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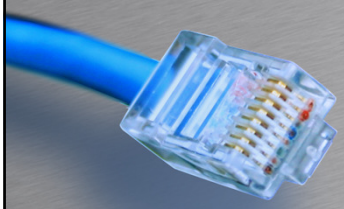
IP Training Programme



HOUSE OF TECHNOLOGY

- en del af mercantec

Module 1: IP Generic

Session 2: IP Connectivity

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Subjects

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- The OSI model
- Transport protocols (TCP/UDP).
- Application protocols for example SIP, H.323 and RTP.
- DHCP Client.
- DNS Client and domain names.
- Activities

SMALL REVIEW FROM SESSION 1

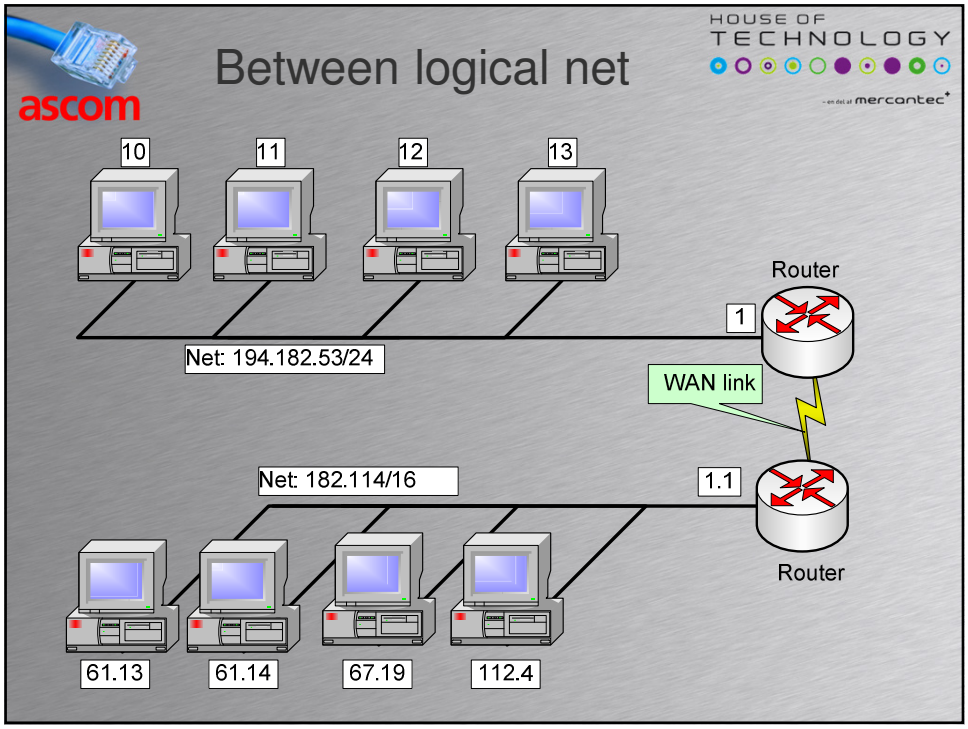
Just the important stuff

IP Classes

Class	Purpose	First byte between	Subnet mask	Prefix	Max hosts
A	Unicast	0 and 127	255.0.0.0	/8	16.777.214
B	Unicast	128 and 191	255.255.0.0	/16	65.534
C	Unicast	192 and 223	255.255.255.0	/24	254

Additional classes

Class	Purpose	First byte between	Subnet mask	Prefix	Max hosts
D	Multicast	224 and 239	None special	None	-
E	Reserved	239 and 255	None	None	-


Between logical net
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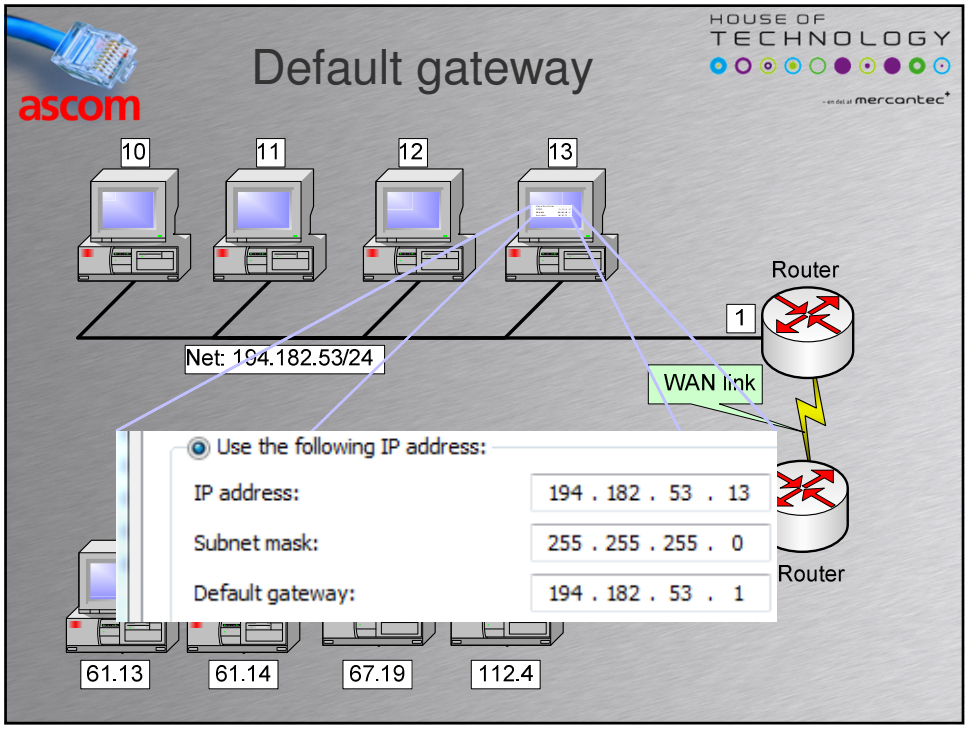
10
11
12
13
Router
1
Net: 194.182.53/24
WAN link
Net: 182.114/16
1.1
Router
61.13
61.14
67.19
112.4


