S-72.423 Telecommunication Systems

Overview
Topics Today

- Practicalities & course program
- Networking paradigms
- Network evolution
  - Voice and low rate data (PSTN+ISDN)
  - Mobile (2G, 2.5G, 3G)
  - Next generation (NGN/4G)
- Peek to course contents in selected topics
  - The OSI-model
  - PSTN, ISDN, Mobile networks
- Telecommunication market
- Future trends
Practicalities

- Lectures (Thursdays 14-16 in hall B): Timo Korhonen (09 451 2351), Michael Hall (09 451 2322)
- Tutorials (Wednesdays 14-16 in hall S1): Mika Nupponen (09 451 5416), NaserTarhuni (09 451 2362)

- **Textbooks:**

- Grading: \((E + T \times 0.15)\) consists of
  - Compulsory closed book **Exam**
  - Voluntary **Tutorials**

- Homepage: [http://www.comlab.hut.fi/opetus/423](http://www.comlab.hut.fi/opetus/423)
Lecture Topics

- Introduction
- Public Switched Telephone Network (PSTN)
- Integrate Services Digital Network (ISDN) and SS7
- Asynchronous Digital Subscriber Line (ADSL)
- Automatic Transfer Mode (ATM) and Broadband-ISDN
- X.25, Frame relay
- Public Land Mobile Networks (PLMN)
  - GSM
  - WCDMA
- The Internet
  - Network topology
  - TCP/IP Suite
  - Services
Subtopics in Networks & Examples

- User services as
  - IN services: call last dialed, alternate billing services (as calling card, collect call)
  - Internet: web, mail, ftp ...
- Terminals (modems and PSTN/ISDN phones), user interfaces (DSS1)
- Standards (IETF, IEEE, ITU-T ...)
- Routing and switching (unicast - multicast, devices & protocols RSVP)
- Transmission and links (fibre, coax-cable..)
- Access and transport techniques (flow control, error control)
- Signaling (SS7, X.25, Frame relay ...)
- Network management (as OMAP of SS7...)
- Interworking (gateways, bridges ...)
- Network planning

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 (in ISDN)
OMAP: Operation and Maintenance Application Part
Information Society

“Information and Communication Anytime, Anywhere, and in Any Form”

Key development fields:

To understand how networks/terminals/services evolve consider especially services because all network costs are paid by service users:

Services shape telecommunications’ evolution and effect greatly on which technology is chosen!
Paradigm Shift

Traditional view

network
has
services
have

users
have

New approach

services

network

subscribers
Telecommunication Networks

- Trunk and access parts
- Access part terminated by terminals
- Network nodes and links are optimized for certain assumed traffic sources and transmission channels
- Model applies for both data (packet) and voice networks
- All telecommunication networks realized by following layered structure (Open System Interconnections (OSI) or a structure having similar functionalities)
## Open System Interconnection (OSI) Layers

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1. **Physical** | Transmission of electrical signals in medium.  
Layer or repeaters (multiplexing/bit transmission) |
| 2. **Data Link** | Sends data blocks with synchronization, error and flow control for link layer connections. Layer of bridges. |
| 3. **Network** | Routing & switching service for transport layer.  
Layer of routers. |
| 4. **Transport** | Reliable, transparent data transfer for lower level data segments or blocks (end-to-end flow & error control) |
| 5. **Session** | Establishing, managing and termination of connections (sessions~dialogues) between cooperating applications |
| 6. **Presentation** | Independence of applications from differences in data presentations (compression & coding) |
| 7. **Application** | Access to OSI environment applications |

**Gateway Layers**

**LAN Layers**
Each OSI-layer has its Standardized Services

<table>
<thead>
<tr>
<th>Layer</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical</td>
<td>V.24, V.35, <strong>V.90</strong>, 10Base5, 10Base2, 10BaseT, FDDI, SDH, G.703...</td>
</tr>
<tr>
<td>2. Data Link</td>
<td><strong>IEEE 802.X</strong>, ANSI X3T9.5, SMT,...</td>
</tr>
<tr>
<td>3. Network</td>
<td>IPX, RIP, SAP, IDP, <strong>IP</strong>, ARP, <strong>RSVP</strong>, ICMP, X.25, RIP...</td>
</tr>
<tr>
<td>4. Transport</td>
<td>SPX, PEP, <strong>TCP</strong>, <strong>UDP</strong>, NSP...</td>
</tr>
<tr>
<td>5. Session</td>
<td>NetBIOS, NetBEUI, <strong>DNS</strong>, ...</td>
</tr>
<tr>
<td>6. Presentation</td>
<td>SNA Presentation services</td>
</tr>
<tr>
<td>7. Application</td>
<td>NCP, FTP, Telnet, <strong>SMTP</strong>, SNMP, LAT, AFP, SMB...</td>
</tr>
</tbody>
</table>
Data and Voice Networks

- 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/PSTN carries nowadays both!

