Beykent University Network Courses

Module 1 : An Introduction to Networks and Networking Systems

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Course Outline

- Telecommunications Engineering
- Introduction to Communication Networks
- Mathematical foundations of Communication
- Networking Technology, Infrastructure and components
- Routing in Networks
- Network Simulations
- Q&A

Books :

Tanenbaum. Computer Networks: 4th Edition. Prentice-Hall
Telecommunications and Data Communications Handbook – Wiley

Watch out

- As teaching method, the questions that are asked by the lecturer have the holly purpose of encompassing YOU to the direction of knowledge.
- Everything that'll be told, will be base of other big thing. Please try to keep in mind.
- Almost every sentence in the presentation, is thereby chosen carefully. Watch out the details, underlines, **bolds** and colours.

Please participate

Please do not hesitate, whenever, raise hand and ask questions.

About me

Alcatel-Lucent · Technikum Wien · msCNS · T-Mobile

Education and training

Bachelor

• Date (from – to)	06.10.2004 – 10.09.2008
• Name and type of organisation providing education and training	Uludag University
Duration of the program of study	4 years – 8 Semesters
• Principal subjects/occupational skills covered	Electronics Engineering (Telecommunications)
• Title of qualification awarded	B.Sc

graduation thesis

Title	"Design of a Microstrip Antenna for GPS purposes at 1.5805 GHz frequency"

Master

• Date (from – to)	05.10.2011 – 29.10.2013
• Name and type of organisation providing education and training	University of Applied Sciences Technikum Vienna - FHTW
Duration of the program of study	2 years – 4 Semesters
• Principal subjects/occupational skills covered	Telecommunications and Internet Studies
• Title of qualification awarded	M.Sc
Final mark obtained	1.52 / 1.00 (max 1.00)

graduation thesis

Title	"Different mechanisms for feedback based control of operating modes and Tandem Free Operations - Transcoder Free Operations"

• Date (from – to)	15.12.2008 – 18.02.2011
• Name and address of firm	**Alcatel – Lucent Turkey**, Organize Sanayi Bölg. 2.cadde no:17/1 34776 Umraniye / Istanbul
• Date (from – to)	21.02.2011 – 30.06.2013
• Name and address of firm	**Alcatel – Lucent Austria**, Scheydgasse 41 A-1210 Vienna / Austria
• Date (from – to)	07.10.2013 –
• Name and address of firm	**ms – CNS Communications and Network Solutions**, Scheydgasse 34-36 A-1210 Vienna / Austria

Honors and Awards

Yarım Elma Achievement Grant - Uludag University Electronics Eng. (2005)
Generic Scholarship - Uludağ University Rectorate (2006 - 2008)
Best Global Team Player - Alcatel – Lucent (2009)

Publications and articles

To obtain the full version of the papers please visit : http://kaanavsarasan.weebly.com/

Author(s) and title	**Asan A**, "A Presentation on Energy Consumption Analysis of Converged Networks : Node consolidation vs Metro simplification "
Language and Date	EN - Mar 2014
Publication place	Teleconference Presentation, KTH School of Electrical Engineering Sweden
Author(s) and title	**Asan A**, "A Practical Approach to OSPF Link State Advertisement mechanism"
Language and Date	EN - Mar 2012
Publication place	Seminar Paper, University of Applied Science Technikum Vienna
Author(s) and title	**Asan A**, "Deployment of the Network topology to Internet over a NIC card in GNS3"
Language and Date	EN - Mar 2012
Publication place	Seminar Paper, University of Applied Science Technikum Vienna
Author(s) and title	**Asan A**, "Agile Project Management in comparison with IPMA"
Language and Date	EN - Mar 2012
Publication place	Seminar Paper, University of Applied Science Technikum Vienna
Author(s) and title	**Asan A**, "MMANA and Ansoft Designer aided antenna design applications and FDTD Method"
Language and Date	EN - Oct 2007
Publication place	Panel Seminar, Opole Technical University

Technical skills and competences

Wireshark , MATLAB , C , C++ , TNMS , MS Office , GNS3 , Packet Tracer , TCP/IP, DWDM , LTE , 3G , GSM , Optical Communication , SDH , SONET , SIP , IMS

Expertise on	Knowledge of
Alcatel 1660SM	Cisco 3600 & 7200 & 10k Series Routers
Alcatel 1650 SMC	Cisco Catalyst Switch 2950 – 2960 series
Alcatel 1640 FOX	Alcatel 7750 SR (Service Router)
Alcatel 1642	Alcatel 7450 ESS (Ethernet Services Switch)
Alcatel 1678 MCC	Nortel 10M & 20M & 30M
Alcatel 1350 ASON	Huawei 91x series Routers
Nortel OME 6500	Huawei 39xx series Routers
T::DAX	Huawei 95x series Routers

Areas of Interests

Future Networks and Systems, Congestion control and QoS, Converged Networks, Wireless Networks, Network Simulations, Network Protocols, Transmission services, TFO and TrFO, Network Performance metrics, Network Optimization, SDH, SONET, Optical Communication, Switch and Router Architecture, Signal Processing, Networked Systems, IP Routing

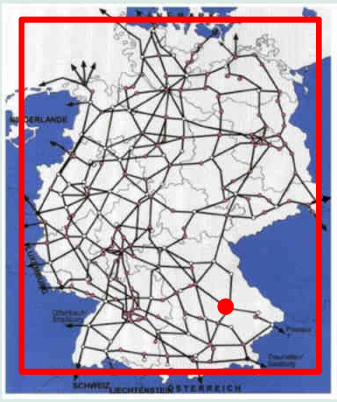
Being aware of what we are

1) Data Communication vs Telecommunication

Bits → Frame → Segment →Data

See OSI Layer properties

A worldwide interconnection of Data Communication Systems



Communication Network

Data Communication System

Being aware of what we are

1) Data Communication vs Telecommunication

Bits → Frame → Segment →Data

See OSI Layer properties

A worldwide interconnection of Data Communication Systems

2) Electronics and Telecommunication Engineering

Electronics Engineering + Computer Science + Electrical Engineering

Today; a telecommunication engineer is a specialist on a particular network technology who at the same time have enough knowledge to install, repair, develop and use it.

