic shopping, distance learning..

Definition ans terms

- Multimedia terminals:

- **Multimedia terminals** are used for searching, storing and transmitting: written content (data), sound and visual content.

- **A multimedia workstation** in a home and office environment is shown with a block diagram that usually contains:

- **A set-top box** is a device that is attached to a standard TV receiver and enables the reception of digital TV signals, access to the Internet, etc.

- **A bus** is one or more conductors that serve as a common connection for signal transmission between a certain group of devices.

- **The Ethernet network** uses the so-called procedure of multiple access with detection (carrier sense multiple access with collision detection - CSMA/CD).

Definition ans terms

- Packet video signal transfer:

- ENCODER: Transformation, Quantization, Entropy coding, Binary flow control

- APPLICATION: Data structuring

- NETWORK MULTIPLEXING, ROUTING: Forward error correction, error detection, loss detection, error correction

- APPLICATION: Resynchronization

- DECODER: Entropy decoding, Inverse transformation, Loss concealment, Postprocessing, Dequantization

- USER

Audio-visual integration, audio and visual effects

- Sound characteristics:

- Properties: reflection, refraction and diffraction.

- A sound wave has its own: frequency, amplitude (loudness) and envelope (waveform).

- Sound frequency range: Infra sound (from 0 Hz to 20 Hz), Audible sound (from 20 Hz to 20 kHz (audio range)), Ultrasound (from 20 kHz to 1 GHz), Hypersound (1 GHz to 10 GHz)

- The spectrum of audio signals includes: frequencies, their harmonics and modulation products.

- **The largest number of fundamental frequencies of sound waves is below 5 kHz**

Audio-visual integration, audio and visual effects

- Sound characteristics:

- Sound waves travel at a speed of 340 m/s at room temperature (20 °C).

- Therefore, the wavelength varies from 17 m (corresponding to a frequency of 20 Hz) to 1.7 cm (corresponding to a frequency of 20 kHz).

- Humans hear sounds with a frequency above 15 kHz.

- The largest number of fundamental frequencies of sound waves is below 5 kHz. Sound waves in the range of 5 kHz to 15 kHz mainly consist of harmonics.

- Sound intensity is calculated in two ways: **acoustic level** (the intensity registered by the ear), **electrical level** (sound converted into an electrical signal). In both cases, the intensity is calculated in dB

Audio-visual integration, audio and visual effect
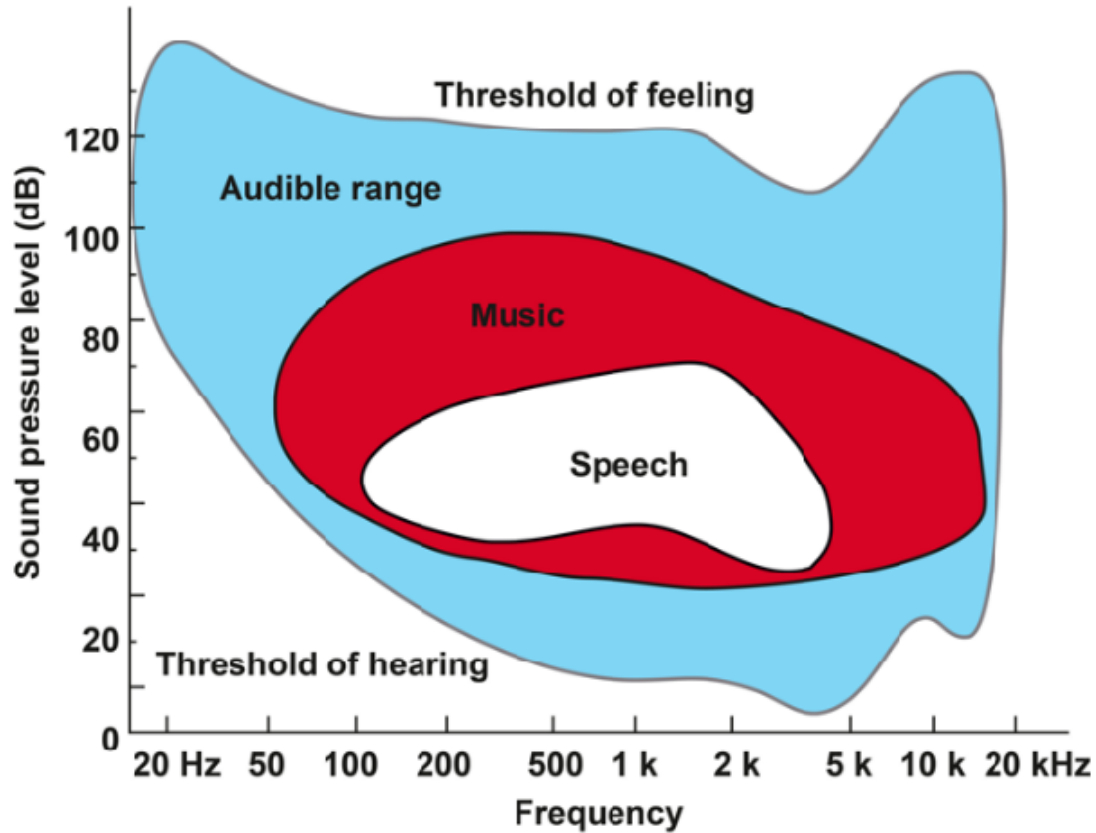
The limit of audibility and the area of speech and music

Audio-visual intergration, audio and visual effects

- Visual effects:

- The modern industrial world is very oriented towards visual communication.

- 70% of the information we receive is transmitted through the sense of sight.

- the eye is the most important sensor compared to other sensors, such as the sense of hearing, smell, touch or taste.

- The retina is covered with photoreceptor cells, two types of photoreceptor cells: rods and cones.

- The rods enable monochromatic vision at night.

- The cones allow viewing in color, but only at a high level of illumination.

