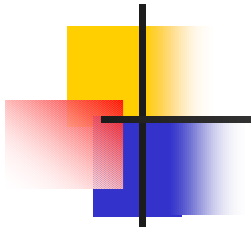
S-72.423 Telecommunication Systems

An Overview to Course Contents



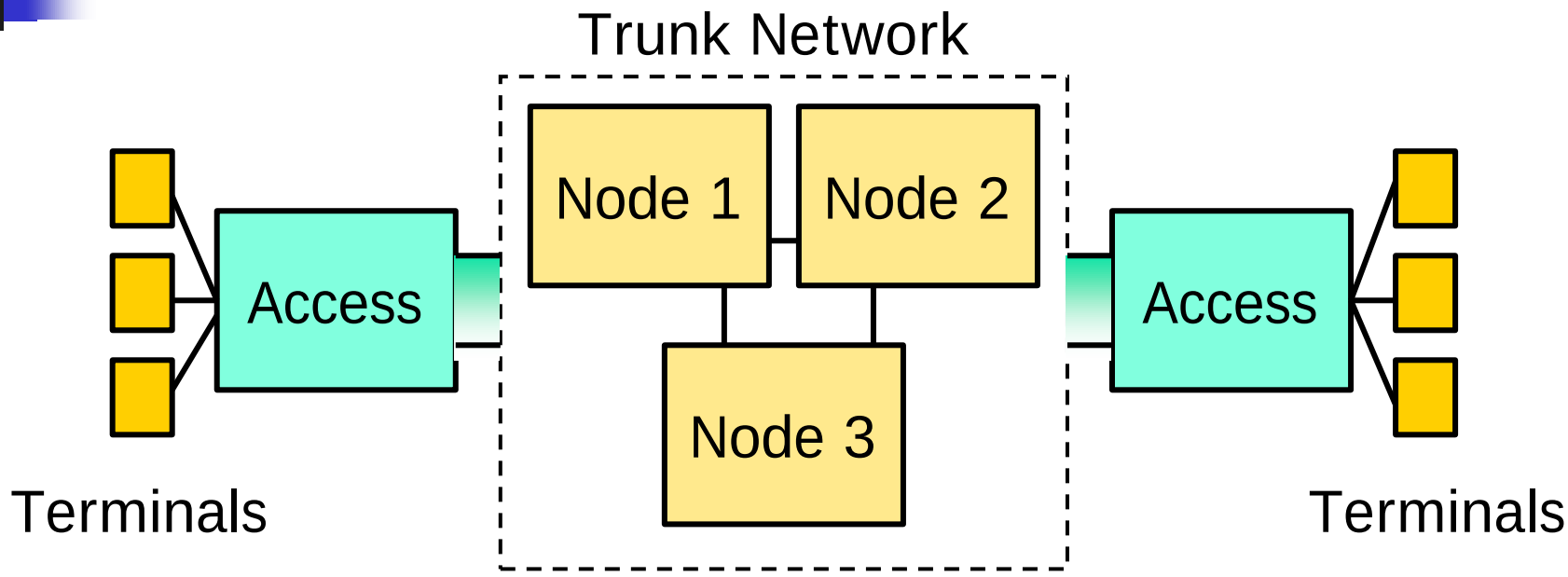
Topics today

- Practicalities
- Table of course contents
- Networking paradigms & networking trends
- Network evolvement
  - Topology
    - divided
    - integrated
    - mobile
  - Telecommunication markets
- Review of course contents in selected topics
  - The OSI-model
  - Networking approaches: PSTN, ISDN, Mobile, Internet
- Future trends

Practicalities

- Lectures (Fridays 12-14 in hall B)
  - Timo Korhonen (09 451 2351)
  - Michael Hall (09 451 2322)
- Tutorials (Wednesdays 14-16 in S1)
  - Mika Nupponen (09 451 5416),
  - Naser Tarhuni (09 451 2362)
- *Textbooks*: Ericsson, Telia: Understanding Telecommunications, Part II, ISBN 91-44-00214-9 (Studentlitteratur), James F. Kurose, Keith W. Ross: Computer Networking (2nd Ed.,Addison Wesley),*Reference:* A.S. Tanenbaum: Computer Networks (4th Ed., Prentice Hall)
- Course grade (**E**+**T***0.15) consists of
  - Closed book **E**xam (0...5, compulsory)
  - **T**utorials (0...5, voluntary)
- Homepage: http://www.comlab.hut.fi/opetus/423

Telecommunication networks have much in common



- Trunk and access parts
- Access part terminated by terminals
- Network nodes and links are optimized for certain assumed traffic patterns
- This model applies for both data (& packet) and voice networks
- Due to these network similarities network analysis carriers common subtopics

Some topics from course contents

- Introduction
- Public Switched Telephone Network (PSTN)
  - Exchange techniques
  - Transmission
- Integrate Services Digital Network (ISDN)
  - Functions
  - Interfaces
- Automatic Transfer Mode (ATM) and Broadband-ISDN
- X.25, Frame relay
- Public land mobile networks
  - GSM
  - WCDMA
- Signaling networks: SS7
- The Internet: Network topology, TCP/IP Suite, Services

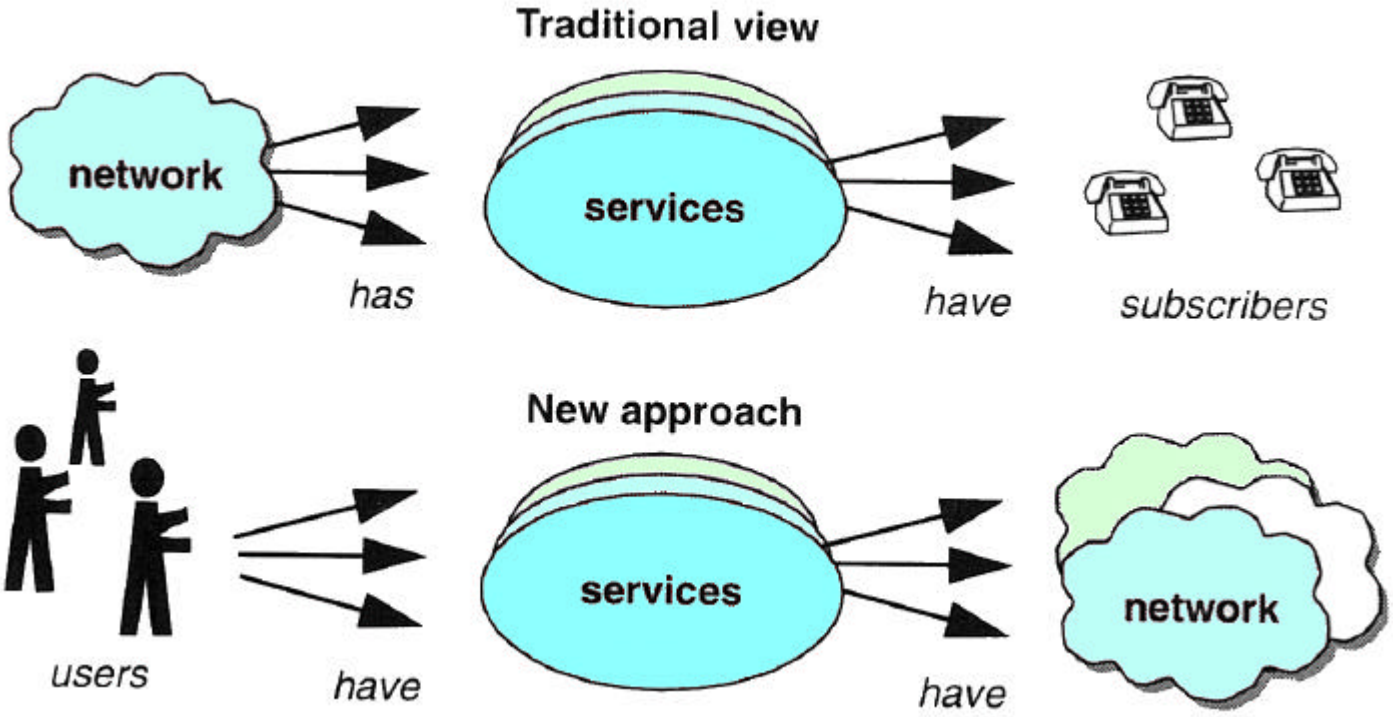
Course contents: Networking subtopics

- User services and terminals (as IN services: call last dialed...)
- Standards (IETF, IEEE, ITU-T ...)
- Routing and switching (unicast - multicast, devices)
- Transmission and links (as fibre, coax-cable.., RSVP*)
- Access and transport (terminals, local-loop techniques..)
- Services (web,mail,ftp ...)
- Signaling (SS7**, X.25, Frame relay ...)
- Network management (as OMAP of SS7...)
- Interworking between networks (gateways, bridges ...)
- Network planning

*Sets up resources in routers
**Signaling in ISDN

IN: Intelligent Network
IETF: Internet Engineering Task Force
IEEE: the Institute of Electrical and Electronics Engineers, Inc
RSVP: Resource ReSerVation Protocol
ITU: International Telecommunications Union
SS7: Signaling System 7
OMAP: Operation and Maintenance Application Part

