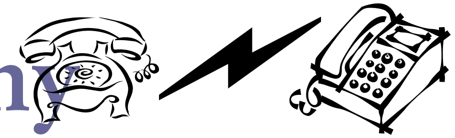
Telecommunication Networks and Services

Gusztáv Adamis
BME TMIT

Content

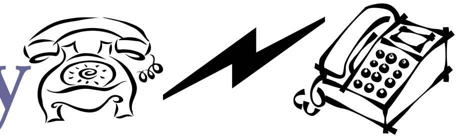
- 1. **Introduction**
  - Voice digitalisation
- 2. Access to IP networks through telecommunication and cableTV networks
- 3. Switching
- 4. Mobile networks
- 5. Signalling

Analogue <-> digital telephony



- Analogue: 4 kHz   Digital: approx. 64 kHz
- Then why digital?!
- Because:
  - simpler and more reliable
  - nowadays it is cheaper (10-15 years ago was more expensive)
  - signal/noise ratio independent from the size of the network
  - production of digital equipments does not require individual adjusting
  - smaller equipments
  - lower voltage / smaller power consumption
  - more intelligent services can be implemented
  - more sophisticated signalling
  - integrated data and voice transmission
  - simpler maintenance
  - switching can be implemented without moving parts
  - in mobile systems: new codec types -> smaller bandwidth
- In developed countries the switches, core network pure digital

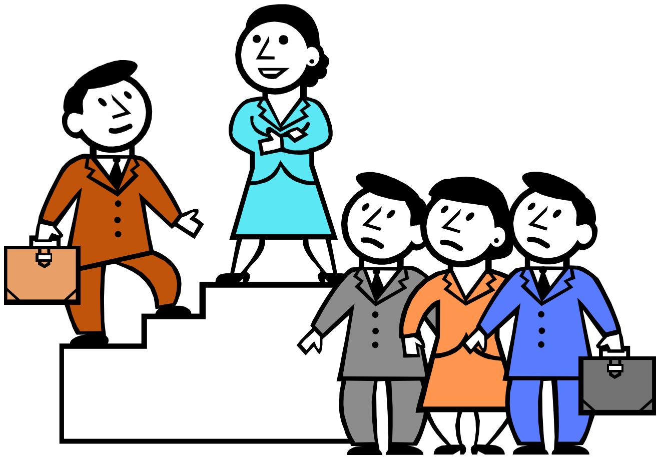
Analogue <-> digital telephony



- But: terminals in fixed networks are mainly analogue
  - quality is acceptable
  - lot of users do not want to pay for the new services
  - lot of new services can be accessed by analogue equipments, too:
    - intelligence in the switch not in the equipment!
    - digital extensions in analogue equipments: number presentation (display), SMS
  - See in ISDN chapter!

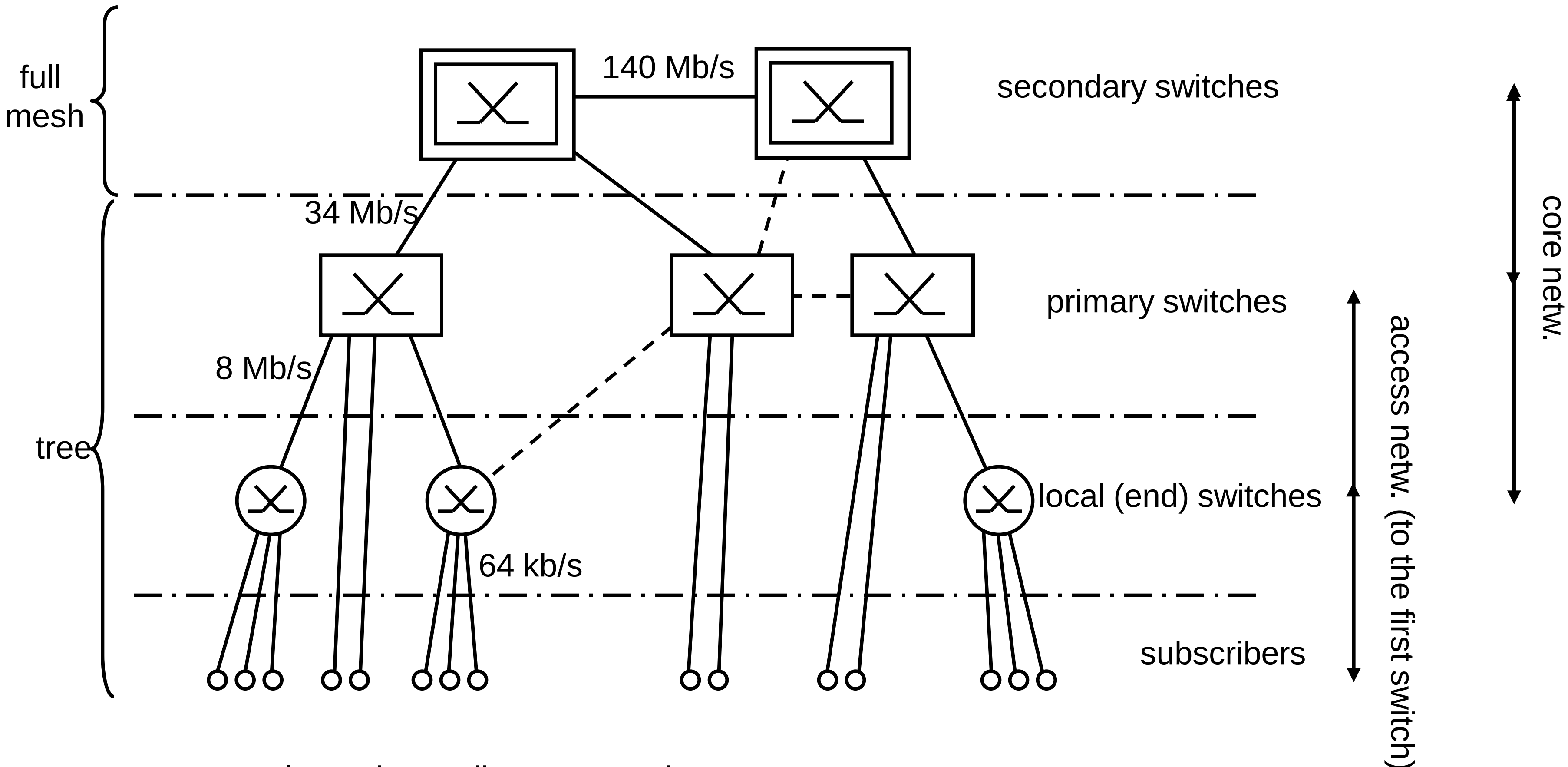
Introduction

- Basics of telecommunication networks
  - Analogue and digital transmission
  - Topological overview of telecomm. networks
  - Numbering
  - ISDN
  - Next Generation Networks



