# Infocommunication system

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## Tartalomjegyzék

# 1. What is the convergence in the field of information and communication technology? What are the consequences?

## Telecom industry

computer industry → infocom industry
media indusrty

**Reasons:**

- common technology platform (digital technology): common development rate
- unlimited telecom possibilities (bandwidth, distance)
- easy information storage, copying and searching

**Convergence:** traditionally different networks for different purposes, today we use networks for many activities

| Telecom | Computer |
|---|---|
| Sate monopoly/income | Market oriented |
| International standards | Proprietary solutions |
| Detailed legal regulation | Self regulation (if any) |
| Statistical figures available | Estimations only |

## Convergence in networks

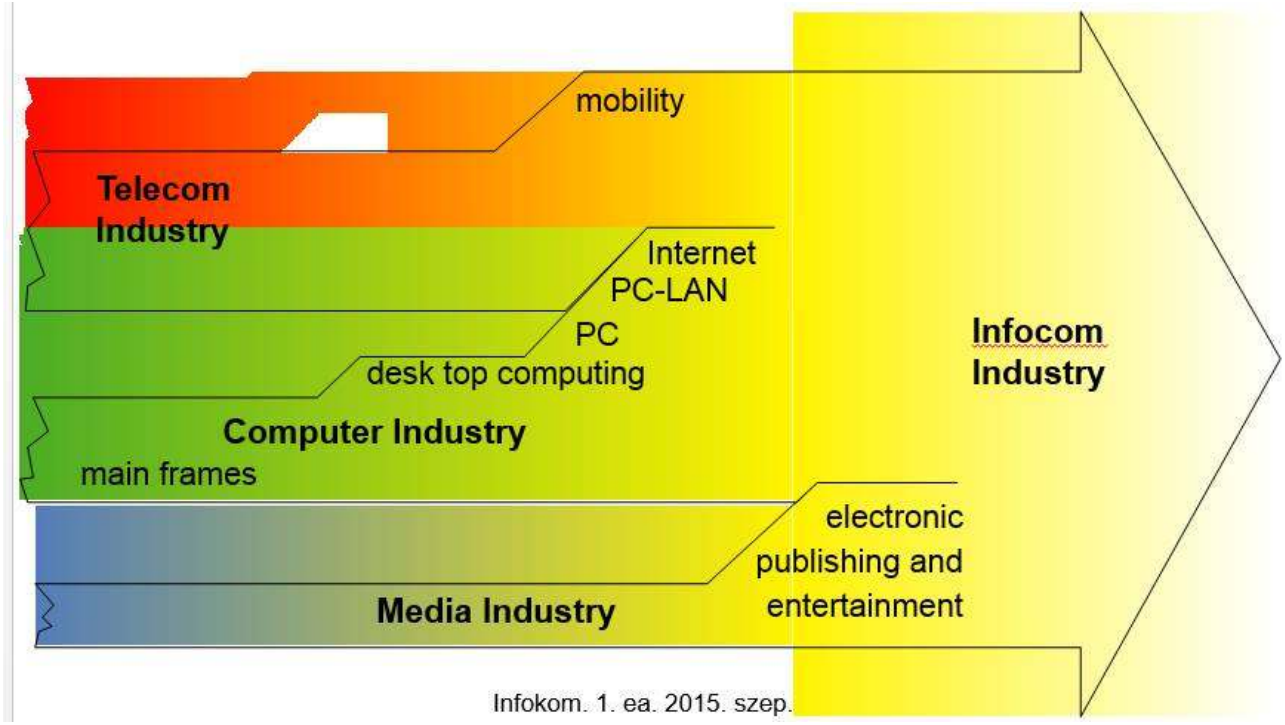
- Traditionally separate networks and different technologies for telephone, for cable TV, for radio program broadcasting, for data communications
- Today: we make telephone calls on CaTV networks, on Internet, we access to Internet via telephone lines (ADSL) or using Mobil telephone networks
- Today we download films on the Internet and can receive TV news on mobile networks

## Convergence in terminal

- Traditionally it was telephone, TV set, computer, CD player...
- Today: we play MP3 files on mobile telephone, watch TV programs on Computer, edit excel files on mobile phone, read e-mails on TV screen...
- Which is intelligent equipment is not a real terminal?

## Consequences in communication technology

- Common technology platform – digital technology – common development rate
- Unlimited telecom possibilities – no practical limit in bandwidth and no limit in geographic distance
- Store, copy and searching of information content
- Mobile communications




1. ábra. Convergence

## 2. Which fields of technologies develop faster? What are the consequences?

- Processing power (Moore law: processing power doubling every 18 months)
- Transmission capacity (Gilder law: bandwidth is tripling every 12 months)
- Storage capacity (Ruettger law: memory capacity doubling every 12 months)
- it's cheaper a stored bit, a processed bit or a travelling bit?
- How will its cost vary with time?

### Statements

- The winner is the bit transport
- We are in the age of practically infinite bandwidth
- We are in the age of the practically free bandwidth („too cheap to meter")
- No distance limits within the globe
- These facts together can lead to revolution in the field of infocommunications

### Verification

- The transport bit is the winner
  - Highest exponent
  - The physical limits are close in memories and processors

- Infinite bandwidth in fibre optic cables
  - 10 Gbit/s per carrier
  - 1000 carrier per fibre
  - 1000 fibre per cable
  - Totally $10^{16}$ bit/s as practically infinite bandwidth?
  - 1 optical cable is suitable to download within 1 s videos for 4 persons full life!!
- Free bandwidth
  - PPKE has connection to the NIIF network by 2 Gb/s link
  - The leasing fee for the dark fibre takes about 200.000 Ft/month
  - downloading 1Gb takes in the ITK = 0,079 Ft!
- Verification
  - The smallest attenuation in fibre cables nowadays 0,001 dB/km
  - Using such cable Práter u. - Berkeley can be connected without repeaters !

### Consequence

Infinite and free bandwidt

- Free(??) products are not good basis of business ! Only way to have profit to force wasteful usage or to pay for other products
- New network philosophy, structure, new functions in the nodes
- Completely different user behaviour
- New ratio of computing – downloading – storing!

## 3. Which kind of limits are in the field of electronic communications?

Higher and higher limits in memories?

- Samsung unveils 2.5-inch 16TB SSD: The worlds largest hard drive
- Hard disk storage prices: Price decreasing from about US$15,000 per megabyte to less than $0.0001 per megabyte ($100/1 terabyte), a greater than 150-million-to-1 decrease.
- **Transmission:** fibre optic cable (practically infinite), we have to choose the right technology
- **Processing:** packet switching by $10^{16}$ bps (physical limits are close)
- **Storage:** bigger and bigger memories, hard drives

## 4. What are the main transmission characteristics of twisted pair cables (attenuation, characteristic impedance, crosstalk. . . )? What are the main applications of twisted pair cables?

Wireline transmission media

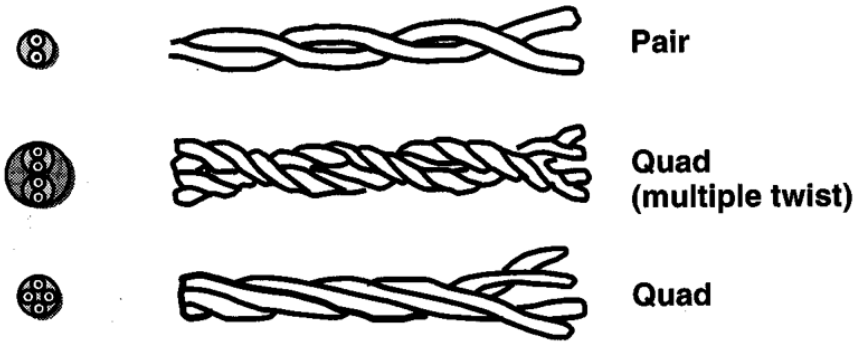
- Symmetrical twisted pair copper cable

- Coaxial cable
- Optical fibre cable
- Constuction issues, connecting, error detection, error localization

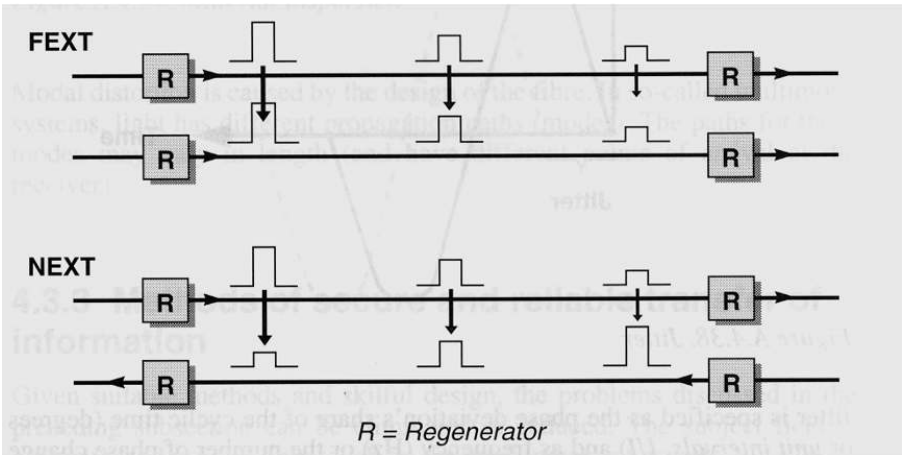
Media and cable characteristics

- Transmission parameters (attenuation, delay, reflection, crosstalk, noises, interferences)
- Laying, connecting technologies
- Faults, fault localization
- Matching, accessories, termination

**Twisted pair cable:** Twisted pair cabling is a type of wiring in which two conductors of a single circuit are twisted together for the purposes of canceling out electromagnetic interference (EMI) from external sources.
**Attennuation:** Reduction in the strength of a signal. Unit: [dB] Characteristic impedance: Z0. The characteristic impedance of a transmission line is the ratio of the voltage and current of a wave travelling along the line.
**NeXT:** Near-end Crosstalk. Interference between two pairs in a cable is measured at the same end of the cable as the interfering transmitter.
**FeXT:** Fear-end Crosstalk. Interference between two pairs of a cable measured at the other end of the cable with respect to the interfering transmitter.
**Main applications of twisted pair cable:** Ethernet cabling (UTP).




2. ábra. Cable twist type



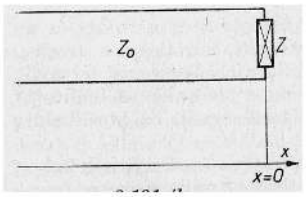

3. ábra. FeXT - NeXT

$$\alpha = \pm \sqrt{\frac{1}{2}(RG - \omega^2 LC) + \frac{1}{2}\sqrt{(R^2 + \omega^2 L^2)(G^2 + \omega^2 C^2)}}.$$

$$\beta = \pm \sqrt{\frac{1}{2}(\omega^2 LC - RG) + \frac{1}{2}\sqrt{(R^2 + \omega^2 L^2)(G^2 + \omega^2 C^2)}}.$$

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

4. ábra. Characteristic impedance



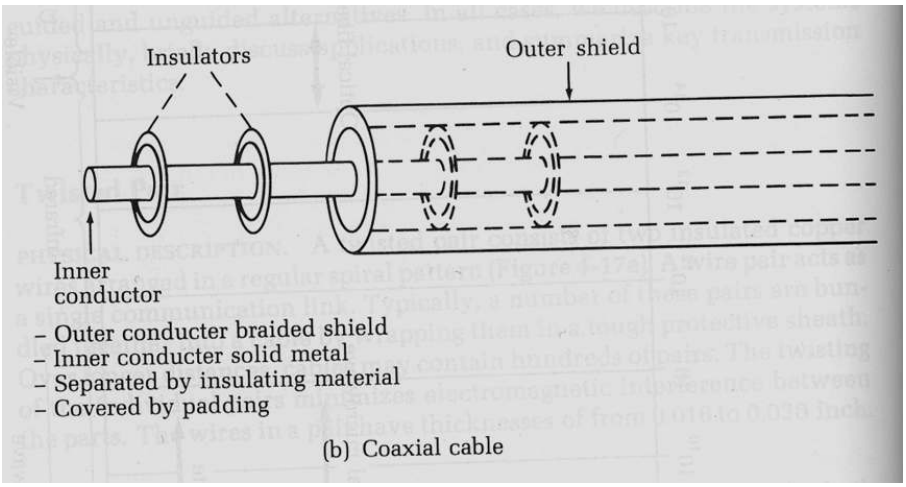

$$r = U_0^- / U_0^+$$

$$r = \frac{Z - Z_0}{Z + Z_0}.$$

5. ábra. Phenomenon at the end of terminated wire

## 5. What are the main characteristics of coaxial cables? What are the main applications of coaxial cables?

Coaxial cable, or coax, is a type of cable that has an inner conductor surrounded by a tubular insulating layer, surrounded by a tubular conducting shield.The term coaxial comes from the inner conductor and the outer shield sharing a geometric axis. Coaxial cable was invented by English engineer and mathematician Oliver Heaviside, who patented the design in 1880.

