# Telecommunication Networks and Services

Access to IP networks through telecommunication and cableTV networks

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## Content

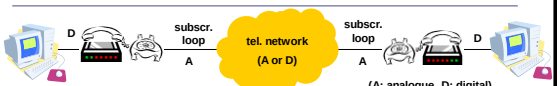




## Overview

- **Telephone line modems**
  - Acoustic modems
  - PSTN modems
  - ISDN modems
- ADSL, xDSL
- Internet access through cable TV

## Acoustic modems




(A: analogue, D: digital)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## Acoustic modems

- Connection establishment, release – by hand (dialling, putting the receiver down)
- 300 or 1200 bps (ITU-T V.21, V.22)
  - Interesting: They still can interwork with some PSTN modem types
- 1970s, early 1980s
- Main reason: no direct access to the network
  - forbidden, only the Post-owned equipments were legal
  - not only in Hungary, in Western Eu, USA
- Forgotten history...

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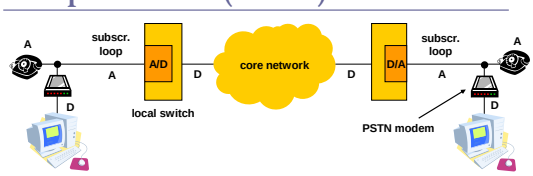
## Telephone line (PSTN) modems




- „ dial-up" Internet
  - but connections between two subscribers
- modem: *mo*dulator-*demo*dulator
- initially that was the only possibility
- today, an obvious, but not the optimal solution (D/A/D/A/D)

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## PC modems

- Internal (ISA, PCI bus)

- External with serial connection (serial port)

- External with USB connection

- Compact Flash connection

- External with PCMCIA connection
  - to connect laptops

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## Modem history - FYI

- First modem in 1950s
  - Used by US Air Force to send military data through telephone lines
  - First commercial modem – Bell 103 (1962)
    - 300 bps full duplex transmission
    - ITU-T V.21
- Newer standards
  - ITU-T V.22 – 600 or 1200 bps (PSK, QPSK) (1980)
  - ITU-T V.22bis – 1200 or 2400 bps (QPSK, QAM-16) (1984)
  - ITU-T V.32 – 9600 bps (QAM) (1984)
  - ITU-T V.32bis – 14.4 Kbps (1991)
  - ITU-T V.34 – 33.6 Kbps (1998)
  - ITU-T V.90 – 56.6 Kbps downlink, 33.6 Kbps uplink (1998)
  - ITU-T V.92 – 56.6 Kbps downlink, 48 Kbps uplink (2000)
- Standards can be downloaded free of charge:
  - http://www.itu.int/ITU-T/publications/recs.html

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## How far can it be developed?

- Shannon's law:
  - $C = B * \log_2 (1 + S/N)$
    - C – bitspeed (bps)
    - B – channel bandwidth (Hz)
    - S/N – signal to noise ratio
- Today the core network is digital
  - Upper bound: PCM encoding – 64 kbps
  - Because of the quantisation noise of the A/D and D/A conversion – the practical limit is appr. 33 kbps
  - In 56 kbps connection (V.90) only the download speed is as high!

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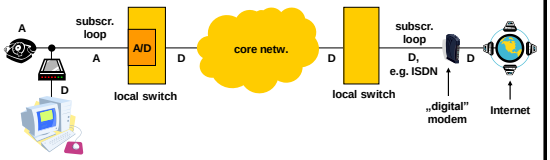
## How far can it be developed?




- In 56 kbps connection (V.90) only the download speed is as high!
  - content provider has a digital access to the network
  - downlink:
    - digital modem: digital data (0,1)
    - local switch of the user: PCM decoding
    - analogue modem: special encoding ("inverse-decoding")
  - uplink:
    - analogue modem – according to V.34 standard 33.6 kbps
    - local switch of the user : PCM encoding
    - digital modem: PCM decoding

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## ISDN Internet access

- 2B+D: 128 kbps max.
- Popular around 2000
- Not attractive since the appearing of ADSL
  - Slow: 128 kbps (2 B channels), with a parallel tel. connection: only 64 kbps
  - Expensive: chargig proportional to time
  - But – in contrary to ADSL – can be accessed everywhere