Topological overview of telecomm. networks

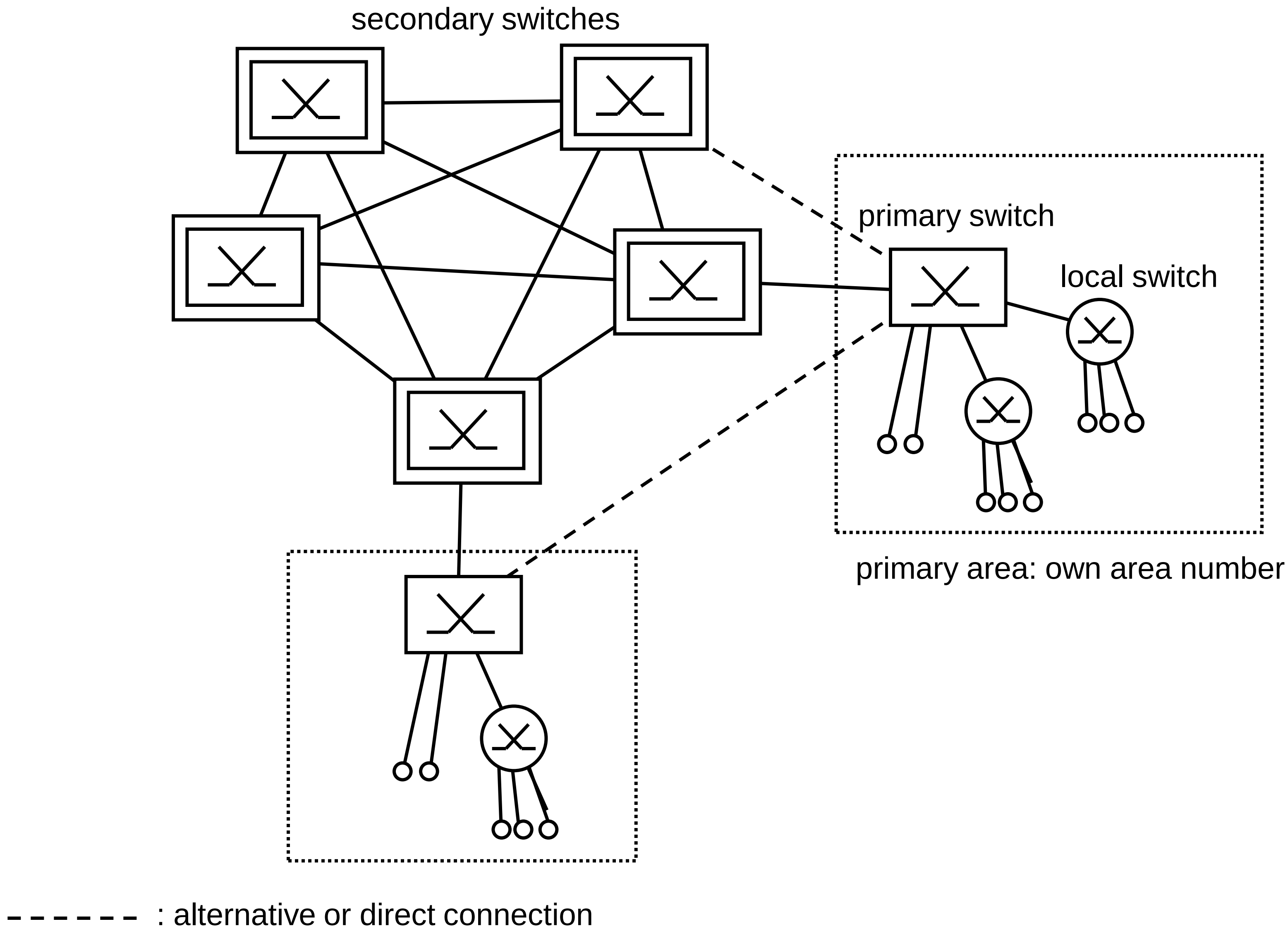
- Topology of Public Switched Telephony Network (Hungary)



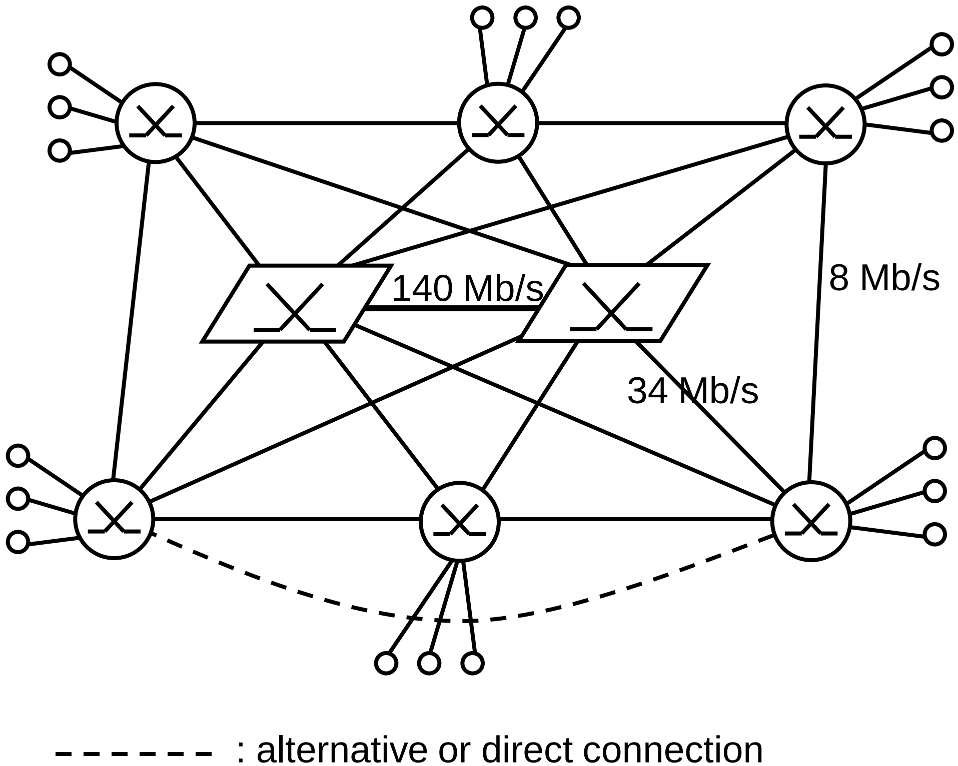
- - - - - - : alternative or direct connection:
goal: to optimize routing, make the network more reliable (redundancy!)