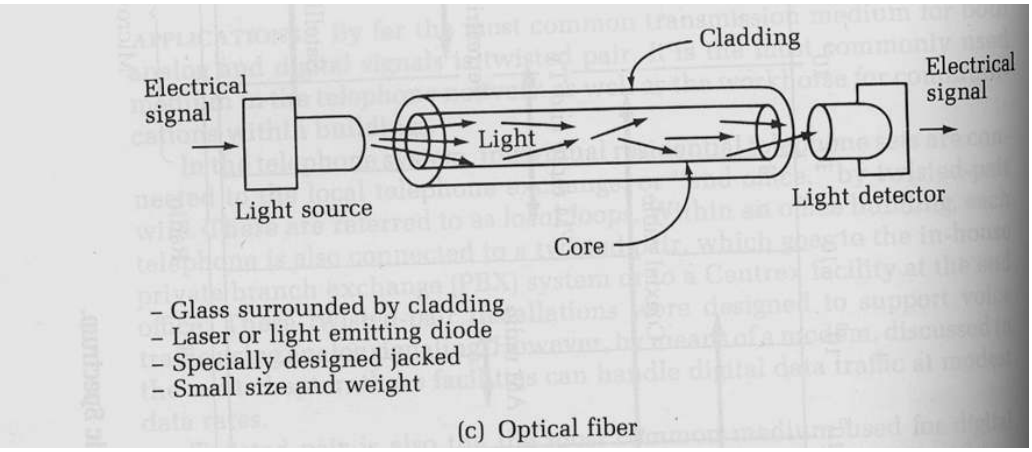



6. ábra. Structure of a coaxial cable

**Coaxial cable:** is a type of cable that has an inner conductor surrounded by a tubular insulating layer, surrounded by a tubular conducting shield.

**Characteristics:** Characteristic impedance, attenuation, velocity of propagation (the ratio of the speed at which a wavefront passes through the medium, to the speed of light in a vacuum), Peak Voltage (the peak voltage is set by the breakdown voltage of the insulator).
**Main applications:** Coax cable is often used to carry data/signals from an antenna to a receiver—from a satellite dish to a satellite receiver, from a television antenna to a television receiver, from a radio mast to a radio receiver, etc. Short coaxial cables are commonly used to connect home video equipment, in ham radio setups, and in measurement electronics. Long distance coaxial cable was used in the 20th century to connect radio networks, television networks, and Long Distance telephone networks.

## 6. What are the main transmission characteristics and propagation modes of fiber cables? What are the main applications of fiber cables?

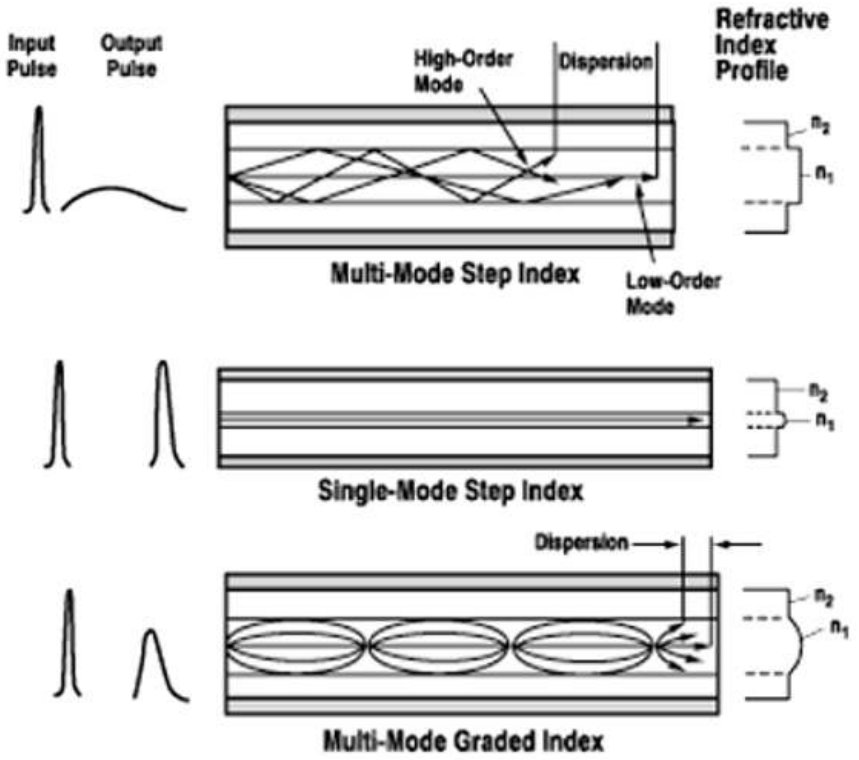



7. ábra. Principle of optical fibre

The intermodal dispersion discussed above can be characterized by the intermodal dispersion coefficient

$$D_{lm} = \frac{\Delta\tau}{L}[ns/km] \tag{1}$$

where $\Delta\tau$ is the group delay differnce between the slowest and fastest mode and L is the length of the cable.




8. ábra. Types of mode propagation in fiber optic cable

## 7. What are the main transmission characteristics of radio connections? What is the fading?

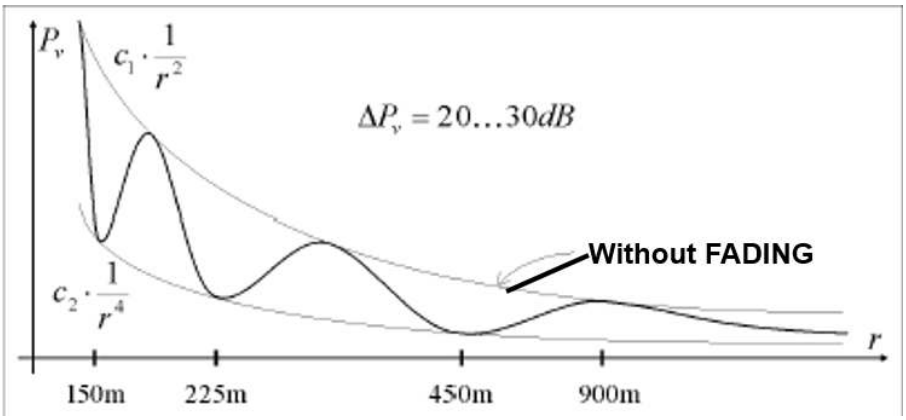
Radio transmission media

- Frequency bands and wave propagation modes
- Terrestrial radio connection
- Satellite communication
- In door radio connection

Media characteristics

- Transmission parameters (path loss, delay, fading, radio interferences)
- Reliability and availability - equipment and propagation parameters (lightning, snow, rain, fog, smoke)
- Openness – interferences - privacy

**Fading:** In wireless communications, fading is deviation of the attenuation affecting a signal over certain propagation media. The fading may vary with time, geographical position or radio frequency, and is often modeled as a random process. A fading channel is a communication channel comparising fading. In wireless systems, fading may either be due to multipath propagation, referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading.

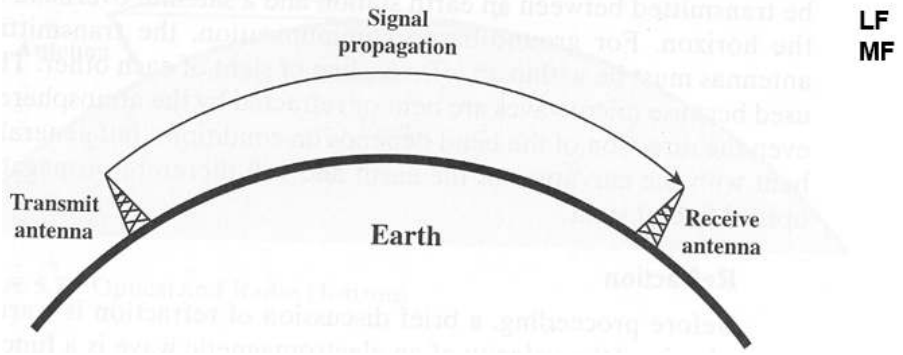



9. ábra. Fading

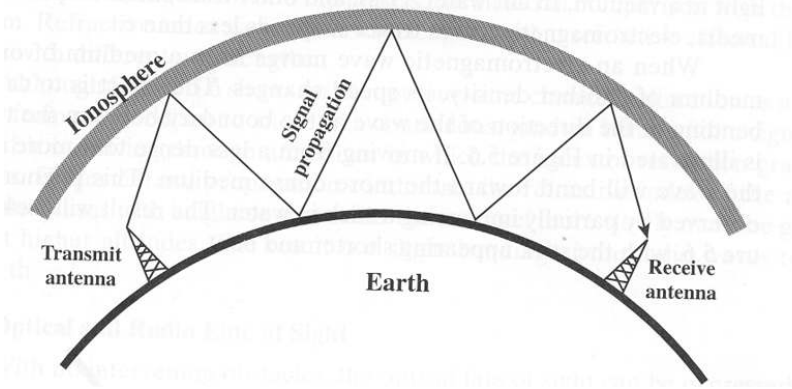
## 8. Which frequency bands are used in radio communications? What are the main wave propagation modes?

Frequency bands and wave propagation modes

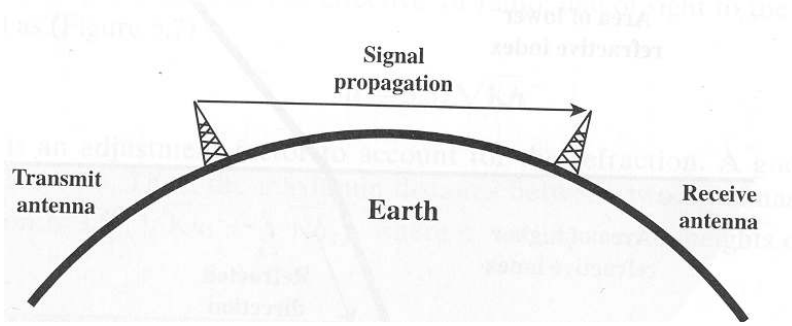
- LF (30-300 kHz)
- MF (300-3000 kHz)
- HF (3-30 MHz)
- VHF (30-300 MHz)
- UHF (300-3000 MHz)
- SHF (centimetric waves, 3-30 GHz)
- EHF (millimetric waves, 30-300 GHz)




10. ábra. Ground wave propagation (below 2 MHz)




11. ábra. Sky wave propagation (2 to 30 MHz)




12. ábra. Line-of-sight (LOS) propagation

## 9. What are the characteristics and main application of terrestrial and space radio communications?

**Radio link types:**

1. point-point connection
2. point-multipoint connection
3. cellular system

**Earth orbit altitudes:**

1. LEO (Low Earth Orbit): 500 – 1500 km
2. MEO (Medium Earth Orbit): 5000 – 12.000 km
3. GEO (Geostationary Earth Orbit): 36.000 km, 40% surface covered by one satellite

Radio transmission media

- Frequency bands and wave propagation modes
- Terrestrial radio connection
- Satellite communication
- In door radio connection

Media characteristics

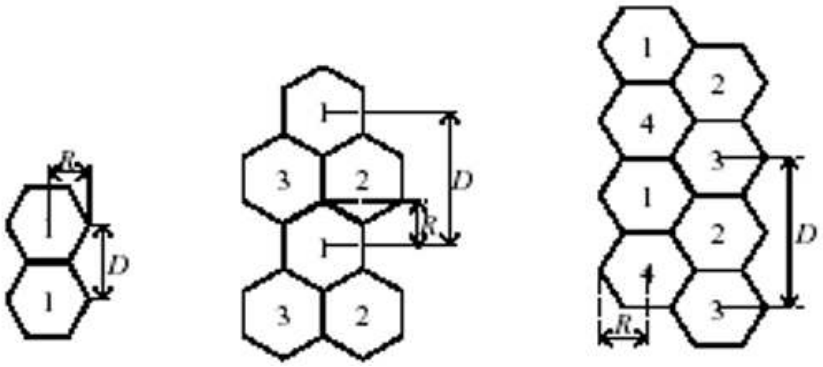
- Transmission parameters (path loss, delay, fading, radio interferences)
- Reliability and availability - equipment and propagation parameters (lightning, snow, rain, fog, smoke)
- Openness – interferences - privacy

**Path loss:** Path loss (or path attenuation) is the reduction in power density (attenuation) of an electromagnetic wave as it propagates through space.
**Delay:** The time difference in propagation (called propagation delay) between two signals which had taken different paths may interfere with reception, since the data streams that are received overlap with one another.
**Fading:** In wireless communications, fading is deviation of the attenuation affecting a signal over certain propagation media. In wireless systems, fading may either be due to multipath propagation, referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading.
**Reflection:** When a radio wave hits an obstacle, some or all of the wave is reflected, with a loss of intensity. Reflection is such that the angle of incidence is equal to the angle of reflection.
**Polarization:** Property of a radiated electromagnetic wave describing the time varying direction and relative magnitude of the electric-field vector. In general, the field is elliptically polarized.

