Networking Technologies and Applications

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BME TMIT

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Lecturers

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Administrative details

Slides on the webpage:

http://www.tmit.bme.hu/vitmac05

No book, but (quite) detailed slides

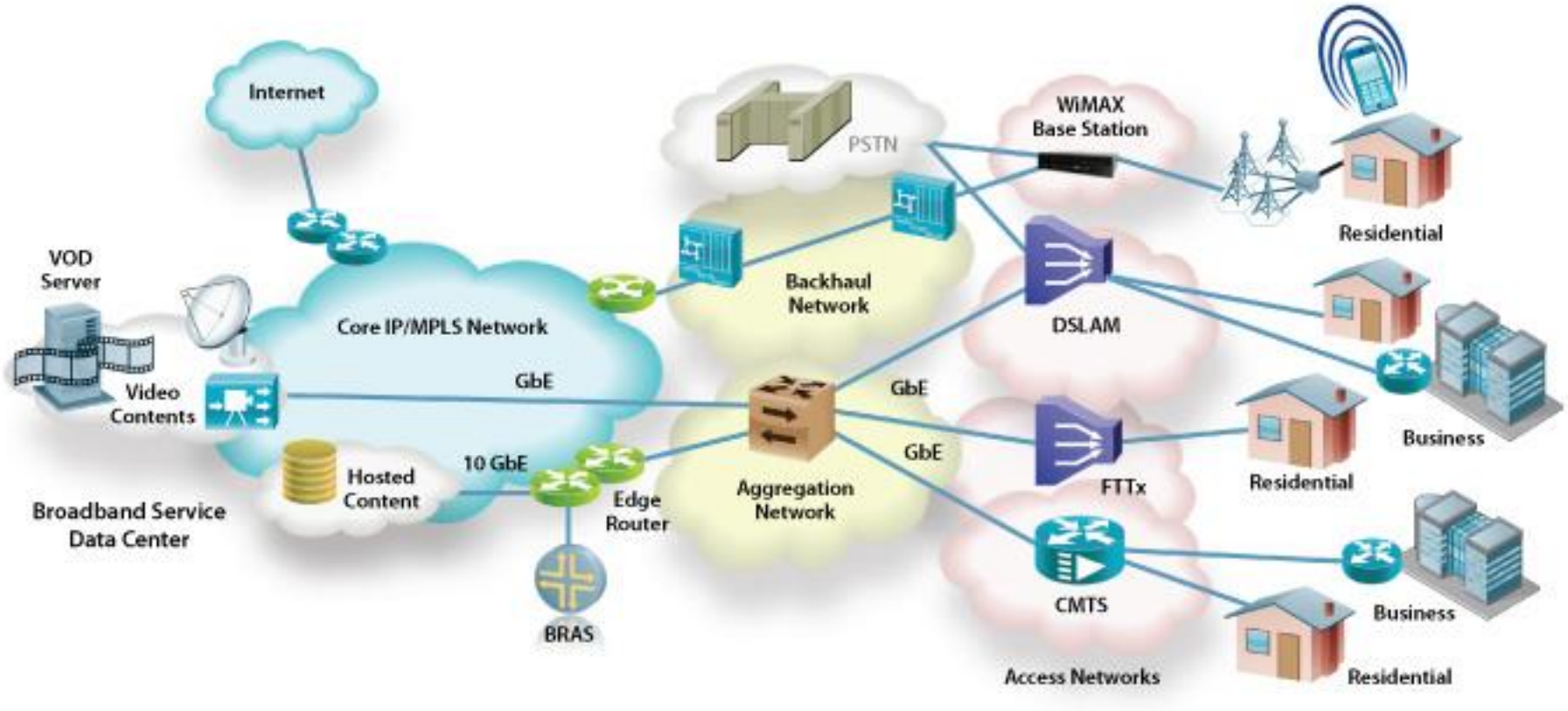
Presence at the lectures not mandatory **(but advised)**

Exams

- 1 mid-term exam, around end of October
- 1 re-take for the mid-term, during the last week
  - The grade of the mid-term exam will not be part of the final grade, you just have to pass it for the signature
  - Material for the mid-term and the re-take are the same