Telecommunications Engineering – What do we do?

- Electronic Circuit Design
- Hardware and Software Technologies
- Installation and Configuration of Network Technologies
- Network Design and Management
- Network Technology Engineering
- Network Monitoring, Traffic and Congestion Management
- Troubleshooting and Repairment
- Maintenance and software updates... and much more

Introduction to Communication Networks

Telecommunication

Tele (distance) + communication

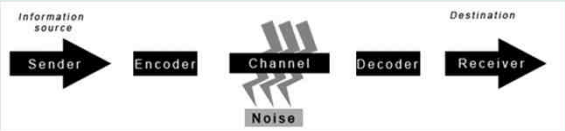
Text, Numbers, Images, audio, video

Telecommunication Network

Is a community of interconnected hosts sending, receiving and processing data, sharing resources and information over a common medium.

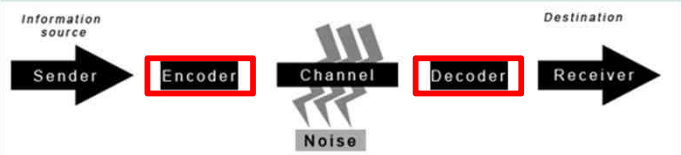
Fundamental Network Scheme

Mass communications / Maßenkomunikation 1949 - Wilbur Schramm



Introduction to Communication Networks

Fundamental Communication Components



Sender – the information source

Transcoder– conversion of the signals into a transmittable format

Channel – carrier transmission medium

Receiver – destination of the information

Introduction to Communication Networks

Speaking the same language / Dieselbe Sprache sprechen

multiplexing/de-multiplexing	A purpose built/resolve of one or more signals
encapsulation/de-capsulation	Coating/ undressing data or header
baseband transmission	Transmission of a native (unchanged) signal
Transcoding	The tandem conversion process of one format to another
Attenuation	Signal level degradation (opposite of amplification)
line coding	Chosen coding mechanism within a channel
baud rate	Number of symbols transferred per second
distortion	Warping. Deformation
white noise	A random noise signal that has constant power density
communication channel	Is a path which signals can flow through
(λ) wavelength	A full tour of a signal to complete a phase ($c = f. \lambda$)
channel capacity	An indication of how fast the data can be transmitted
Bandwidth	Measure of the amount of data that is transferred (bps)
Jitter	Variation in the delay of received packets
Bit error rate	The percentage of bits with errors to total bits received

Introduction to Communication Networks

Transcoding Phenomena

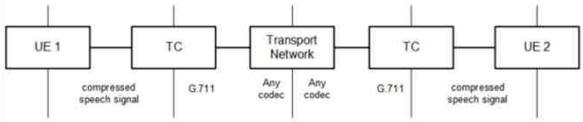


Figure 5.6 : Typical transcoder arrangement

Is transcoding a must?
NO. But the necessity comes from the effective resource management in networks. Available resources of the network should best accommodate the user number.
Is coding a must?

Why we do transcoding?
Transcoded signals are easy to transmit, low in volume, secure, hard to interfare and advantagous depending on the situation.

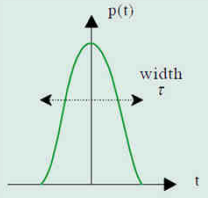
Disadvantages of transcoding?
Signal distortion, degradation and network latency due to transcoding process

Why transcoding is more important in Wireless Networks than in others?
Limited air interface + More expensive deployment expenses + Excessive subscriber number

Introduction to Communication Networks

Essential Details

- The width of each pulse is τ (seconds), data transmit rate is given $1/\tau$ bps
- The narrower the pulse, the higher the bit rate
- (with reasonable fidelity - Vernuenftigengenauigkeit)
- The bigger the BW, the narrower the pulses
- Available BW depends on the link characteristics



$0 \rightarrow p_0(t)$
$1 \rightarrow p_1(t)$

Analog →Digital : Quantization

BW is akin to the number of lanes in a highway. A wider highway can handle more cars per day [bps]

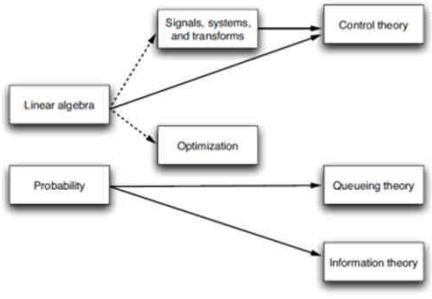
Type of Cable and LAN	Transfer Rates
Twisted Pair	
• 10Base-T (Ethernet)	10 Mbps
• 100Base-T (Fast Ethernet)	100 Mbps
• 1000Base-T (Gigabit Ethernet)	1000 Mbps
• Token ring	4 - 16 Mbps
Coaxial Cable	
• 10Base2 (ThinWire Ethernet)	10 Mbps
• 10Base5 (ThickWire Ethernet)	10 Mbps
Fiber-Optic Cable	
• 10Base-F (Ethernet)	10 Mbps
• 100Base-FX (Fast Ethernet)	100 Mbps
• FDDI (Fiber Distributed-Data Interface) token ring	100 Mbps

Mathematical foundations of Communication

Probability, get out of my network!!!

Discreet information sources

Statistical receipt of symbols



Information Theory helps us to

- to compress data
- to code channels
- to code sources
- finding the uncertainty conditions of received signal = Entropy

Mathematical foundations of Communication

Considering a discreet information source / diskret informationsquelle

Sample space of M.

$S = \{s_1, s_2, \ldots, s_M\}, \qquad k = 1,2,\ldots,M$

$P(X = s_k) = p_k$ *Under the condition*

$$\sum_{k=1}^{M} p_k = 1$$

Example : Rolling a fair dice

$$S = \{s_1, s_2, s_3, s_4, s_5, s_6\}$$ elements of sample space

$$S_A = \{s_2, s_4, s_6\}$$ Event A

$$0 \le P[s_i] \le 1$$ probability function

$$P[s_1] + P[s_2] + P[s_3] + P[s_4] + P[s_5] + P[s_6] = 1$$ normalization function

$$P[A] = \frac{N_A}{N} = \frac{3}{6} = \frac{1}{2}$$ probability of Event A

Goal 1 : Information Content

Probability functions will tell us the amount of information can be transferred

$$I(s_i) = \log_2\left(\frac{1}{p_i}\right) = \underbrace{\log_2(1)}_{0} - \log_2(p_i) = -\log_2(p_i) \qquad \text{[bits]}$$

Why dual logarithm?