Audio-visual integration, audio and visual effects
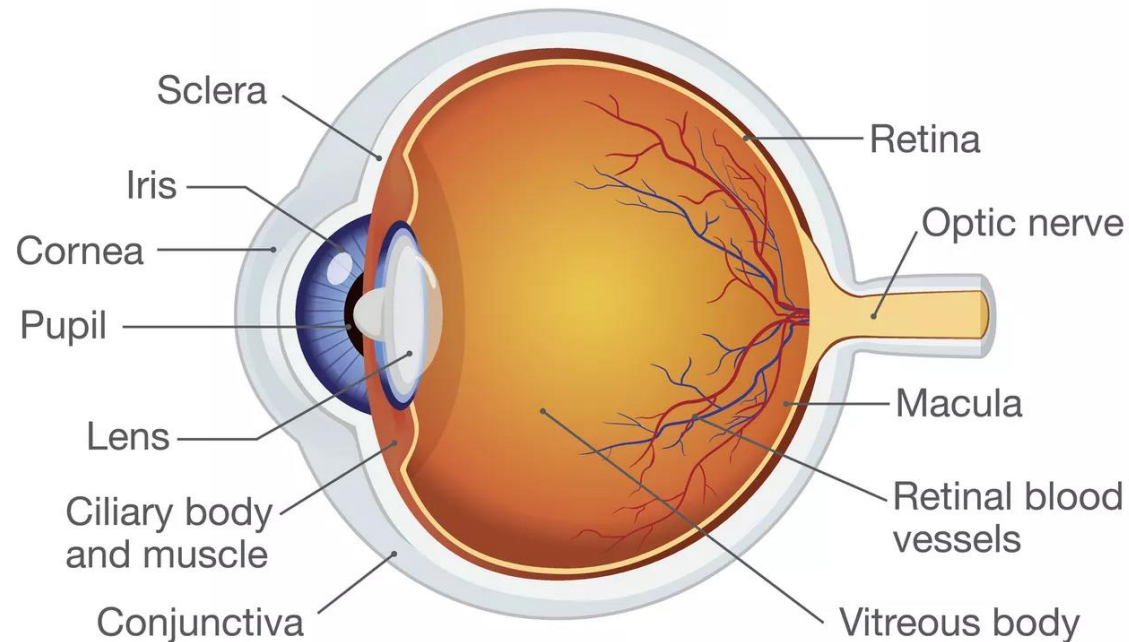
Structure of the human eye

Audio-visual integration, audio and visual effects
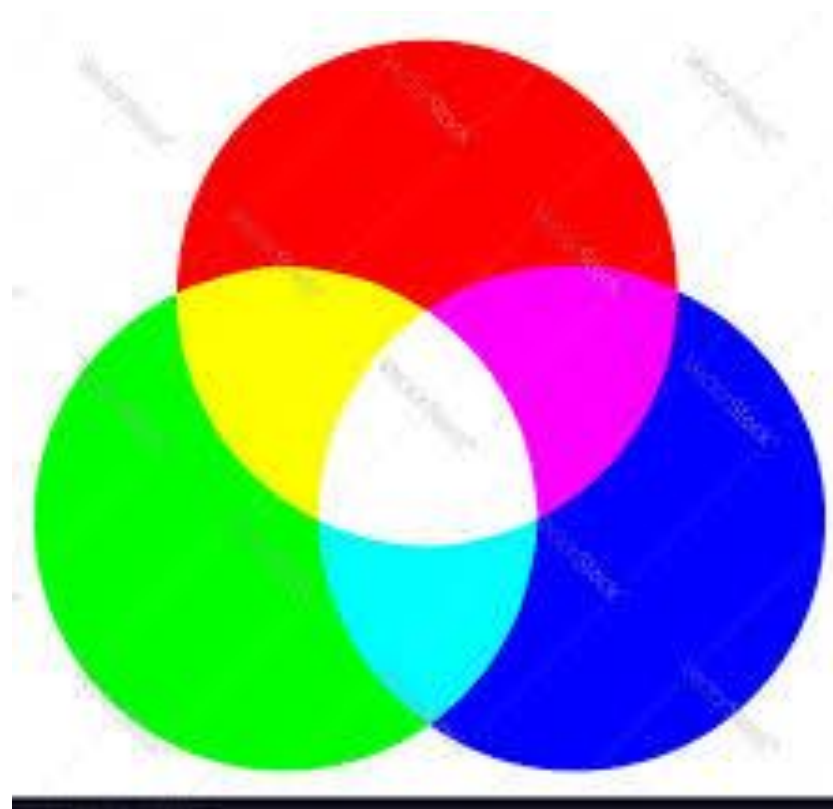
RGB color model

Audio-visual integration, audio and visual effects

- Visual effects:

- HVS (*human visual system - HVS*) is studied for the most efficient use of multimedia technologies.

- Electromagnetic waves have different wavelengths in a wide range, from long to extremely short waves (gamma rays).

- The eye can detect narrow-spectrum waves from approximately 400 nm to 700 nm. Sunlight has a spectrum in this wavelength range and is the main source of terrestrial EM waves.