# 10. Principles of cellular systems

- In a cluster each cell has a separate frequency
- a is the area of one cell
- A is the cluster area
- R is the cell diameter
- D is the distance between clusters (the distance between cells with identical frequencies)
- K is the number of the cluster cells

$$K = \frac{A}{a} = \left(\frac{D}{\sqrt{3}R}\right)^2 \tag{2}$$




13. ábra. Clusters

**Increasing capacity in cellular systems:**

- Adding new channels
- Frequency borrowing
- Cell splitting

- Cell sectoring
- Microcells

## 11. Which frequency bands are used in satellite communications? What are the main communications problems in satellite communications?

**Table 9.1** Frequency Bands for Satellite Communications

| Band | Frequency Range | Total Bandwidth | General Application |
|---|---|---|---|
| L | 1 to 2 GHz | 1 GHz | Mobile satellite service (MSS) |
| S | 2 to 4 GHz | 2 GHz | MSS, NASA, deep space research |
| C | 4 to 8 GHz | 4 GHz | Fixed satellite service (FSS) |
| X | 8 to 12.5 GHz | 4.5 GHz | FSS military, terrestrial earth exploration, and meteorological satellites |
| Ku | 12.5 to 18 GHz | 5.5 GHz | FSS, broadcast satellite service (BSS) |
| K | 18 to 26.5 GHz | 8.5 GHz | BSS, FSS |
| Ka | 26.5 to 40 GHz | 13.5 GHz | FSS |

14. ábra.

The problem:

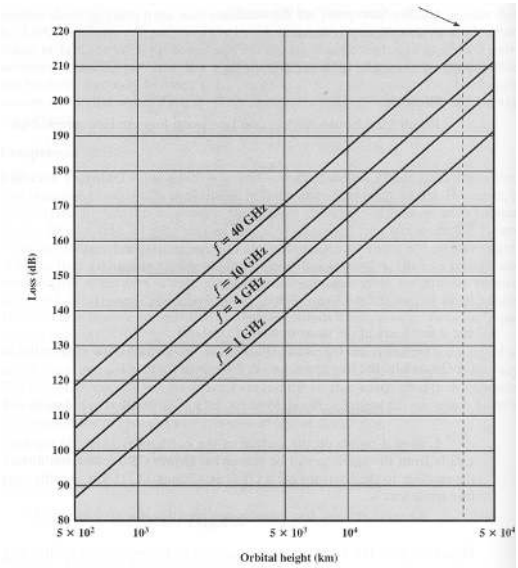


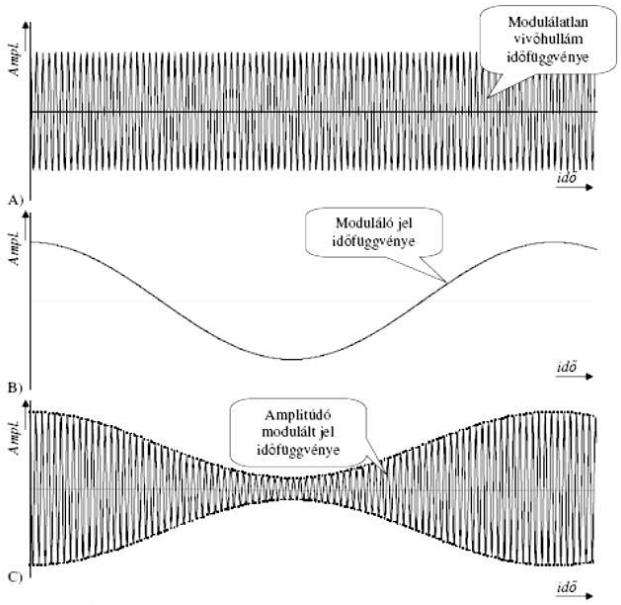

**Figure 9.5** Minimum Free Space Loss as a Function of Orbital Height

15. ábra.

# 12. Analog modulation systems (AM-FM)

**AM:** Amplitude modulation. The momentary amplitude of the carrier is proportional to the momentary amplitude of the modulating signal.

$$u = \Big[U_v + U_m cos(\omega_m t)\Big] cos(\omega_v t) \tag{3}$$




16. ábra. Anolog modulation systems (AM)

**FM:** The momentary frequency of the carrier is proportional to the momentary amplitude of the modulating signal.

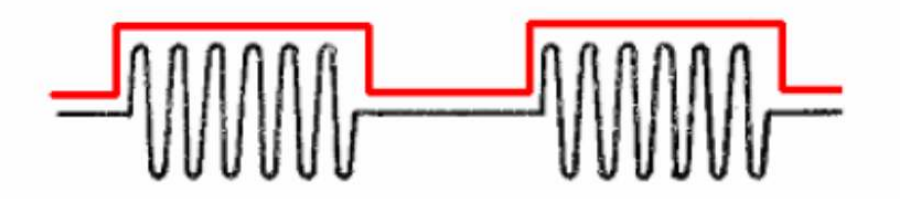
$$u = U_v \cdot cos\left[\omega_v t + \frac{\Delta\omega}{\omega_m} \cdot sin(\omega_m t)\right] \tag{4}$$

**Switching technologies:**

- circuit
  - PSTN
  - ISDN
- packet
  - frame relay (variable length)
  - cell (fixed length)
    - ATM

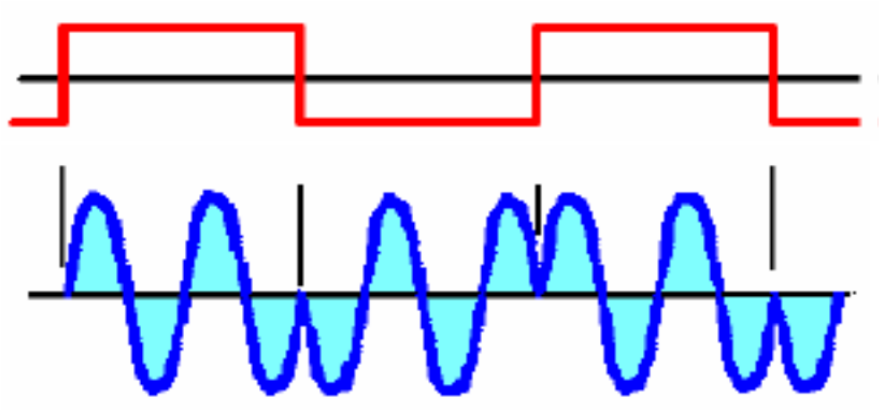
# 13. Digital modulation systems (BPSK, QPSK, QAM)

## Digital modulation methods - Amplitude Shift Keying (ASK)



17. ábra. Amplitude Shift Keying (ASK)

## Digital modulation methods – Binary Phase Shift Keying (BPSK)



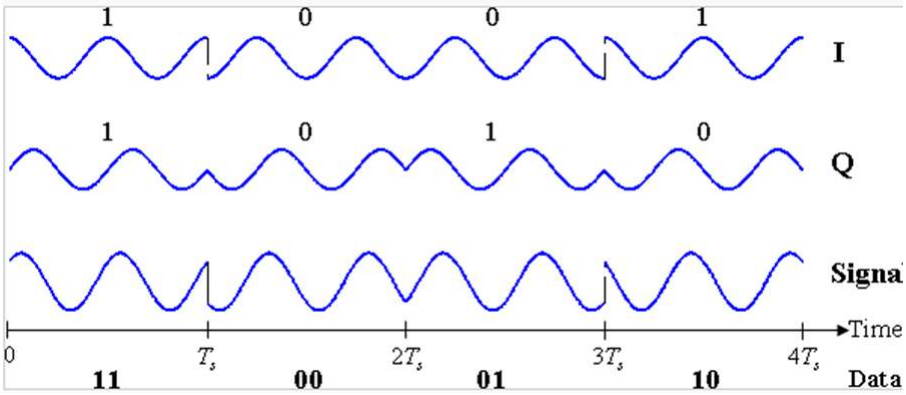
18. ábra. Binary Phase Shift Keying (BPSK)

## Digital modulation methods – Qadrature Phase Shift Keying (QPSK)

- Two carriers: sine wave (Q) and cosine wave (I)
- The modulated signal is the sum of the two components
- One symbol is two bits

## Digital modulation methods –Qadrature Amplitude Modulation (QAM)

- Two carriers: sine wave (Q) and cosine wave (I)
- The modulated signal is the sum of the two components
- Different amplitude and differnt phase values for one symbol
- 16QAM means: one symbol is four bits

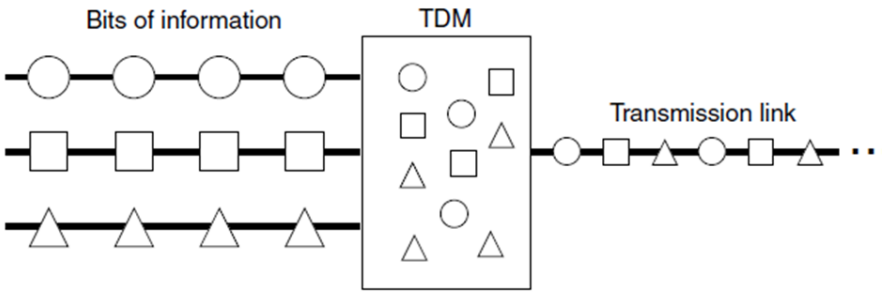



19. ábra. Qadrature Phase Shift Keying (QPSK)

## 14. What are the main functions of multiplexing and switching nodes in the networks?

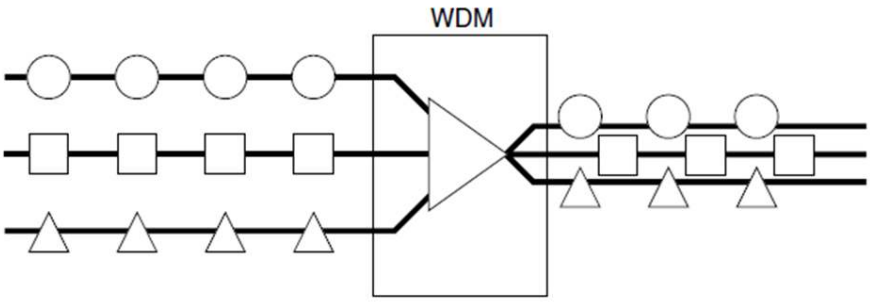
- To reduce transmission costs
- To utilize higher bandwidth
- "Framing" and "packing" of information
- TDM - Time Division Multiplexing
- FDM - Frequency Division Multiplexing
- CDMA - Code Division Multiple Access
- WDM - Wavelength Division Multiplexing

The Time Division Multiplexing concept

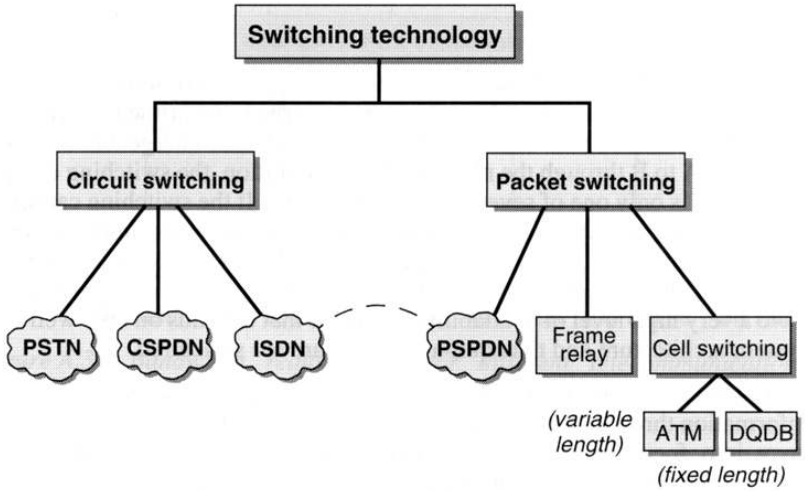



20. ábra. TDM

Wavelength Division Multiplexing Frequency Division Multiple Access principles
Switching techniques in public networks




21. ábra. WDM




22. ábra. Switching technology

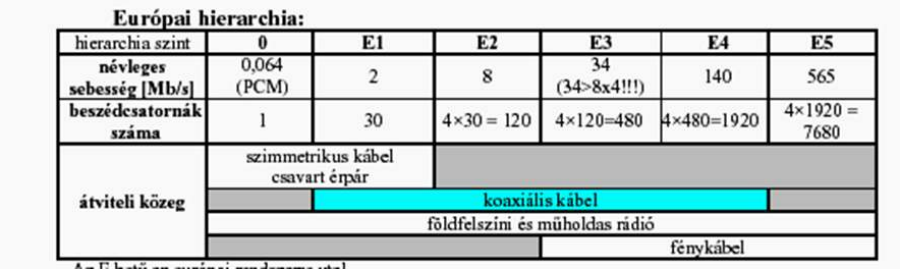
## 15. What are the main elements and characteristics of PDH systems?