Paradigm shift

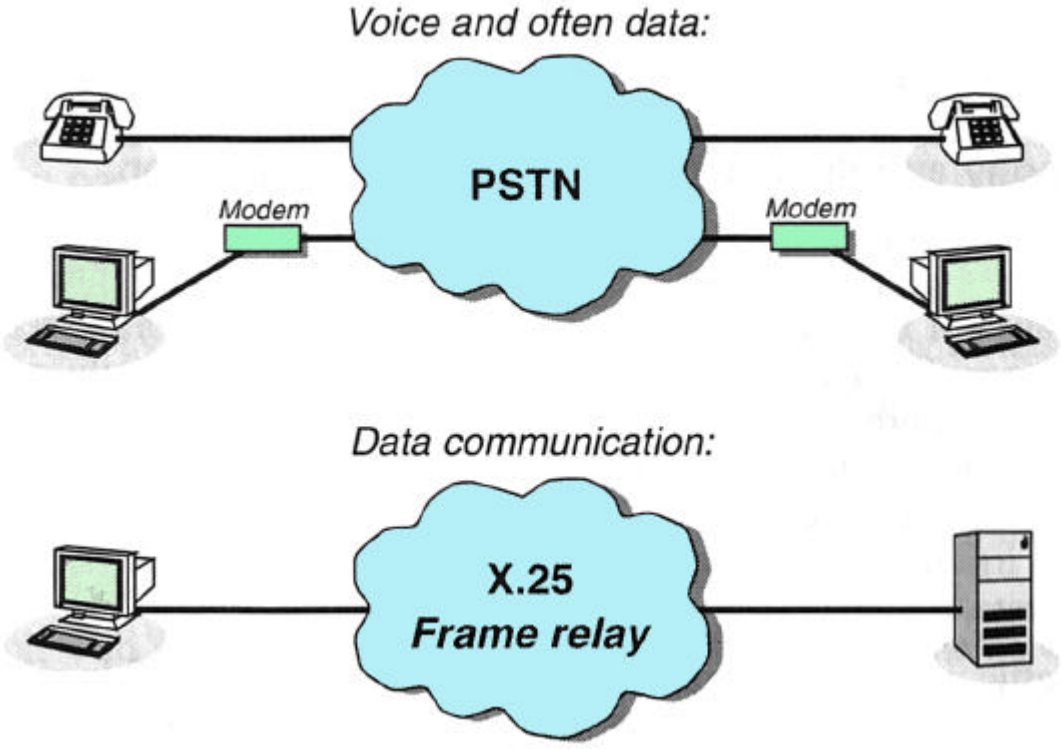


Network evolvement

- Most people have observed that a telecommunications network is a system transmitting the messages (even SMS) ... In this course we focus on analyzing that the networks can be divide to ...

Data and voice networks

Divided networks



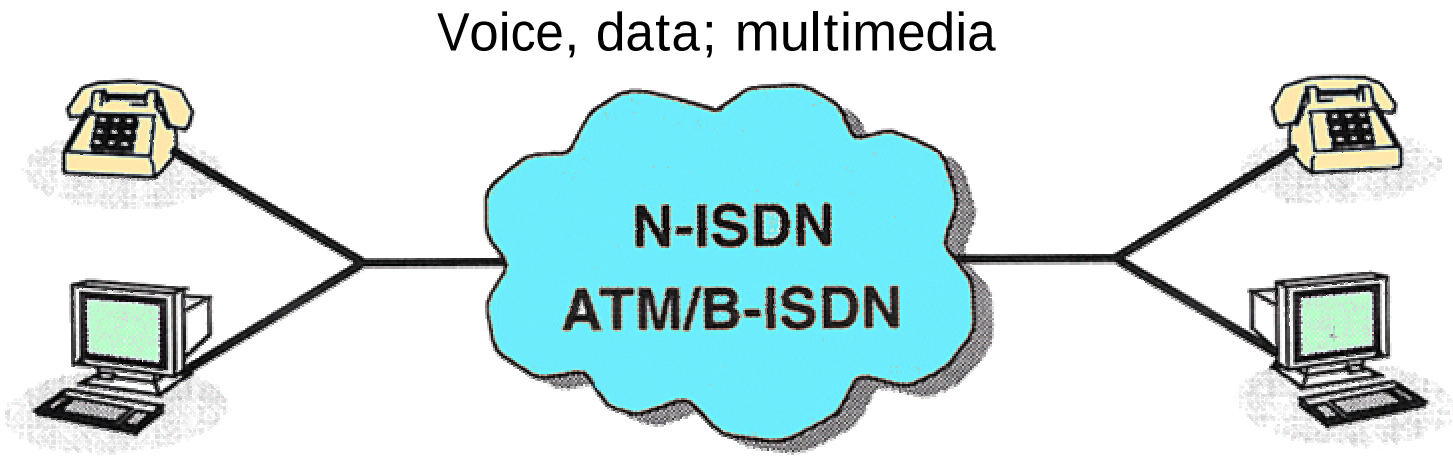
Frame relay:
- virtual circuits
- used to connect two LANs
- compromises in error correction & flow control
- for high quality links
- rates: 2-50 Mb/s

Frame Flow Control:
- service for a pair of communicating entities
- reassures non-over-whelming comms. (not too many packets)

- Nodes, links & layers with well defined (standardized) interfaces
- Network is optimized for certain, assumed traffic
- Traditional assumption: Voice and data services in different networks - problem: Internet carries nowadays both!

Integrated Services Digital Network (ISDN)

Merged networks



- Modern PSTN exchanges apply ISDN technology (common user interface 64 kb/s...2 Mb/s)
- ISDN and its broadband version B-ISDN (up to 100Mb/s) support data communications also for future PLMNs
- Differentiated services: Transportation system differentiated into constant rate, real-time and higher-latency

ATM: Asynchronous Transfer Mode PLMN: Public Land Mobile Network

UMTS and Differentiated Services

- UMTS supports wide range of applications that posses different quality of service (QoS) requirements.
- Applications and services can be divided to different groups, depending on QoS requirements. Four traffic classes can been identified:
  - Conversational class (very delay-sensitive traffic)
  - Streaming class
  - Interactive class
  - Background class (the most delay insensitive)
- Hence TCP (Connection-oriented transport-layer) is not always applied - one may use also UDP (Connectionless transport-layer protocol) - Why?

Network/service adaptivity

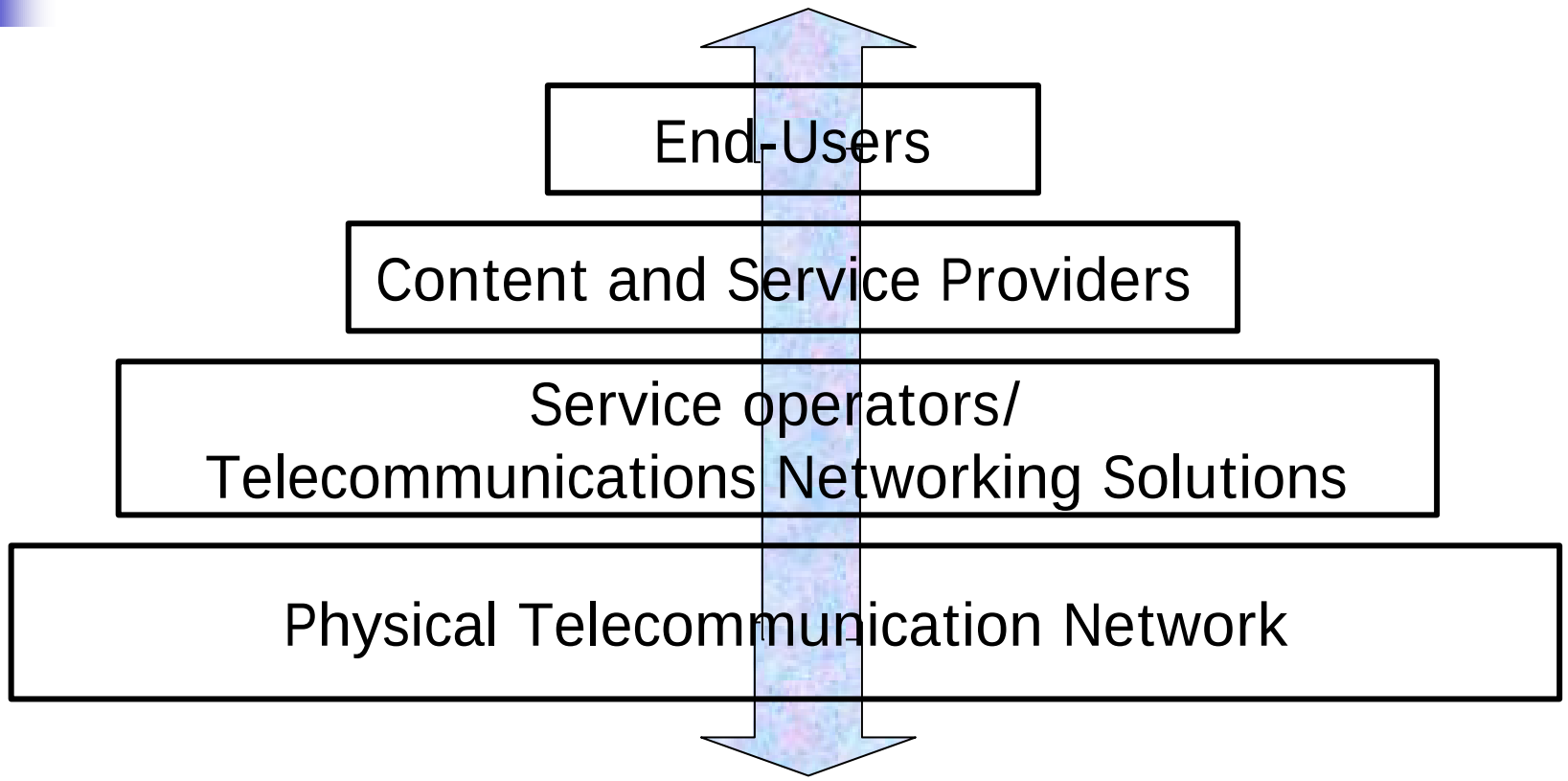
- Services manifest themselves via various customer profiles (that may differ within a short time period), and thus efficient adaptivity should be supported by network configurations
- Advanced networks have a tendency to carry intelligence in terminals (and not in exchanges)
  - Reduces signaling traffic
  - Moves costs to end-users
- IN (Intelligent Network) solutions developed first for PSTN but a typical important part of most networks as in PLMNs
  - Enables service flexibility in exchanges (software radio does the same in terminals)
  - IN services designed in cooperation with terminal intelligence