- Written exam

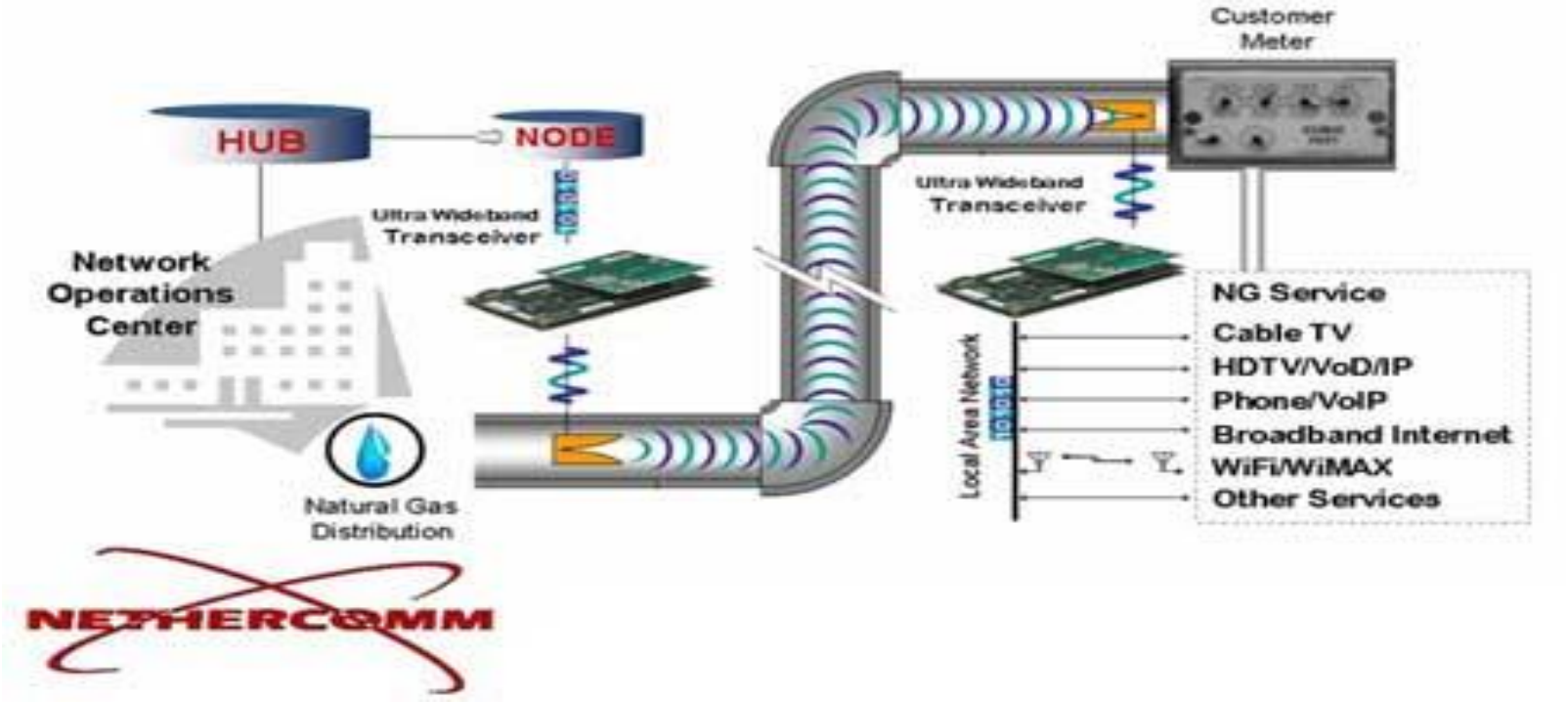
Big picture


Internet
PSTN
WiMAX
Base Station
Residential
VOD
Server
Core IP/MPLS Network
Backhaul
Network
DSLAM
GbE
GbE
GbE
Video
Contents
Hosted
Content
10 GbE
Edge
Router
Aggregation
Network
FTTx
Residential
Business
Broadband Service
Data Center
CMTS
Business
BRAS
Access Networks
Residential

Access Networks

- Easiest way for two computers to communicate – direct connection
- If long distances and many computers – too expensive
  - It's not the cost of the wires…
    - But the digging, and the work inside the buildings
- Solution: use some existing infrastructures/networks
  - Public Switched Telephone Network (PSTN)
  - Cable TV network
  - Electric network
  - Gas pipes (?)
    - Ultra Wideband radio communication
  - Drainpipes (?)
    - Optical fiber cables
- But sometimes you can build new ones as well…

Internet through the gas pipe?