The plesiochronous digital hierarchy (PDH) is a technology used in telecommunications networks to transport large quantities of data over digital transport equipment such as fibre optic and microwave radio systems.
**PDH hierarchy:**

- different in Japan, United States, Europe
- levels:
  - E1: 2 Mbit/s
  - E2: 8 Mbit/s
  - E3: 34 Mbit/s
  - E4: 140 Mbit/s
  - E5: 565 Mbit/s

**PCM (Pulse Code Modulation): 125$\mu$s frames**

- European PCM Frame: 32 time slots * 8 bits * 8000 = 2048 kbit/s
- American PCM Frame: (24 time slots * 8 bits + 1 bit) * 8000 = 1544 kbit/s



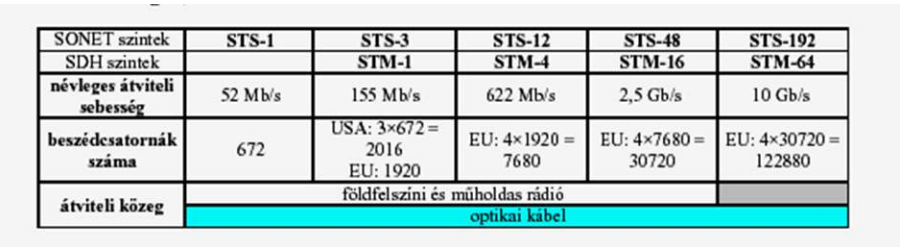
**Európai hierarchia:**

| hierarchia szint | 0 | E1 | E2 | E3 | E4 | E5 |
|---|---|---|---|---|---|---|
| **névleges sebesség [Mb/s]** | 0,064 (PCM) | 2 | 8 | 34 (34>8x4!!!) | 140 | 565 |
| **beszédcsatornák száma** | 1 | 30 | 4×30 = 120 | 4×120=480 | 4×480=1920 | 4×1920 = 7680 |
| **átviteli közeg** | szimmetrikus kábel csavart érpár | | | | | |
| | | koaxiális kábel | | | | |
| | földfelszíni és műholdas rádió | | | | | |
| | | | | fénykábel | | |

23. ábra. PDH Europe hierarchy

# 16. What are the main elements and characteristics of SDH systems?

- SDH – Synchronous Digital Hierarchy
- VC – Virtual Container (multiplexing level)
- STM-N Synchronous Transport Modules (line signal level)
- POH – path overhead (control and supervisory information)
- POH+Payload=VC
- A number of VCs can packaged into a larger VC



| SONET szintek | STS-1 | STS-3 | STS-12 | STS-48 | STS-192 |
|---|---|---|---|---|---|
| SDH szintek | | STM-1 | STM-4 | STM-16 | STM-64 |
| **névleges átviteli sebesség** | 52 Mb/s | 155 Mb/s | 622 Mb/s | 2,5 Gb/s | 10 Gb/s |
| **beszédcsatornák száma** | 672 | USA: 3×672 = 2016 EU: 1920 | EU: 4×1920 = 7680 | EU: 4×7680 = 30720 | EU: 4×30720 = 122880 |
| **átviteli közeg** | földfelszíni és műholdas rádió | | | | |
| | optikai kábel | | | | |

24. ábra. SDH Europe hierarchy

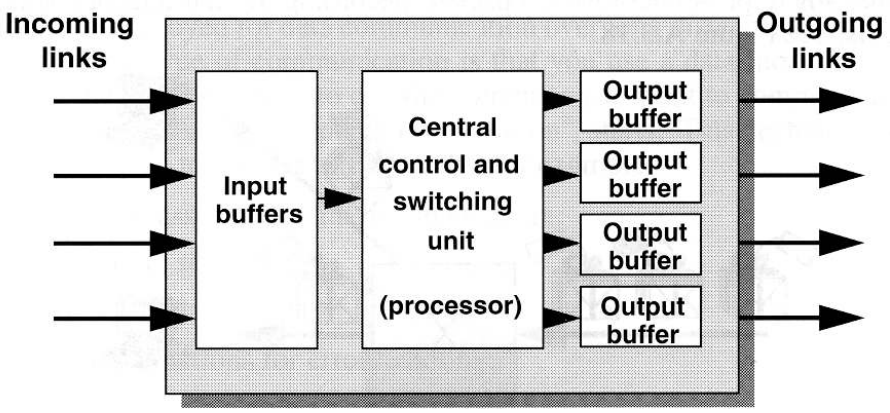
Transport modules

- RSOH - Regenerate Section Overhead
- MSOH - Multiplexer Section
- AU Pointer – Administrative Unit Pointer (specifies where the payload starts)
- Duration of STM-1 module is 125 $\mu$s

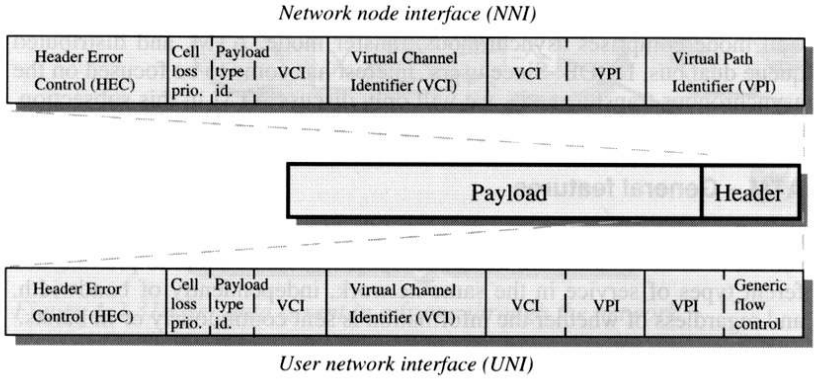
# 17. What are the main elements and characteristics of ATM systems?

**ATM:** Asynchronous Transfer Mode (ATM) is, according to the ATM Forum, "a telecommunications concept defined by ANSI and ITU (formerly CCITT) standards for carriage of a complete range of user traffic, including voice, data, and video signals".

- ATM cell switching principle




25. ábra. ATM packet node structure

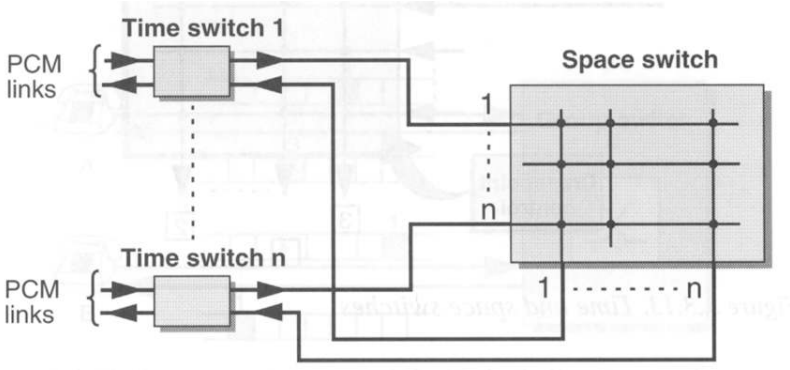



26. ábra. header

- Fixed cell (packet) length - 53 bytes
- 5 octets header, 48 octet payload

A **Virtual Channel (VC)** denotes the transport of ATM cells which have the same unique identifier, called the Virtual Channel Identifier (VCI). This identifier is encoded in the cell header.
A **Virtual Path (VP)** denotes the transport of ATM cells belonging to virtual channels which share a common identifier, called the Virtual Path Identifier (VPI), which is also encoded in the cell header. A virtual path, in other words, is a grouping of virtual channels which connect the same end-points. This two layer approach results in improved network performance. Once a virtual path is set up, the addition/removal of virtual channels is straightforward

## 18. What are the elements of time and space switches?

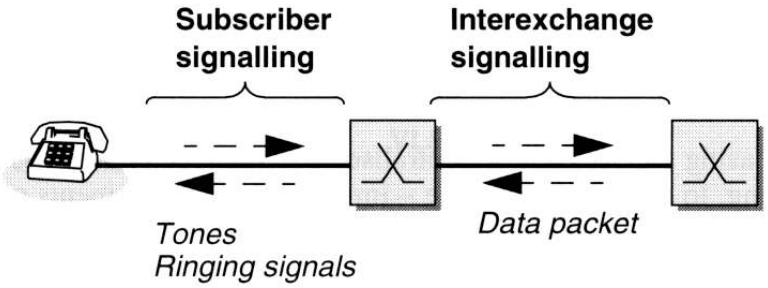



27. ábra. The principle of TST switching

**Group Switch:** interconnects incoming and outgoing time slots.
**TSP Switch:** Time switches (n) + space switch ($n \times n$ matrix)

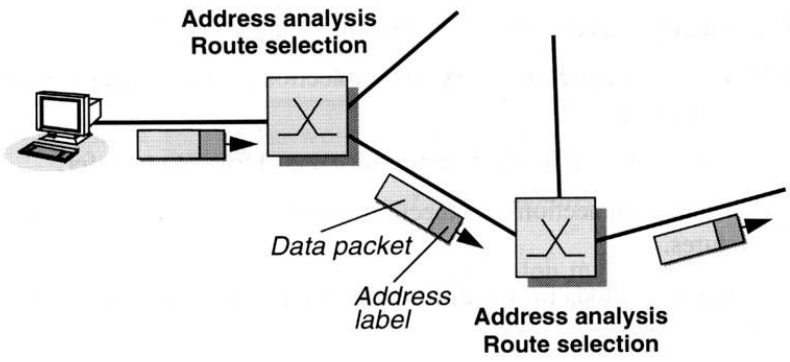
## 19. What are the main features of circuit switching, packet switching and cell switching?

**Circuit switching:** Circuit switching is a methodology of implementing a telecommunications network in which two network nodes establish a dedicated communications channel (circuit) through the network before the nodes may communicate. The circuit guarantees the full bandwidth of the channel and remains connected for the duration of the communication session. The circuit functions as if the nodes were physically connected as with an electrical circuit.



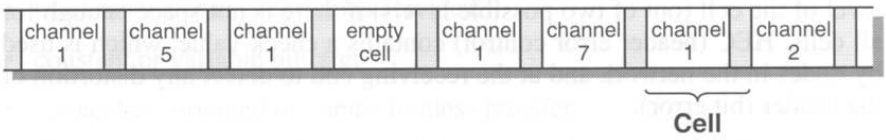

28. ábra. Signalling principles in circuit switching

**Packet switching:** Packet switching is a digital networking communications method that groups all transmitted data into suitably sized blocks, called packets, which are transmitted via a medium that may be shared by multiple simultaneous communication sessions. Packet switching increases network efficiency, robustness and enables technological convergence of many applications operating on the same network.