Public Land Mobile Networks (PLMN)

- **Mobility is required** practically for all services in the very near future!
- In this course we will discuss especially the **GSM** (Global System for Mobile communications) (9.6 kbit/s++) and **WCDMA** (Wideband Code Division Multiple Access, or UMTS) networks
- UMTS will be launched 2002-2003 yielding mobile data rates up to 2 Mb/s. However, the GSM network will be upgraded for higher rates thanks to
  - **GPRS** (General Packet Switched Data),
  - **HSCSD** (High Speed Circuit Switched Data) and
  - **EDGE** (Enhanced Data Rates for GSM Evolution)

2G +

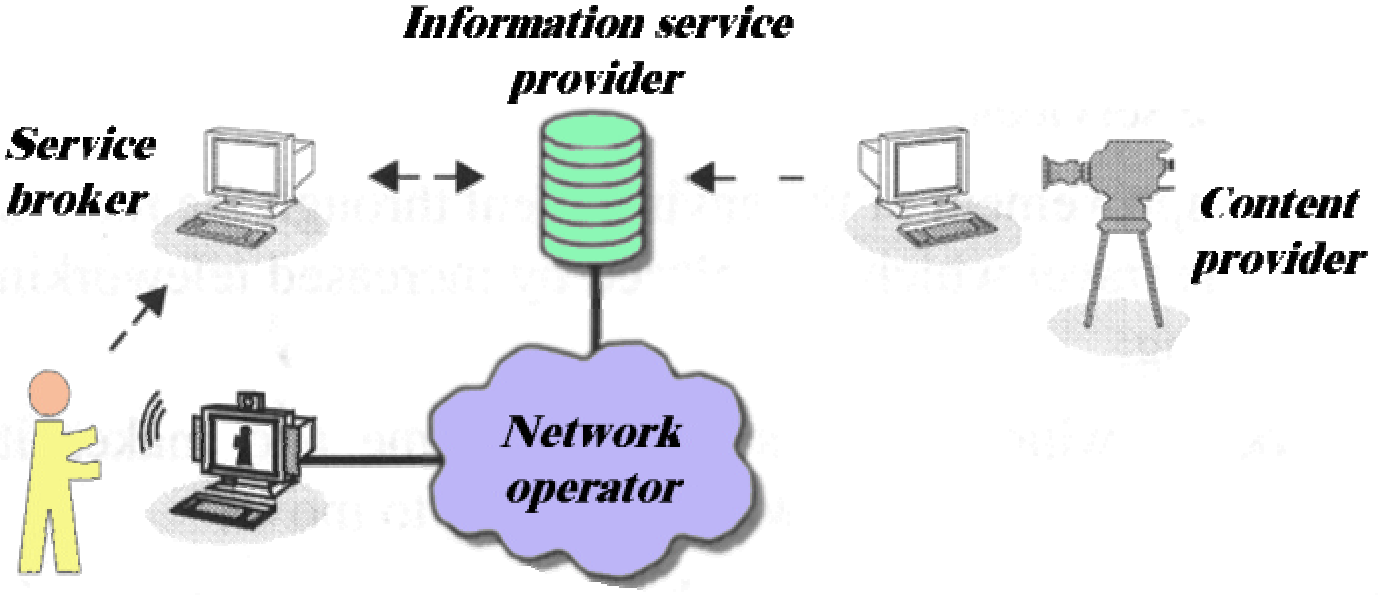
Telecomm market players



- Telecommunication network content and technology producers, operators and consumers form an interoperable hierarchy

Telecomm market players

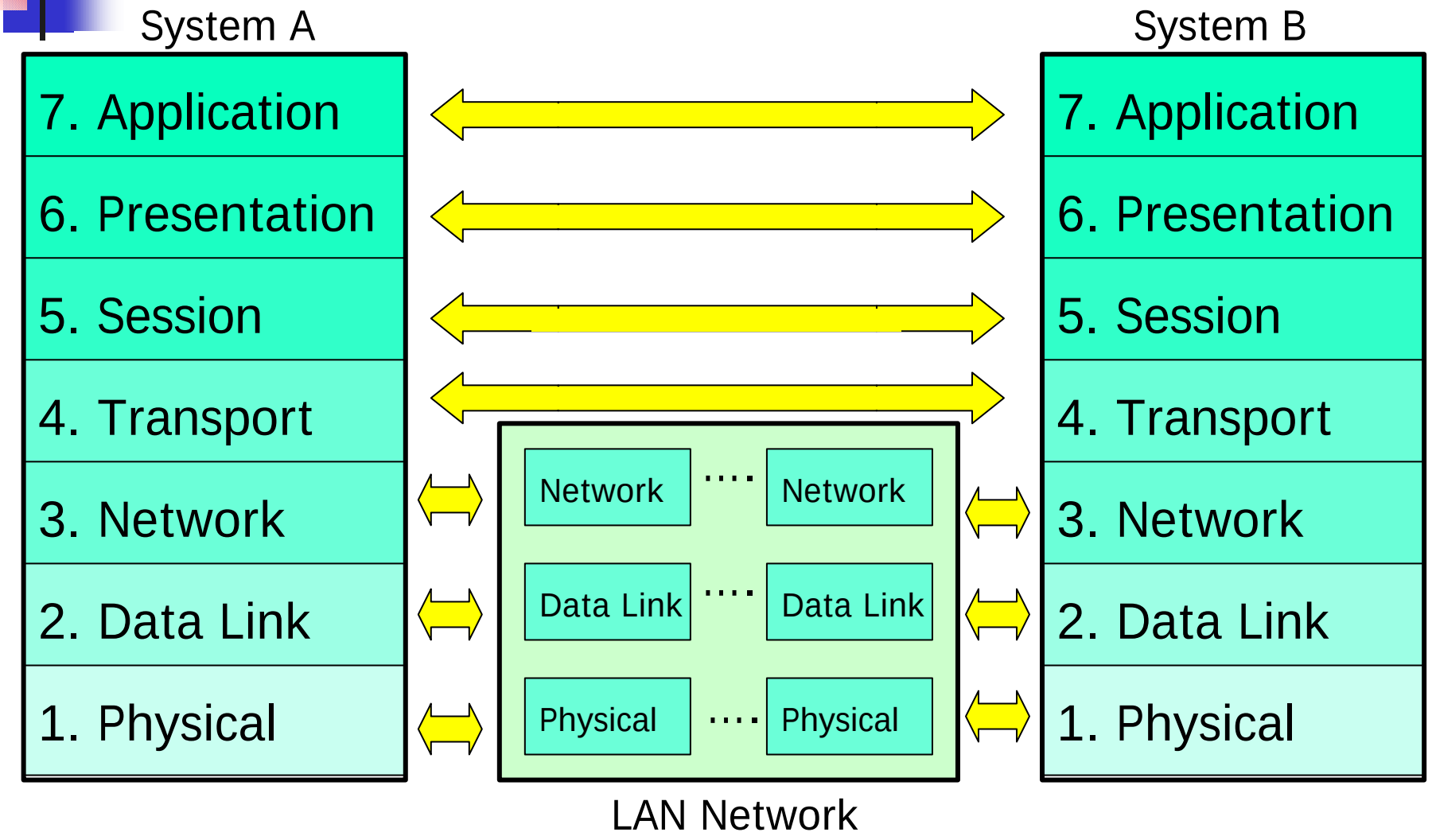
- **End-users** (individuals , companies, machine-to-machine communications)
- Information **service providers** (As a telephone catalog services designed by a company, giving telephone numbers when you give a name or an address)
- **Service brokers** sell dedicated service packages (as MySAP)
- Network **operators** (as Elisa, Telia, or Radiolinja)
- **Content providers** (as Paramount Pictures)