Audio-visual integration, audio and visual effects
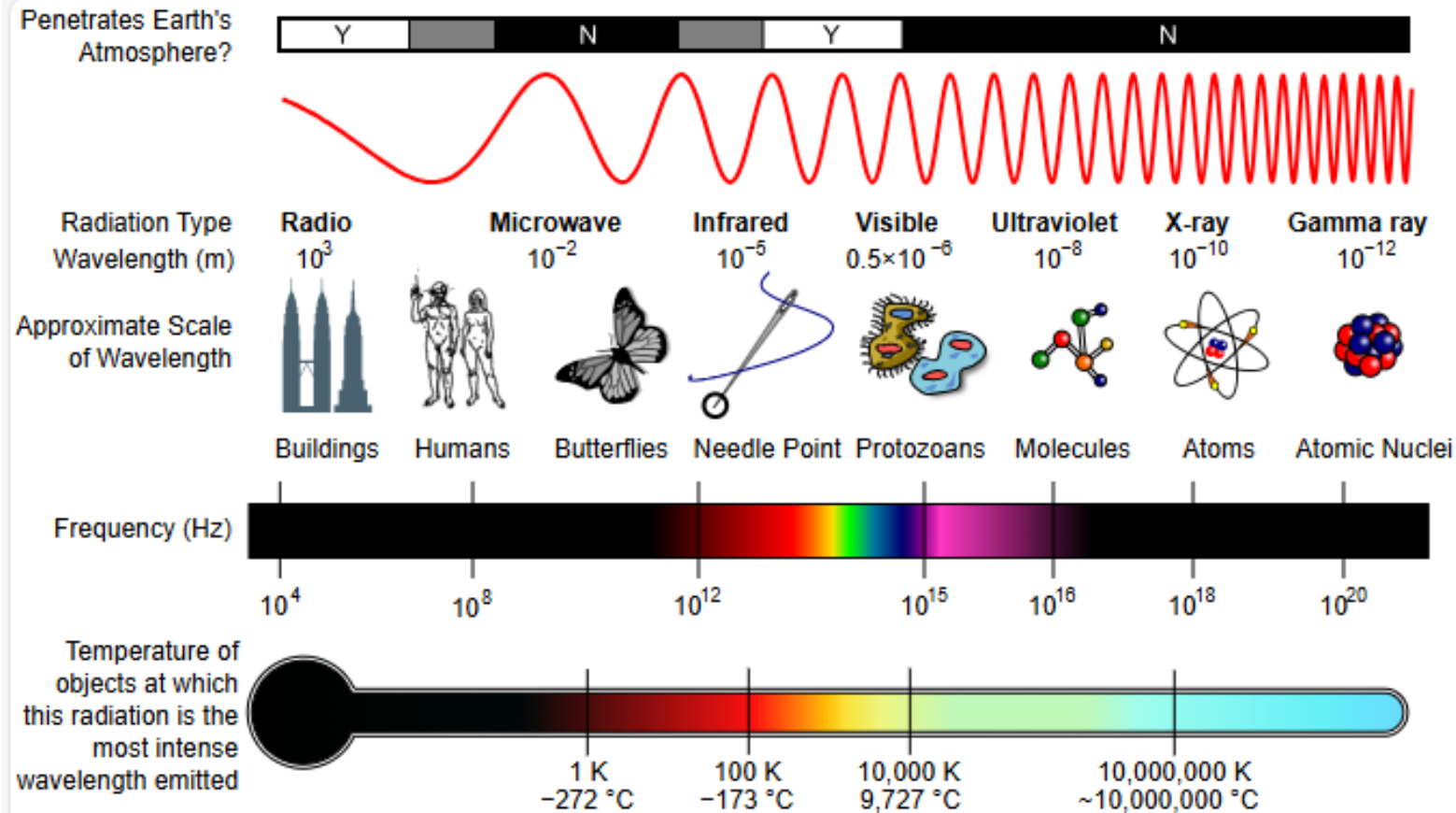
EM spektrum

Audio-visual integration, audio and visual effects
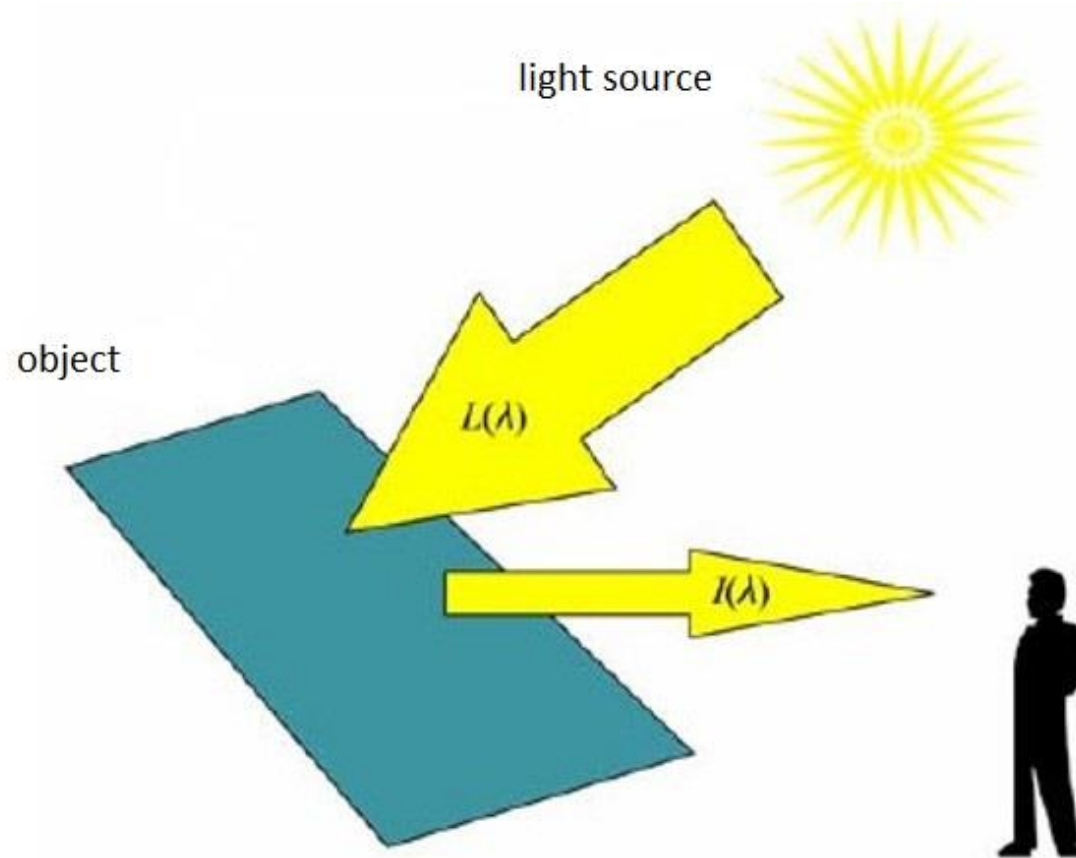
Light in object detection