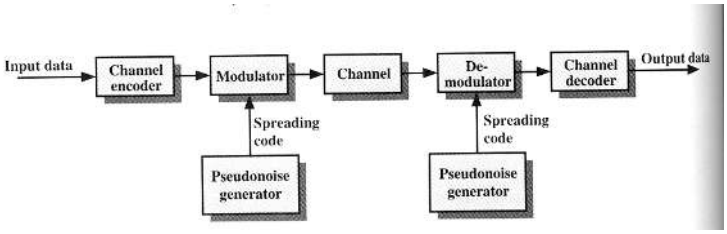

29. ábra. Signalling in packet switched networks

**Cell switching:**

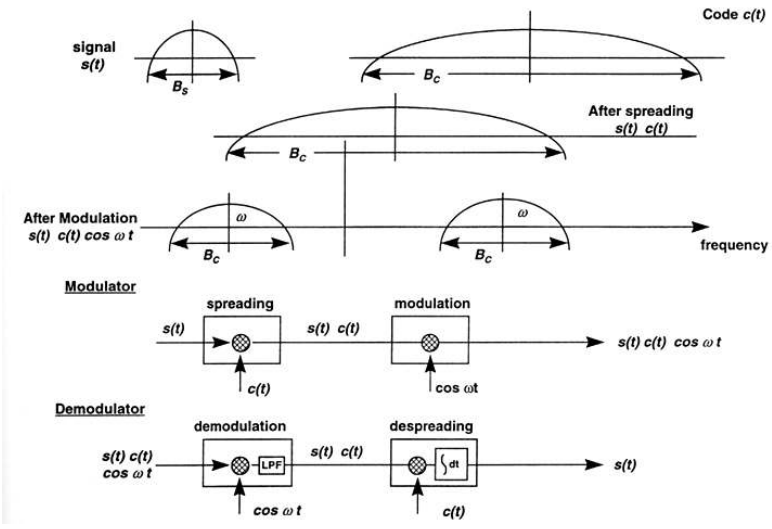



30. ábra. Cell switching

# 20. Spread spectrum, FHSS, DSSS



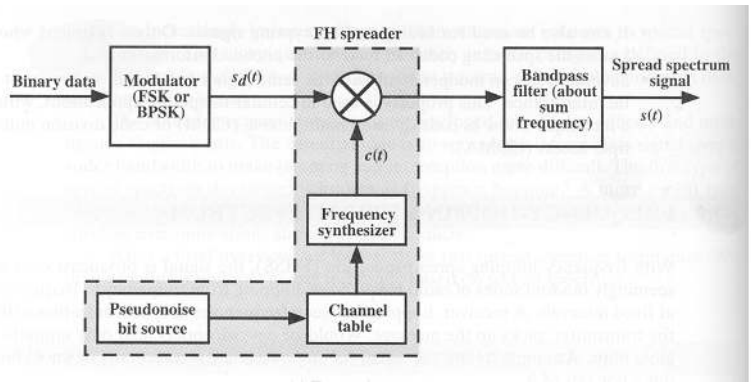

31. ábra. General Model of Spread Spectrum Digital Communication System



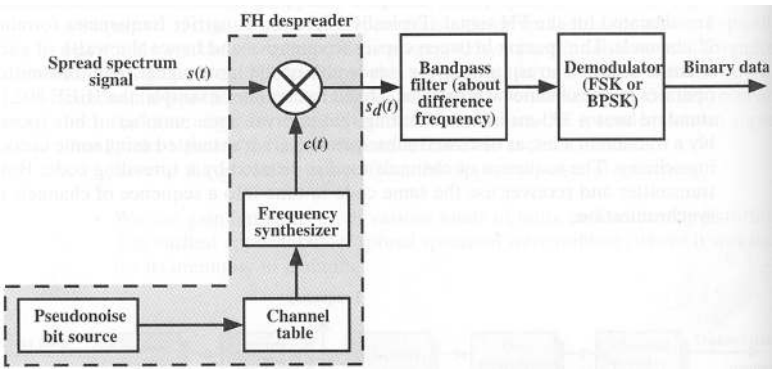

32. ábra. The Spread Spectrum Concept

## FHSS

- A number of channels are allocated for FH
- The transmitter operates in one channel at a time for fixed time interval (Tc)
- During that interval, some number of bits or a fraction of a bit are transmitted (signal elements)
- The time interval of signal elements Ts
- The sequence of the channels used is dictated by spreading code
- Both transmitter and receiver use the same code to tune into a sequence of channels in synchronisation

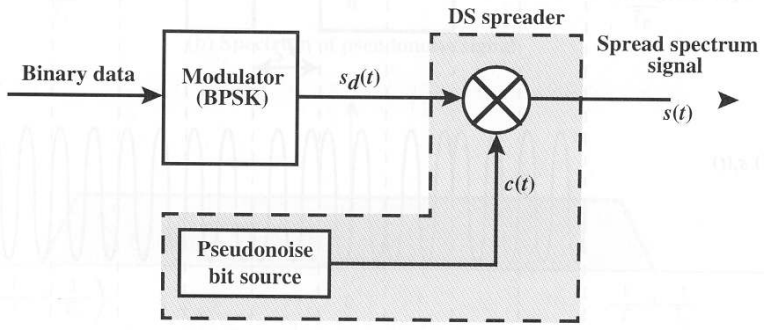



33. ábra. Transmitter of the FHSS System




34. ábra. Receiver of the FHSS System

### DSSS

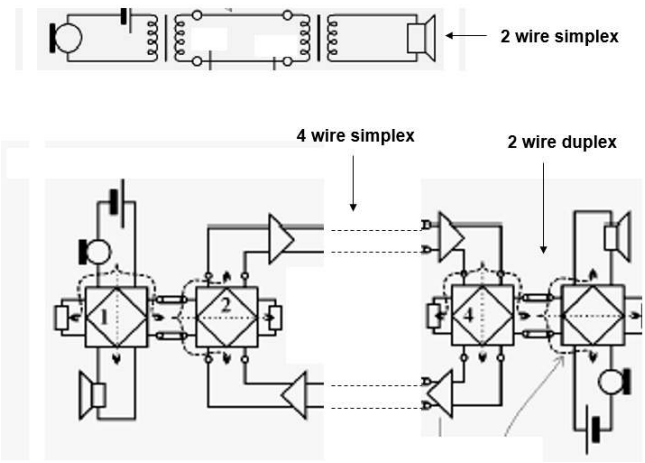



35. ábra. DSSS system Transmitter

## 21. What are features of 2 wire and 4 wire connections?

### Basics of telephony

- 2/4 wire for voice
- Feeding of circuit
- Access solutions
- Backbone
- Signalling basics for a telephone call
- Source of revenues
- ADSL principles

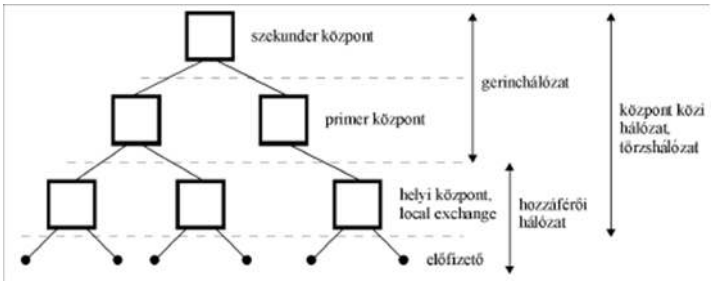



36. ábra. 2/4 wire for voice

## 22. What is the network structure of the MATÁV network?

- International exchange (2 gateways)
- Secondary exchange (backbone network, inter. exchange network)
- Primary exchange (backbone network, inter. exchange network)
- Local exchange (access network, inter. exchange network)
- Subscriber (access network)
- Secondary level: optical, meshed topology.

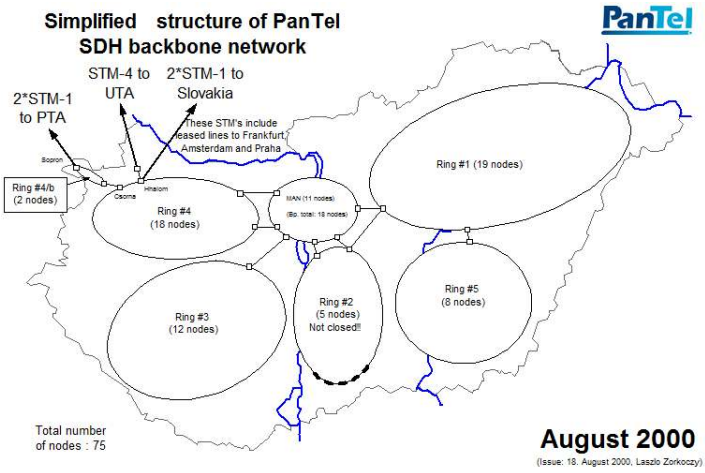
The primary level is divided into 8 logical rings, each one connected with at least 2 secondary level nodes. The network has 52 primary areas, 2-3 / county, not crossing county borders. Budapest's network is divided into 5 logical rings.




37. ábra. Telephone network structure of MATAV

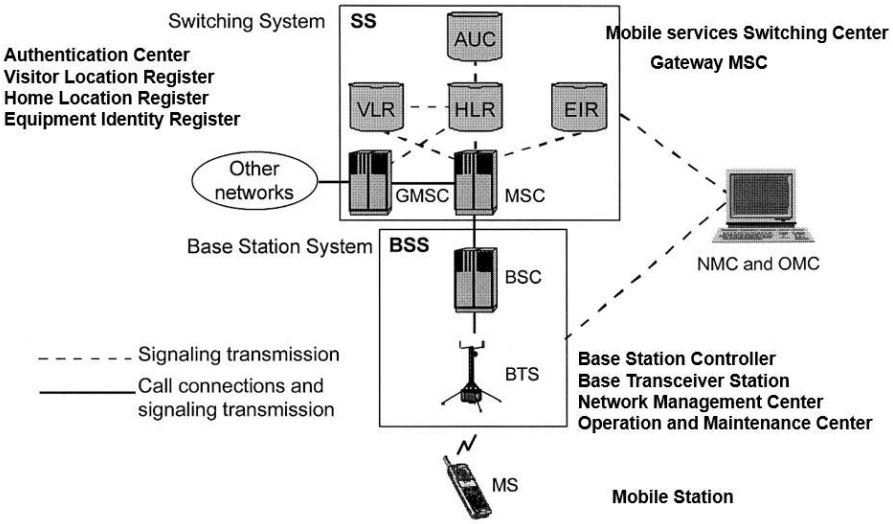
## 23. What is the network structure of the PANTEL network?

Pantel network nodes and interconnections (optical air cables) follow the railway. MÁV is a shareholder in it. This backbone network is divided into 5 main SDH rings.




38. ábra. Pantel logical SDH rings

## 24. What are the main components of a GSM network?




39. ábra. GSM network components

## 25. What are the operating statuses of a MS?

### Mobil station

- Used by mobile subscriber to communicate with the network
- Consist of mobile terminal and Subscriber Identity Module (SIM)
- Subscription is separated from the mobile terminal
- Subscription information is stored in a „smart card”
- Hand-held MS, Car-installed MS

## MS states

- Idle: the MS is ON but a call is not in progress
- Active: The MS is ON and a call is in progress
- Detached: The MS is OFF

#### Idle key terms

- Registration: MS informs a network that it is attached
- Roaming: MS moves around the network in idle mode
- International Roaming: MS moves into a network which is not its home network
- Location Updating: MS inform the network when enters in new LA
- Locating: BSC function to suggest connection to another cell based on MS measurement reports
- Paging: The network tries to contact an MS by broadcasting message containing MS identity

#### Active key terms

- Handover: Process, where a call is switched from one physical channel to another, while MS moves around

## MS registration

- MS power ON
- MS scans for control channel frequencies
- MS measures signal levels and records it
- MS tunes to the strongest frequency
- MS register to the network
- Network update the MS status to idle
- Network store location information

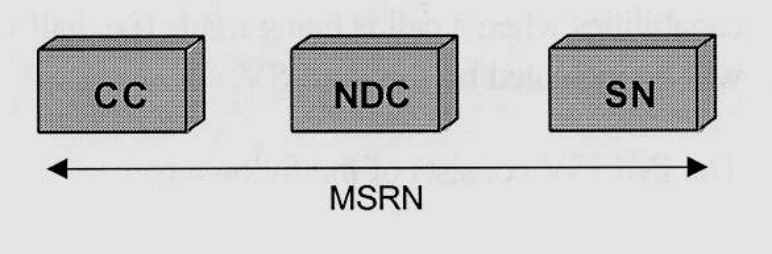
## MS roaming

The idle MS moves thorough the network, scan the control channels, tune to the strongest channel, in new LA inform the network of its new location.