Telecom services categorized B2C, B2B, P2P

Category	Important application
Communications	teleworking, multimedia, mail
Knowledge	distance education, database retrievals
Entertainment	games etc. (getting increasingly important!)
Information	Marketing, yellow pages, catalogues
Service	home shopping and banking, telemedicine
Remote control/remote supervision	Automation applications

The ISO-OSI Model



OSI: Open System Interconnections
ISO: International Organization for Standardization

The OSI-functions

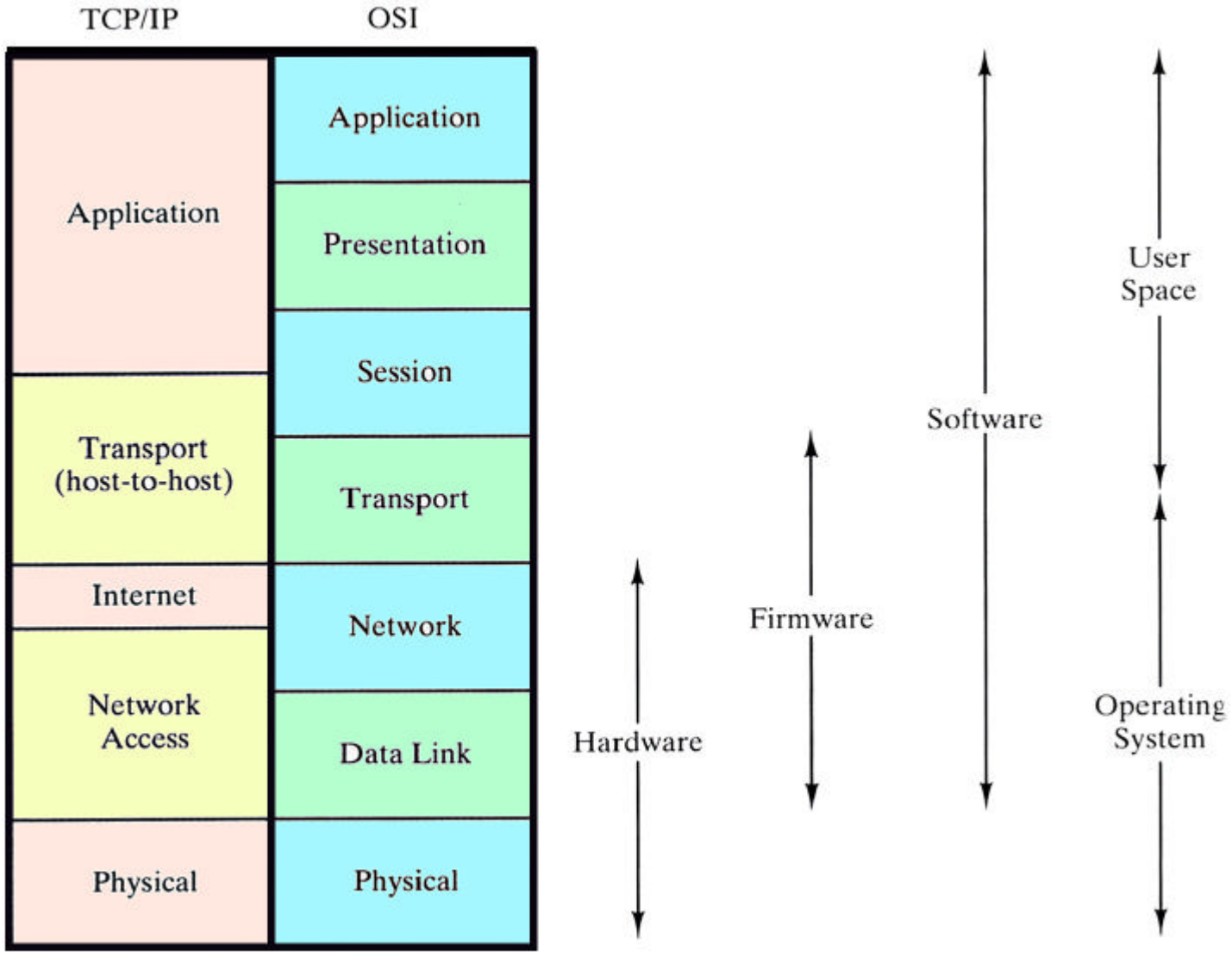
7. Application	User access to OSI environment applications
6. Presentation	Provides independence of applications from differences in data presentations
5. Session	Establishing, managing and termination connections (sessions) between cooperating applications
4. Transport	Provides reliable, transparent data transfer for lower level data segments or blocks
3. Network	Gives routing service for transport layer. Layer of routers.
2. Data Link	Sends data blocks with synchronization, error and flow control for end-to-end connections*. Layer of bridges.
1. Physical	Transforms electrical signal into bits. In local networks standardized by 802.x standard. Layer or repeaters

Gateway Layers

LAN Layers

*For instance in a classroom of workstations

Practical networks usually melt OSI

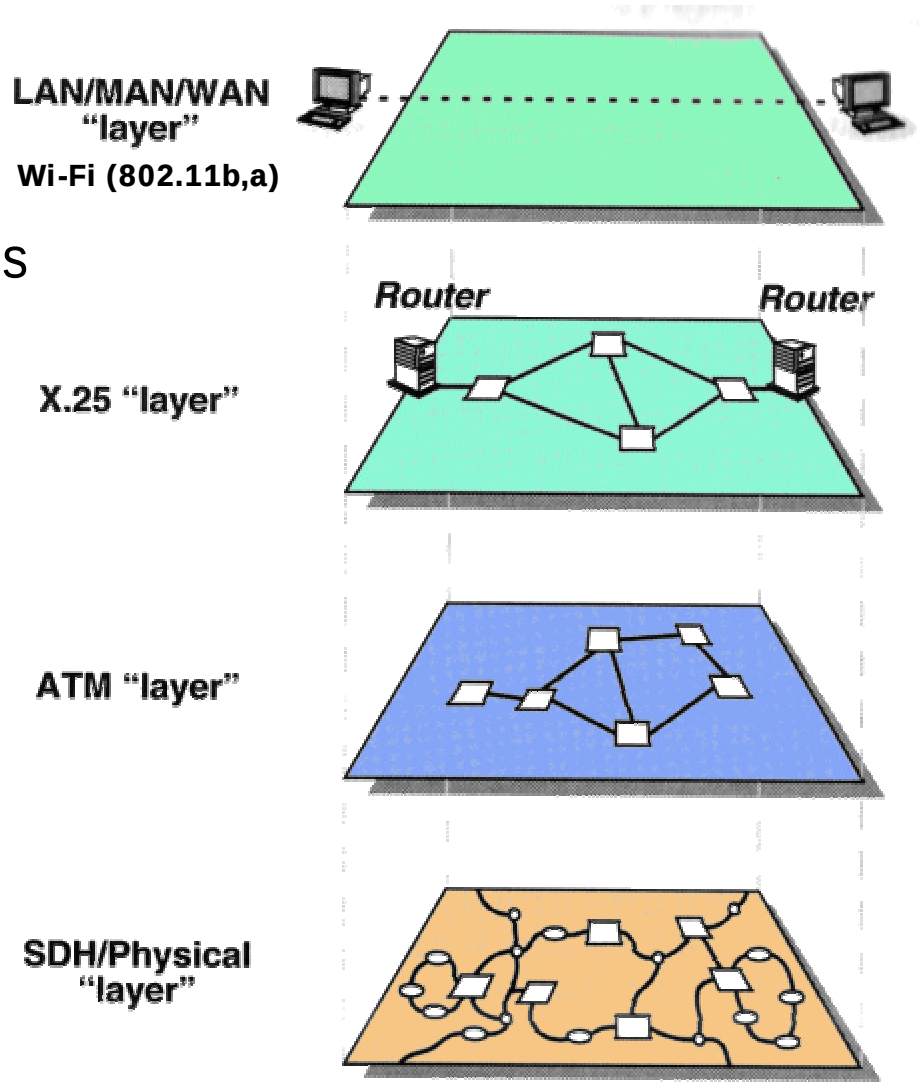


Each OSI-layer has its standardized services

7. Application	NCP, FTP, Telnet, SMTP, SNMP, LAT, AFP, SMB...
6. Presentation	SNA Presentation services
5. Session	NetBIOS, NetBEUI, DNS, ...
4. Transport	SPX, PEP, TCP, UDP, NSP...
3. Network	IPX, RIP, SAP, IDP, IP, ARP, RARP, ICMP, X.25, RIP...
2. Data Link	IEEE 802.X, ANSI X3T9.5, SMT,...
1. Physical	V.24, V.35, V.90, 10Base5, 10Base2, 10BaseT, FDDI, SDH, G.703...