Bit speeds are (typical) examples, other solutions are also possible

Geographical topology - example



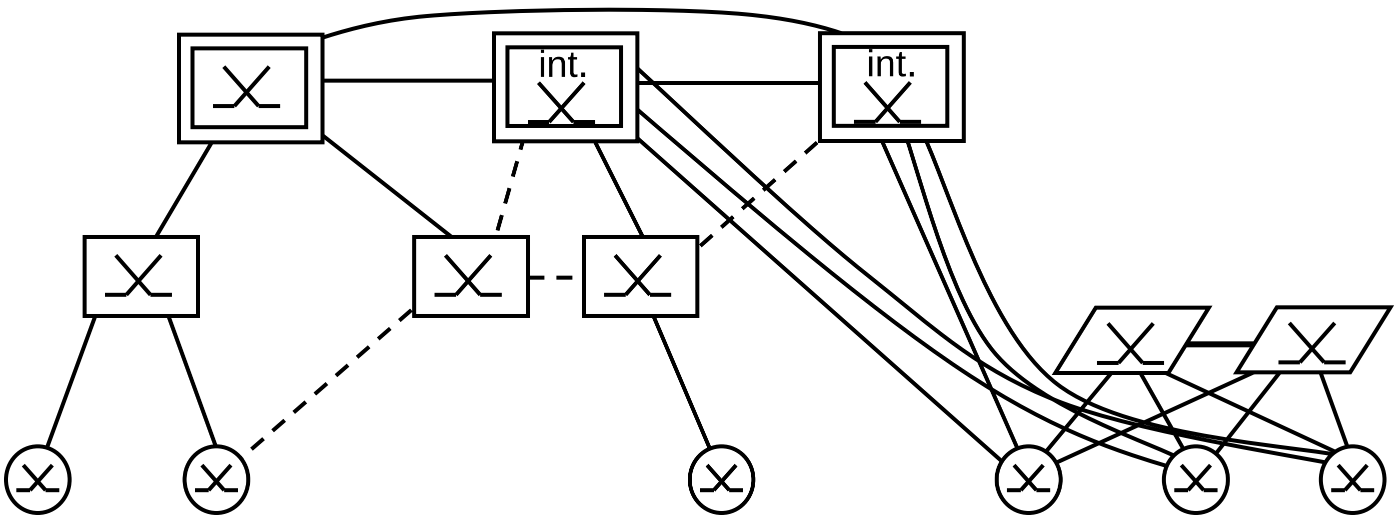
Metropolitan network architecture



- E.g.. Topology in Budapest:
  - approx. 30 local switches
  - 2 *tandem switches*
- Tandem switches:
  - at the hierarchial level of the local switches
  - Bp.: Városmajor, Angyalföld (local + tandem switch)
- Special primary area:
  - Metropolitan network (local switches + tandem switches) = primary area, without a primary switch

Nationwide & metropolitan network (integrtd)

- There are 2 international gateway switches in 2 secondary switches in Budapest
  - Kelenföld, Józsefváros (local, secondary, international switch)
- Integrated topology (simplified):