Because:

$$\log_2 1 = 0 \quad , \quad \log_2 2 = 1 \quad , \quad \log_2 4 = 2 \quad , \quad \log_2 8 = 3 \quad , \quad \log_2 16 = 4$$

$$\log_2(xy) = \log_2 x + \log_2 y$$

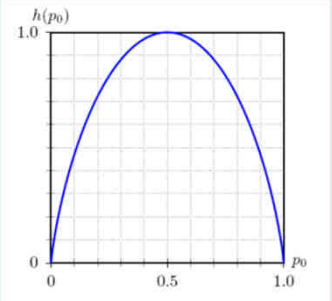
$$\log_2\left(\frac{x}{y}\right) = \log_2 x - \log_2 y$$

Goal 2 : Defining the uncertain conditions in transmission

The uncertainty associated with sum of the probabilities

$$H = \sum_{i=1}^{N} p_i \cdot I[s_i] = \sum_{i=1}^{N} p_i \cdot \log_2\left(\frac{1}{p_i}\right) = -\sum_{i=1}^{N} p_i \cdot \log_2 p_i$$

$$h(p_0) = -p_0 \log_2 p_0 - (1 - p_0)\log_2(1 - p_0)$$



Networking Technology, Infrastructure and components

Classification of Communication Networks

By communication structure : switching, broadcast, point-to-multipoint

Switching Networks : Transmitting information from a sender to one receiver (unicast communication)

Broadcast Networks : Sending information through a channel to unknown number of recipients

Point-to-Multipoint Networks : Intermediary between switching networks (multicast communication)

Classification of Communication Networks

By communication structure : switching, broadcast, point-to-multipoint
By Switching principle : circuit (CS) or packet switching (PS)

Circuit Switching	Packet Switching
A physical connection has to be established BEFORE data exchange.	Prior to tranmission, data is broken into packets, which are sent randomly over different routes.
PSTN, ISDN	IP,ATM, FR
dedicated BW	adjustable BW
guaranteed BW and QoS	better resource utilization and robust against failures and cheaper
waste of BW, Expensive to manage, failure recovery is a disaster.	unreliable, no guaranteed QoS

Classification of Communication Networks

By communication structure : switching, broadcast, point-to-multipoint
By Switching principle : circuit (CS) or packet switching (PS)
By Connection principle : connection oriented or connectionless

Connection Oriented

There are 3 operations are used:
Connection establishment
User data transmission
Connection release

Can be implemented both PS or CS networks

Telephony with ISDN
Internet with TCP/IP

Connectionless

No need to establish a connection. Packets are sent randomly through different routes and paths.

only in PS networks

IP network with UDP

Classification of Communication Networks

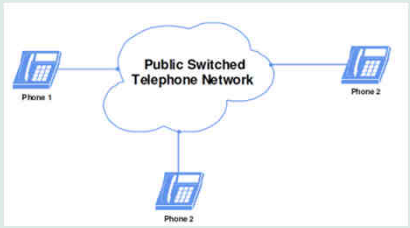
By communication structure : switching, broadcast, point-to-multipoint
By Switching principle : circuit (CS) or packet switching (PS)
By Connection principle : connection oriented or connectionless
By Coverage : PAN,LAN,WAN,MAN

Distance between Endnodes	Location of Endpoints	Name
0,1 m	Platine, Palmtop	Personal Access Network (PAN)
1 m	Body	Body Area Network (BAN)
10 m	Room	Local Area Network (LAN)
100 m	Building	Local Area Network (LAN)
1000 m	Campus	Local Area Network (LAN)
10 km	City	Metropolitan Area Network (MAN)
100 km	Country	Wide Area Network (WAN)
1000 km	Continent	WAN, Europe
10.000 km	Planet	Global Area Network (GAN), Internet
100.000 km	Earth-Moon-System	WAN, Satelites

Classification of Communication Networks

By communication structure	:	switching, broadcast, point-to-multipoint
By Switching principle	:	circuit (CS) or packet switching (PS)
By Connection principle	:	connection oriented or connectionless
By Coverage	:	PAN,LAN,WAN,MAN
By Supported Services	:	Telephone, data, Broadcast or Converged

Public Switched Telephone Network (PSTN)



Circuit switching network
Analog or digital support
Needs low delay

Classification of Communication Networks

By communication structure	:	switching, broadcast, point-to-multipoint
By Switching principle	:	circuit (CS) or packet switching (PS)
By Connection principle	:	connection oriented or connectionless
By Coverage	:	PAN,LAN,WAN,MAN
By Supported Services	:	Telephone, data, Broadcast or Converged

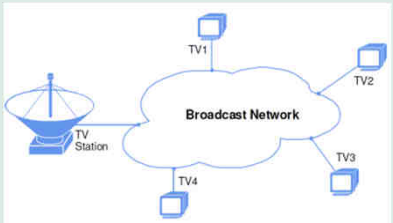
Data Network

Packet switching network
QoS in data communication
Low bit error rate
low jitter

Classification of Communication Networks

By communication structure	:	switching, broadcast, point-to-multipoint
By Switching principle	:	circuit (CS) or packet switching (PS)
By Connection principle	:	connection oriented or connectionless
By Coverage	:	PAN,LAN,WAN,MAN
By Supported Services	:	Telephone, data, Broadcast or Converged

Broadcast Network

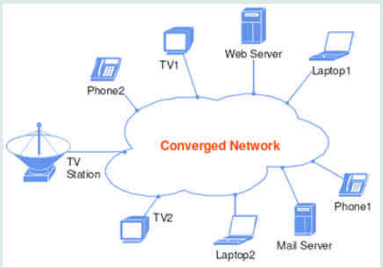


Coaxial and/or satellite networks

Classification of Communication Networks

By communication structure	:	switching, broadcast, point-to-multipoint
By Switching principle	:	circuit (CS) or packet switching (PS)
By Connection principle	:	connection oriented or connectionless
By Coverage	:	PAN,LAN,WAN,MAN
By Supported Services	:	Telephone, data, Broadcast or Converged