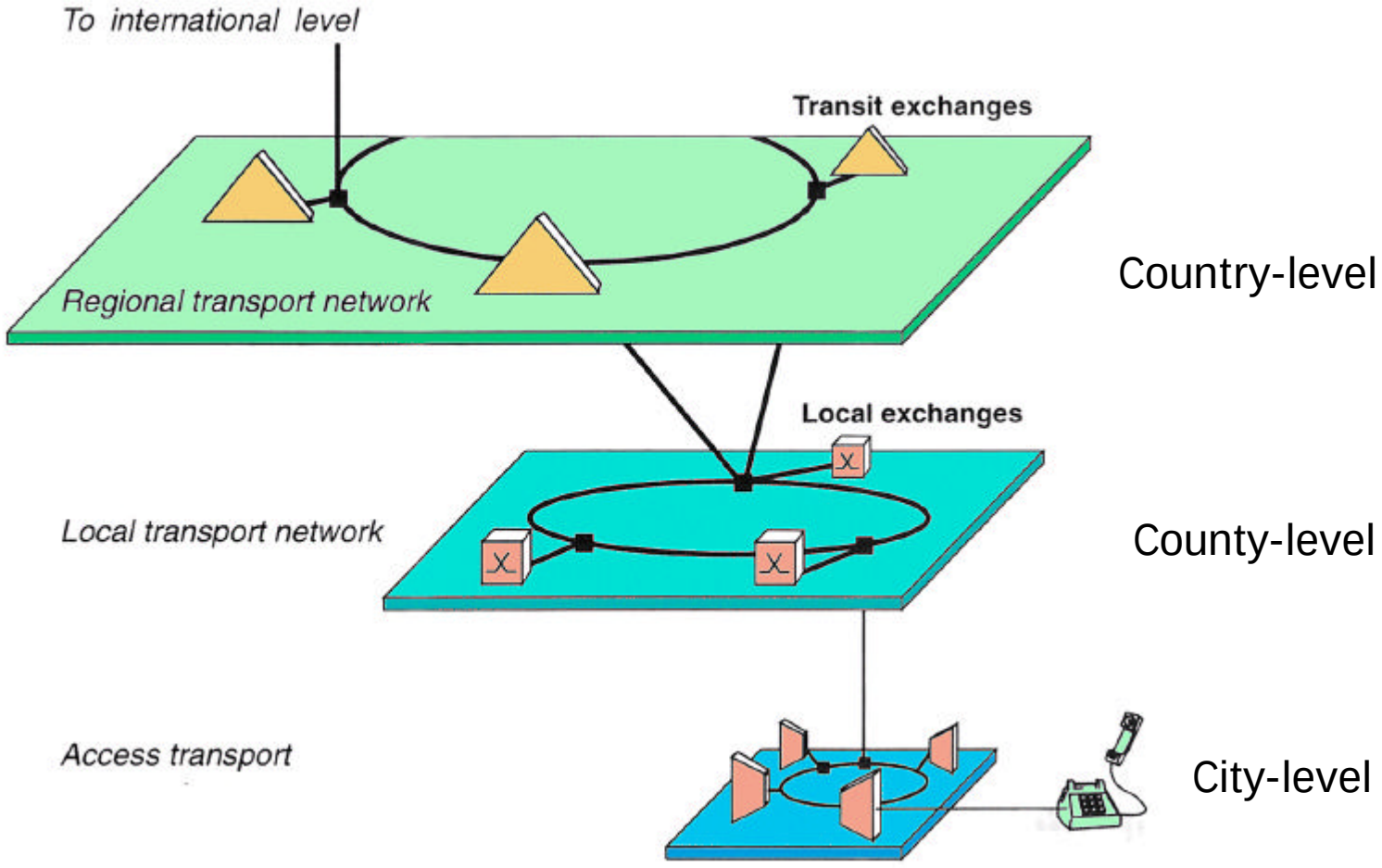
Practical network stratums

- OSI is seldom realized as itself but several layers are melted together into stratums
- In this example X.25 packet network operates on ATM based SDH access stratums.
- ATM forms an efficient info pipe (virtual circuits) where no address checking or error correction is done but it is left for lower layers

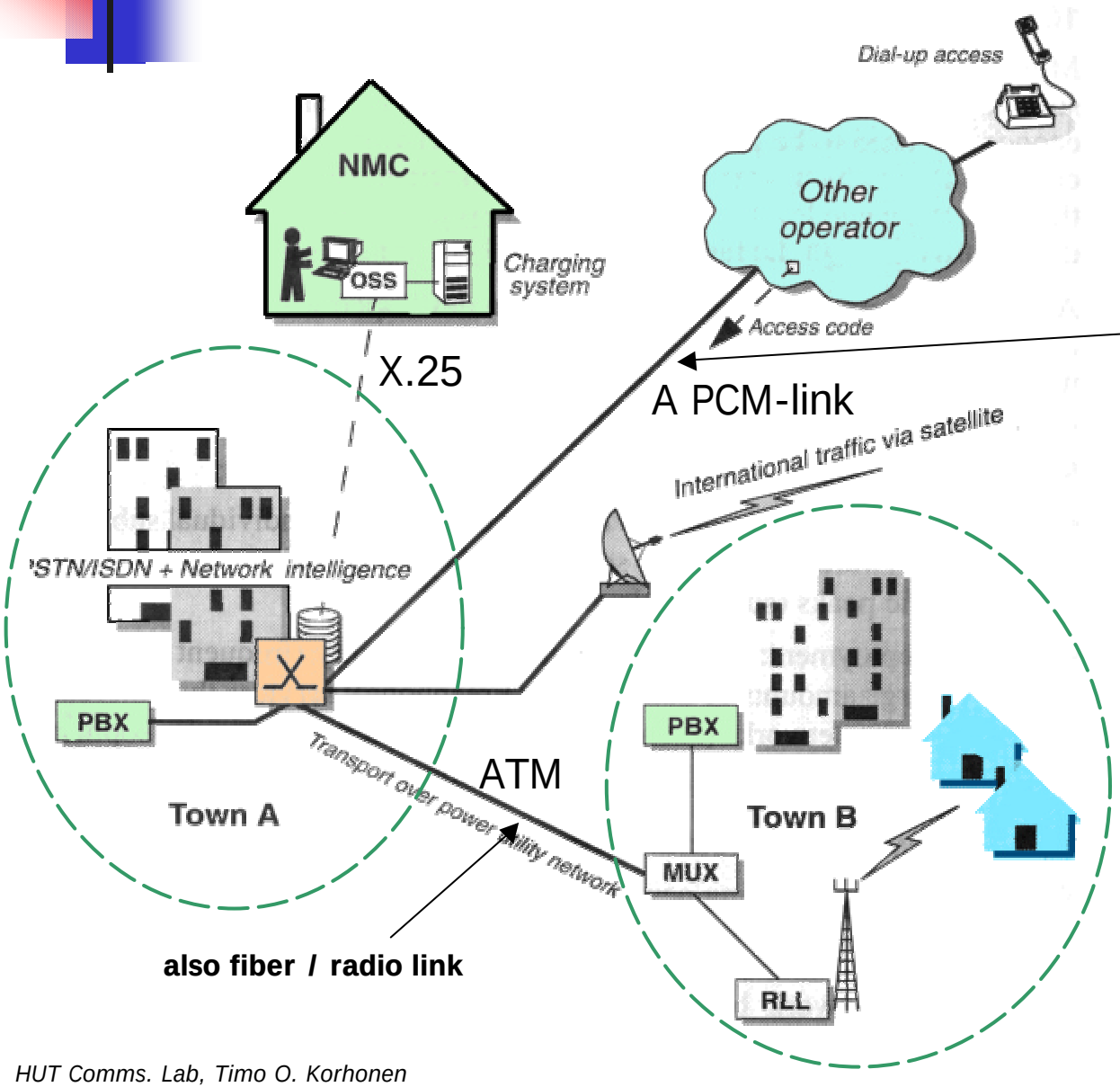


The PSTN hierarchy

- Since ‘96, all the exchanges of PSTN have been digital in Finland
- However, there still exists analog phones
- Natural connection to the modern PSTN is the ISDN-interface



Example: Network architecture for new operators: PSTN Network operator in two towns