Default gateway
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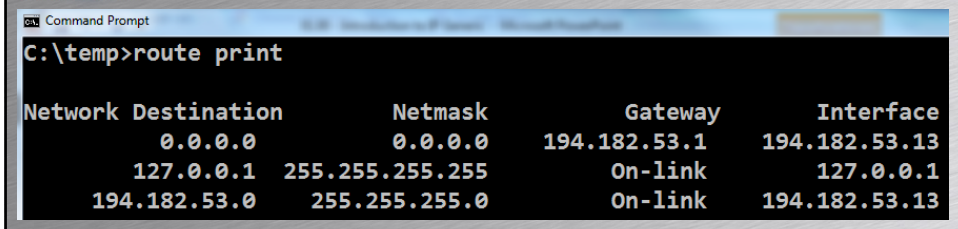
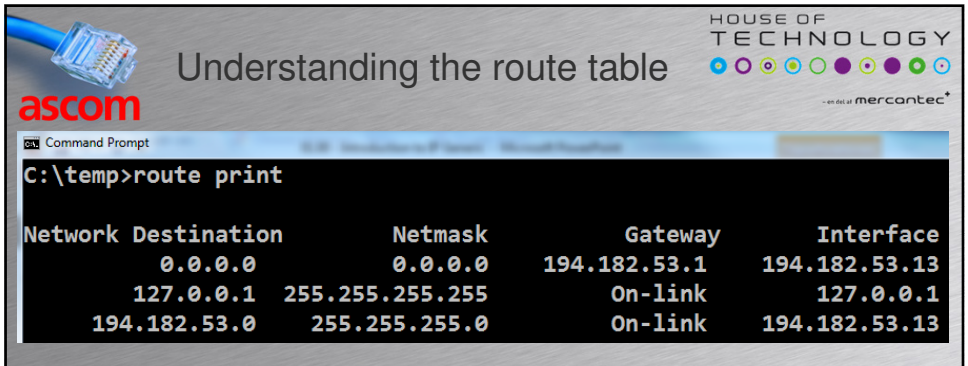
10
11
12
13
Router
1
Net: 194.182.53/24
WAN link
Use the following IP address:
IP address:
194 . 182 . 53 . 13
Subnet mask:
255 . 255 . 255 . 0
Default gateway:
194 . 182 . 53 . 1
Router
61.13
61.14
67.19
112.4

Understanding the route table



- If the host have to send a packet to the destination 194.182.53.67 it will search the route table and find two possible ways to the destination
  - 0.0.0.0/0 via 194.182.53.1 out of interface 194.182.53.13
  - 194.182.53.0/24 on-link out of interface 194.182.53.13
- It will choice the most specific route. The one with the best subnet mask. /24 is better than /0

Understanding the route table

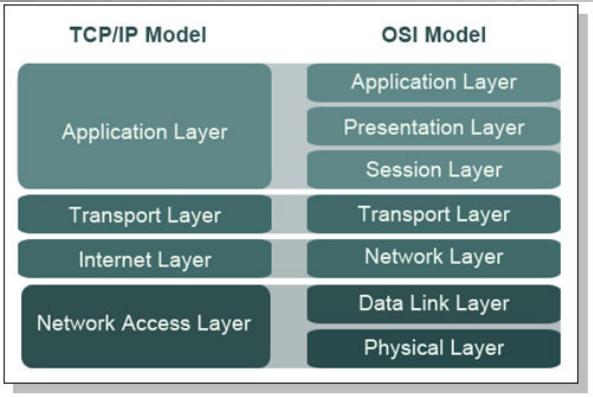


- If the host have to send a packet to the destination 8.8.8.8 it will search the route table and find one possible way to the destination
  - 0.0.0.0/0 via 194.182.53.1 out of interface 194.182.53.13
- The packets to 8.8.8.8 will be send to the default gateway as 8.8.8.8 is on another logical network

IP Summary

- A host can send direct to other host on its own logical network
- To send to hosts on other logical network the host need to know a router.
  - A router is an intermediate device which passes packets on towards its destination.
- 172.16.0.0/16 is a class B net
  - Network: 172.16.0.0
  - Subnet mask: 255.255.0.0