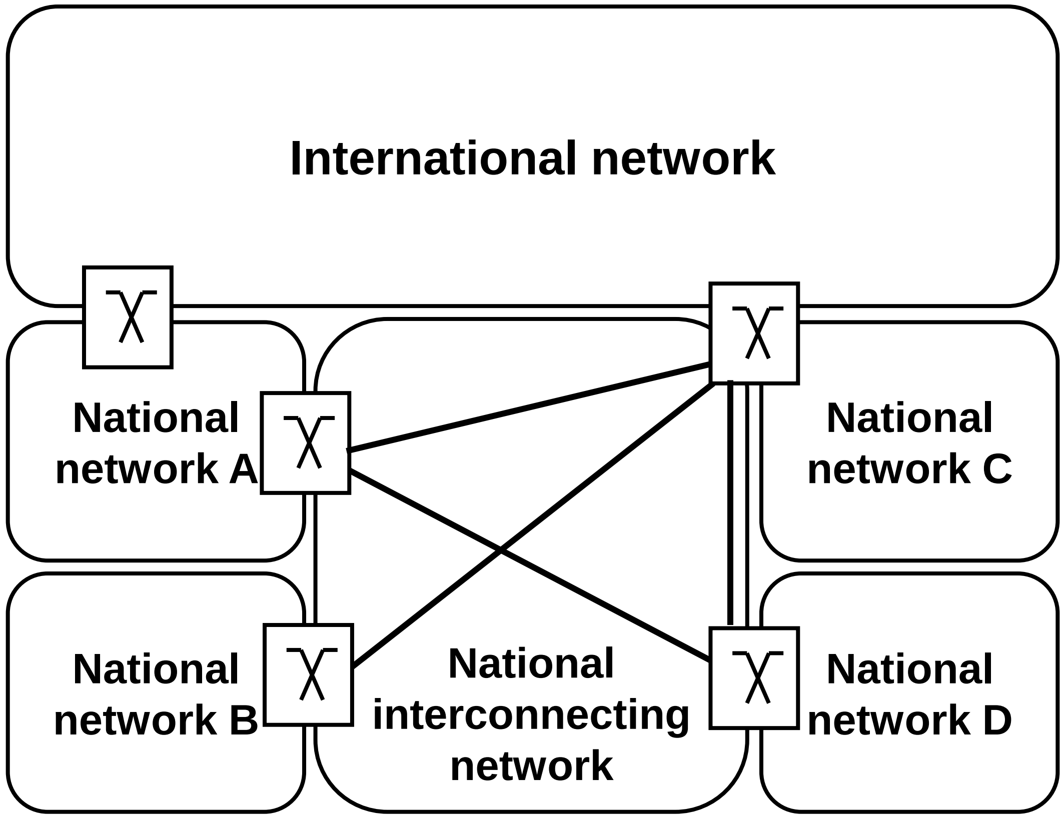


int. = international

Public switches in Hungary

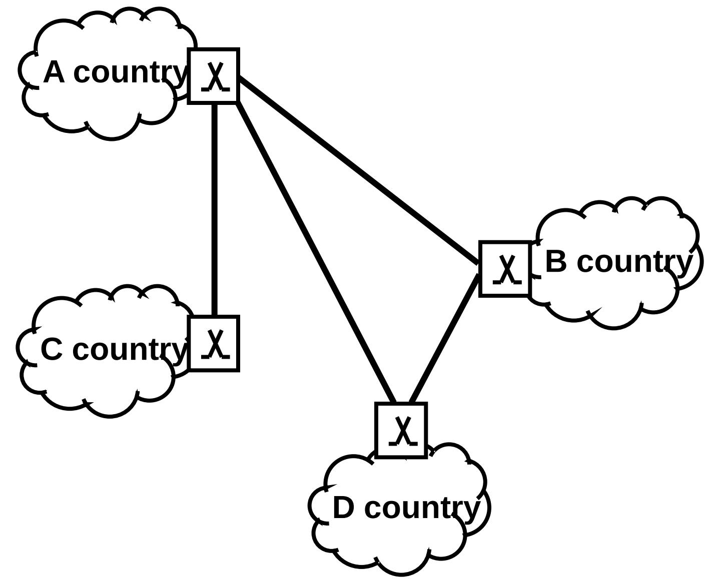
- 2 international switches
  - Kelenföld, Józsefváros
- 2 tandem switches
  - Városmajor, Angyalföld
- 10 secondary (5+5 at both sides of the Danube) switches
  - Kelenföld, Józsefváros
  - Győr, Zalaegerszeg, Pécs, Székesfehérvár
  - Szeged, Szolnok, Debrecen, Miskolc
- 54 primary switches
- about 400 local switches
- about 1300 remote modules

Structure of the telephony network of a country – competitive service providers



International telephony network

- Larger service providers have international gateways
- Several competiting international service providers
- No need for direct connections between any two countries
- ... but 1 international connection may contain maximal 6 trunks (7 switches)
  - (including national parts)



Introduction

- Basics of telecommunication networks
  - Analogue and digital transmission
  - Topological overview of telecomm. networks
  - Numbering
  - ISDN
- Next Generation Networks

Numbering (addressing)

- Called party's number: identified originally the location (address)
- Now tendency: identifies the subscriber itself (name)
  - mobile networks - obviously
  - examples in fixed networks:
    - number portability
    - premium rate, freephone (green), shared cost (blue) numbers
- E.164 Recommendation (ITU-T, http://www.itu.int/rec/T-REC-E.164/en)
- An international number: max. 15 digits
  - country code (1-3 digits) + national destination code (area code, service or network identifier) + subscriber number

1	North America
2	Africa (+Greenland)
3,4	Europe
5	Middle and south America
6	Australia Oceania
7	Russia, Kazakhstan
8	Far East (+Inmarsat, Internat. green number: 800)
9	Middle and Near East

Numbering (addressing)

- National Destination Code:
  - Area code, e.g.: 33: Esztergom
  - Network Code, e.g.: 30: t-mobile
  - Service Code, e.g.: 80: green number
- Subscriber Number
- National Destination Number = NDC + SN
- Connection between the network and numbering hierarchies

Numbering (addressing)

- Open numbering scheme:
  - Two forms: national/local number
  - Local numbers shorter, but national prefix (06 – in Hungary, 0 – in other European countries)
- Closed numbering scheme :
  - Always national destination number
  - Simple, unambigous
  - Same length, independently where to start the call from
  - Tendency in Europe (Norway, France, Italy, UK....)

Short codes

- Short numbers:

104, 105, 107, 112	emergency numbers
116c(d)	
118de	
12cd	
140d-144d, 145de-149de	
17c(d(e))	
18c(d)	
190-194, 197-199	operator services

- Prefixes:

00	internat. prefix
06	nat. prefix
130	number presentation allowance prefix
131	number presentation disabling prefix
15cd	carrier selection prefix

National Destination Codes in Hungary

- Area codes

A\B	2	3	4	5	6	7	8	9
2	Székesfehérvár	Biatorbágy	Szigetszentmiklós	Dunaújváros	Szentendre	Vác	Gödöllő	
3	Salgótarján	Esztergom	Tatabánya	Balassagyarmat	Eger	Gyöngyös	-	-
4	Nyíregyháza	-	Mátészalka	Kisvárda	Miskolc	Szerencs	Ózd	Mezőkövesd
5	Debrecen	Cegléd	Berettyóújfalu	*for test purposes*	Szolnok	Jászberény	-	Karcag
6	Szeged	Szentes	-	-	Békéscsaba	-	Orosháza	Mohács
7	Pécs	Szigetvár	Szekszárd	Paks	Kecskemét	Kiskunhalas	Kiskőrös	
8	Kaposvár	Keszthely	Siófok	Marcali	-	Tapolca	Veszprém	Pápa
9	Zalaegerszeg	Nagykanizsa	Szombathely	Sárvár	Győr			

National Destination Codes in Hungary

- Service and Network Codes:

A\B	0	1
2	GSM (Telenor)	Nomadic service
3	GSM (T-Mobile)	GSM (Other operators)
4	Shared cost service („blue” number)	-
5	Reserved for new GSM operator	Internet access
6	-	-
7	GSM (Vodafone)	Corporate Networks
8	Freephone („green” number)	-
9	Premium rate service	Premium rate service (restricted content and price)

Introduction

- Basics of telecommunication networks
  - Analogue and digital transmission
  - Topological overview of telecomm. networks
  - Numbering
  - ISDN
  - Next Generation Networks

ISDN

- ISDN = Integrated Services Digital Network
- Improvement of PSTN
  - Public Switched Telephone Network,
    - or POTS: Post Office Telephone Service -> Plain Old Telephone Service
- since 1987, more than 20 years old!
- **IS**-: integrated service: more services on one network, e.g.:
  - voice (POTS), videoconference, data transfer
- -**DN**: full digital: voice codec in terminal
- switches, transmission paths are digital
    - (UNI: user-network interface,
      NNI: netwrok-network interface)

ISDN – motivation

- A bit of history: C64 is the computer of the year in 1982!