# 26. What are the actions of the network during roaming and handover?

## Mobile Station Roaming Number (MSRN)

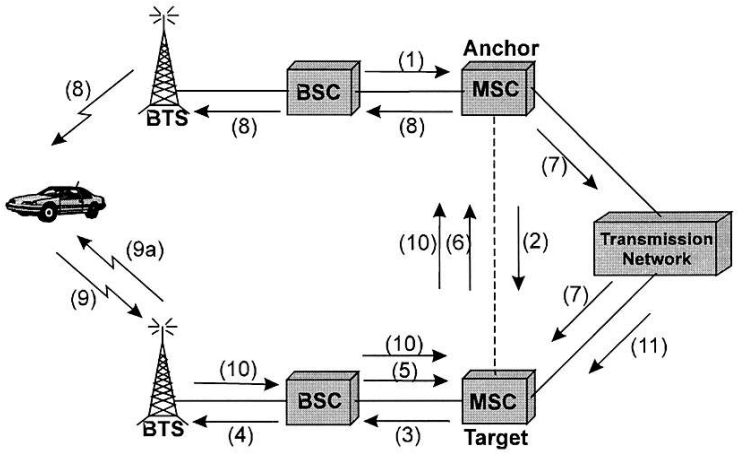
- CC Country Code (36 for Hungary)
- NDC National Destination Code (20 for Telenor)
- SN service Node




40. ábra. Mobile Station Roaming Number (MSRN)

## Basic Handover

- BSC send handover-required message to the MSC
- The MSC ask the target MSC to assist. The Target MSC allocates a handover number that reroutes the call
- A handover request is sent down to the new BSC
- The BSC tells the new BTS to activate a TCH
- The MSC receives the information about the new Traffic CHannel
- The MSC passes info on new TCH from new BSC
- A speech path to the new MSC is set up
- A handover command goes to the MS with frequency and time slot data in the new cell
- The MS sends handover burst on the new TCH
- The target MSC is informed that the handover successful
- A new path in the Group Switch is set up




41. ábra. Basic Handover

## 27. What are the functions of HLR and VLR in the GSM network?

### Home Location Register (HLR):

Centralized network database for

- Subscriber identity
- Subscriber supplementary services
- Subscriber location information
- Subscriber authentication information

### Visitor Location Register (VLR):

Information about subscribers located in an MSC service area (a copy of HLR information)

## 28. What are the functions of MSC and BSC in the GSM network?

### Station Controller (BSC):

- Manages all the radio related functions of the network
- MS handover
- Radio channel assignment
- Collection of cell configuration data
- Controlled by MSC

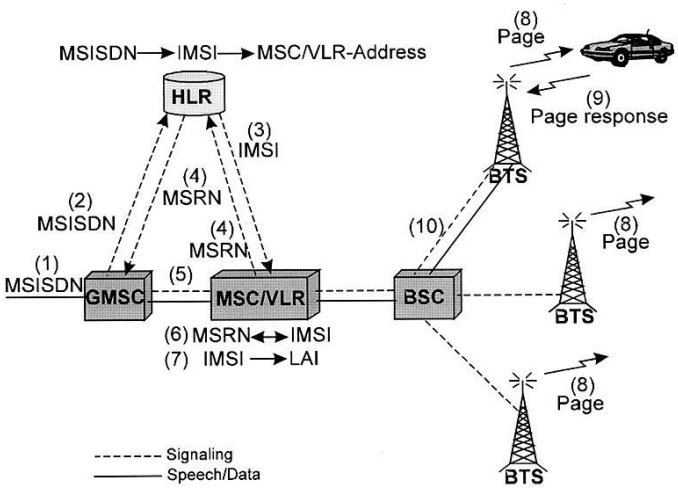
### Mobile Switching Center:

- Billing
- Delivers SMSs from subscribers to SMSC
- Arranges handovers
- supplementary services
- Controls BSC

## 29. What are the steps to call MS?

1. Call entering to GSM network is routed to the nearest GMSC
2. The GSM analyse the MSISDN to find the HLR (subscriber registered in) The MSC/VLR address is stored in HLR, the IMSI is stored in HLR
3. The HLR send request to an MSRN to the MSC/VLR included in the message the IMSI
4. The MSRN is returned via HLR to the GMSC
5. The GMSC routes the call to the MSC/VLR by MSRN
6. The MSC/VLR retrieve the Ms's IMSI
7. Using IMSI MSC identifies LA
8. The MS is paged in cells in the LA

9. MS responds, authentication, cipher mode setting, IMEI check are carried out
10. Traffic channel connected from MSC to BSC and the BTS




42. ábra. Call to an MS

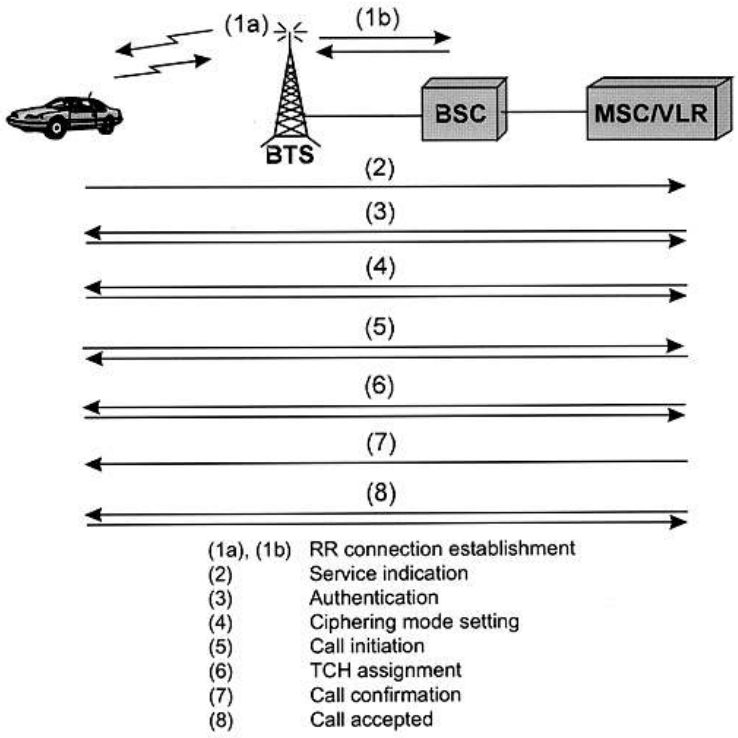
## 30. What are the steps call from MS?

1. Call start with a signalling channel using RACH (Random Access Channel)
2. MS indicates request, IMSI is analyzed, MS marked busy in The VLR
3. Authentication is performed by MSC
4. Ciphering is initiated, IMEI validated
5. MSC receives a setup message from MS (including B number)
6. Link established between MSC and BSC to assign traffic channel
7. Call confirmation
8. Call accepted

## 31. Which services are supported in GSM system and how?

### GSM specification items

- Voice oriented services
- Separation of terminal and subscription
- Europe-wide international roaming
- Low bit-rate speech coding
- High bandwidth utilisation
- Low power consumption in inactive mode




43. ábra. Call from MS

- Standards for system concept and air interface
- No direct call number information on air interface
- Encrypted speech coding on air interface
- Authentication process
- Handover up to 200km/h (car-phone or hand-held in train)
- Outdoor and indoor coverage

## 32. What is the function of a private network?

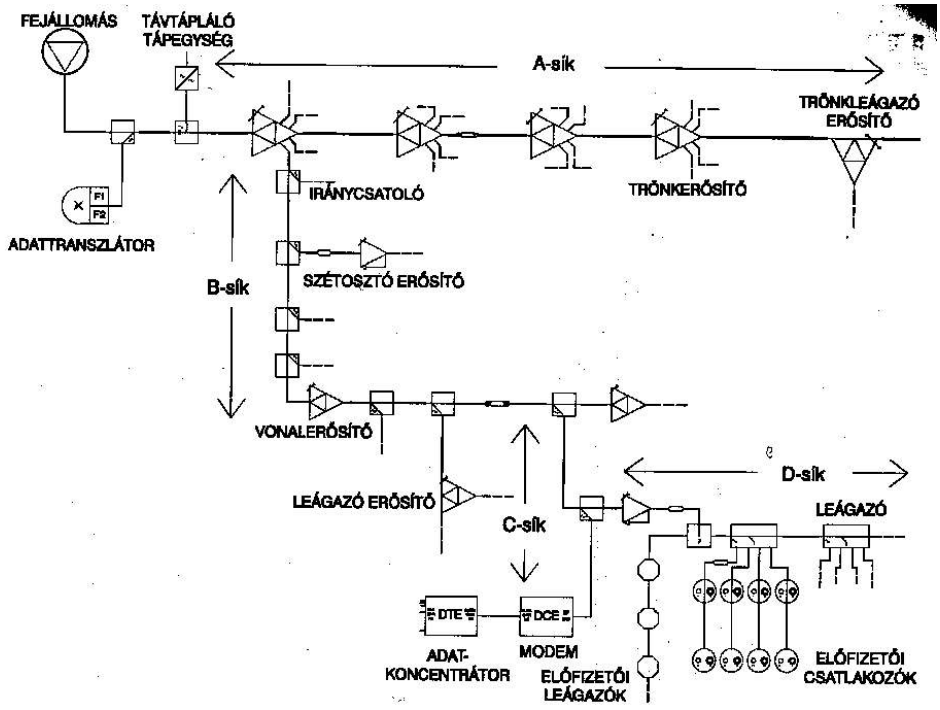
- Closed User Group, Special Purpose network
- Railway, transport, pipeline, fleet
- Water management
- Energy systems
- Emergency services
- Police networks
- Company-wide networks (MOL, OTP)
- Global Company Networks (Coca Cola)
- Internal numbering schemes, addressing system
- Strictly regulated gateway function for interconnection to other (public) networks

- The transmission part of networks might be leased line or own connection (radio)
- The multiplexing, switching, management, authentication processes are private functions
- Task oriented service quality parameters (reliability, usability, error rate, response time, redundancy, backup time . . . )
- Separated frequency management („governmental" use)

# 33. What are the function and structure of a CATV network?

## Main characteristics of CaTV systems

- Traditional AM VSB TV sets
- Set top boxes for receiving DVB programs (including demodulator, MPEG decoder and some sort of descramblers)
- Internal frequency plan with 8 MHz raster (free assignment of programs to 8 MHz channels)
- Low split system: from 5 MHz up to 55 (50, 68) MHz for the uplink path, from 70 (87) MHz up to 630 MHz for the analogue downlink path and 630-862MHz for digital downlink path
- 8 TV and 8 radio channel in one 8 MHz channel (in the digital channels)
- The nominal impedance at all connection points of CATV system is 75 ohms




44. ábra. CATV structure

Cable television is a system of providing television to consumers via radio frequency signals transmitted to televisions through fixed optical fibers or coaxial cables as opposed to the over-the-air method used in traditional television broadcasting (via radio waves) in which a television antenna is required. FM radio programming, high-speed Internet, telephony and similar non television services may also be provided.

**Topologies**

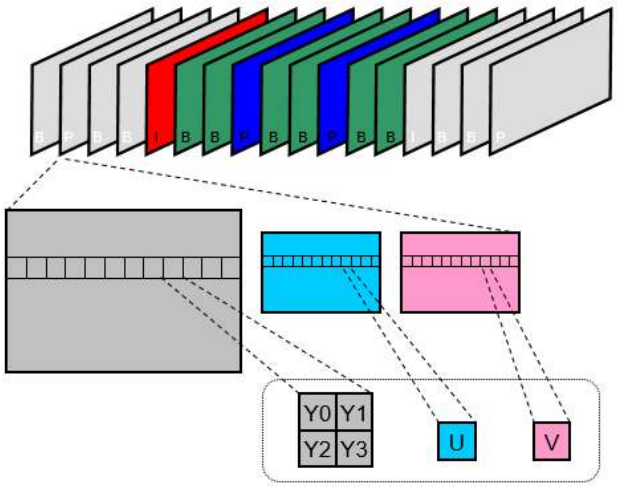
- string
- tap-off
- star

# 34. MPEG-2 principles

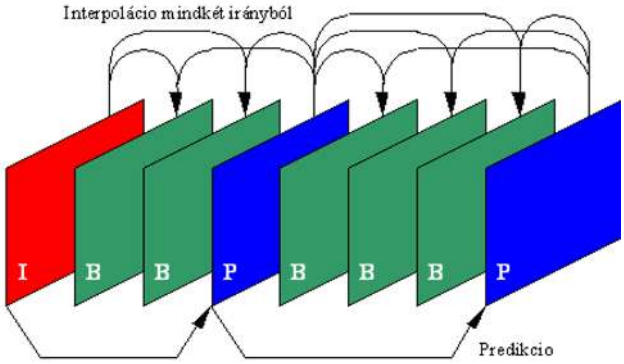
- Intra-coding relies on two characteristics of typical images. First, not all spatial frequencies are simultaneously present, and second, the higher the spatial frequency, the lower the amplitude is likely to be. Intra-coding requires analysis of the spatial frequencies in an image.
- Inter-coding relies on finding similarities between successive pictures. The next picture can be created by sending only the picture differences. The shifting process is controlled by a pair of horizontal and vertical displacement values (collectively known as the motion vector) that is transmitted to the decoder. The motion vector transmission requires less data than sending the picture-difference data.