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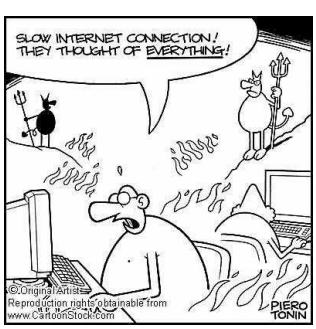


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## Overview

- Telephone line modems
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  - PSTN modems
  - ISDN modems
- **ADSL, xDSL** ⇦
- Internet access through cable TV

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## ADSL

- ADSL = Asymmetric Digital Subscriber Line,
- Goal: maximize the utilisation of the subscriber loop
  - subscriber loops are the top values in telecommunications networks!!
  - „last critical mile”
- Telephone connection (analogue or ISDN) and high speed data transfer at the same time

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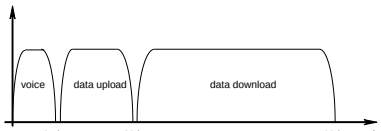
## Functioning of ADSL

- Theory: FDM:




- More precisely:
  - 0-4 kHz – voice
  - (4-25 kHz – gap)
  - 25-160 kHz – upload band
  - 200 kHz - 1.1 MHz – download band
- But it depends on the concrete situation!
  - Different in analogue/ISDN tel. subscription
  - upload/download may be overlapped
  - depends on noise

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# ADSL modulation

- DMT – Discrete Multitone Modulation (ITU-T: G.992.1)
  - 1.1 MHz frequency range
  - 256 channels, 4,3125 kHz each
    - 0. channel – POTS (voice)
    - 1-5. channels – gap (empty)
      - to reduce the interference between voice and data transmission
    - from the rest 250 channels: 1-1 to indicate if there is an upload/download traffic, or not
    - the rest is for user traffic
      - if the transfer is poor on a channel – that channel is not used
      - at higher distance the attenuation on higher frequencies is high

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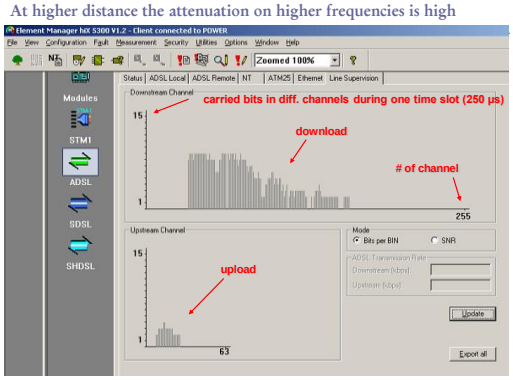
# At higher distance the attenuation on higher frequencies is high




- 4 km subscr. loop, 2 Mbps down, 64 kbps up

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# Speed of ADSL

- Asymmetric:
  - intentionally: usually we download more than upload
  - but not always (e.g. peer-to-peer, videotelephony)
- upload: 16 kbps -- 1 Mbps
- download: 0,1 -- 8 Mbps
  - depends on distance (best: under 2,5 km, poor: more than 5 km)
  - service providers may restrict the speed
- now, in Hungary (up/down):
  - 128k/1M, ... , 512k/8M

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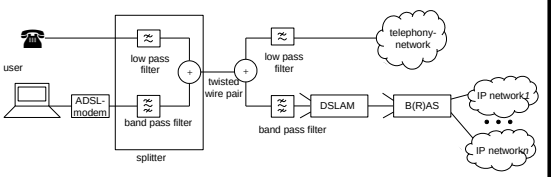
# ADSL topology




- DSLAM (Digital Subscriber Line Access Multiplexer):
  - „peer entity of the modem" - conversion by DMT (Discrete MultiTone - modulation)
  - multiplexer: it connects to several modems, but has only one (some) output ATM or Ethernet
- B(R)AS (Broadband (Remote) Access Server): access handling, ATM – IP gateway
- From the picture the voice codec is left out (ANA: in switch, DIG in ISDN terminal)

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# ADSL modem, splitter, microfilter

ADSL modem

ADSL splitter

ADSL microfilter
(filter on the tel. line)