- In those days the high-tech in telephony was still something like this ☹

ISDN – motivation

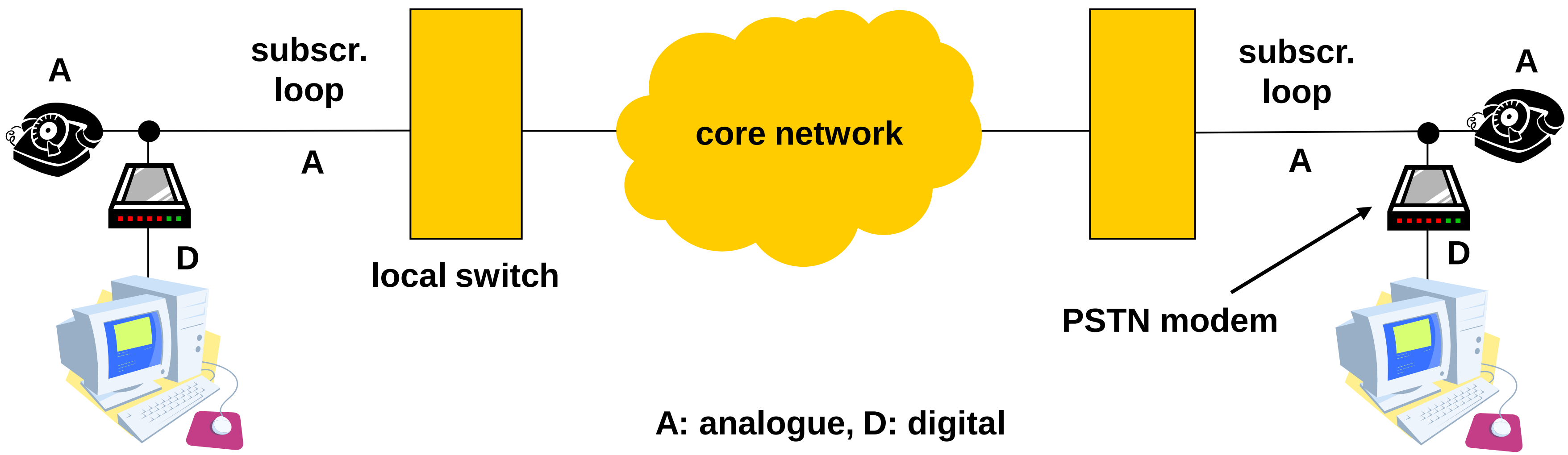
- Need for improved services
  - Better voice quality than in PSTN
  - Value added supplementary services, e.g.:
    - number presentation
    - conference call
    - call forwarding
    - call waiting
  - videotelephony (!)
  - faster data transmission
- Solution: digitalisation – that is ISDN

ISDN – motivation

- Producer side: digital trunks (PCM), digital switches
  - easier to sell if there are new services... → ISDN
- Not sure that the new *services* would have been enough:
  - 2 „telepone lines” on one wire pair
  - that is the real benefit!

PSTN – analogue/digital transmission

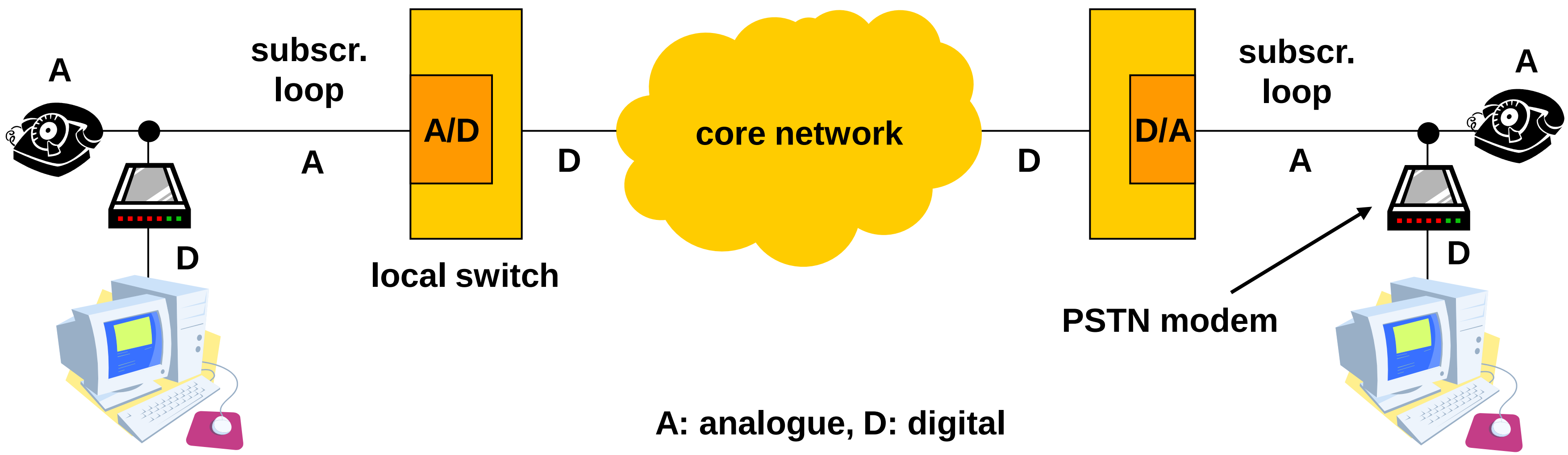
- PSTN data transmission with modems:



- While the core network was analogue, the D/A, A/D converting funcion of the modem was necessary

PSTN – analogue/digital transmission

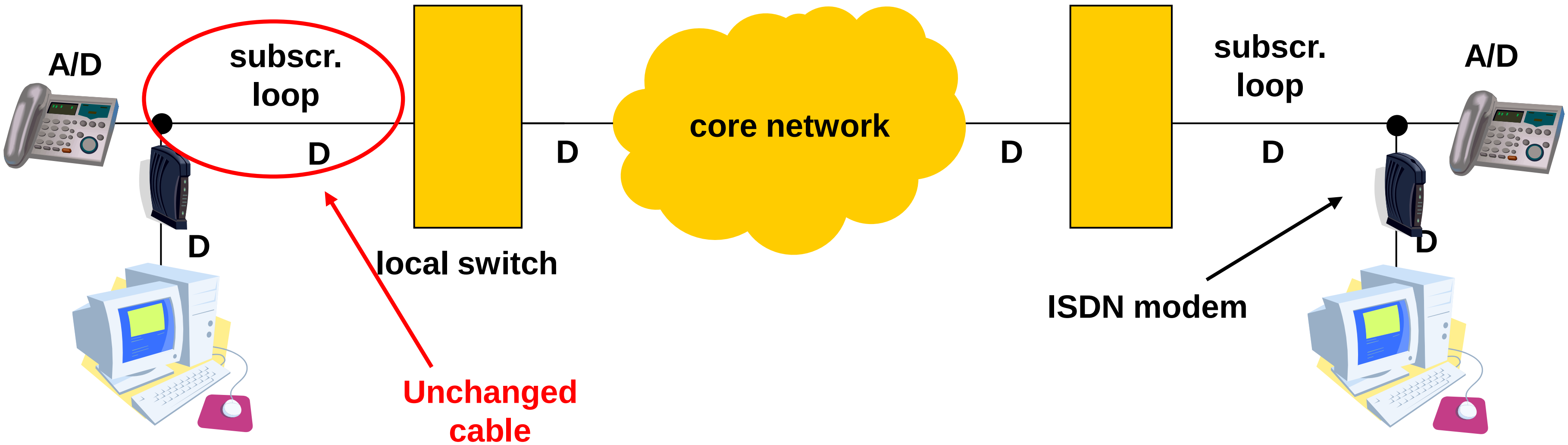
- PSTN data transmission with modems:



- When the core network is digital, the D/A/D/A/D transmission sounds not too good ☹
  - Not effective: 33 kb/s instead of 64 kb/s
- Solution: ISDN – Digital Subscriber Loop

ISDN – digital transmission

- ISDN transmission with modems :



- Data path is digital all along the way!
- Voice codecs in terminals
- **Then, why do we need a modem?**
  - ISDN signalling: connection establishment, release
  - Data transmission interface
    - PC: e.g.. RS-232
    - ISDN: D channels

ISDN implementation

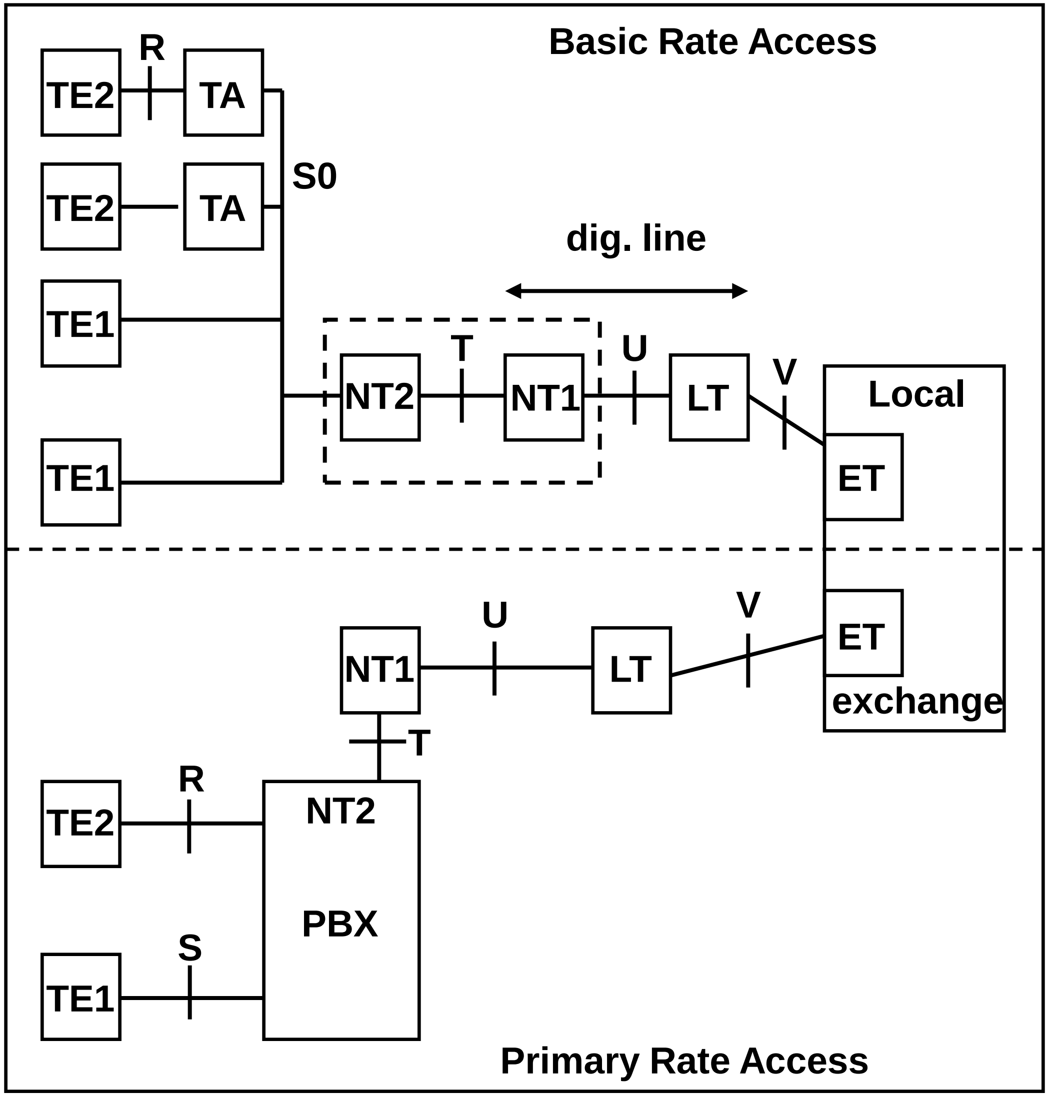
- (Re)usage of the existing copper wire pairs in digital subscr. loops
  - Though only several km, but expensive (copper, lay down,...)
  - Half (!!) of the total cost of a telephony network lays in the copper wires of the subscriber loops!

- Digital transmission instead of analogue
- Speed depends on the number of channels
- Two channel types:
  - **B channel**: 64 kb/s, bidirectional (full duplex), voice OR digital data OR video
  - **D channel**: 16 or 64 kb/s: signalling (e.g. call establishment, release, etc.) 1 D channel is enough for SEVERAL B channels
  - more details later