THE OSI MODEL

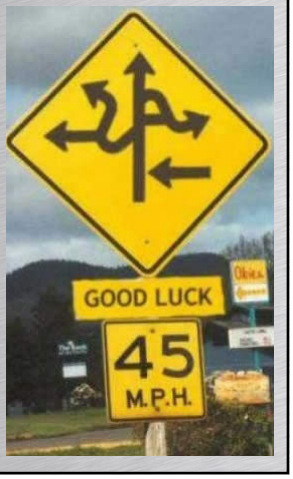


The OSI model

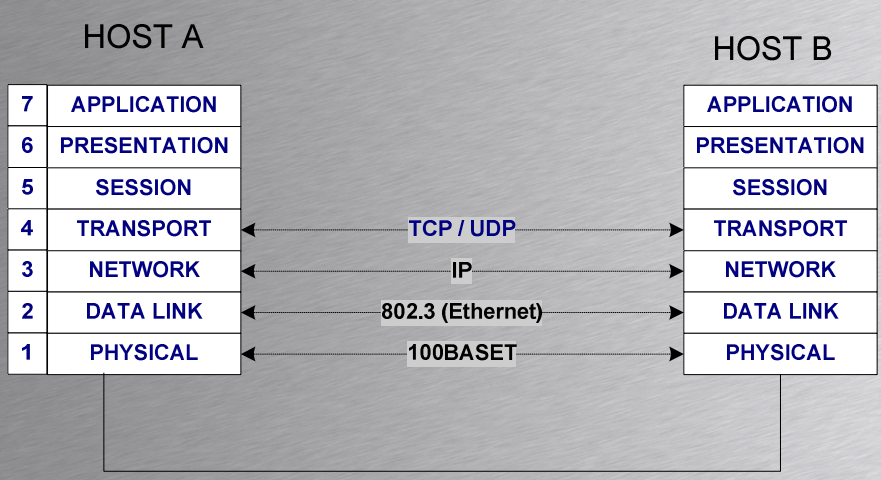
- The OSI model or
  - Open Systems Interconnection model.
- Also called the 7-layer model.
- The OSI model is layered description of network functionality, including:
  - Physical layout, cables, speed, voltages….
  - Exchange and error control of frames
  - Logical networking and transport of packets
  - Retransmission of lost and faulty packets

The OSI model

- The OSI model is a very complex theoretical description of network functionality
  - TCP/IP is not OSI
  - TCP/IP is compared to OSI
- The OSI model is good for dividing network functionality into eatable chunks

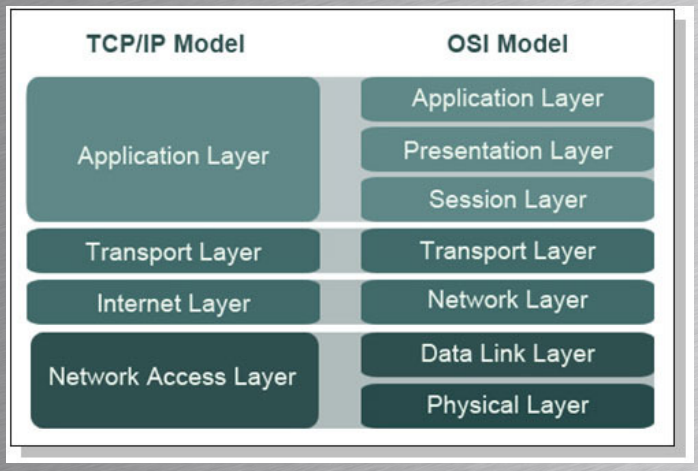


The seven layers

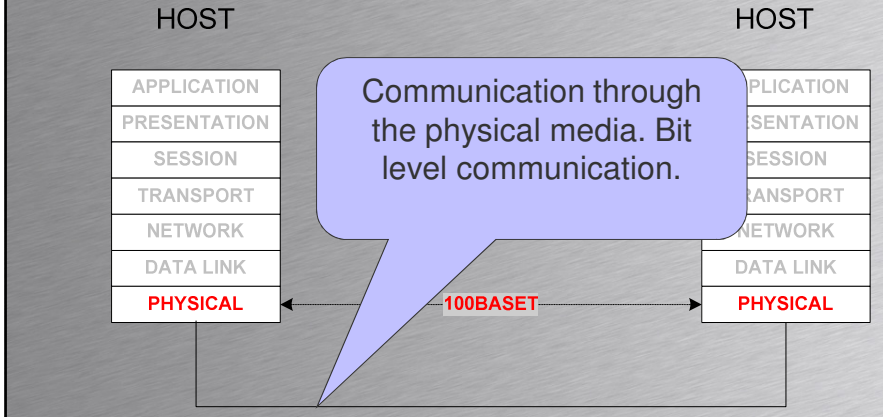


TCP/IP vs. ISO

- TCP/IP was developed with four layers.



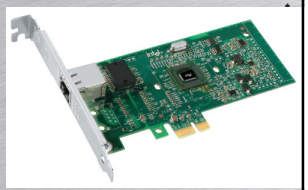
Layer 1: physical



10BASET = 10 Mbps Ethernet twisted pair cable
100BASET = 100 Mbps Ethernet twisted pair cable
1000BASET = 1000 Mbps or 1 Gbps Ethernet twisted pair cable