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# DSLAM

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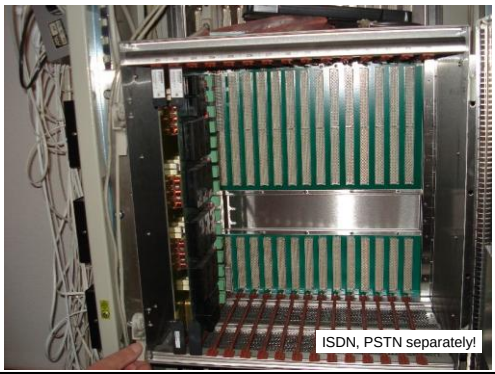
## Splitters

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## Modem cards

2. ISDN modem card with 32 modems
3. PSTN modem card with 16 modems
4. SDSL modem card
6. SHDSL modem card
9. Broadband gateway card to IP network. (ATM in this concrete case)

## Cross connect

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## DSLAM

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## ADSL2 DSLAM

With Ethernet interface instead of ATM

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## ADSL2/2+

- ADSL2 (G.992.3)
  - more efficient modulation, download max. 8-12 Mbps
  - may be approx. by 200 m longer
  - may use the voice channel temporarily
  - power saving: detects, if there is traffic or not
- ADSL2+ (G.992.5)
  - max. frequency 2.2 MHz
  - voice, upload frequencies - same
  - max. download bandwidth 16-20 Mbps
  - within 1.5 km range

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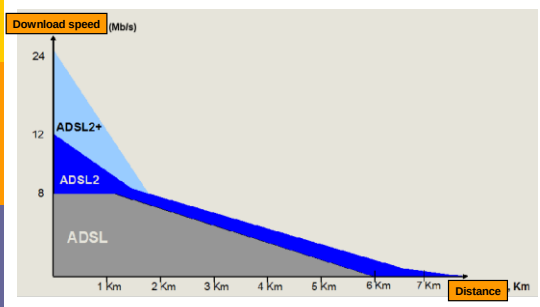
## Comparision of ADSL technologies

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## xDSL

- Idea - same: better utilisation of the subscriber loop
- SHDSL: Symmetric High-speed DSL (G.991.2):
  - max. 2.3 Mbps in both directions
  - max. 3 km
  - no voice transmission
  - relatively new DSL version (2001)
  - typically for business applications
- VDSL - Very high rate Digital Subscriber Line (G.993.1)
  - 13 Mbps - 55 Mbps (down), 1-3 Mbps (up)
  - or 26-26 Mbps symmetrically
  - 300 - 1500 m twisted copper wire pair, then fiber optic
- VDSL2 (G.993.2)
  - 100 Mbps in both directions
  - frequency range: 30 MHz
  - DSLAM is compatible with ADSL modems
- xDSL: all together

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## Triple Play

- Triple Play
  - marketing name for an IP service including the following 3 services:
    - Internet
      - min. 5 Mbps
    - Television
      - typically min. 3 TV channels in parallel / household
    - Telephony
      - Voice over IP (VoIP)
  - A business model, not a technical standard
- Quad(ruple) Play
  - Triple Pay + wireless access

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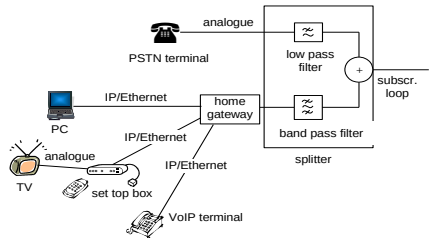
# Triple play on ADSL




- voice, video has priority over the data
- e.g. three different ATM VCs (virtual connection)
- extra services, e.g.:
  - video-on-demand
  - dynamic bandwidth assignment

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# Overview

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- **Internet access through cable TV**

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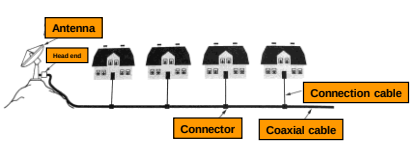
# Early cable TV systems

- Idea: at the end of 1940s (USA)
  - Better receiving in suburbs, in mountains
- Community Antenna Television – CATV
  - A big antenna on a hill
  - One amplifier (head end)
  - Coaxial cable
- Unidirectional transmission: from head end to users

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## Development of cable TV

- 1970: several thousands independent systems (USA)
- 1974: HBO starts, only on cable
  - Several new cable channels – news, sport, cooking, etc.
- Large companies start to buy the existing cable networks up, new cables are laid down
  - Cables among towns to unite sytems
  - Later: inter-town cables were replaced by fibre optic