Converged Network



Specified networks are expensive

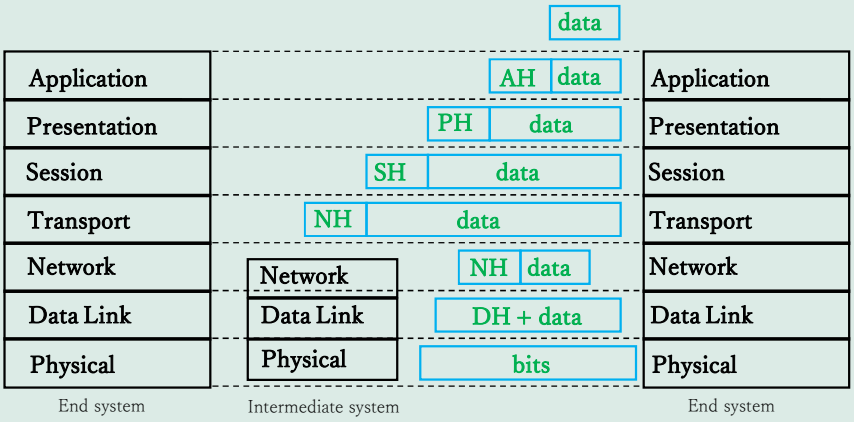
All-in-one networks are called Converged Networks

All types of data

Complicated QoS needs for different data types must be arranged

OSI Networking Model

explicit structure allows identification & relationship of complex system's pieces
-layered reference model for discussion
modularization eases maintenance & updating of system
- change of implementation of layer's service transparent to rest of system



OSI Networking Model - details

Physical Layer (represented = bits)

Deals with the characteristics of the transmission medium.

e.g - Connectors, pins, use of pins, electrical currents, encoding and light modulation.
Devices: Hubs and Repeaters

A **hub** regenerates and retimes network signals at the bit level. A hub is able to interconnect a large number of hosts which are connected to different ports.

A **repeater** is a hub with 2 interfaces only.
They are working in half-duplex-mode! Collisions are possible if 2 stations want to transmit simultaneously.
Collision Domain: The part of a network where collisions can occur

Detailed info : Module A3 Optical Networks

OSI Networking Model - details

Data -Link Layer (represented= frames)

Specifies the delivering of data across one particular link or medium using protocols. It transmits data by formatting the bits in frames and has the following functions:

- Frame synchronization to detect start and end of a frame.
- Error detection and recovery on the link (CRC, FEC)
- Multiple Access to a medium (Medium Access Control MAC, e.g. for Ethernet).

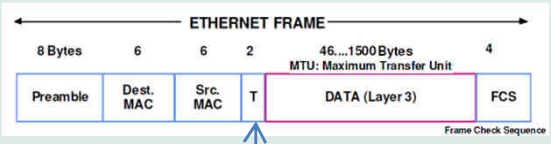
ETHERNET

Today's LAN Networks are based mainly on Ethernet Technology

- All stations are using a common media (shared media)
- All stations (hosts) are independent and have the same rights in communicating.
- Every station is able to communicate with every other station on the network segment
- Addresses of stations are in a flat hierarchy and are not grouped logically
- The coverage of the network is limited to the local site
- High bit rates
- Low error rates
- Operates in layer 1 and 2 of OSI
- Broadcasts are sent on the network from one to all other stations

OSI Networking Model - details

Data -Link Layer (rep = frames)



0x0800: IP – Internet Protocol
0x0806: ARP – Address Resolution Protocol
0x0BAD: Banyan Systems
0x0BAF: Banyan VINES Echo
0x6008: DEC
0x809B: Ether Talk (Apple Talk over Ethernet)
0x80F3: Apple Talk Address Resolution Protocol AARP
0x8138 IPX/SPX – Novell Inc.
0x9000: Loopback (Configuration Test Protocol)

CSMA/CD – Carrier Sense Multiple Access – Collusion Detection

If more than one port detects an input signal. A collision presence signal is sent out as long as activity is sensed on any of the input lines. Each host is interpreting this signal as an occurrence of a collision.

Today hub networks are replaced by switched networks, where collisions cannot occur.

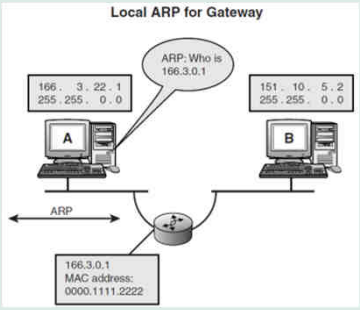
OUTDATED

OSI Networking Model - details

Data -Link Layer (rep = frames)
Physical Addressing : MAC addresses and ARP

Address Resolution Protocol (ARP) – (shouting protocol)

- Routers must determine whether to **shout** or **route** traffic to forward packets to a destination host
- **Shouting** can only be on the same LAN, by broadcasting the Address Resolution Protocol (ARP) to resolve the IP address to a MAC address.
  Associated table of IP addresses+ MAC addresses, router then know if a packet goes to other LANs or not
- The packets that are addressed to other LANs, will be **Routed**



OSI Networking Model - details

Data -Link Layer (rep = frames)
Layer 2 Devices : Bridges and Switches

Switch Operation
Switches function = Flooding, Forwarding and Filtering

Ethernet/Fastethernet/Gigabitethernet Frame:

8 Byte	6 Bytes	6 Bytes	2 Bytes	46 – 1500 Bytes	4 Bytes
Preamble	MAC Destination Address	MAC Source Address	Type	Data	Frame Check Sequence

Step 1 - Switches analyze the received frames: First the Frame Check Sequence is calculated. If there is an error the frame is discarded without notification to the sender or receiver host.