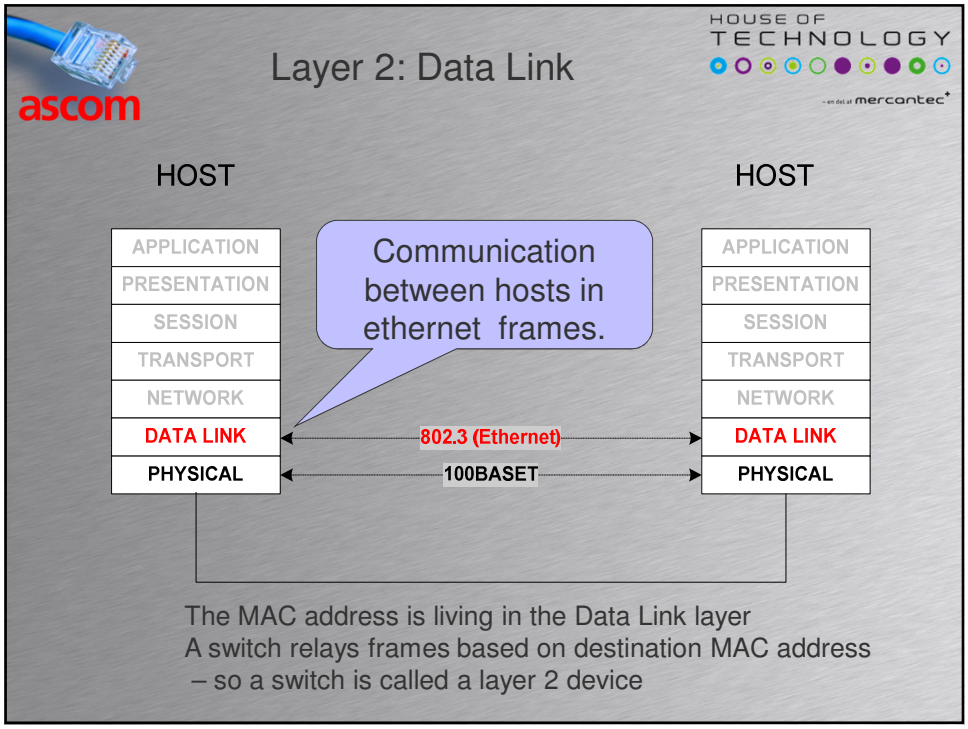
Intel PRO/1000 NIC

– NIC = Network Interface Card
- UTP = Unshielded Twisted pair



Connector	RJ45
Ethernet standards	10BASET, 100BASET, 1000BASET
Wiring	Category 5, UTP, 4 pair

– UTP = Unshielded Twisted pair
– RJ45 male plug with crimped on 4 pair UTP cable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Layer 2: Data Link
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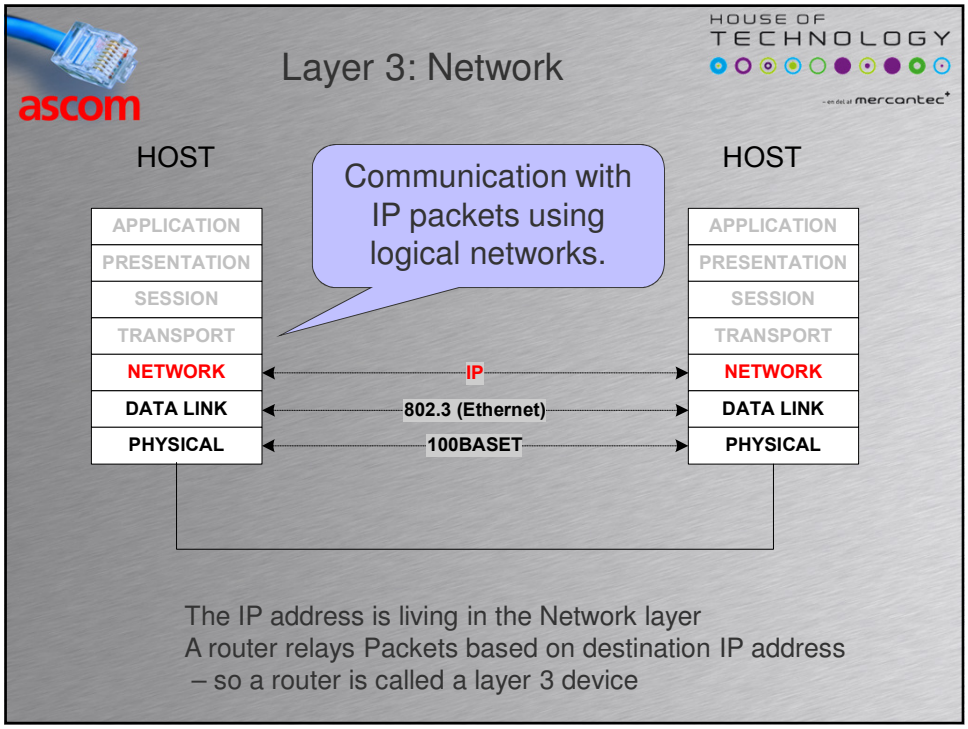
HOST
HOST
APPLICATION
PRESENTATION
SESSION
TRANSPORT
NETWORK
DATA LINK
PHYSICAL
Communication between hosts in ethernet frames.
802.3 (Ethernet)
100BASET
The MAC address is living in the Data Link layer
A switch relays frames based on destination MAC address
– so a switch is called a layer 2 device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Layer 3: Network
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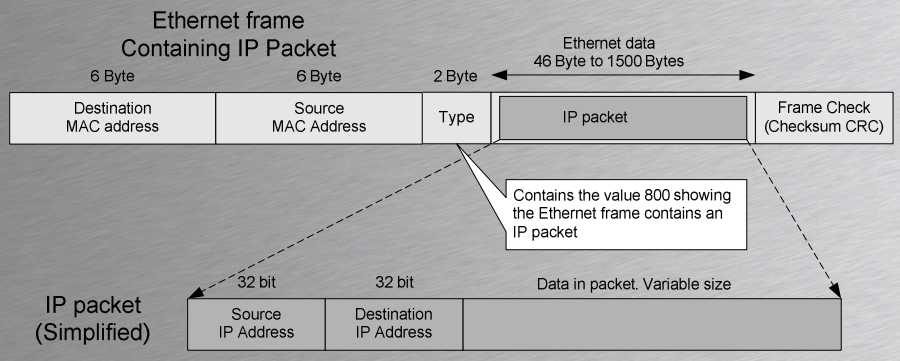
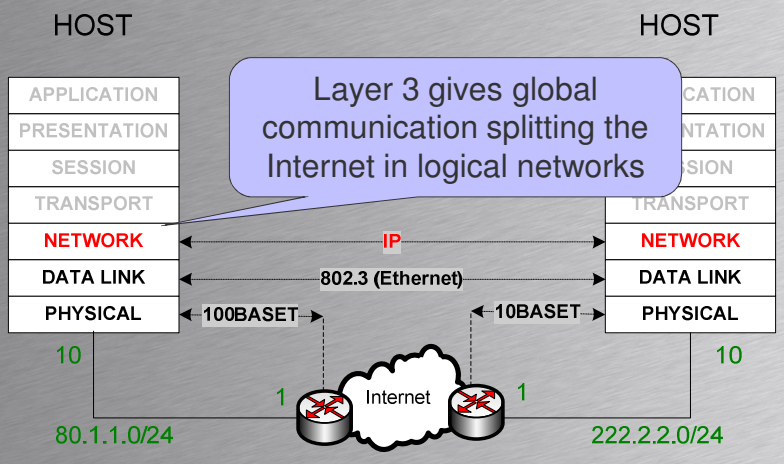
HOST
HOST
APPLICATION
PRESENTATION
SESSION
TRANSPORT
NETWORK
DATA LINK
PHYSICAL
Communication with IP packets using logical networks.
IP
802.3 (Ethernet)
100BASET
The IP address is living in the Network layer
A router relays Packets based on destination IP address
– so a router is called a layer 3 device