Audio-visual integration, audio and visual effects
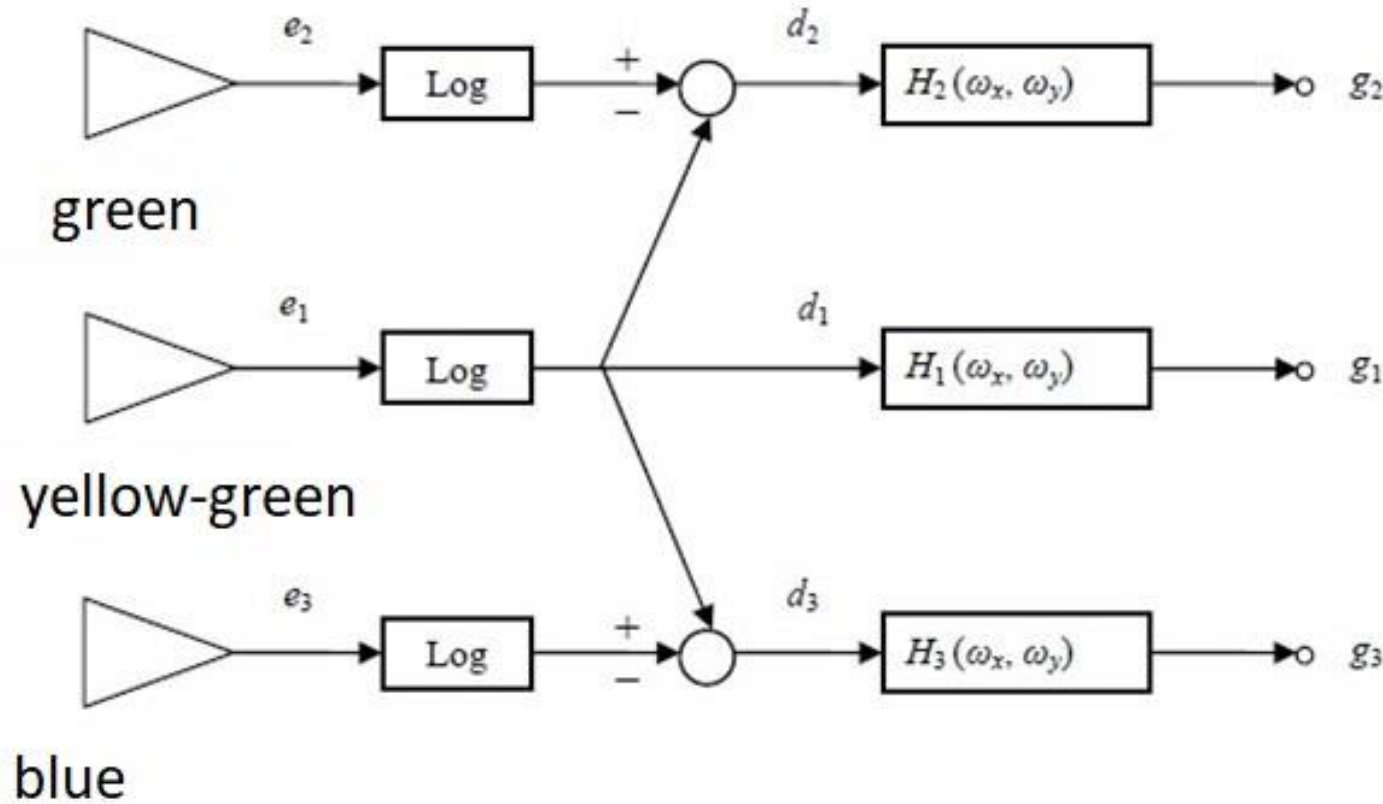
Block diagram of Frei visual model

Audio-visual integration, audio and visual effects
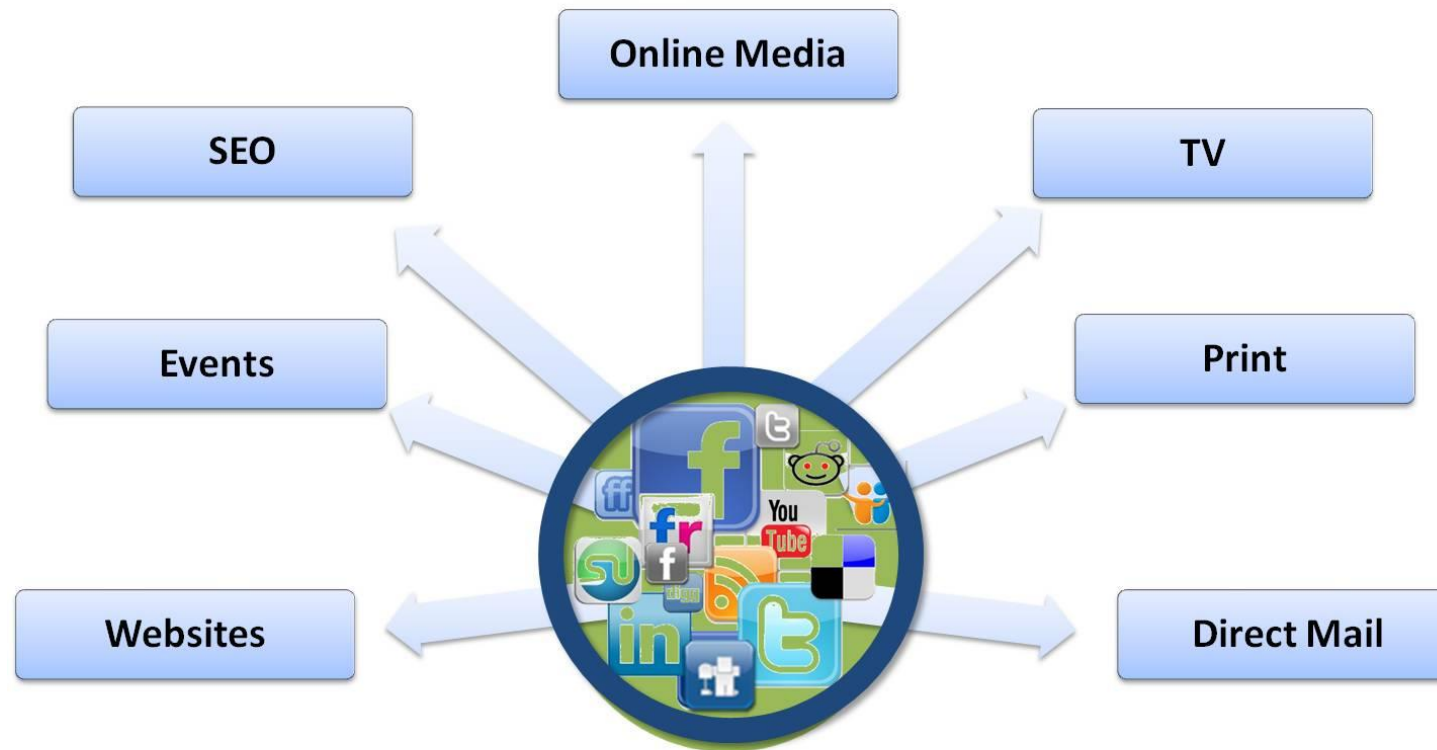
Media integration