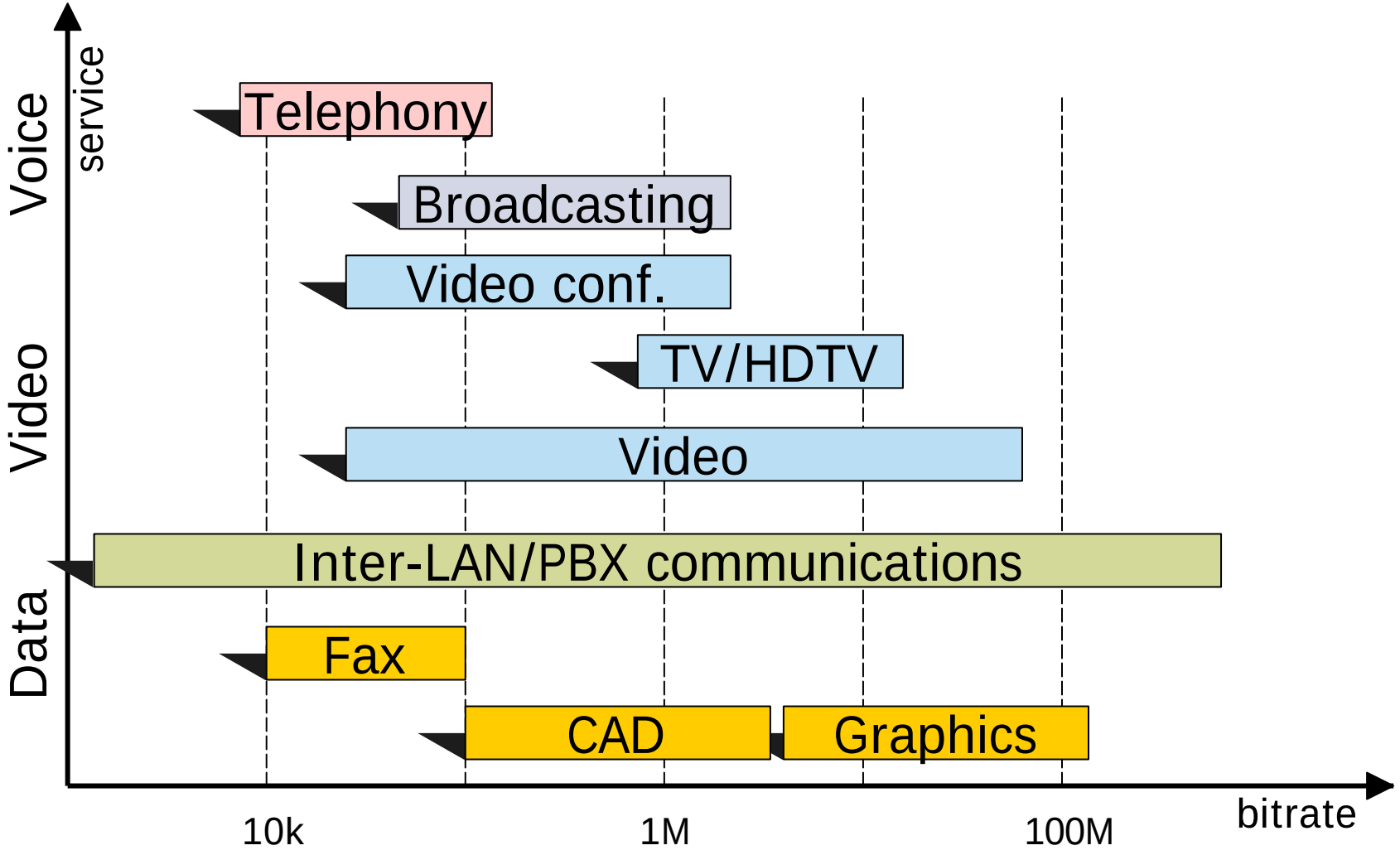
- New operator requires:
  Subscriber database, charging,
  O&M (own switch)
- Note that by *dial-up networking* (using special access code) part of local exchange capacity is allocated for the new operator

OSS: Operations Support System
NMC: Network Maintenance Center
RLL: Radio in the Local Loop
MUX: multiplexer
PBX: Private Branch Exchange

Telecommunications service requirements from the physical level: QoS

- Networking requirements: What services require from the network in respect of
  - Bandwidth,
  - Burstiness,
  - Symmetry (uplink /downlink rates),
  - Bit errors and blocking
  - Delay
  - Security
- These define QOS (Quality of Service)

Different services require different rates

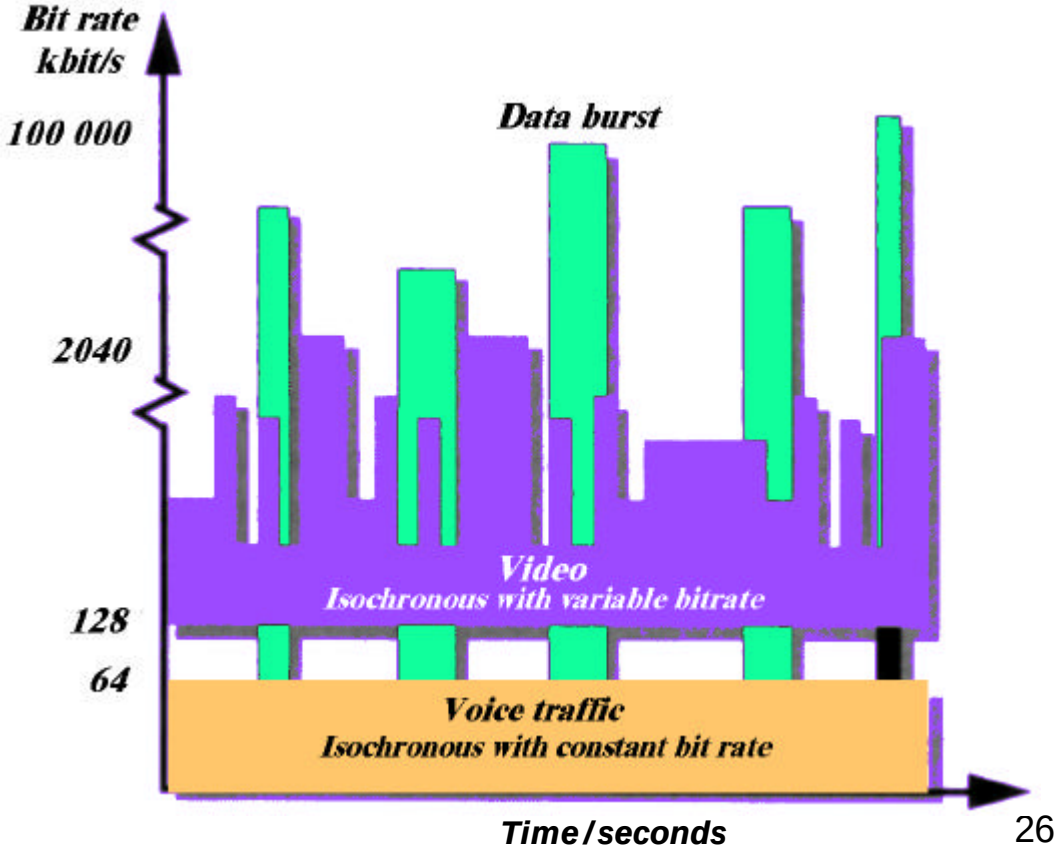


Burstiness: video, voice, data

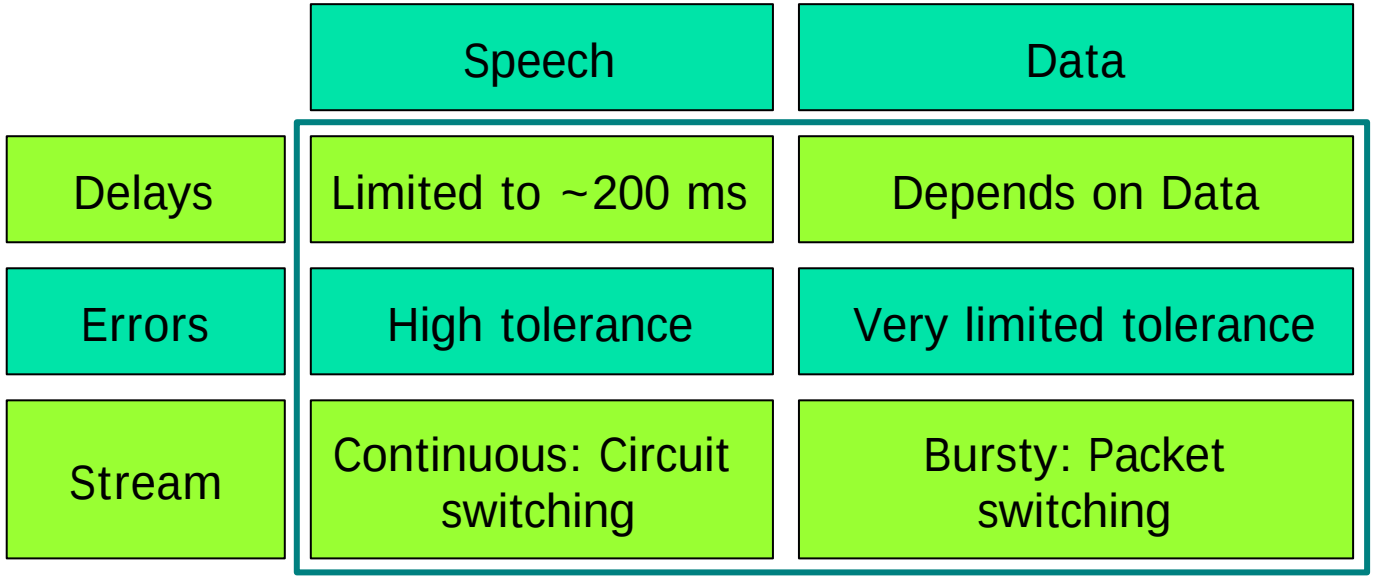
- Different services (telecomm. traffic) require different networking abilities
- Most real-life sources produce bursty traffic
- Modern networks can adapt into bursty service by allocation capacity very rapidly for other users