The packet – so far

- A host receive an ethernet frame on the pysical layer
- The physical layer passes the frame to the Data Link layer
- The Data Link Layer checks the frame and deliver it to the layer 3 Network protocol indicated by the Type field. It this case IP.

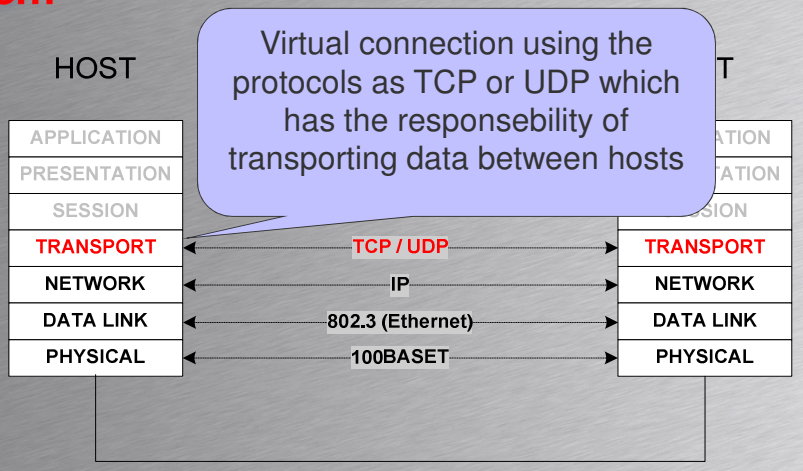


Layer 3: Network



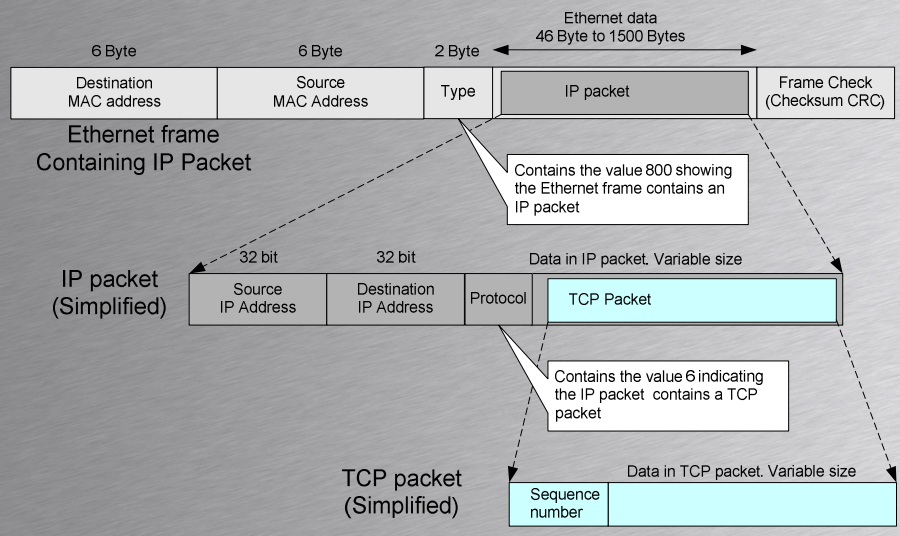
There is no delivery guaranty for IP packets
Packets are dropped and lost frequently

Layer 4: Transport



TCP: Transmission Control Protocol – retransmit lost packets
UDP: User Datagram Protocol – do not retransmoit lost packets

TCP in IP in Ethernet



Port numbers

- Port numbers are virtual end connection points in TCP and UDP
  - TCP port 80 = Web-server connection
  - TCP port 25 = Mail-server connection
  - TCP port 443 = encrypted Web-server connection

```
Command Prompt
C:\Users\Henrik thomsen>netstat -n

Active Connections
  TCP    192.168.1.14:49800     195.181.54.24:80       ESTABLISHED
  TCP    192.168.1.14:49801     195.181.54.24:80       ESTABLISHED
  TCP    192.168.1.14:49811     217.113.99.169:80      ESTABLISHED
  TCP    192.168.1.14:49812     217.113.99.169:80      ESTABLISHED
  TCP    192.168.1.14:49858     87.67.4.123:443        ESTABLISHED
```