Data acquisition

- In order to carry out the analysis and processing of multimedia data, it is necessary to place the digitized audio or video data in a computer.

- After processing, the digital signal is reconstructed, i.e. converted into analog form.

- Audio sources (microphones) or image sources (cameras) generally produce analog signals that are continuous in time. In order to collect audio or video data, we have to measure and digitize it.

Data acqusition

- Discretization of a continuous signal:

- discretization of the signal **by time (measurement)** i

- signal discretization **by current values (quantization).**

- When the digitalization of a continuous signal needs to be performed, a third operation is also performed - **coding,** i.e. representing the digital values of the signal by a group of digits or pulses.

- A digitized signal is usually represented by a diagram or a table

Data acqusation
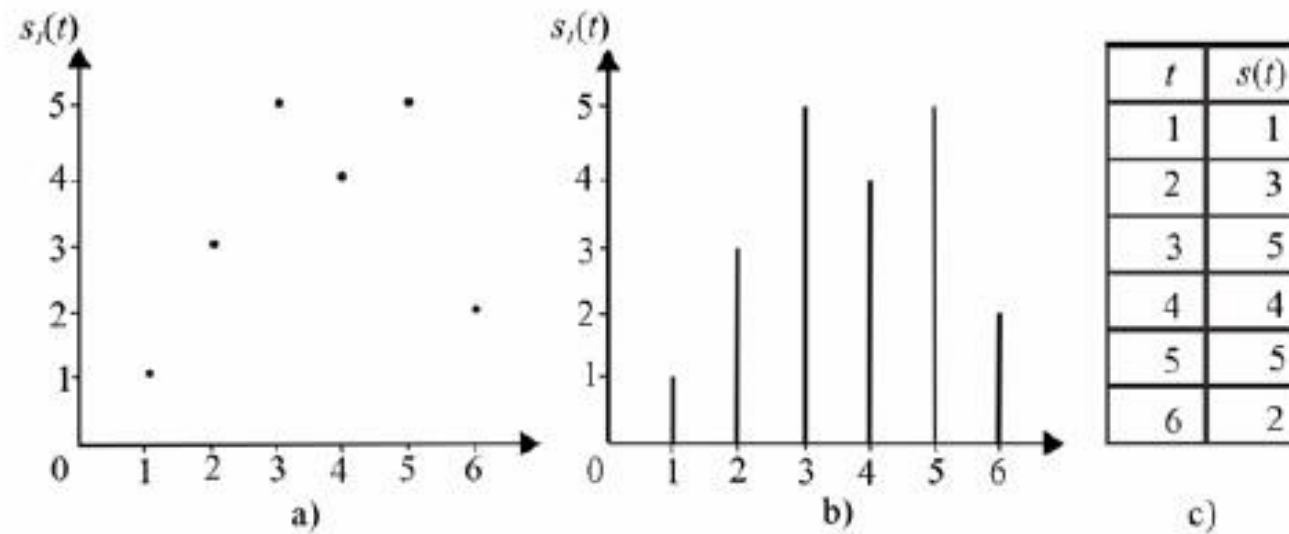
Representation of the digitized signal a) and b) diagram, c) table

Data acqusation

- Dependence of the frequency range of the signal on the noise level:

- Message signals are considered to have limited duration and limited spectrum width.

- It can be seen that there is no reason to transmit a part of the spectrum above the frequency indicated by ωg during signal transmission.

- Therefore, by continuous differences, we bring into correspondence continuous time functions that have a strictly limited spectrum.

- For example, for the operation of a telephone signal, it is sufficient to transmit all components that are in the frequency range from **300 Hz to 3400 Hz,** while preserving the intelligibility and power of the signal.