## Structure

- Hierarchikus
- Szekvencia
- Képcsoport
- Kép
- Szelet
- Makroblokk
- Blokk



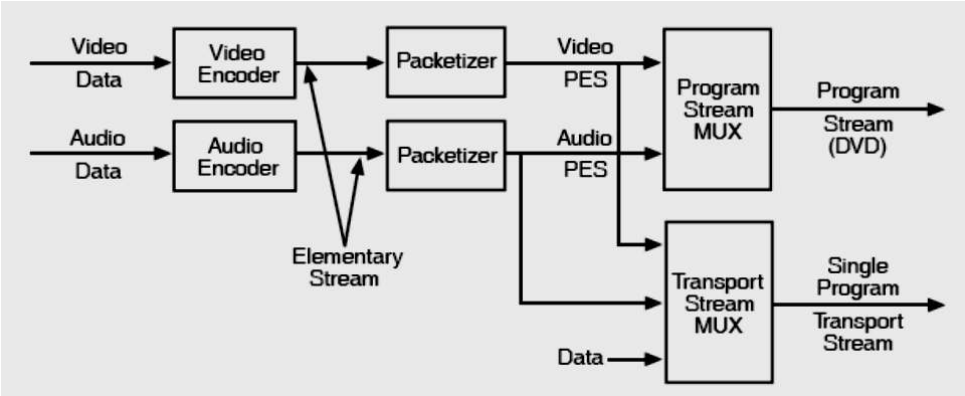

45. ábra. MPEG2 structure




46. ábra. MPEG2 structure

## 35. What is the MPEG stream and transport stream?

An elementary stream is an endless near real-time signal. Program streams have variable-length packets with headers. In a transport stream the PES packets are further subdivided into short fixed-size packets and multiple programs can be carried in the same stream.




47. ábra. MPEG2 streams

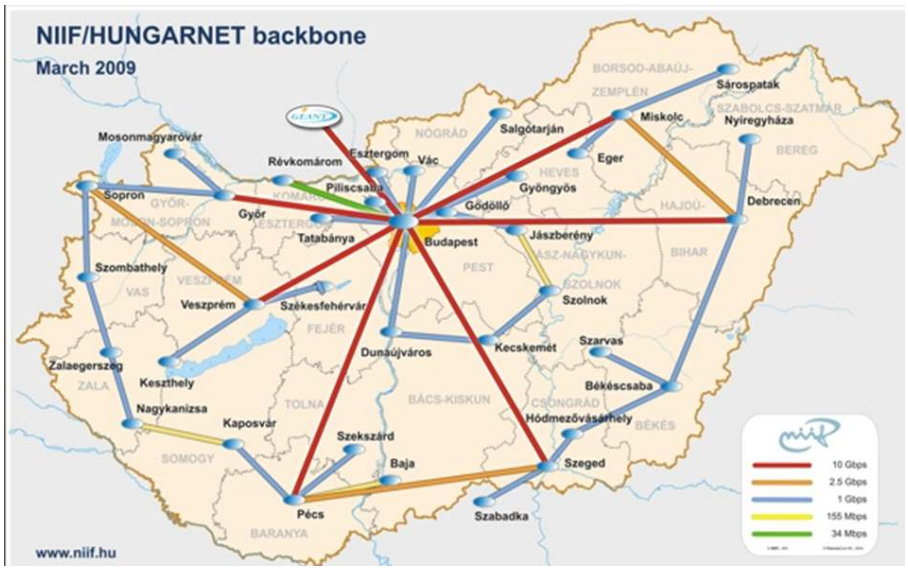
## 36. What is the structure of the HUNGARNET network? Why?

- NIIF üzemeltetésében
- Élenjáró technológiák pl: IPv6
- 40 Gbps elsőként a régióban
- Hibrid hálózati infrastruktúra
- IP/MPLS réteg - a szokásos komplexebb hálózati igények kiszolgálására
- DWDM réteg - a nagy és/vagy speciélis hálózati igények kiszolgálására

## 37. Which technologies and structures are applied in the networks of ITK building?

### Alapszolgáltatások

Az NIIF a tagintézmények által képzett zárt felhasználói kör számára az alábbi alapszolgátatásokat nyújtja:




48. ábra. NIIF/HUNGARNET backbone

- Internet hozzáférés
  - HBONE
  - ADSL
  - Behívás
- Regisztrációs szolgáltatás
  - Név regisztrációs szolgáltatás
  - IP cím allokáció
- Elektronikus levelezés
- Web hosting
- Felhasználói weblap
- Egyéb (ftp, news, idő)

## Planning principles

- 1000 computers and 100 telephone in the networks
- Fast, error free and reliable operation
- Ready system for any new technologies
- Popular test bed for system suppliers
- No disturbing in outlook

## Consequences

- Robust, multi-path external connections, meshed topology, load sharing operation
- Copper, optical, radio technologies in internal and external links
- Over dimensioned and accessible duct system

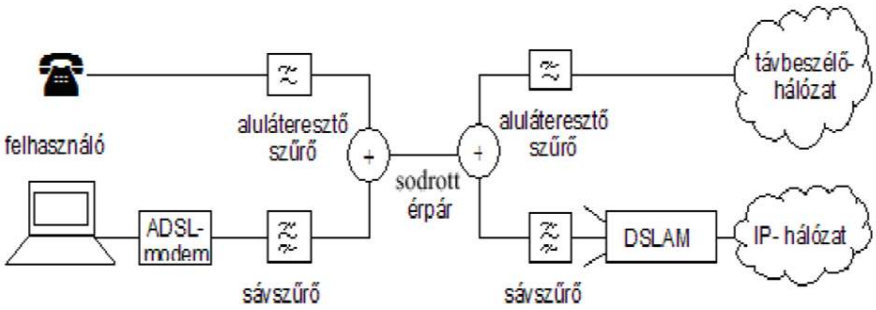
# 38. Principles of ADSL, Technology of ADSL, features of ADSL, VDSL.

## ADSL principles

- Asymmetric Digital Subscriber line
- A modem technology
- Convert existing twisted-pair telephone lines into access paths for multimedia and high speed data communication
- Can transmit to 30 Mbps downstream (VDSL 100 Mbps)
- Can transmit up to 20 Mbps upstream
- Transform the existing PSTN network to a powerful system capable of bringing multimedia, full motion video to the subscriber's home

### Technology

- No ultimate technology!
- Frequency division multiplexing, time division multiplexing, modulation, error control, flow control, scrambling, signal processing, adaptation, STM-ATM, trellis coding, in-service performance monitoring and surveillance, initialisation, handshaking, channel analysis, are all mixed in ADSL
- More room for further development...




49. ábra. ADSL system components

## VDSL

Very-high-bit-rate digital subscriber line (VDSL or VHDSL) is a digital subscriber line (DSL) technology providing data transmission faster than asymmetric digital subscriber line (ADSL) over a single flat untwisted or twisted pair of copper wires (up to 52 Mbit/s downstream and 16 Mbit/s upstream), and on coaxial cable (up to 85 Mbit/s down- and upstream) using the frequency band from 25 kHz to 12 MHz. These rates mean that VDSL is capable of supporting applications such as high-definition television, as well as telephone services (voice over IP) and general Internet access, over a single connection. VDSL is deployed over existing wiring used for analog telephone service and lower-speed DSL connections. This standard was approved by ITU in November 2001.

## 39. What are the basic services, supplementary services?

Teleservices from provider point of view:

- Basic services (mandatory service elements with minimal quality requirements e.g. real time, understandable...)
- Supplementary services (to make basic services even more usable, e.g. call transfer, conference call, automatic call back on busy, wake up services, least cost routing services, credit card based call...
- Value added services (e.g. bank transaction by phone, televoting, telephone based donation...)

## 40. What is the main difference in between electronic communication activity and electronic communication service provision?

**Electronic communication activity:** transmission of messages in the form of electronic signals.
**Electronic communication service:** activity or other entity for free (service, facility, feature).

## 41. What are the main service quality requirements in different services?

Network and terminal requirements:

- Voice, music, video
  - sensitive on delay (max. 300 ms)
  - sensitive on jitter (max 30 ms)
  - sensitive on video/voice synchrony (lip-sync)
  - error tolerant, (bit error rate 10-3 acceptable!!!)
- Games
  - sensitive on delay (max. 10 ms)
  - sensitive on error
- Data, still picture
  - sensitive on error (BER min. 10-6 , error control)
  - delay and jitter tolerant (www=world wide waiting)

## 42. What are the main service classes in electronic communications?

Teleservices from user point of view:

- Interactive services (telephone, videoconference...)
- Messaging services (voice mail, e-mail...)
- Retrieval services (account balance retrieval, time table...)
- Distribution services ( cable TV, personalized news by fax...)

## 43. What are the historical stages of regulation? What is the reason of competition instead of monopoly in electronic communication?

Az elektronikus hírközlés szabályozásának korszakai

- Természetes (állami) monopólium (hatósági ár, ellátási kötelezettség, végberendezések, egységes rendszer - kevés szabályoznivaló)
- Posta, távközlés, műsorszórás, hatósági területek szétválasztása
- Magánkézbe adás, koncessziós működés a kizárólagosság – ellátási kötelezettség megtartásával és fejlesztési kötelezettséggel
- Korlátozott verseny, új piacralépők segítése a „kimazsolázás" lehetőségével, jelentős piaci erővel rendelkezők kötelezettségeivel (RIO-RUO) , eszközpiac liberalizálása (rengeteg szabályoznivaló)
- Kiegyenlített, piaci viszonyok által áthatott működés (kevés szabályoznivaló)

## 44. What are the scope, objective, and main principles of the electronic communications act?

....establishment of a reliable, transparent regulatory framework that facilitates the development of the electronic communications infrastructure... services and new technologies related to it, enhancing competition regardless of the technology applied

## 45. What kind of licenses are necessary to provide electronic communication services, construct electronic communication facilities, distribute electronic communication equipment?

Numbering and addressing (identifiers)

- Identifiers may only be used subject to assignment licenses
- Except: Internet Protocol (IP) and electronic mail addresses as well as domain names

## 46. Which kind of obligations are present in the electronic communication act to promote competition?

Promoting issues of competition

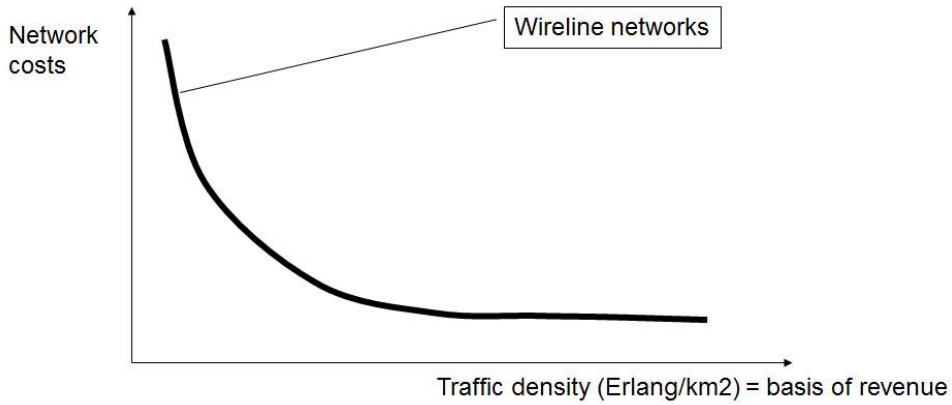
- Carrier selection
- Unbundling of local loop
- Number portability

## 47. What kind limited resources are regulated in the electronic communication act? Why and how?

electronic communications service

means a service normally provided for remuneration which consists wholly or mainly in the conveyance of signals on electronic communications networks, including telecommunications services and transmission services

in networks used for broadcasting, but exclude services providing, or exercising editorial control over, content transmitted using electronic communications networks and services; it does not include information society services, as defined in Article 1 of Directive 98/34/EC, which do not consist wholly or mainly in the conveyance of signals on electronic communications networks;




50. ábra. Market failure of electronic communication services = need for regulation

- Szakpolitikai terület: Információs társadalom
- Stratégiák (Európa2020), cselekvési tervek (Digital Agenda)
- Feltárt problémák:
  - Szétdarabolt digitális piacok
  - Együttműködési (interoperability) problémák
  - Növekvő internetes bűnözés (cybercrime), bizalmatlanság a hálózatokkal kapcsolatban
  - Csökkenő befektetési kedv a hálózatoknál
  - Elégtelen kutatás és innováció
  - Digitális írástudatlanság és nem elegendő szaktudás
  - Kevés lehetőség a társadalmi problémák ilyen megközelítésű megoldására EU cselekvések
- Cél volt az elektronikus kommunikációs szektor liberalizációja és a verseny élénkítése. Ennek jogi alapját adta a 2002-ben elfogadott öt direktíva: 'Framework' 'Access', 'Authorisation', 'Universal Service', 'Privacy'. Ezt ültette a magyar jogrendbe a 2003. évi C. törvény
- 2009-ben a Bizottság felülvizsgálta a direktívákat és létrehozta az Európai Elektronikus Hírközlési Szabályozók Testületét (BEREC) és Hivatalát. A módosított direktívák tartalmát tette át a magyar jogrendszerbe a 2011. évi CVII. Törvény

## 48. What are the main functions of a terminal?

Terminals:

- Terminals are parts of the networks but individual elements
- No terminals = No electronic communications
- Terminals are commerced in normal shops and supermarkets and they are owned by users