Some of my established (active) connections the day i wrote this

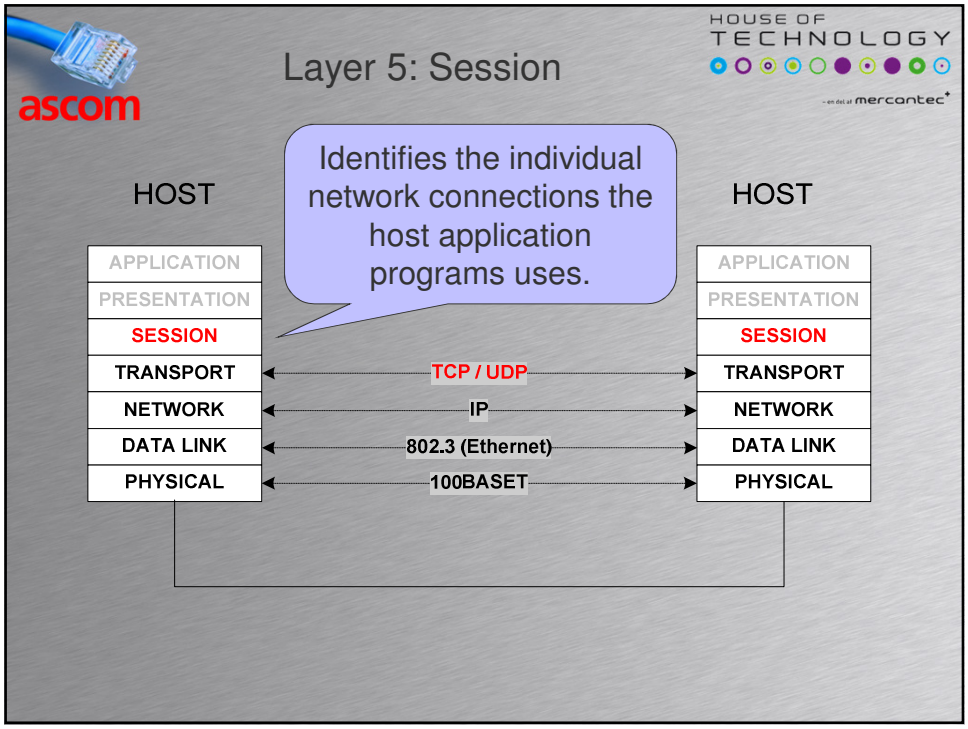
Connections

- A connection is unique based on
  - Source IP address — example 192.168.1.14
  - Destination IP address — example 195.181.54.24
  - Protocol — example TCP
  - Source port — example 49801 (Chosen randomly)
  - Destination port — example 80 (A Web-server)

```
Command Prompt
C:\Users\Henrik thomsen>netstat -n

Active Connections
  TCP    192.168.1.14:49800     195.181.54.24:80       ESTABLISHED
  TCP    192.168.1.14:49801     195.181.54.24:80       ESTABLISHED
  TCP    192.168.1.14:49811     217.113.99.169:80      ESTABLISHED
  TCP    192.168.1.14:49812     217.113.99.169:80      ESTABLISHED
  TCP    192.168.1.14:49858     87.67.4.123:443        ESTABLISHED
```

Every line is unique referring to a unique connection between a program On the local host and a program on the remote host.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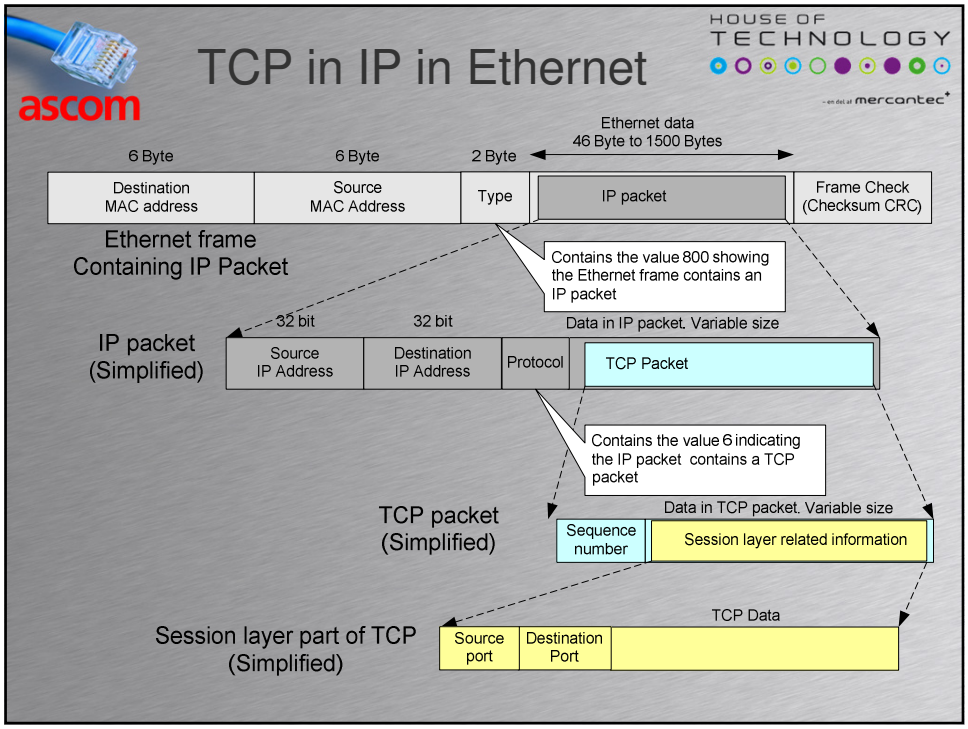
Layer 5: Session
Identifies the individual network connections the host application programs uses.
HOST
HOST
APPLICATION
PRESENTATION
SESSION
TRANSPORT
NETWORK
DATA LINK
PHYSICAL
TCP / UDP
IP
802.3 (Ethernet)
100BASET
APPLICATION
PRESENTATION
SESSION
TRANSPORT
NETWORK
DATA LINK
PHYSICAL