ISDN implementation

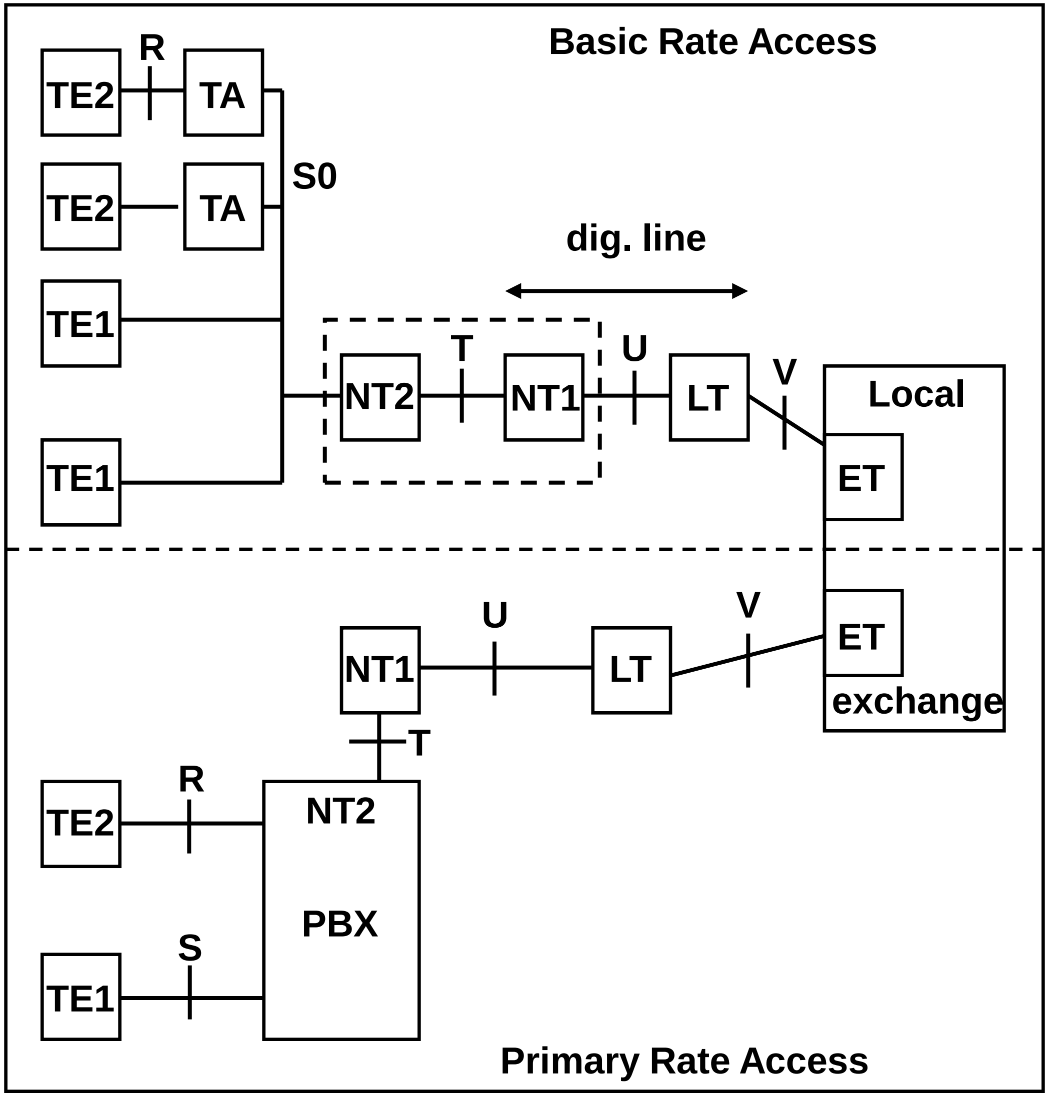
- Allowed combinations:
- 2B+D16: BRA/BRI: Basic Rate Access/Interface,
  - 144 kb/s useful speed
  - on one wire pair – bandwidth of the copper pair is more than enough
  - tipically for individuals / small companies
  - possible combinations:
    - 2 independent voice connections
    - 1 voice + 1 fax
    - 1 voice + 64 kb/s data transfer (e.g. Internet access)
    - 128 kb/s data transfer
    - can be changed dynamically
- 30B+D64 (Eu, 23B+D US): PRA/PRI Primary Rate Access/Interface
  - 1984 kb/s ~2 Mb/s
  - typically on 1, 2 or 3 wire pairs: depending on the quality of wire, length, encoding
  - for large companies, 30 independent channels
  - typically controlled by a P(A)BX

ISDN system architecture



- R, S, T, U, V: reference points
- left from T: subscriber's network – next slide
- **right from T: service provider's network**
- Local exchange
- ET: Exchange Termination,
- LT: Line Termination
- NT1/2: Network Termination
- LT–U interf.–NT1: digital line
  - serv.prov/vendor specific
  - must be replaced by an other line type, that provides the same service but in a different way (e.g. different line encoding)

ISDN system architecture



- TE: Terminal Equipment,
  - TE1: ISDN terminal
  - TE2 PSTN terminal
- TA: Terminal Adapter
- S bus: max 8 terminal, 4 wire, 192 kb/s: 2B+D+48kb/s synchronisation
- P(A)BX: Private (Automatic) Branch eXchange
- NT1+NT2: in BRA no NT2
- in PRA NT2 in PBX

ISDN BRA NT

- BRA NT=NT1+NT2
- But in practice it often provides other features:
  - S_0 bus, but often provides direct connetions for ISDN terminals
  - may contain 1-2 TA to connect analogue equipments (telephone, fax)
  - may contain PC plug-in (RS-232, or USB), so it serves as a modem, too.

S_0 bus

- Speed: 2B + D16 + synchronisation (48 kb/s) = 192 kb/s
- 4 wires
- One end: NT, other end closed by a proper impedancy
- Max. 8 TE can be connected to it
- But terminals can also be connected directly to NT
  - 1 TE: point-point topology
  - more TEs: star topology

Telephone numbers

- Max. 10 tel. number may be assigned to 1 BRA subscription (in Hungary, but this is typical)
- Max. 8 terminals
- We may use max. 2 B channels in parallel
- ...?!
- Simple!
  - TEs are programmed which number they recognize („ring”)
    - In case of an analogue equipment - TA
  - Any (of max. 10) number is called, the message is transmitted to ALL TE
  - That will answer the call, which is programmed for that number
  - Without PBX!
  - (This is the Multiple Subscriber Number (MSN) ISDN service)

ISDN past, present, future

- Enormous technological progress
- in 1990s-2000 that was the „high speed” Internet access for homes/small companies
- But only 10% of the PSTN subscriber lines
  - in Western Europe 25%
- Reasons:
  - most popular supplementary services can be reached nowadays by analogue equipments
    - plus functionalities in switches
    - digital elements in analogue equipments (display, SMS, memory)
  - In 1990s: much more expensive equipments
  - For Internet-access ADSL/cable TV etc. better
  - Because of mobiles - no need for two telephone lines