**Eg. Telephone:**

- Basic technical functions and requirements

- Handset requirements
- Hands free terminal requirements
- Keyboard requirements
- Display requirements
- Intelligence in the terminal
- Special requirements of elderly or handicapped people

### Main function

- **B** (battery supply)
- **O** (overload protection)
- **R** (ringing)
- **S** (supervision, signalling)
- **C** (coding)
- **H** (hybrid, 2/4 wire transformation)
- **T** (testing)

## 49. Bluetooth, ZigBee

### WPAN (Wireless Personal Access Network, Rádiós személyi hozzáférési hálózat)

- Személyi eszközök közötti rövidtávú átviteli összeköttetés
- Jellegzetes átviteli távolság: 10 m vagy kisebb
- Jellegzetes szabvány: IEEE 802.15
- Jellegzetes megoldás: Bluetooth, ZigBee

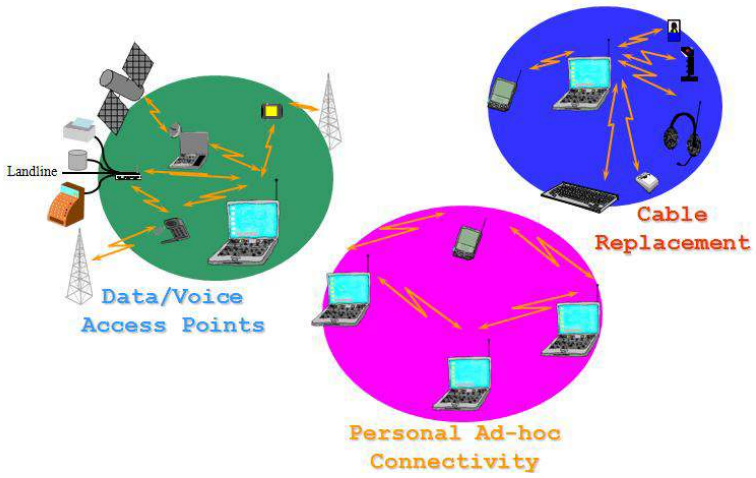
**Usage scenarios:**

- Headset
- Synchronization
- Data access points

**What does Bluetooth do for me?**

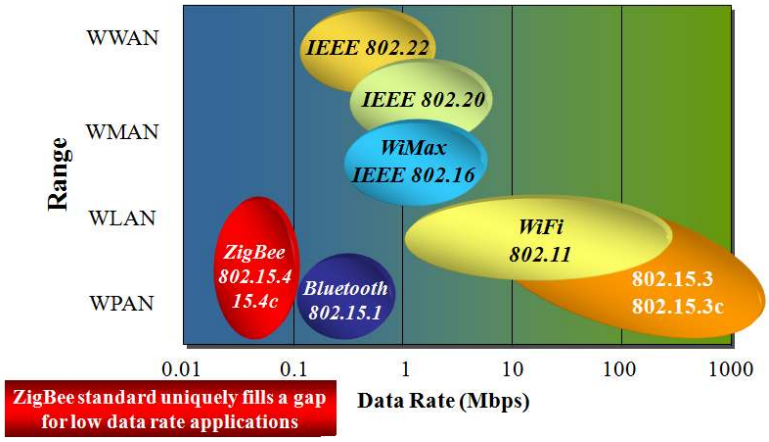
### Bluetooth characteristics

- Operates in the 2.4 GHz band at a data rate of 720Kb/s
- Uses Frequency Hopping (FH) spread spectrum, which divides the frequency band into a number of channels (2.402 - 2.480 GHz yielding 79 channels)
- Radio transceivers hop from one channel to another in a pseudo-random fashion, determined by the master
- Supports up to 8 devices in a piconet (1 master and 7 slaves)
- Piconets can combine to form scatternets
- Piconet:




51. ábra.

  - A collection of devices connected in an adhoc fashion.
  - One unit will act as a master and the others as slaves for the duration of the piconet connection.
- Scatternet
  - The linking of multiple co-located piconets through the sharing of common master or slave devices



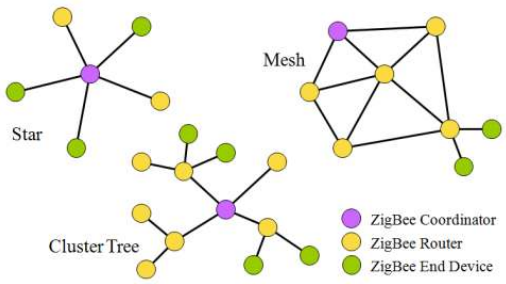

52. ábra. The IEEE 802 Wireless Space

## ZigBee Alliance Owerview

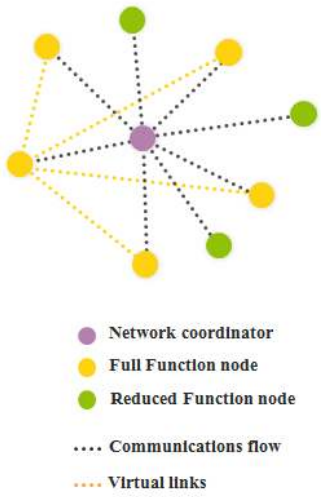
- Organized as an independent, neutral, nonprofit corporation in 2002
- Open and global
  - Anyone can join and participate
  - Membership is global
- Activity includes
  - Specification creation
  - Certification and compliance programs

  - Branding, market development, and user education

- Characteristics:
  - 65,536 network (client) nodes
  - 27 channels over 2 bands
  - 250Kbps data rate
  - Optimized for timing-critical applications and power management
    * Full Mesh Networking Support

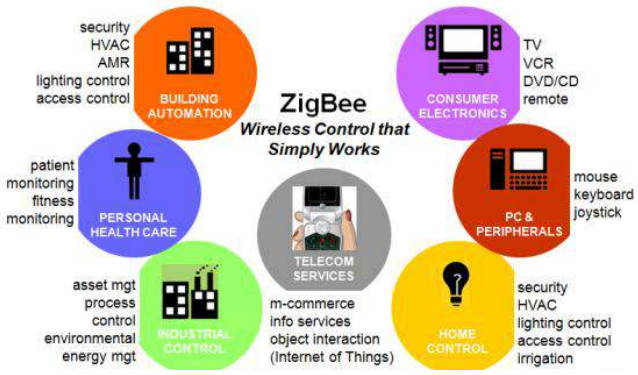



53. ábra. Cluster Tree




54. ábra.

**Applications of ZigBee**



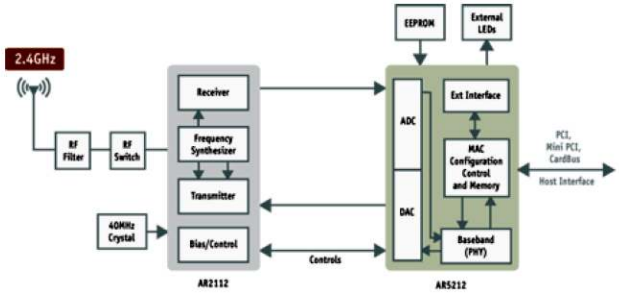

55. ábra.

# 50. WiFi principles, media access control

**RLAN (Radio LAN, Rádiós helyi hálózat más néven WLAN)**

- LAN rendszer rádiós megoldása
- Jellegzetes átviteli távolság: 150 m vagy kisebb

WiFi (Wireless Fidelity) – Olyan RLAN kereskedelmi neve, ami az IEEE 802.11 szabványnak felel meg és a 2,4 GHz-es sávban (2400 – 2483,5 MHz) működik.



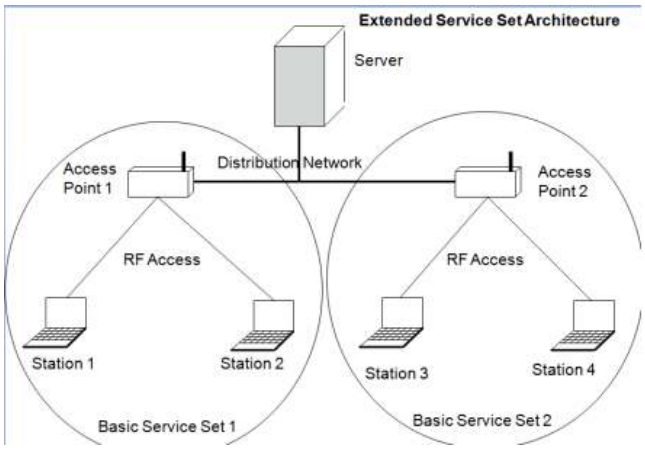

56. ábra.

**The 802.11 Architecture**

- User Stations (laptop PCs and PDAs)
- Access Points (APs)
- Backbone Network (Distribution System, DS)
- The User Stations competing for access over a shared medium is termed the Basic Service Set (BSS)
- Two or more of these BSSs are interconnected by a DS network
- The complete set of BSSs and the interconnecting network are termed an extended service set (ESS)

**Media Access Control (MAC)**

- MAC is mandatory for all stations




57. ábra.

- MAC is to assemble data into a frame including local address and error detection field
- MAC checks the frame address, perform error correction on the frame, disassemble the frame and passes it to the Logical Link Control
- The LLC identifies higher layer programs to handle the data and provides and interface to these higher-layer programs while perform flow and error control

## 51. Wireless Home Gateway principles

A home wireless gateway connects a home network to a larger network, or directly to the Internet. The gateway can refer to the actual devices used to connect the networks or to the software component of those same devices. As technology merges more networking devices into single components, home wireless gateway has become an uncommon term. It is more likely called wireless modem or wireless router, depending on its other functions.

## 52. VoIP principles and versions

**Voice over Internet Protocol (VoIP):** voice traffic carried wholly or partly using IP over broadband networks competing with incumbent operators. VoIP is an acronym for Voice Over Internet Protocol, or in more common terms phone service over the Internet. If you have a reasonable quality Internet connection you can get phone service delivered through your Internet connection instead of from your local phone company. VoIP $\neq$ Skype!!

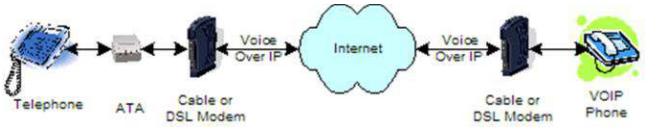
**Key Issues:**

- SIP - Session Initiation Protocol
- Voice CODEC
- Packet Loss Control

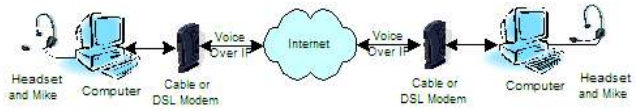
**Versions:**

- Cordless Hard Phones
- Dialup Hard Phones A dialup hard phone is a hard phone with a built-in modem instead of the Ethernet port
- WLAN or WiFi Phones A WLAN or WiFi phone is a hard phone with a built-in WiFi transceiver unit instead of an Ethernet port to connect to a WiFi base station and from there to a remote VoIP server
- Hard Phones (voice and video) Hard phones with video telephony support

- Soft Phones (voice only) A soft phone is an IP telephone in software. It can be installed on a personal computer and function as an IP phone. Soft phones require appropriate audio hardware to be present on the personal computer they run
- Soft Phones (voice and video)




58. ábra.




59. ábra.

## 53. VoIP codecs

Codecs are used to convert an analog voice signal to digitally encoded version. Codecs vary in the sound quality, the bandwidth required, the computational requirements, etc.

Each service, program, phone, gateway, etc typically supports several different codecs, and when talking to each other, negotiate which codec they will use.

**GIPS, GSM, ITU,SILK...**

- GIPS Family - 13.3 Kbps and up
- GSM - 13 Kbps (full rate), 20ms frame size
- iLBC - 15Kbps, 20ms frame size: 13.3 Kbps, 30ms frame size
- ITU G.711 - 64 Kbps, sample-based Also known as alaw/ulaw
- ITU G.722 - 48/56/64 Kbps ADPCM 7Khz audio bandwidth
- ITU G.722.1 - 24/32 Kbps 7Khz audio bandwidth (based on Polycom's SIREN codec)
- ITU G.722.1C - 32 Kbps, a Polycom extension, 14Khz audio bandwidth
- ITU G.722.2 - 6.6Kbps to 23.85Kbps. Also known as AMR-WB. CELP 7Khz audio bandwidth
- ITU G.723.1 - 5.3/6.3 Kbps, 30ms frame size
- ITU G.726 - 16/24/32/40 Kbps
- ITU G.728 - 16 Kbps
- ITU G.729 - 8 Kbps, 10ms frame size
- Speex - 2.15 to 44.2 Kbps
- LPC10 - 2.5 Kbps
- DoD CELP - 4.8 Kbps
- SILK