Bursty traffic:

- Human speech
- Video and multimedia sources
- Data bursts in a packet network



Speech and data communications



- Teletraffic can be forced to fixed rate or bandwidth as speech in PSTN or in ATM traffic

Bit errors and blocking

- Real-time services for video and audio
  - Can not tolerate delays clearly observable by human (in order 200 ms or larger)
  - Can tolerate relatively large error rates
  - Blocking probability depends on number of customers in a service area
- Fixed rate data services require much non-reusable capacity:
  - Fixed delay
  - demanding error rate limit
- High-latency data:
  - Large flexibility in delay
  - demanding error rate limit

Symmetry

- Categories:
  - **Symmetrical channel** as in fixed line telephony
  - **Asymmetrical channel**
    - Most technical Internet realizations (As xDSL-techniques or data over DVB, ADSL: 64 kb/s DL, 256 kb/s and up UL) are based on idea that downlink traffic is much larger that uplink traffic (in Welho® (by HTV) connections 525 kb/s DL, 120 kb/s UL)
  - **Point-to-multipoint** channel
    - TV and Fax are point-to-multipoint distributive services
- Note, however that some **new P2P (peer-to-peer) services** in Internet (where your PC works as a server, using Gnutella network) might require symmetrical traffic channel
- Also Internet is used for **point-to-multipoint (multicast)** services as in Webcasting (as in Web-broadcasting or in the PointCast news service.)
- Rapidly developing Internet services set stringent requirements for network infrastructure & planning (flexibility & upgradability)

Security and secrecy*

- Services require usually security & secrecy, e. g. reliable, shielded transfer. Especially for
  - rescue services
  - police
  - defense force
  - some special applications as telesurgery
- Networks can provide this by using:
  - fixed lines (PSTN, frame relay)
  - flexible routing (SS7)
  - scrambling or encryption (PLMNs)
  - coding or ciphering (in all modern telecom links & nets)
- Often reassured in several network levels

*
- Message goes to the right receiver
- Others can not do eavesdropping

Public switched telephone network (PSTN)

- The oldest (1876) bearer network (other: ISDN, ATM, frame relay, The Internet)
- After 1960 has got many renovations: data, fax, processor exchanges, PCM, satellite communications, network intelligence
- Primary characteristics
  - Analog access 300-3400 Hz
  - Circuit switched connection
  - Switched bandwidth 64 kbit/s (Digital exchanges)
  - Immobility (or limited mobility as in DECT=PABX RF-interface)
  - Integrated nowadays especially with N-ISDN

The PSTN (cont.)

- The PSTN is optimized for fixed speech service, statistically distributed, analog subscribers (by using the circuit switching technology that was made available beginning of this century).
- Support for data traffic "artificially added" by
  - modems
  - ISDN (integrated into exchanges)
  - xDSL (x digital subscriber line)
- However, PSTN is
  - Easily congested when subscriber services (or behavior) changes unexpectedly (no graceful degradation as in CDMA-PLMN): resource wasting

The PSTN (cont.)

- Vulnerable: network paralyzed easily in exchange malfunctions (still parallel system(s) provided)
- Network intelligence in exchanges and dummy terminals
- Poor adaptivity
- However, an important backbone for other networks!

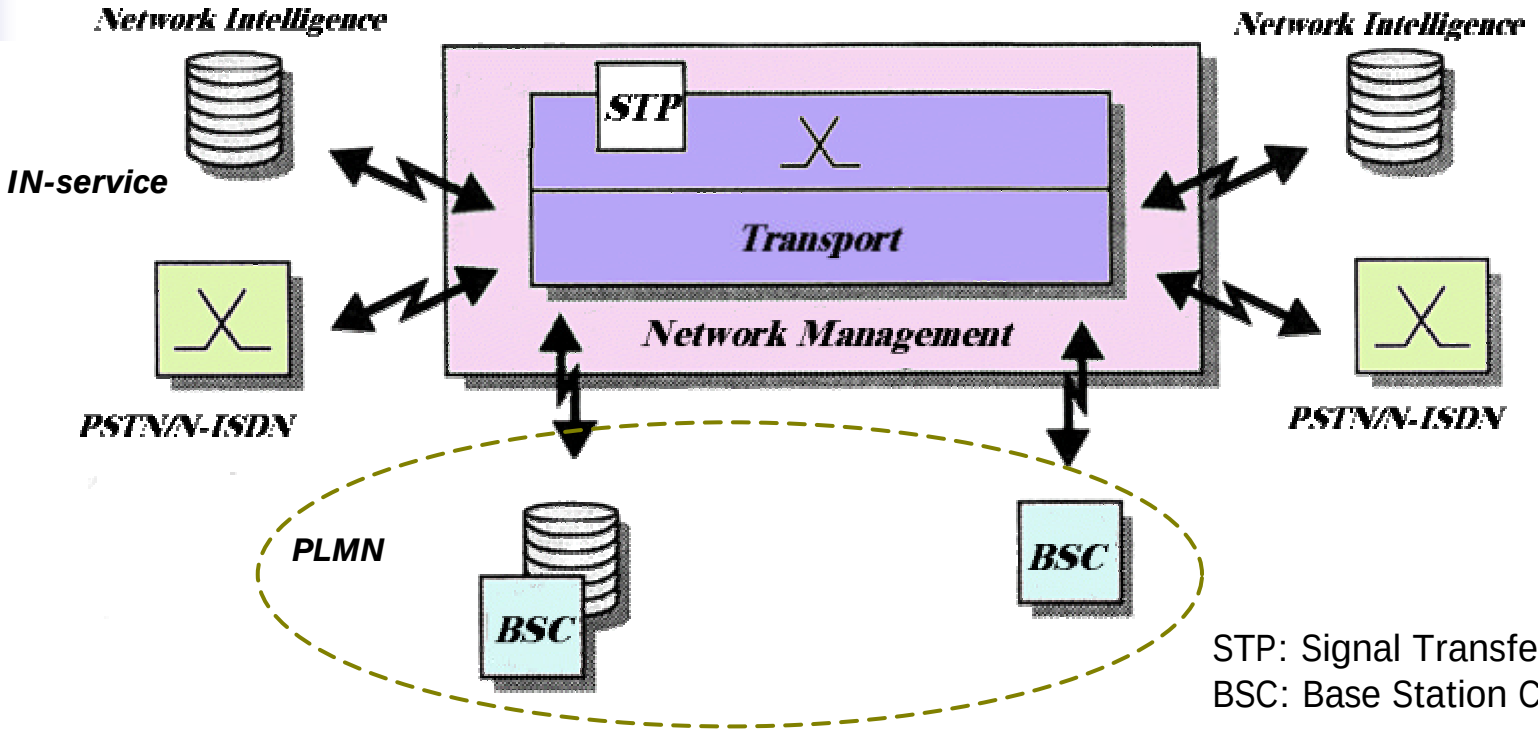
- The PSTN will be there for a long time and it seems that it can be used for modern day networking also on quite high data rates by using various extension techniques
- Modern day networks are constructed thus that the required services can be supported: Thus

Services shape the modern networks!

Integrated Services Data Network (ISDN)

- In N-ISDN (narrow band 2x64 kb/s +16 kb/s, extendable up to 30x64=1.92 Mb/s), B-ISDN (rates exceeding 100 Mb/s) and ATM (asynchronous transfer mode) networks all services are handled integrated, circuit switched way.
- Mobility enabled by DECT (Digital Enhanced Cordless Telecommunications)
- Nowadays there exists many competitive techniques for ISDN as
  - Cable modems,
  - ISM -band (Industry, Science, Medicine) LANs (as Wi-Fi, HiperLAN I & II,)
  - Digital satellite networking by DVB (SAS Astra®)
  - WCDMA
  - PSTN with 56 kbit/s (V.90) technology

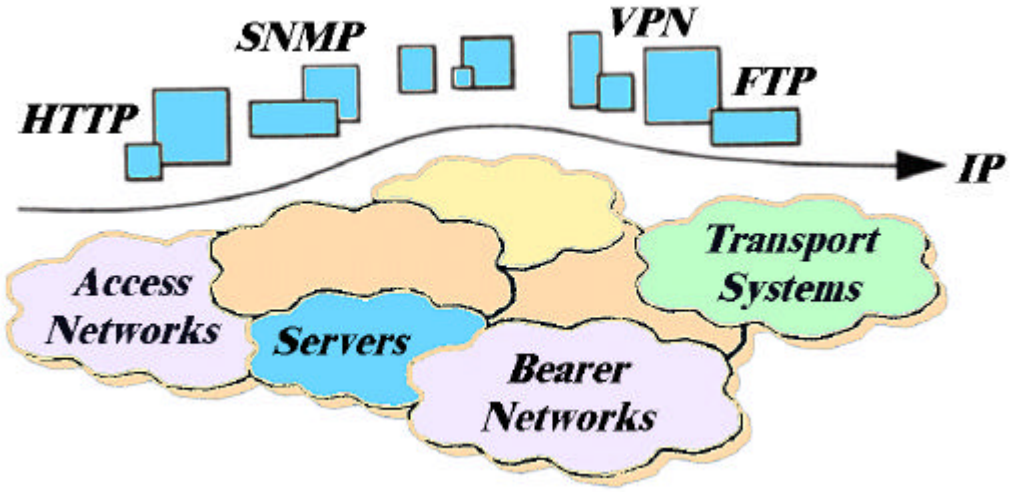
Signaling networks



STP: Signal Transfer Point
BSC: Base Station Controller

- Telecom nets require more and more processor capacity:
  - More subscribers
  - Setting up connection is getting increasingly complex
  - Number of supplementary services increasing
- Thus the need to transmit signaling information (=interactive network telematic communication) is increasing