A)If the destination MAC address is not in the switching table (MAC-table) or the destination address is the broadcast address (FF:FF:FF:FF:FF:FF) the frame is sent out all the interfaces except the receiving interface: **Flooding.**

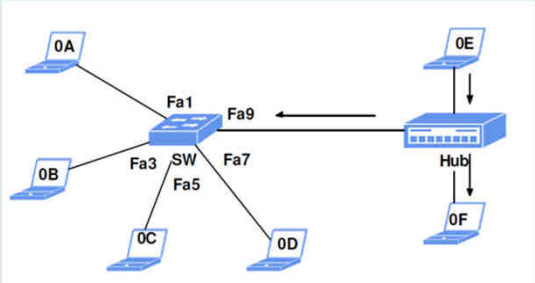
B)If the destination MAC address is not on the interface of the sending host the frame is forwarded out the proper interface (port): **Forwarding**.

C)If the destination MAC address of a received frame is on the same interface as the sending host the frame is not forwarded: **Filtering**.

After a given time every entry in the MAC-table will be erased. **Aging mechanism**.

OSI Networking Model - details

Data -Link Layer (rep = frames)
Lil' exerciz



Question 1 – Please create in the MAC table of Switch

Question 2 – Determine the decision of Switch when a packet comes with

a)– source MAC – OE and destination MAC – OF

b)– source MAC – OF and destination MAC – FF

c)– source MAC – OA and destination MAC – OF (and what if OF is somehow not in the MAC table?)

OSI Networking Model - details

Network Layer (represented = packet OR datagram)

- It defines the connectionless delivery of packets between network nodes
- Maintains the logical addressing schemes(Internet Protocol, IPX, Apple Talk) between a source and destination host
- Fragmentation and Reassembly

Fragmentation, is the process of breaking information up into smaller pieces.
Reassembly is the process of putting these pieces back together.

Packet size depends on the underlying network architecture in use.
When mixed architectures exist end systems communicating across them must adhere to the smallest supported frame size.

OSI Networking Model - details

Network Layer (represented = packet OR datagram)
Logical Addressing : IP Addresses

Internet Protocol (IP)

Consists of four Octets
IP address = (network number) (host number)
This simplifies the global administration of IP addresses and router complexity considerably, as only the network portion has to be designated and used for routing between different networks.

Class	1st Octet Decimal Range	1st Octet High Order Bits	Network/Host ID (N=Network, H=Host)	Default Subnet Mask	Number of Networks	Hosts per Network (Usable Addresses)
A	1 – 126 *	0	N.H.H.H	255.0.0.0	126 ($2^7 - 2$)	16,777,214 ($2^{24} - 2$)
B	128 – 191	10	N.N.H.H	255.255.0.0	16,382 ($2^{14} - 2$)	65,534 ($2^{16} - 2$)
C	192 – 223	110	N.N.N.H	255.255.255.0	2,097,150 ($2^{21} - 2$)	254 ($2^8 - 2$)
D	224 – 239	1110	Reserved for Multicasting			
E	240 – 254	11110	Experimental; used for research			

Subnet Masks are used to mask off a portion of an IP address to delineate the network and sub-network from the host address.

OSI Networking Model - details

Network Layer (represented = packet OR datagram)
Logical Addressing : IP Addresses

Network Address Translation (NAT)

Public IP addresses

- Public IP addresses are addresses which are no private addresses.
- Private IP addresses are a reserved block of numbers that can be used by anyone
- All public Internet addresses must be registered with a Regional Internet Registry (RIR).
- Organizations can lease public addresses from an ISP. Only the registered holder of a public Internet address can assign that address to a network device.
- Packets with private IP addresses are not allowed to be routed over the public Internet. Therefore packets with private IP addresses must be translated to packets with public IP addresses: Network Address Translation (NAT).

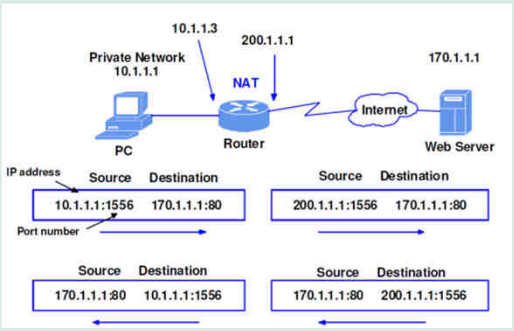
OSI Networking Model - details

Network Layer (represented = packet OR datagram)
Logical Addressing : IP Addresses

Network Address Translation (NAT)

- Inside local address - Usually not an IP address assigned by a RIR or service provider and is most likely an RFC 1918 private address.
- Inside global address - Valid public address that the inside host is given when it exits the NAT router.
- Outside global address - Reachable IP address assigned to a host on the Internet. For example, the web server is reachable at IP address 209.165.201.1.
- Outside local address - The local IP address assigned to a host on the outside network. In most situations, this address will be identical to the outside global address of that outside device.

Inside local: 10.1.1.1 (private address)
Inside global: 200.1.1.1 (public address)
Outside global: 170.1.1.1



OSI Networking Model - details

Network Layer (represented = packet OR datagram)
Network Control Mechanism: ICMP

Internet Control Message Protocol (IP)

ICMP is a feedback mechanism in case of problems in the network.
ICMP messages are IP designated without Layer 4 protocols TCP/UDP

Main messages are;

Echo Request (PING)
Echo Reply (PING)
Network Unreachable
Host Unreachable
Fragmentation needed
Source coding failed
Destination Network Unknown
Redirect
Router Advertisement

OSI Networking Model - details

Network Layer (represented = packet OR datagram)
Layer 3 Device : Routers

Routers

Interconnect network segments with different network addresses (IP addresses) or a LAN with a WAN.
Routers decrease the broadcast domain size of network by blocking broadcast messages at their ports.
Each port of router has to have a MAC address (layer 2) and a logical address (IP address, layer 3).

Basic functions of a router:

- Construction and maintenance of a routing table. This table has information how to forward a packet to a destination network address.
- Collection of information to calculate the routing table (routing protocol)
- Periodic transmission of information to other routers to enable the maintenance of the routing tables („advertising").
- Disadvantage of routers: expensive, comparable slow

OSI Networking Model - details

Network Layer (represented = packet OR datagram)
DHCP and DNS

Dynamic Host Control Protocol - DHCP

DHCP, like its predecessors, is a service that may be implemented on a server or router configured with valid IP address ranges identifying sub-networks (referred to as scopes) and other IP configurations necessary for hosts to participate on an IP network.