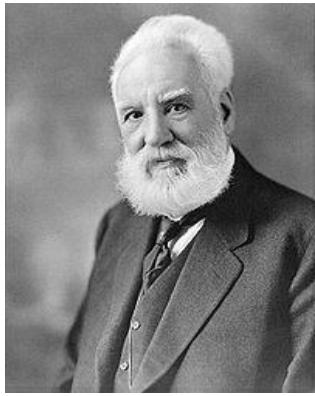


Internet through the gas pipe?

- Idea from NetherComm in 2005
- Ultra Wideband
  - Large frequency band (>500 MHz), large transfer speeds (100 Mbps)
  - In case of high power transmitters too much interference with other wireless technologies. Therefore, its operation only allowed for short ranges
  - In underground gas pipes this is not a problem, we can use higher transmit powers
- The UWB technology seemed promising, but …
  - Strict regulations, slow standardization, lower speeds than promised
  - In 2008-2009 the industry support melts away
  - NetherComm disappears

PSTN

- The telephony network was designed only for speech transmission
- 1876 – Graham Bell patents the first telephone
  - A few hours before Elisha Gray
- You could buy the phone, but the wire was installed by the users
  - A separate wire for each pair of users
  - In a year the cities became completely „wired”



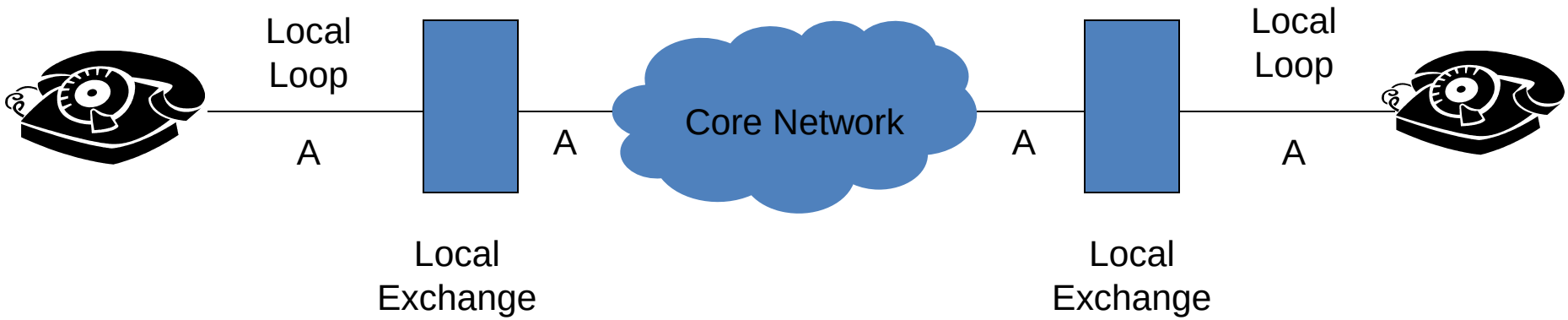
PSTN

- 1878 – Bell Telephone Company
  - The first switching center – New Haven, Connecticut
  - A human operator switching manually between the users
- Inter-city calls
  - Linking the telephone switching centers
  - Secondary centers, hierarchical architecture
- Only in the US more than 22.000 centers today, 5-level hierarchy

PSTN

- Elements of the PSTN network:
  - Local loop
    - From the user's home to the local exchange point
      - „last mile"
      - Optical local loop, wireless local loop
    - Twisted pair of copper wires
  - Switching centers / telephone exchanges
  - Optical trunks
    - Linking the a switching centers
    - Core network
- The first network was completely analog
  - Step by step transition to digital transmission, mainly in the core