The Internet(*working*)



- The Internet carries “Everything over any physical medium” but still by following the 'best effort’-principle = no service quality guaranteed!
- Internet topics in this course:
  - TCP/IP: Frames and sessions
  - Routing: Backbone connected subnets
  - Network planning: Core - Regional nets - Access nets - Users
  - Signaling: TCP client – server communications
  - Services: http, ftp, email, irc, news, telnet ….
  - Internetworking (!) for instance data over PSTN: PPP, SLIP

PSTN: Public Switched Telephone Network, PPP:Point-to-Point Protocol:
SLIP: Serial line IP

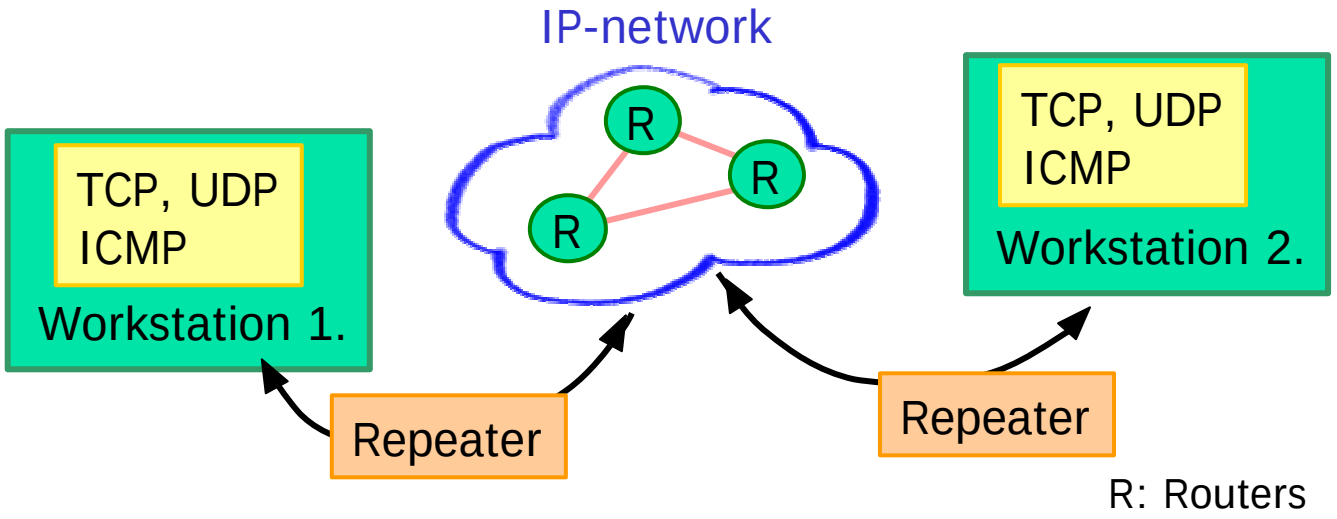
TCP/IP: Transmission Control Protocol Internet Protocol: a distributed triumph

- The first Internet was ARPANET in 1969's with four nodes
- Present TCP/IP version 4 has problems especially in
  - Quality or Service (QoS)
  - lacking of address capacity
  - security
- In 1997 ipV6 was initiated - However not too much used yet due to compatibility problems
- TCP/IP does not have any general advance (except that it is so widespread) when compared to IPX, AppleTalk, DECnet etc.

TCP/IP Network architecture

- Essential high level network functions
  - routing management
  - name servers
  - network management protocols
- Network consists of
  - hardware as workstations, networks, routers, bridges
  - software as applications and protocols

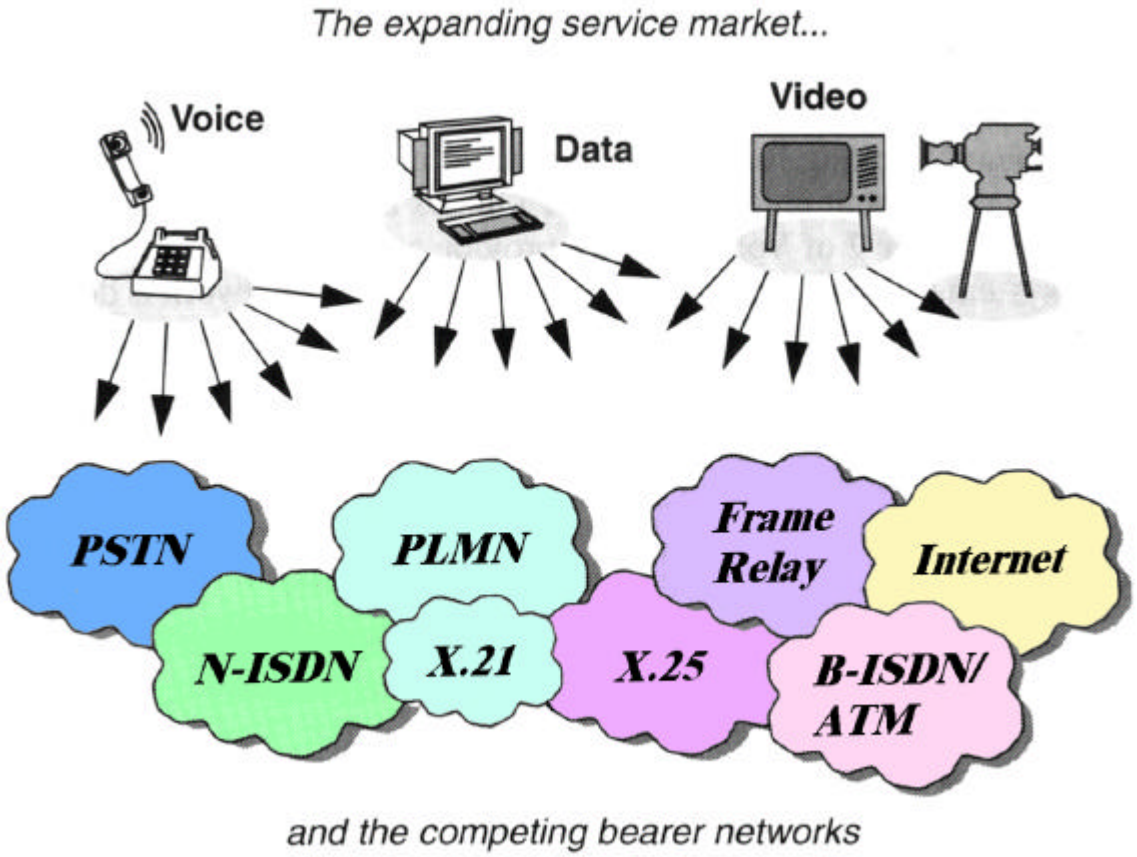
TCP/IP Network transmission



- TPC/IP tasks: end-to-end transmission, error correction, maintain packet order
- Internet is based on datagrams that address subnets via routers
- A simple routing could be accomplished by a lookup table between target IP and subnet IP

UDP: User Datagram Protocol, downgraded TCP/IP for good quality connections
ICMP: Internet Control Message Protocol, testing usage

The playground of telecommunications markets



- The expanding service markets and the competing bearer networks form an interesting playground!

Future trends

- Inter(net)working between networks increases
- PLMNs and especially wireless LANs develop very fast in home & office networks
- Increasing data rates
- Traffic gets more symmetrical
- PSTN:
  - Is used to transfer more and more data traffic
  - Traditional voice service of PSTN uses packets (for instance by SLIP) and moves to Internet
- Also data networks (as Frame Relay) will be used for voice and there is a strong tendency to put everything over IP

PLMN: Public Land Mobile Network, IP:Internet Protocol
SLIP: Serial line IP

Web resources

- xDSL: www.adsl.com
- 3:rd generation PLMN: www.w3.org, www.3gpp.org
- Telehallintokeskus: www.thk.fi
- IEEE standards: www.ieee.org
- Finnish standards: www.thk.fi/tele/suomi/standard.htm
- Network & terminal realization: www.nokia.com
- Have a look on link list at Kurose-Ross's homepage: open resources/references (!)
- ... and so many more!

Important auxiliary use for abundant abbreviations is their applicability for Internet search!