Domain Name Service - DNS

Domain name service. A protocol within TCP/IP used for discovering information about resources using a database distributed among different name servers. Interpreted in the TCP/IP PI suite.

OSI Networking Model - details

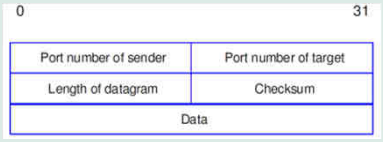
Transport Layer (represented = segments)

The Transport layer does the following:

- Controls end-to-end communication between two processes running on different hosts.
- Provides connection-oriented or connectionless services to upper layers.
- Uses client and server port addresses to identify processes running within a host.
- Reliable (TCP) or unreliable delivery (UDP)

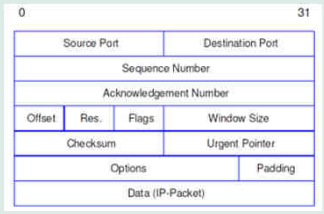
User Datagram Protocol (UDP)

- Simple Internet-Protocol
- Connectionless
- unreliable – „fire and forget“
- 20 Byte IP-Header + 2 x16 bit Portnumber, 16 bit length and 16 bit Check sum (optional!)
- Length Datagram: header plus payload



Transmission Control Protocol (TCP)

- Controls end-to-end communication between two
- Connection Oriented
- Reliable – ACK mechanism



OSI Networking Model - details

Transport Layer (represented = segments)

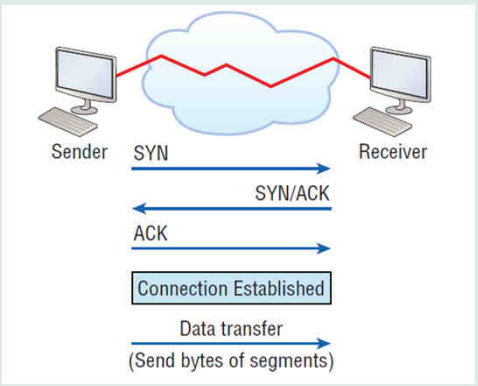
Tasks of TCP Protocol

- Connection Establishment, management and Termination (Three-way-handshake)

The first “connection agreement” segment is a request for synchronization (SYN).

The next segments acknowledge (ACK) the request and establish connection parameters—the rules—between hosts. These segments request that the receiver’s sequencing is synchronized here as well so that a bidirectional connection can be formed.

The final segment is also an acknowledgment, which notifies the destination host that the connection agreement has been accepted and that the actual connection has been established. Data transfer can now begin



OSI Networking Model - details

Transport Layer (represented = segments)

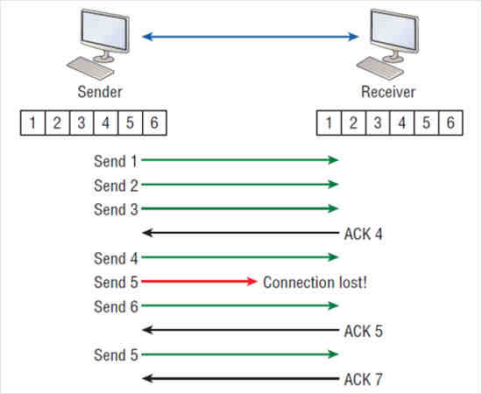
Tasks of TCP Protocol

- Connection Establishment, management and Termination (Three-way-handshake)
- Providing Reliability and Transmission Quality Services

Reliable data delivery ensures the integrity of a stream of data sent from one machine to the other through a fully functional data link.

It guarantees that the data won't be duplicated or lost.

This is achieved through something called positive acknowledgment with retransmission— a technique that requires a receiving machine to communicate with the transmitting source by sending an acknowledgment message back to the sender when it receives data.



OSI Networking Model - details

Transport Layer (represented = segments)

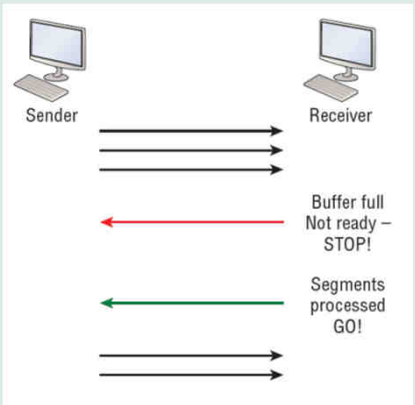
Tasks of TCP Protocol

- Connection Establishment, management and Termination (Three-way-handshake)
- Providing Reliability and Transmission Quality Services
- Providing Flow Control and Congestion Avoidance

The segments delivered are acknowledged back to the sender upon their reception.

Any segments not acknowledged are retransmitted. Segments are sequenced back into their proper order upon arrival at their destination.

A manageable data flow is maintained in order to avoid congestion, overloading, or worse, data loss.



OSI Networking Model - details

Transport Layer (represented = segments)

Tasks of TCP Protocol

- Connection Establishment, management and Termination (Three-way-handshake)
- Providing Reliability and Transmission Quality Services
- Providing Flow Control and Congestion Avoidance
- Multiplexing

OSI Networking Model - details

Transport Layer (represented = segments)

Tasks of TCP Protocol

- Connection Establishment, management and Termination (Three-way-handshake)
- Providing Reliability and Transmission Quality Services
- Providing Flow Control and Congestion Avoidance
- Multiplexing
- Data Transfer

OSI Networking Model - details

Transport Layer (represented = segments)

Tasks of TCP Protocol

- Connection Establishment, management and Termination (Three-way-handshake)
- Providing Reliability and Transmission Quality Services
- Providing Flow Control and Congestion Avoidance
- Multiplexing
- Data Transfer
- Data Handling and Packaging

OSI Networking Model - details

Transport Layer (represented = segments)

The Transport layer does the following:

- Controls end-to-end communication between two processes running on different hosts.
- Provides connection-oriented or connectionless services to upper layers.
- Uses client and server port addresses to identify processes running within a host.
- Reliable (TCP) or unreliable delivery (UDP)

Important TCP and UDP application protocols

- **Simple Mail Transfer Protocol (SMTP) –** For sending e-mails to a mail server
- **Post Office Protocol (POP3)** – For retrieving mails from a mail server
- **Hyper Text Transfer Protocol (HTTP)** – Web Surfing
- **Remote Login (Telnet)** – Communication between different OS computers
- **File Transfer Protocol (FTP)** - Transmission of any data
- **Trivial File Transfer Protocol (TFTP)** – Simple protocol of data transmission
- **Simple Network Management Protocol (SNMP)** – Administration of larger networks by using agent SW
- **Domain Name Service (DNS)** – Resolution of domain names to public addresses and vice versa

OSI Networking Model - details

Session layer

It defines how to start, control and end conversations, called sessions.