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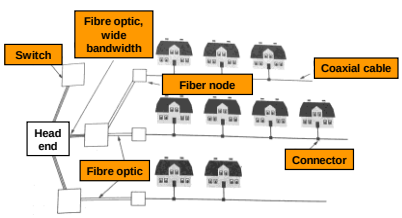
## HFC system

- HFC - Hybrid Fibre Coax
  - Fibre-Coaxial hybrid system
    - Fibre: for long distance, coaxial cable: to subscribers
  - Fiber Node: FN
    - Electro-optical transformer
      - between the optical and electrical parts

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## Internet on cable TV

- Cable service providers started to introduce new services:
  - Internet access
  - Telephony (VoIP)
- Network must have been changed
  - Unidirectional amplifiers -> bidirectional
  - Improve the head end
    - „Stupid" amplifier -> intelligent computer system
    - Cable-Modem Termination System (CMTS)

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## Internet on cable TV

- Coaxial cable: shared resource: several users use in parallel
  - In telephone networks: every user has a dedicated wire pair (subscriber loop)
  - Not necessary for BROADCASTing TV programs
  - Internet: competition among users for the medium
  - But: coaxial cable has a (much) wider bandwidth than a copper wire pair
- Solution: divide a long cable into several shorter sections
  - All of them are directly connected to a fiber node
    - If there are not too many users on a section the traffic may be managed
    - Today: typically 500-2000 subscribers on a section
    - More and smaller sections as the number of subscribers and traffic grow
  - The bandwidth between the head end and fiber node is very high

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## Spectrum allocation

- Cable system not only for Internet access
  - More TV subscribers than Internet subscribers
  - NRA regulations : TV service mandatory
  - Distribution of frequencies between TV and Internet
- Europe
  - TV channels above 65 MHz
  - 8 MHz wide channels
    - Because of higher resolution of PAL és SECAM systems
      - (PAL - Phase Alternating Line)
      - (SECAM - Séquentiel Couleur à Mémoire)
      - Resolution: 768 x 576, 25 fps
- USA, Canada
  - FM radio: 88 – 108 MHz
  - Cable TV channels: 54 – 550 MHz
    - 6 MHz wide channels
      - NTSC - National Television System Committee
      - Resolution : 720 x 480, 29.97 fps

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## Cable modem

- 2 interfaces – one to PC and one to cable network
  - Between modem and PC: 10 Mbps Ethernet, sometimes USB
  - In future: possibly internal modems
- Initially: every provider had a special modem type that could have been installed only by technicians (expensive modems!)
  - Need of an open standard
    - Competition on the market of the modems
    - Prices decreased
    - Inspire the spreading of the service
    - If user installs the modem – no charge for the installation
    - Good for the users ☺, not good for the cable companies ☺ ☺

- CableLabs
  - Association of the largest cable companies
  - DOCSIS standard
    - Data Over Cable Service Interface Specification
    - EuroDOCSIS – European version

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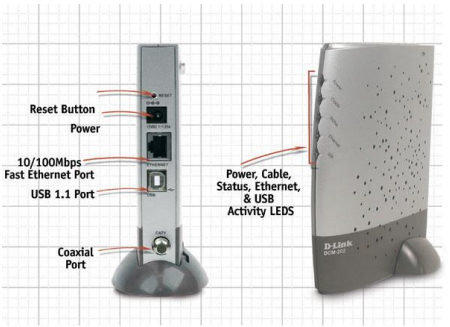
## Cable modem

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## Cable modem

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## Cable modem

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## Secure communication

- Cable is a shared medium
  - Anybody can look in the traffic goes by ☹
- Traffic must be encrypted in both directions
  - Common encryption key in both directions

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## Cable vs. DSL

| | ADSL | Cable |
|---|---|---|
| medium | twisted wire pair | coaxial cable |
| bandwidth | more or less the same | |
| access (to the first router...) | dedicated | shared |
| range | only near to switch | anywhere on the area of a cable tv |
| security | physical separation | encryption |
| more ISP | frequently, regulation supports | typically one |

- Cable now cheaper & faster
- Future: fibre optic cables even to the home
  - FTTC/FTTCab: Fiber to the Curb/Cabinet, VDSL(2)
  - FTTH: Fiber to the Home
  - Details later

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