PSTN

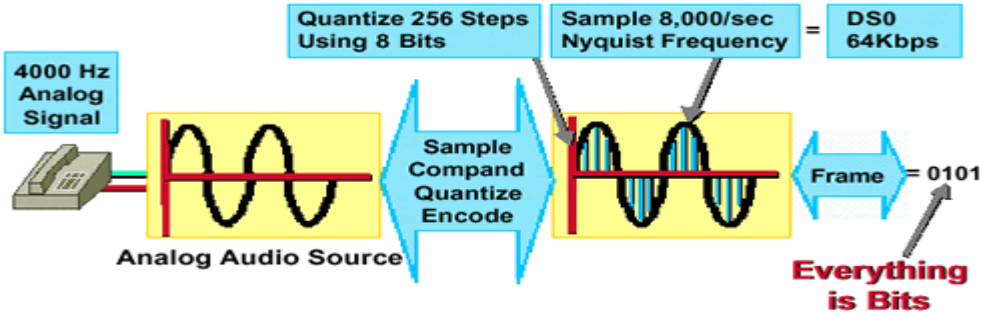

Local
Loop
A
A
Core Network
A
Local
Loop
A
Local
Exchange
Local
Exchange

Voice channel

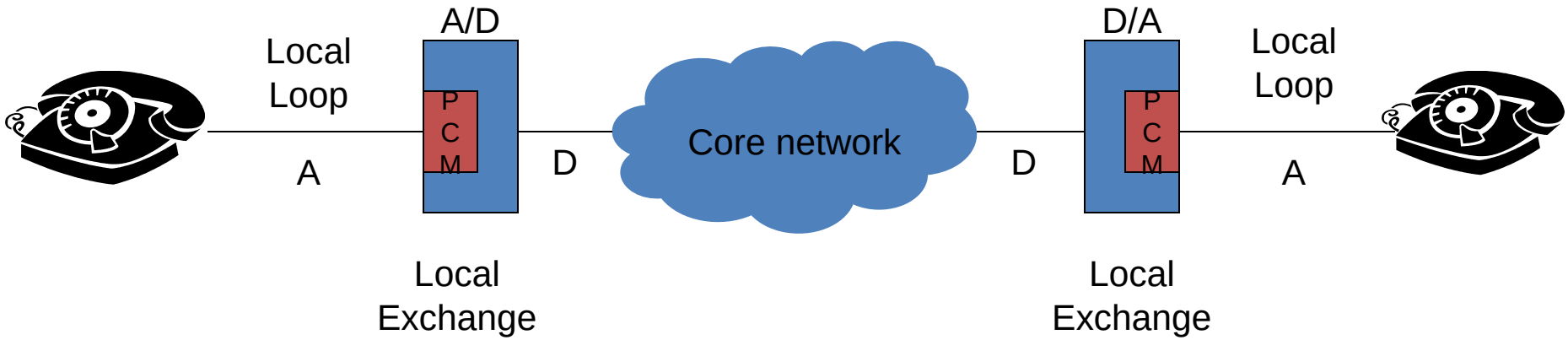
- 4kHz bandwidth for the voice channel
  - The transmission domain of the voice signal between 0.3 and 3.4 kHz
  - Some added guard bands
- The frequency range sensed by the human ear: 20Hz – 15-20 kHz
  - The goal was to transmit the voice signals
  - Not all the sounds should be transmitted
    - Economic aspects

PCM

- Pulse Code Modulation
  - Transforming analog signals to digital
- Based on the Nyquist rule, for a 4kHz signal we need an 8kHz sampling
  - Quantized to 256 signal levels
    - Represented on 8 bits
  - Transmission speed: 8bit x 8kHz = 64 kbit/s