Presentation layer

It defines data formats (eg. ASCII text, EBCDIC text, binary, BCD, JPEG) of the application layer.

Application layer

It defines the interface between the communication software and any applications. For example, a web browser is an application on a computer. The browser needs to get contents of a web page. Layer 7 defines the protocols used on behalf of the application to get this web page.

Protocol	Description	Port	Application
HTTP	Hypertext Transfer Protocol	80	WWW...World Wide Web
HTTPS	Secure HTTP	443	Web-access with authentication and encryption
SMTP	Simple Mail Transfer Protocol	25	E-mail sending and transferring
POP3	Post Office Protocol version 3	110	E-mail retrieving from a server
DNS	Domain Name Service	53	Resolution of domain names into IP addresses
DHCP	Dynamic Host Control Protocol	67, 68	Assignment of a IP address for a client computer
Telnet	Remote Login	23	Remote login on a computer using IP connection
SSH	Secure Shell	22	Telnet with authentication and encryption
FTP	File Transfer Protocol	20, 21	Transfer of (large) files from computer to computer
TFTP	Trivial File Transfer	69	Simplified file transfer, used for small files
SIP	Session Initiation Protocol	5060	Signalling of calls in Voice-over-IP networks

Routing in Networks

Router Networks

- Interconnection of networks with dissimilar technology or protocol like LAN with WAN (ADSL, ISDN, Cable modem, Telephone network, Wireless LAN)

  DTE: Data Terminal Equipment (Router, PC)
  DCE: Data Communication Equipment (Modem, ADSL-Modem etc.)

- They interconnect network segments with different network addresses (IP addresses) or a LAN with a WAN.
- Routers decrease the broadcast domain size of network by blocking broadcast messages at their ports.
- Each port of router has to have a MAC address (layer 2) and a logical address (IP address, layer 3)

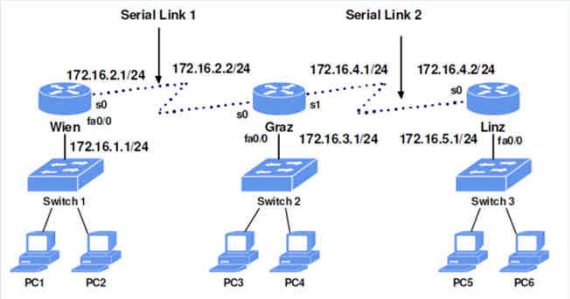
Default Gateway, Is the destination host in another network or sub-network than the packet is sent to the default gateway by the source host (computer). Normally the default gateway is a router port.

STATIC ROUTING

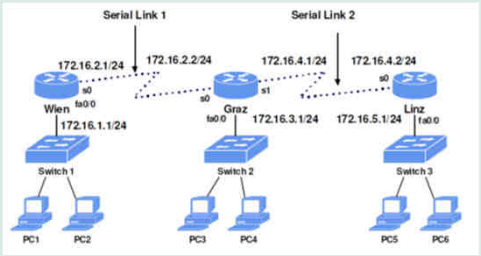
After configuration of all interfaces on a router it only knows how to reach directly connected networks, but the router has no information of the remote network addresses and how to reach them.

Static routing means, that a router gets the information of the best path to remote networks in the topology by a human administrator.

- Static routes are used mostly in the case of a stub network. A stub network is a network with one route only to reach it, e.g. the access to the public internet.
- Another case to use static routes is to determine a route to a „gateway of last resort", if no other (dynamic) route is known.



STATIC ROUTING

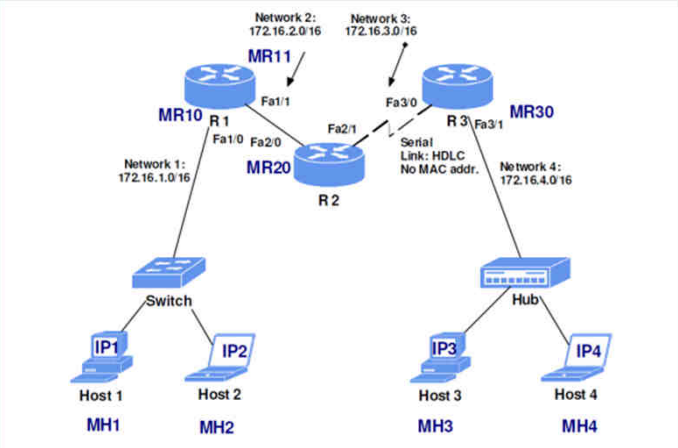


fa0/0: Fastethernet Interface
s0, s1: Serial Interface

Forwarding to Router Wien:
Graz(config)# ip route 172.16.1.0 255.255.255.0 s0
(destination outgoing interface)

Forwarding to Router Linz:
Graz(config)# ip route 172.16.5.0 255.255.255.0 s1

LIL' Exercize



How many networks are there?
How many collision domains are there?
Draw the routing table

DYNAMIC ROUTING

A router is a device to calculate the best route (path) through a network to the destination network.
A router has 2 tasks:

- Path determination: Calculation of the route from source to destination for a specific datagramm (e.g. IP packet)
- Switching (forwarding of frames)

Path determination is a functionality of the network layer (layer 3). All possible routes to a destination network (address) and the best one are calculated using a „Routing Protocol".