Data acqusition
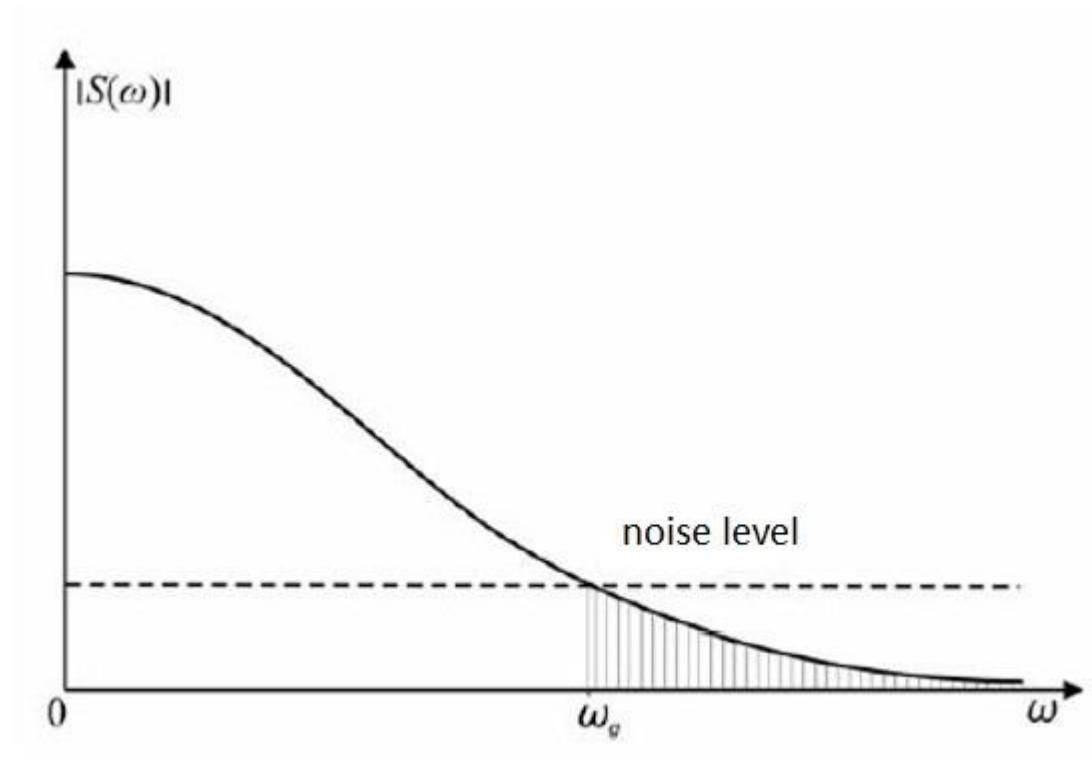
Dependence of the frequency range of the signal on the noise level

Data acqusition

- **Theorem**:

- any continuous time signal whose frequency range is limited and is in the interval from 0 Hz to fg can be uniquely defined by the finite number of its discrete values in the finite time interval, provided that the measurement is performed in time intervals. Where T0 is the measurement frequency.

Data acqusition

- Analog to digital (A/D) converter:

- It serves for the equivalent digital representation of an analog signal

- Multiplexing of a series of bits coming from different channels is done using a multiplexer.

- Compression reduces redundancy and compresses the size of the audio file while maintaining an acceptable level of audio signal quality.

- When an audio signal is quantized using a small number of bits per sample, the quality of the audio signal is poor.

- It has been found that if a small amount of dither noise is added before quantization, the subjective quality improves.

Text compression

- Text is another important medium for presenting multimedia information, **the oldest medium** for storing and transmitting information.

- **Most of today's information is still stored in text form**.

- The source has its own alphabet, that means it can emit any symbol (message) that belongs to the given alphabet.

- To describe a source, we can consider all the possible symbols that the source can emit.

- **Entropy** represents the average amount of information per symbol that the source provides to the observer, that is, the average source of uncertainty that the observer possesses before examining the output from the source.

Text compression

- **Shannon's Theorem:**

- A source can be losslessly encoded with an average number of bits close to its entropy but not less than its entropy. The source entropy is bounded by 0 and $\log_2 K$

- The relation shows that if the source has an alphabet of size K, the maximum entropy of the source is $\log_2 K$. If the entropy is $\log_2 K$, the source can be said to have zero redundancy. In most cases, the information contains redundancy.

Text compression

- **Huffman's theorem:**

- Correct the original information with the average number of bits R .

- Huffman provided a practical method for designing an encoder that yields a bit count close to entropy.

- This method provides a variable length code (**VLC**) for each source symbol, so that the number of bits in the code is approximately inversely proportional to the probability of the symbol's occurrence.

Text compression

original source		code assignment			
symbil	probabilyti	1	2	3	4
e	0.3	0.3	0.3	0.4	0.6
a	0.2	0.2	0.3	0.3 ←	0.4
c	0.2	0.2	0.2 ←	0.3 ←	
b	0.1	0.2 ←	0.2 ←		
d	0.1 ←	0.1 ←			
!	0.1 ←				

Huffman source reduction process

Standards in multimedia technologies

- Importance of standardization:

- Modern multimedia data compression techniques provide the ability to store or transmit a large amount of information necessary for the presentation of digital content in an efficient manner.

- With the continuous increase in transmission and storage capacity, compression is becoming one of the basic components for multimedia services

- **The goal of a compression algorithm is to achieve the most efficient compression possible while minimizing the distortion** that occurs in the process.

Standards in multimedia technologies

- Importance of standardization:

- MPEG was formed in 1988. with the task of developing standards for coding moving images, audio and their combinations.

- ISO/IEC, 11172 – Coding of moving images with associated audio up to about 1.5 Mbit/s **(MPEG-1)**

- ISO/IEC, 13818 – Moving image coding and audio association **(MPEG-2)**

- ISO/IEC, 14496 – Coding of audio-visual objects **(MPEG-4)**

- ISO/IEC, 15938 - Multimedia Content Description Interface **(MPEG-7)**

- ISO/IEC, 21000 – Multimedia Framework **(MPEG 21)**

Standards in multimedia technologies

- Importance of standardization:

- MPEG-4 enables:

- **Display of audio, visual and audio-visual content called media objects. These objects can be of natural or synthetic origin, meaning they can be captured by a camera or microphone or generated by a computer**

- **Part 1: Systems**. Determine the system architecture and the tools that should be associated with binary format for scenes (BIFS),

Standards in multimedia technologies

- **Part 2: Visual**. Specifies the code tools associated with visual objects of natural and synthetic origin.

- **Part 3: Audio**. Coding solutions for music and speech data for a very wide range of bitrates and synthetic audio including 3D audio spaces.

- **Part 4: Custom testing**. Defines tests that allow checking that streams (content) and decoders conform to technical specifications.

- **Part 5: Reference software**. Video and audio encoders and decoders.