ISDN past, present, future

- ISDN = dead end?
  - No!
    - > 100 million B channels worldwide
    - network services can be used by analogue equipments
    - ISDN interswitch signalling system is still the universal telecommunications signalling system (chapter 6)
    - provided the basics for GSM networks
  - But: it is the technology of the present and near past, but not of the future

Introduction

- Basics of telecommunication networks
  - Analogue and digital transmission
  - Topological overview of telecomm. networks
  - Numbering
  - ISDN
  - Next Generation Networks

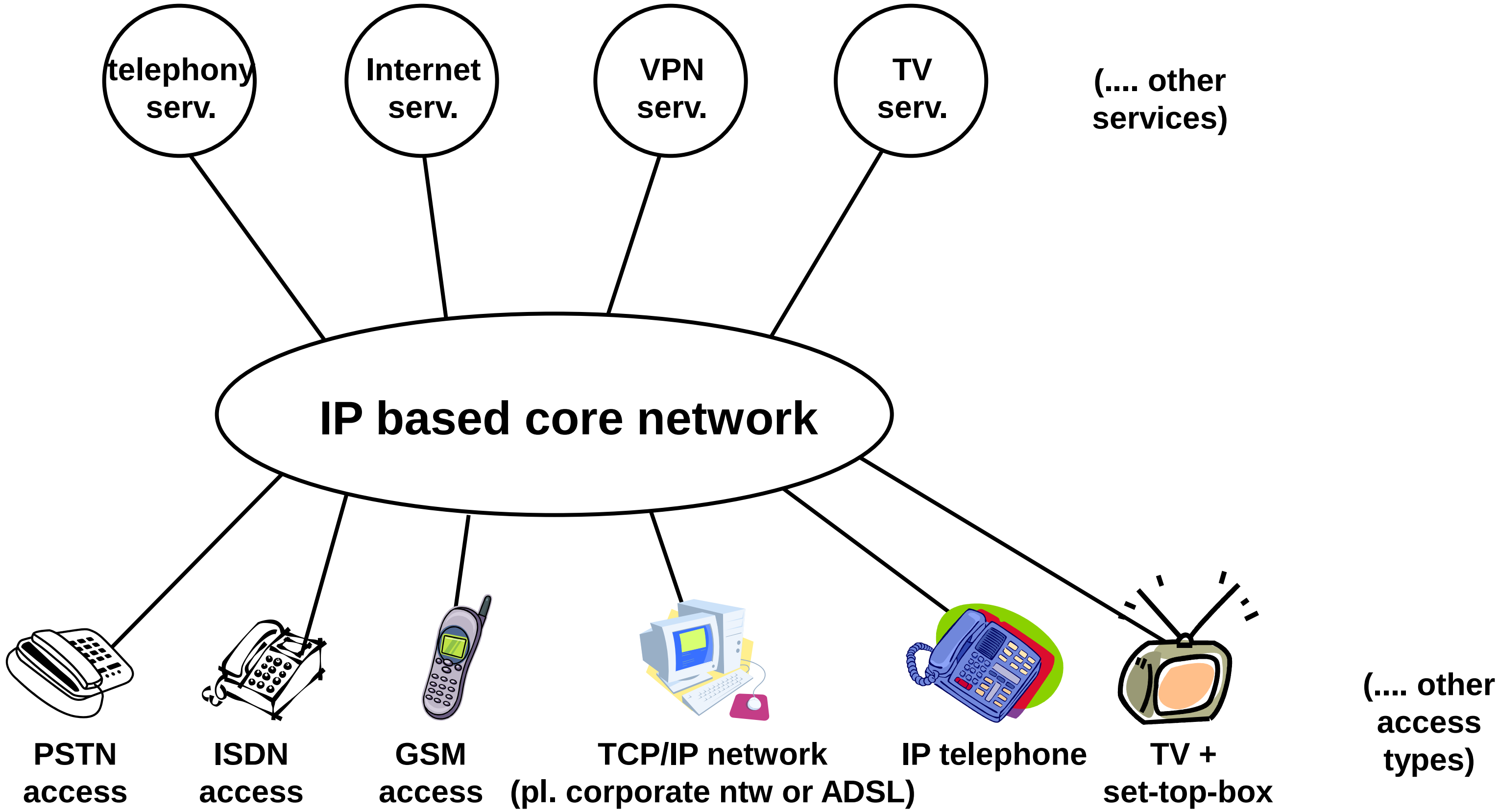
Next Generation Networks

- Next Generation Networks, NGN
- Basic idea: Build a *common* core network to different *services*:
  - voice transmission (telephone)
  - vodeotelephony and other multimedia data transfer
  - television
  - Internet
  - Virtual Private Network, VPN
  - instant messaging (chat)
  - distributed games
  - other, existing and not yet existig services

Next Generation Networks

- These services can be reached from:
  - different terminals
  - different access networks
- But the service is the same
- And for each service
  - same core network (transport network)
  - full IP based („all-IP network”)
- E.g. a telphone call may end on the called party’s:
  - fixed telephone
  - mobile
  - PC
  - PDA through WLAN
  - depending on how the called party has set it
  - independently what the calling party has dialled

NGN architecture



- Application layer separates from transport layer!
- NGN is a concept, and not a concrete techonlogy

Transition to NGN

- This means, that the hierarchical telephone-switch based network becomes obsolate sooner or later
- The transition from the existing networks is not so easy
  - build the NGN network and switch to it at a given moment
    - two networks in parallel during the development of the NGN
  - or the different parts of the existing network is replaced continually
    - also not easy: old and new parts of the network should interwork...
  - different solutions at different service providers
  - leading service providers (BT, France Telecom, ...) predict to finish the transition in 2009-2012
    - that has been started...

Motivation

- NGN:
  - technology allows
    - IP + Ethernet
  - convergence of the different technologies
    - e.g. telephone-computer-television
    - e.g. fix-mobile
  - more flexible architecture, cheaper, more services can be offered
    - e.g. PSTN architecture is not competitive with different VoIP services (skype...)

Reliability

- NGN, Infocommunication = beautiful new world?
- Hope! But:
  - PSTN:
    - Reliable, well-proved technology: switches, core network
    - good maintenance
    - $\Rightarrow$ simple, relatively expensive, but *very reliable services*
  - NGN:
    - new architecture, equipments, protocols
    - wide technology change in a highly important infrastructure
    - (Computer) vendors/products are less reliable as is common in the PSTN/ISDN world
    - IP has a lot of known vulnerable points
    - common architecture is a hard core: if it goes out-of-service it stops every service
    - $\Rightarrow$ cheap and plentiful services, but *will it be reliable enough?*