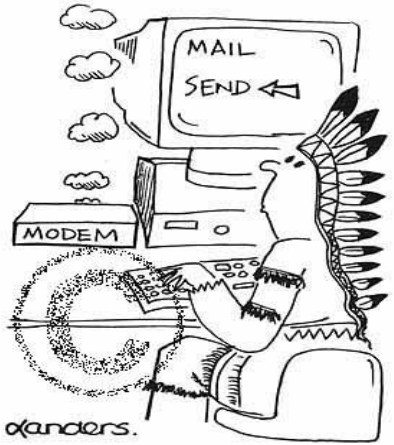


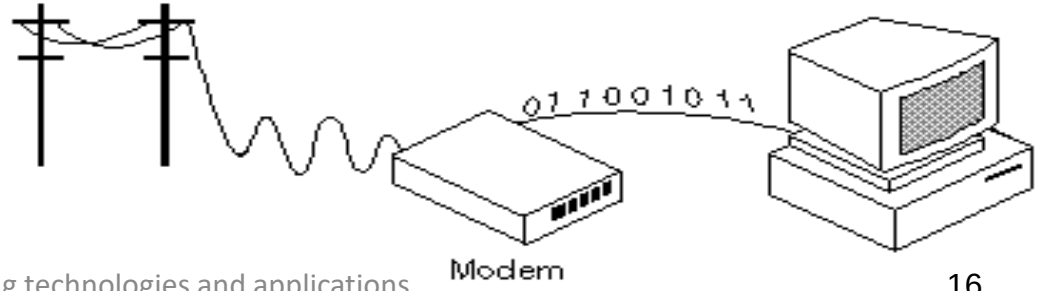
Digital speech transmission



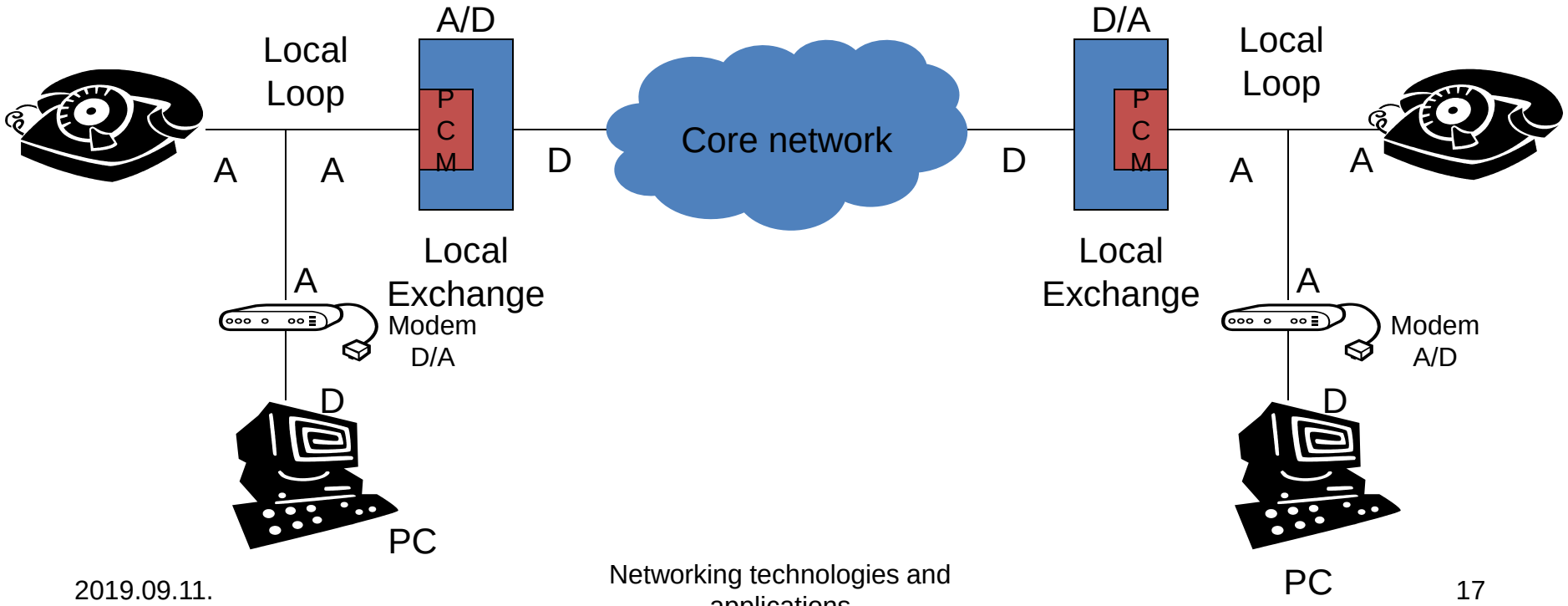
Dial-up Access

- The digital information of a computer transformed into analog signals, and transmitted over a PSTN network
  - „Modem” – modulator-demodulator
    - Amplitude modulation
    - Frequency modulation
    - Phase modulation





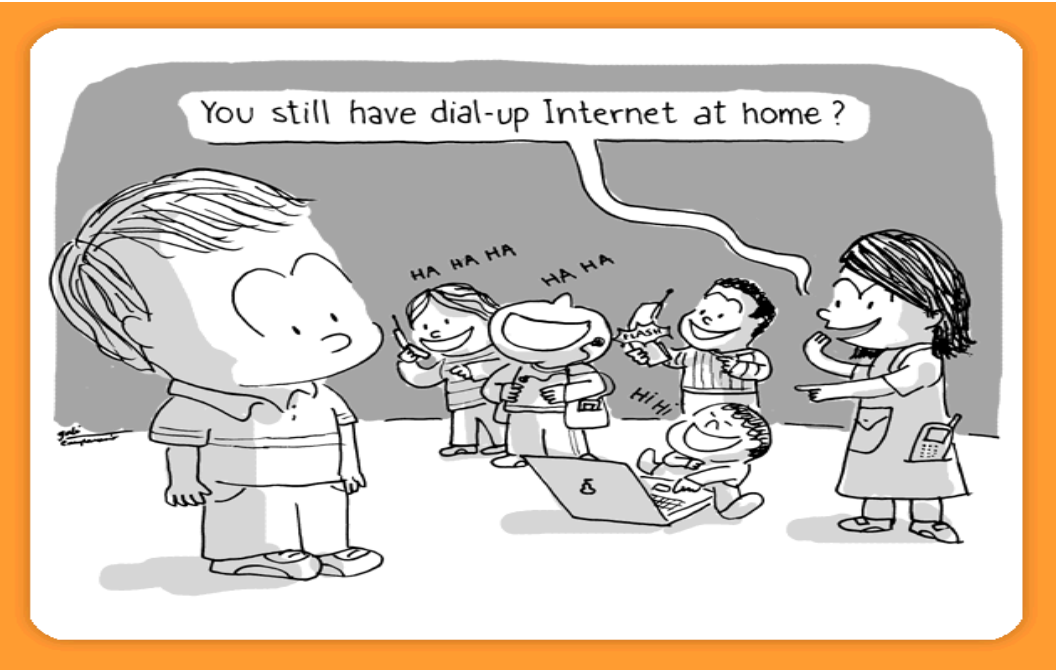
Dial-up access



What’s the limit?

- The core network is digital
  - After the PCM coding, the signal is restricted to a 64 Kbps channel, this is the upper limit
    - In most of the systems 1 bit/byte for signaling
    - Max. 56Kbps
  - Quantization noise due to the A/D and D/A conversions
    - The actual limit is 33.6 Kbps

Dial-up is dying out…?



Why DSL?

- DSL – Digital Subscriber Line
- Dial-up speed – 56 Kbps
  - Other technologies – much higher speeds
  - Obliged to move, if you want to keep the subscribers
- Emerges the broadband connectivity
  - Mostly a marketing term
  - Not clear what broadband means
- xDSL – different DSL versions

Why is DSL fast?