- **Part 6: Delivery multimedia integration framework (DMIF)**

- **Part 7: Optimized software tools for MPEG-4.**

- **Part 8: Transport of MPEG-4 content over IP networks.**

Standards in multimedia technologies
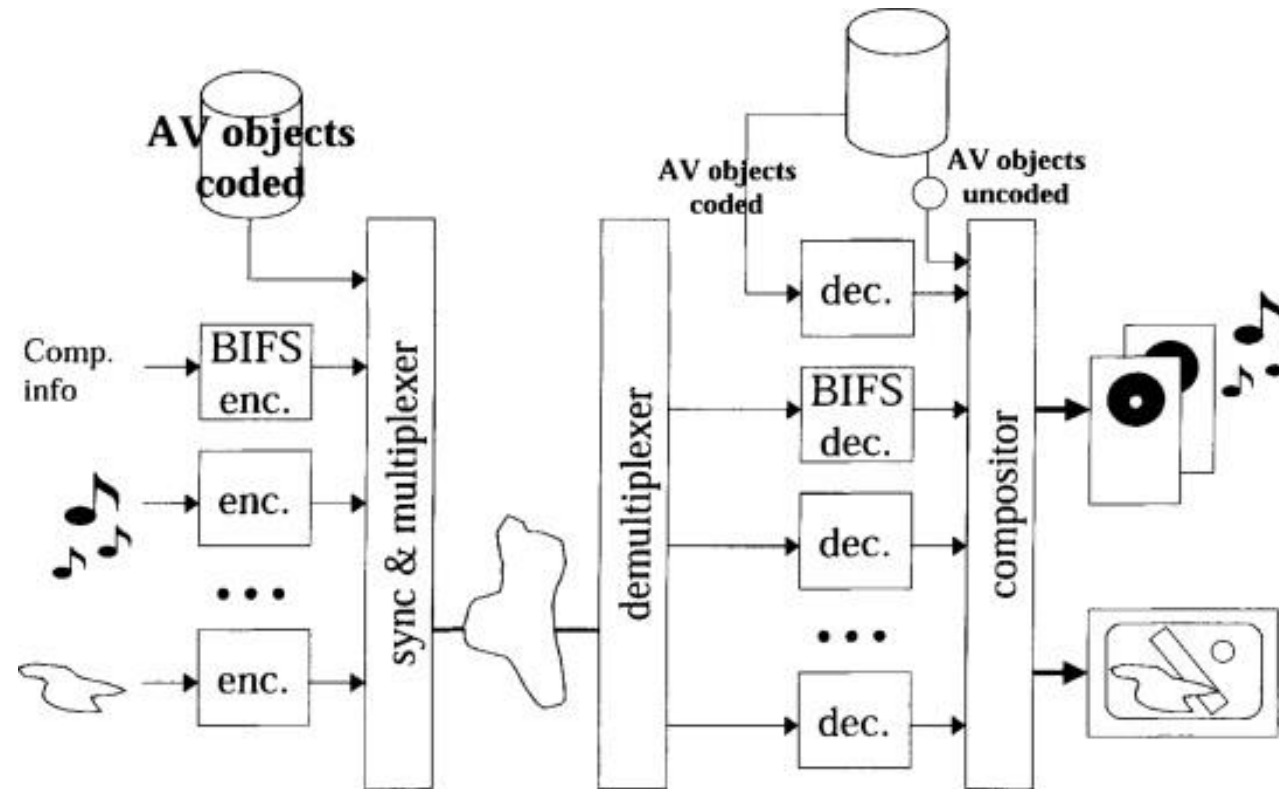
MPEG-4 object-based architecture

Standards in multimedia technologies

- **The H.264/AVC standard** specifies two alternative entropy coding methods: context adaptive variable length coding (CAVLC) and the more computationally demanding context adaptive binary arithmetic coding (CABAC) algorithm.

- **MPEG-4 VTC** is an algorithm used in the MPEG-4 standard to compress texture information in photo-realistic 3D models. Since the texture in 3D models is similar to that of a still image, this algorithm can also be applied to compress still images.

- **MPEG-7** meets a number of requirements from previous MPEG standards, the audio-visual performance here does not aim to compress and reproduce data, but deals with the so-called metadata (data about data).

Standards in multimedia technologies

- **The objectives of the MPEG-21 Standard are:**

- To understand how the various available components can be fitted together,

- Necessary standards if there is space for it in the appropriate infrastructure,

- Integration of different standards.

- Seven parts:

- **1. Declaration in the digital part**: they enable protection of standards, adaptation and grouping of formed digital parts.

- 2. **Identification and description of the digital part**: The goal is that all digital content and media resources within the MPEG-21 standard transmit unique identifiers.

Standards in multimedia technologies

- **3. Content management and application**: Introduction of the MPEG-21 standard in the area of network, server and multimedia content management by the client.

- **4. Intellectual property management and protection** (*digital rights management - DRM)*

- **5. Terminals and networks**: This layer creates transparent access for advanced multimedia content.

- **6. Presentation of content**: Presented by MPEG standards.

- **7.Event Reporting**: Standardizes metrics and interfaces for digital parts interactions.

Application aspect

- **Interactive multimedia implies the existence of interaction with the user.**

- **Hypermedia is interactive multimedia with links to guide users.**

- In modern society, multimedia is becoming a new literacy and a general way of expression.

- Multimedia is used in marketing, education, entertainment, medicine and business. **There are almost no activities where multimedia is not used.**

Application aspect

- According to the function, the media are classified into: memory, transmission and presentation.

- **A memory medium** is a physical means of storing information, such as: semiconductor, magnetic and optical memories.

- **The transmission medium** is the medium or medium for transmitting signals such as: copper conductors, glass fibers and free space.

- **A presentation medium** is a physical means or device by which information is presented to the user, such as devices with screens for displaying images and devices with speakers for generating sound.

- **Image display media** is characterized by parameters for image resolution, contrast and brightness.

- **The sound generating medium** is characterized by the dynamic and frequency range of audio amplifiers and speakers.

Application aspect

- The basic information and communication terms are: information, message, data, communication, signal and coding.

- **Information** is a set of messages.

- **A message** represents a set of data.

- **Data** represents a characteristic of an element, system, or process.

- **Communication** is the process of transferring information.

- **Information** is transmitted using signals.

- **A signal** is a materialized carrier of information.