**Frame relay:**
- applies virtual circuits
- example to connect LANs
- for high quality (links have modest error correction & flow control)
- rates: 2-50 Mb/s

**Frame Flow Control:**
- service for a pair of communicating entities
- reassures non-overwhelming comms. (not too many packets)
### Speech and Data Communications

<table>
<thead>
<tr>
<th></th>
<th>Speech</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delays</td>
<td>Limited to ~200 ms</td>
<td>Depends on service</td>
</tr>
<tr>
<td>Errors</td>
<td>High tolerance</td>
<td>Very limited tolerance</td>
</tr>
<tr>
<td>Stream</td>
<td>Continuous: Circuit switching</td>
<td>Bursty: Packet switching</td>
</tr>
</tbody>
</table>

- Teletraffic can be forced to fixed rate or bandwidth as speech in PSTN or in ATM traffic (->waste of network resources)
Services Require Different Rates

- Telephony
- Broadcasting
- Video conf.
- TV/HDTV
- Video
- Inter-LAN/PBX communications
- Fax
- CAD
- Graphics

Bit rate:
- 10k
- 1M
- 100M
Symmetry

- Categories:
  - **Asymmetrical channel**
    - based on idea that downlink traffic is much larger than uplink traffic
    - Traditionally in access networks (ADSL, Cable modems)
    - Data over DVB
  - **Symmetrical channel** as in fixed line telephony
    - Some services (as P2P) require symmetrical traffic channel!
  - **Point-to-multipoint** channel (broadcasting)
    - TV and Fax are point-to-multipoint distributive services
    - Webcasting (PointCast news service.)
  - Rapidly developing Internet services set stringent requirements for network infrastructure & planning
    - adaptivity
    - service/system upgradability
Network/Service Adaptivity

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

- UMTS supports wide range of applications that posses different quality of service (QoS) requirements.
- Transportation system differentiated into constant rate, real-time and higher-latency services by Multi-Protocol Label Switching (MPLS) or Differentiated Services (DiffServ)
- User 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 a good choice if errors can be tolerated
- **UDP** (Connectionless transport-layer protocol) appropriate for many streaming applications
Security and secrecy*

- Services require security & secrecy, e.g. reliable, shielded transfer. Important for
  - NGNs - services that are ‘near to users’
  - vulnerable services:
    - medical/health as telesurgery
    - rescue, police, defense
- Networks can provide this in several network levels (problem: overheads);
  - fixed lines (PSTN, frame relay)
  - flexible routing (SS7)
  - scrambling or encryption (PLMNs)
  - coding or ciphering (in all modern telecom links & nets)
- Often used concept: **AAA**: Authentication, Authorization, Accounting

* Message goes to the right receiver
* Others cannot 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 (IN)

- Primary characteristics
  - Analog access: bandwidth 300-3400 Hz
  - Circuit switched connection
  - 2x64 kbit/s + 16 kbits/s (ISDN)
  - Limited mobility (DECT=PABX RF-interface)
  - Exchanges (& often terminals) apply ISDN
Network Stratums of PSTN

- In practical PSTN different networks form ‘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
Expected Evolution of Mobile Networks

- **Terminal**
  - 1995: Single system support
  - 2010: Multi-system support, Software radio

- **Radio interface**
  - 1995: GSM, DECT
  - 2000: GPRS, EDGE, HSCSD, UMTS/4G
  - 2001: ATM, ISDN, B-ISDN

- **Trunk/Core**
  - 1995: PSTN, ISDN
  - 2000: TCP-IP/UDP

- **Services**
  - 1992: Voice, low rate data
  - 2000: Modest-rate Internet
  - 2001: Portable, global virtual reality

- **Bandwidth**
  - 2G: Fax/data SMS 9.6 kb/s
  - 2G: Data compression 2.5x9.6 kb/s
  - 2.5G: HSCSD 28.8 kb/s
  - 2.5G: GPRS 92 kb/s
  - 2.5G: EDGE 384 kb/s
  - 3G: UMTS 2 Mb/s

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Telecommunications Market

- 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** (Telephone catalog services designed by a company, giving telephone numbers when you give a name or an address... Eniro)
- **Service brokers** sell dedicated service packages (...MySAP)
- Network **operators** (...Elisa, Telia, or Radiolinja)
- **Content providers** (...Paramount Pictures)
The expanding service markets and the competing bearer networks form an interesting playground!
4G - Framework

**REQUIREMENTS**
- Interoperability
- Usability
- Security
- Cost-effectiveness
- QoS
- Adaptivity
- Mobility
- Global roaming
- Wireless access

**ENABLING TECHNOLOGIES**
- Artificial intelligence
- MIMO-systems
- UWB
- Software radio
- Bluetooth
- Infra-red
- IP

**NETWORKS**
- PSTN/ISDN
- IEEE 802.11
- HAPS
- HiperLAN 2
- ITS
- Satellite access
- DECT
- 2.4G
- 3G
- Cable modems

**SERVICES**
- Augmented virtual reality
- Games
- Entertainment
- Info-tainment
Future Trends Summarized

- Inter(net)working between networks increases
- PLMNs and especially wireless LANs develop very fast in home & office networks
- Increasing data rates
- QoS very important
- Traffic gets more symmetrical (P2P)
- PSTN:
  - Is used to transfer more and more data traffic
  - Voice services of PSTN use IP (VoIP) and move to Internet
- Need of seamless communication of NGN means that different networks must link efficiently

**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
- 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!