- Why is dial-up slow?
  - The PSTN network optimized for voice transmission
    - A band-pass filter in the local exchange
    - Only the 4 KHz large voice channel remains
  - Data is also restricted to this channel
- The line of the xDSL subscriber has no filter
  - You can use the entire capacity of the local loop
    - It depends on the length of the loop, the thickness and the quality of the cable
    - Optimal case: new cables, thin bundles, short loop
- If you want higher speed, you need many local exchanges
  - If someone lives far away, he or you should move closer
    - Lower the speed, higher the service range – more potential subscribers
    - Lower the speed, fewer interested subscribers

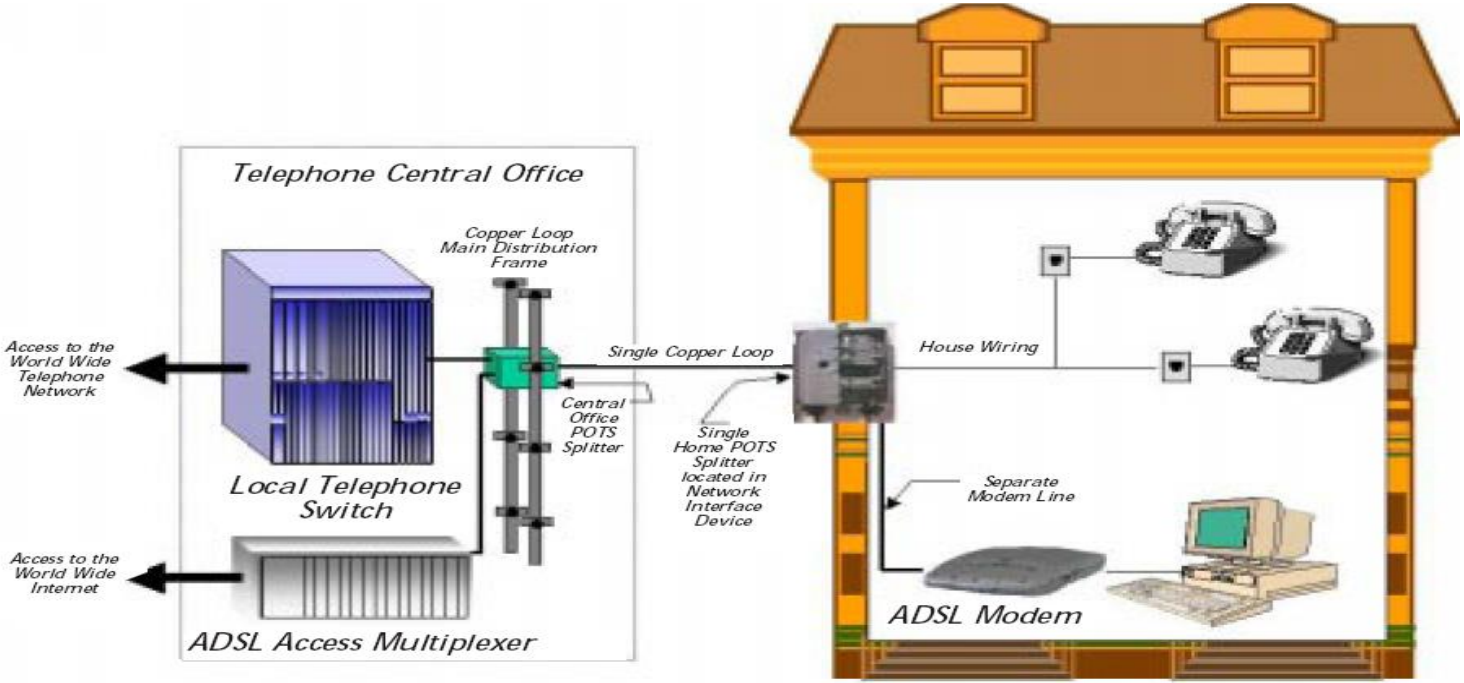
ADSL - Asymmetric Digital Subscriber Line

- DMT – Discrete Multitone Modulation
  - 1.1 MHz frequency domain
  - 256 channels, 4.3125kHz each
    - Channel 0 – POTS (voice)
    - Channels 1-5 – guard band (empty)
      - To avoid interferences between voice and data channels
    - 1 upstream and 1 downstream channel for signaling
    - The remaining channels split between upstream and downstream user data
- Frequency allocation in ADSL
  - 0-4 kHz – voice
  - 4-25 kHz – guard band
  - 25-160 kHz – upstream band
  - 200 kHz - 1.1 MHz – downstream band