Application aspect

- Signals are characterized by dynamic, frequency and time domains.

- **The dynamic** domain of the signal is used to represent the power, that is, the intensity of the signal. For signal processing and transmission, the range or ratio of maximum and minimum signal intensity is significant, which is referred to as signal dynamics. The dynamics of the signal depends on how many bits, basic information units, the analog signal is encoded and translated into digital form.

- **The frequency domain** is used to represent the rate of change of the signal. For signal processing, memorization and transmission, the maximum rate of change, i.e. the maximum frequency - the frequency of the signal, is important. By increasing the maximum frequency, the requirements regarding the required resources for processing, memorizing, and signal transmission also increase.

- **The time domain** is used to represent the rate of change, the duration of individual intervals, and the total duration of the signal. The rates of change are related to the spectrum of the signal, i.e. the frequency domain. The duration of individual intervals and the total duration of the signal determines the occupancy of processor, memory and transmission resources.

Application aspect

- **The multimedia system** represents a set of devices and programs for integrated processing and management of independent discrete and continuous media in order to adapt real stimuli to the human sensory system to satisfy the appropriate perception.

- **Multimodality** represents the connection of mutually dependent channels - modalities for sensory perception, such as the dependence of speech on the movement of the lips and facial expressions.

- **Multimedia activity** is multidisciplinary and includes various technical-technological, economic, sociological and artistic specialties

Application aspect

- Three phases in the realization of multimedia content: pre-production, production and post-production.

- **Multimedia pre-production** represents the first phase of a multimedia project in which the client's/client's requirements are collected and elaborated, goals are defined, user specifications are analyzed and a project plan is created.

- **Multimedia production** represents the second phase of project realization, in which the content that will be incorporated into the product is directly formed. Depending on the complexity of the product, the computer, camera, actors, costumes, studio and scenography are used.

- **Multimedia post-production** represents the final stage of project realization, in which the final version of the multimedia product is formed. In the case of digital multimedia, post-production is reduced to editing. When working with sound and moving images, it is montage.

Application aspect

- Image in multimedia:

- **The image** (from the physical aspect) represents the distribution of light on a surface, in a plane or in space.

- **Light** is an electromagnetic wave with a wide range of wavelengths from 390 nm to 760 nm, which are individually seen as colors of light.

- **Color** represents a narrower part of the light spectrum that the visual system distinguishes from neighboring parts of the spectrum. Colors are classified as primary, secondary and tertiary.

Application aspect

- Image in multimedia:

- **The primary or basic** colors are red, blue and yellow.

- **Secondary or second order colors** are orange (yellow + red), green (blue + yellow) and violet (red + blue).

- **Tertiary colors** – higher order colors are combinations of primary and secondary colors.

- **The human eye** can distinguish about 10 million different colors. A huge range of tertiary colors is obtained by mixing primary and secondary colors.

- **There are two ways to mix colors**, additive and subtractive color mixing.

Application aspect

- Image in multimedia:

- **Additive mixing of colors** takes place on the basis of superposition, the addition of light waves of individual colors. Each color can be synthesized from an appropriate amount of the three primary colors. An example of additive color mixing is images on screens.

- **Subtractive mixing of colors** takes place on the basis of mutual absorption of colored particles, which is the case in painting.

- **A monochrome image** is a black and white image and a chromatic image is a color image.

- **A pixel** (picture element) is an image element determined by its brightness and position in the image.

- **The brightness of a pixel** is expressed by a numerical intensity value.

- **The position of the pixel** is represented by coordinates (x, y).

Application aspect

- Image in multimedia:

- **A bitmapped image** represents a 2D sequence of values of image elements - pixels in digital video memory or displayed on the screen in the form of an optical image. The pixels of a bitmapped image are formed in the process of recording or scanning an optical image.

- **Vector generated images are artificial images** made using vector graphics. Rendering vector images - rendering requires a prior calculation to generate pixel values.

Application aspect

Example of a) vector and b) bitmapped image

Application software for multimedia

- **Proprietary software** are computer programs that are licensed with exclusive legal copyright.

- **Public domain software** is non-commercial software, has no copyright and can be freely downloaded and used.

- **Free software** are programs licensed from the owner with permissive terms.

- **Free and Open source software** is software that is freely licensed to grant users the right to use, or modify the design of, the available source code of the software.

- **Commercial software** (Commercial software, payware software) is produced for sale, or serves commercial purposes.

Application software for multimedia

- Software tools for creating multimedia presentations:
- **Multimedia presentations** represent a combined presentation of textual, image and sound information.
- **PowerPoint** is a program for creating presentations that was launched by Microsoft at the end of the eighties of the last century.
- **HiperStudio,** created by Microsoft, is similar to PowerPoint, but with slightly greater possibilities for interactivity.
- **Flash** is a powerful software tool, the first versions of which were launched by **Macromedia,** then taken over by **Adobe,** designed for creating various presentations.

Application software for multimedia

- Software tools for editing moving images:

- **Editing of moving images** (video editing) is a basic activity in the post-production process, when the final version of the video product is created from the video material recorded and prepared in the production process.

- **Premiere** is one of the first programs for digital video editing developed two decades ago, it is installed on Apple Macintosh and Microsoft Windows operating systems.

- **Final Cut Studio** is a software suite for professional video and audio production in film and television production.

- **iMovie** is an entry-level editing system and includes image filtering, conversion to sepia or black and white, subtitling, and audio editing.

Application software for multimedia

- Software tools for editing moving images:
- **Sony Vegas Movie Studio 9 Platinum** is a video editing and DVD authoring program.
- **SONY Vegas Pro 9** is a professional software for video and audio post-production for broadcast and digital video discs (digital video disc - DVD) and blue - blu-ray discs - optical discs for storing data (blu-ray disc - BD).
- **Adobe Encore DVD** is a software tool designed for professional DVD authoring.
- **Pinnacle Studio HD** is a video editing program in many Windows computers, providing transitions, animations and effects.
- **CINEFORM NeoScene** is a program for non-linear editing in filmmaking.

Questions & Answers

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