Routing Protocols are used for the communication between routers to determine the best route to a destination network.

Interior and exterior routing protocols are used for dynamic routing

- Interior routing protocols (Interior Gateway Protocol···.IGP) are used in an interior network of limited geographic dimension. This network could consist of some subnetworks and is called an Autonomous System (AS).

- Exterior routing protocols (Exterior Gateway Protocol···.EGP) are used to determine the best route between interior networks. The AS used of BGP has to be allocated by the IANA to interconnect interior networks (public AS)

DYNAMIC ROUTING

Routing protocols are proprietary or open protocols

- RIPv1 (Routing Information Protocol), RIPv2: Open routing protocol
- IGRP (Interior Gateway Protocol): Cisco proprietary, not supported yet
- EIGRP (Enhanced IGPR): successor of IGRP, Cisco proprietary
- OSPFv2 (Open Shortest Path First): Open routing protocol
- IS-IS (Intermediate System to Intermediate System): Intradomain Routing Exchange Protocol
- BGPv4 (Border Gateway Protocol): Exterior Gateway Protocol, open routing protocol.

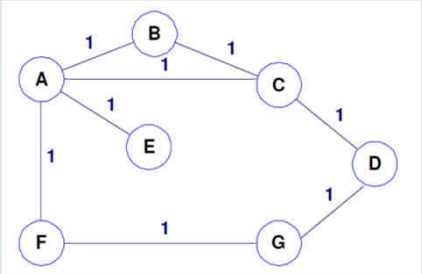
	Interior Gateway Protocols (IGP)				Exterior Gateway Protocols (EGP)
	Distance Vector Routing Protocols		Link State Routing Protocols		Path Vector
Classful	RIPv1	IGRP			EGP: outdated
Classless	RIPv2	EIGRP	OSPFv2	IS-IS	BGPv4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGPv4 for IPv6

Distance Vector Routing

Each router constructs a one-dimensional array (a vector) containing the distances (costs) to all other routers and the interfaces over which the destination networks can be reached (direction out of the router)

This vector is distributed to all neighbours on a regularly basis(seconds)

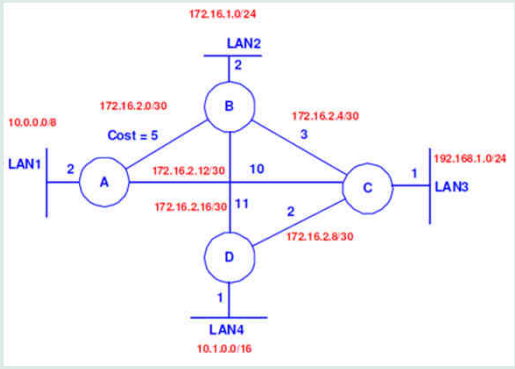
The routing process starts with the assumption that each router knows the number of hops to its directly connected neighbours. The routing vector is calculated and distributed.



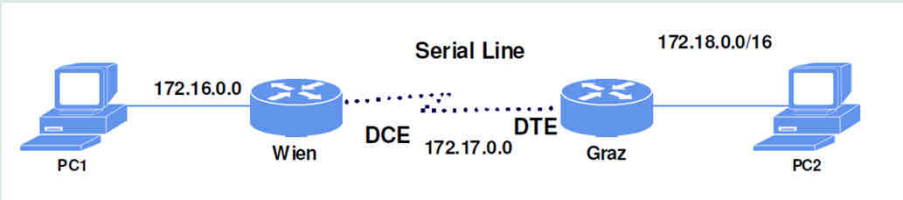
Destination	Hop	Next hop
B	1	B
C	1	C
D	2	C
E	1	E
F	1	F
G	2	F

Link State Routing

- Each router learns about each of its own directly connected networks.
- Each router is responsible for "saying hello" to its neighbors on directly connected networks. An adjacency database (neighbor database) is calculated based on the reply of the hello packets.
- Each router builds a Link-State Packet (LSP) containing the state of each directly connected link.
- Each router floods the LSP to all neighbors, which then store all LSPs received in a database.
- Each router uses the database to construct a complete map of the topology: Topology Database.
- Based on that map it computes the best path to each destination network: Routing Table.



Routing Example - RIP

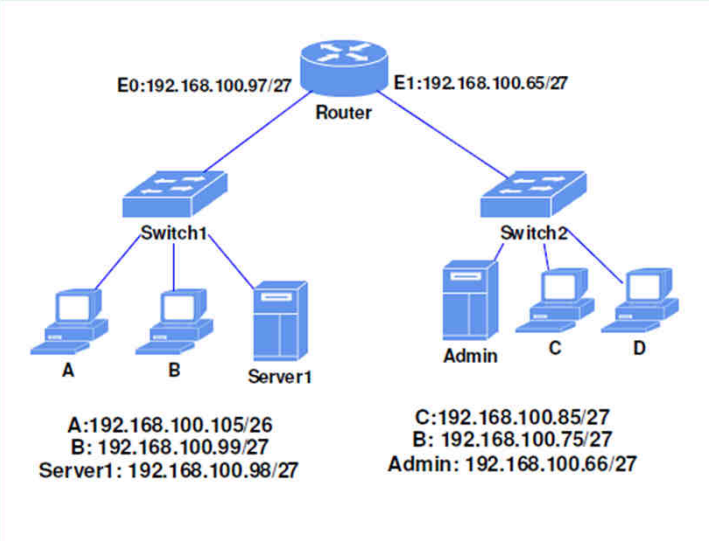


Configuration of routing protocol RIPv2:

Wien(config)#**router rip**
Wien(config-router)#**version 2**
Wien(config-router)#**network 172.16.0.0**
Wien(config-router)#**network 172.17.0.0**
Wien(config-router)#**no auto-summary**
Wien(config-router)#**exit**
Wien(config)#**exit**

Graz(config)#**router rip**
Graz(config-router)#**version 2**
Graz(config-router)#**network 172.17.0.0**
Graz(config-router)#**network 172.18.0.0**
Graz(config-router)#**no auto-summary**
Graz(config-router)#**exit**
Graz(config)#**exit**

A week to think about - Host A is unable to communicate with Admin ☹



Thanks a world for participating