ADSL architecture

- At the operator
  - POTS Splitter
    - Frequency splitter to separate voice and data traffic
      - Voice is directed to the local exchange
      - Everything above 26 KHz is directed to the DSLAM
  - DSLAM – DSL Access Multiplexer
    - Splits the bit stream into packets and sends them to the ISPs network
- At the subscriber
  - POTS Splitter
  - ADSL modem
    - Digital signal processing
  - High speed connection to the PC

ADSL architecture



ADSL G.dmt

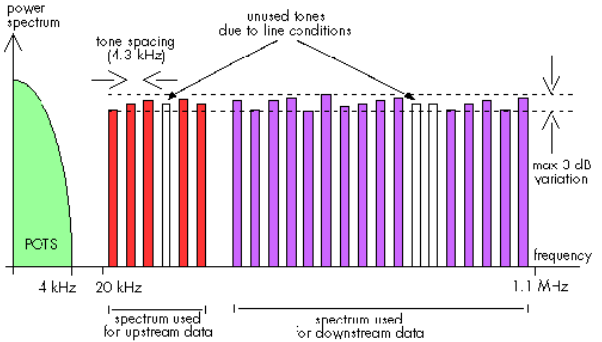
- ITU-T G.992.1 standard (1999)
  - http://www.itu.int/rec/recommendation.asp?type=folders&lang=e&parent=T-REC-G.992.1
- Much larger bandwidth for downstream traffic than for upstream
  - Designed for the needs of web browsing
  - Maximal downlink speed 8 Mbit/s
    - usually 512 Kbit/s – 1 Mbit/s
  - Maximal uplink speed 1 Mbit/s
    - usually 64 Kbit/s – 256 Kbit/s
- Service range of max. 3 km from the local exchange

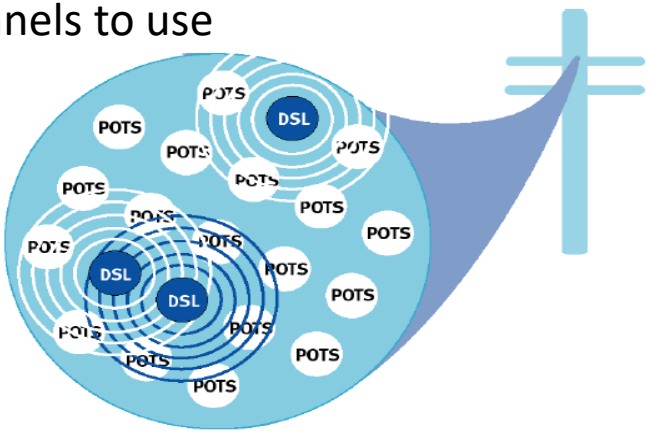
ADSL G.dmt 2

- ITU-T G.992.3 standard (2002)
- Extends the traditional ADSL technology
  - Maximum downlink speed increased to 12 Mbit/s
  - Service range extended with ~ 500 meters
    - The improvements mainly due to the limitation of the interferences on long loops
- ADSL2 is energy efficient
  - As opposed to ADSL, it differentiates between periods with or without traffic
- ADSL2 can temporarily switch to „complete digital” mode
  - The voice and guard channels used for data traffic

ADSL G.dmt 2

- Seamless rate adaptation (SRA)
  - 20-25 twisted pairs in a bundler
  - „Crosstalk” from the neighboring pairs
    - Might lead to the ADSL connection being dropped
  - ADSL2 can adapt the speed
    - If too much noise on a channel, it can be blocked
    - The modem and the DSLAM agree on which channels to use





ADSL 2+

- ITU-T G.992.5 (2003)
- Bandwidth is increased by enlarging the frequency domain
  - The frequencies used for voice and upstream traffic do not change
  - The upper frequency of the downlink channel is increased from 1.1 to 2.2 MHz.
    - The maximum downlink speed increases from 8Mbit/s to 16 Mbit/s
      - The service range is lowered to 1.5 km