ascom
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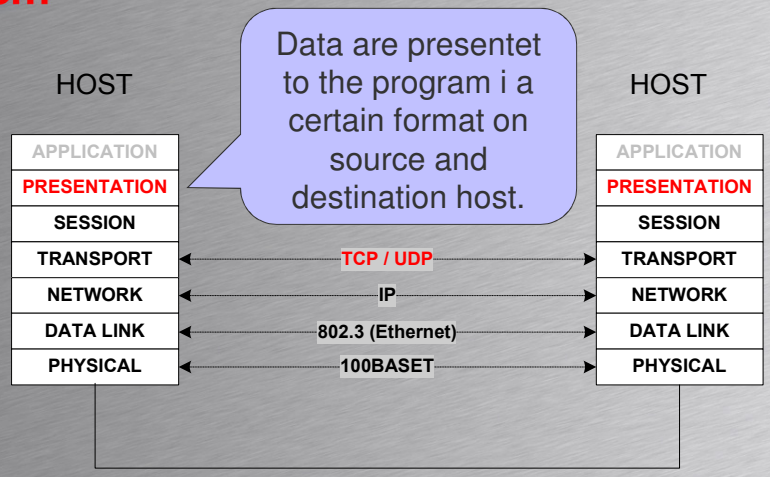
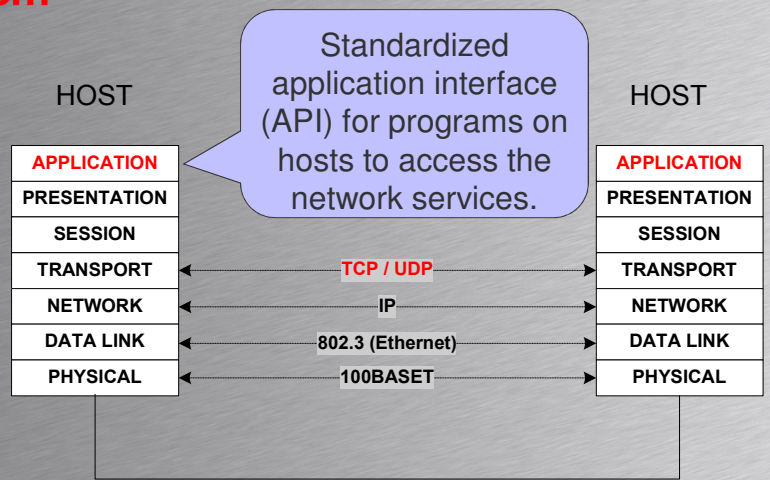
TCP in IP in Ethernet
Ethernet data
46 Byte to 1500 Bytes
6 Byte
6 Byte
2 Byte
Destination MAC address
Source MAC Address
Type
IP packet
Frame Check (Checksum CRC)
Ethernet frame Containing IP Packet
Contains the value 800 showing the Ethernet frame contains an IP packet
IP packet (Simplified)
32 bit
32 bit
Data in IP packet. Variable size
Source IP Address
Destination IP Address
Protocol
TCP Packet
Contains the value 6 indicating the IP packet contains a TCP packet
TCP packet (Simplified)
Data in TCP packet. Variable size
Sequence number
Session layer related information
TCP Data
Session layer part of TCP (Simplified)
Source port
Destination Port

Layer 6: Presentation



For example compressing and decompressing data is the responsibility
Differences between hosts – Linux, MAC, Windows – may need different ways of data presentation. (Common data format in IP packets)

Layer 7: Application



You could say that the application layer is a dating service between the Programs running on the computer and the network services offered by The network stack

TRANSPORT PROTOCOLS

TCP and UDP

Transport and session layer

Transport layer functionality

- Builds, maintains and closes virtual connections between end-points.
- The two most used protocols
  - TCP (Transmission Control Protocol)
  - UDP (User Datagram Protocol)
- They both address their applications or services using port numbers

Lag 7	Applikation
Lag 6	Præsentation
Lag 5	Session
Lag 4	Transport
Lag 3	Netværk
Lag 2	Data Link
Lag 1	Fysisk

TCP and UDP

- TCP builds virtual connections between end points. (hosts)
  - Connection oriented protocol – Create, maintain and close
  - Reliable transport.
  - The transmitter splits data segments. (Ethernet maximum 1500 bytes data)
  - The receiver assemble the data segments.
  - The receiver acknowledges the reception of segments. Lost segments are retransmitted.
- UDP transports data between end points. (hosts)
  - Connection less. Just send data and hoping the receiver is on-line.
  - Unreliable transport. (No guarantee the data is delivered)
  - The receiver do not assemble the data segments.
  - No flow control
  - No error control or recovery

TCP and UDP port numbers

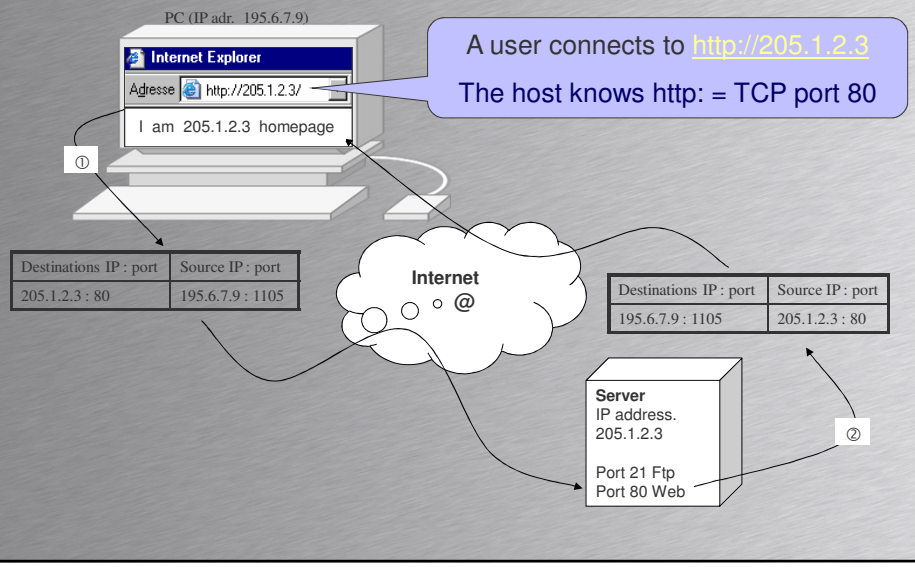
- IP Packets are routed to the destination base on the destination IP address.
- The Packets are delivered to the program inside the host the destination port number. (Web-servers listen to all traffic on TCP port 80)
- A IP address with port number is called a socket. (83.90.47.30:80)
- A port number can be in the rahge from 0 to 65535 – port 0 to 1023 are reserved an called well-known ports. (TCP port 80 is well-known)
- Ports are used as destination and source.
- The officiel list over port numbers can be seen at:

www.iana.org/assignments/port-numbers

Well-known port examples

Name	Port nr.	Protocol	Service description
Ftp	21	tcp	File Transfer Protokol
Telnet	23	tcp	Telnet remote login
Smtp	25	tcp	Simple Mail Transfer Protokol
Domain	53	udp	Domain Name Server
Bootps	67	udp	Bootstrap Protocol Server / DHCP server
Bootpc	68	udp	Bootstrap Protocol Client / DHCP client
Tftp	69	udp	Trivial File Transfer Protocol
Www-http	80	tcp	World Wide Web http
Pop3	110	tcp	Post Office Protocol – Version 3
Nntp	119	tcp	Network News Transfer Protocol
Netbios-ns	137	tcp	NETBIOS Name Service
Netbios-ns	137	udp	NETBIOS Name Service
Netbios-dgm	138	tcp	NETBIOS Datagram Service
Netbios-dgm	138	udp	NETBIOS Datagram Service
Netbios-ssn	139	tcp	NETBIOS Session Service
Netbios-ssn	139	udp	NETBIOS Session Service
	1023		
Free ports	1024-65535		Can be used at pleasure

TCP Port number example

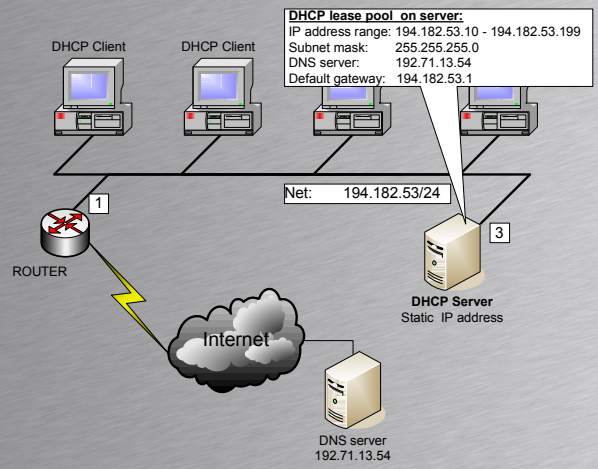


Tracert command

```
Command Prompt

C:\temp>tracert www.ascom.jp

Tracing route to www.ascom.jp [219.118.71.141]
over a maximum of 30 hops:

  1     1 ms    <1 ms    <1 ms  192.168.1.1
  2    23 ms    30 ms    22 ms  0x57382129.ge-1-2-0-1100.vgnqu2.dk.ip.tdc.net [87.56.33.41]
  3    53 ms    53 ms    52 ms  ae1-0.ldn1nqp1.uk.ip.tdc.net [83.88.22.7]
  4    52 ms    61 ms    53 ms  xe-7-3.r00.londen03.uk.bb.gin.ntt.net [83.231.199.245]
  5    53 ms    53 ms    53 ms  ae-2.r23.londen03.uk.bb.gin.ntt.net [129.250.4.133]
  6   313 ms   371 ms   313 ms  as-0.r22.osakjp01.jp.bb.gin.ntt.net [129.250.5.35]
  7   321 ms   340 ms   364 ms  ae-5.r24.tokyjp01.jp.bb.gin.ntt.net [129.250.3.221]
  8   330 ms   324 ms   332 ms  ae-1.r00.tokyjp01.jp.bb.gin.ntt.net [129.250.5.93]
  9   323 ms   317 ms   318 ms  xe-0-0-0-2.r00.tokyjp01.jp.ce.gin.ntt.net [203.105.72.162]
 10   321 ms   321 ms   320 ms  xg2-3-notemachi-core11.sphere.ad.jp [202.239.114.217]
 11   321 ms   327 ms   327 ms  xg1-4-kcd-arena-gw1.sphere.ad.jp [203.138.77.58]
 12   326 ms   327 ms   321 ms  203.138.37.106
 13   326 ms   323 ms   322 ms  fw.kai.ad.jp [219.118.79.135]
 14   324 ms   325 ms   322 ms  fw-inside.inside-sw.kai.ad.jp [219.118.79.158]
 15   327 ms   325 ms   332 ms  www4.lpp.hosting-link.ne.jp [219.118.71.141]

Trace complete.
```

DHCP

- Dynamic Host Configuration Protocol



- Automatic IP configuration

Without DHCP server

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- Each host has a static IP configuration
- Hosts not moveable between logical networks (laptops)
- Lot of work to configure hundreds of hosts on big networks
- Easy to make mistakes
- Change of IP address plan difficult
- Static IP addresses are often used
  - Servers
  - Printers
  - Networking equipment (Routers…)

With DHCP server

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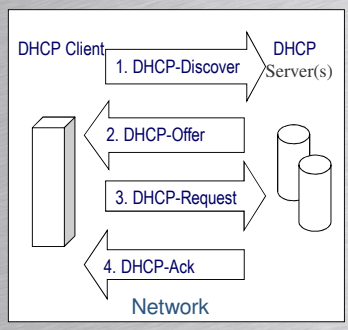
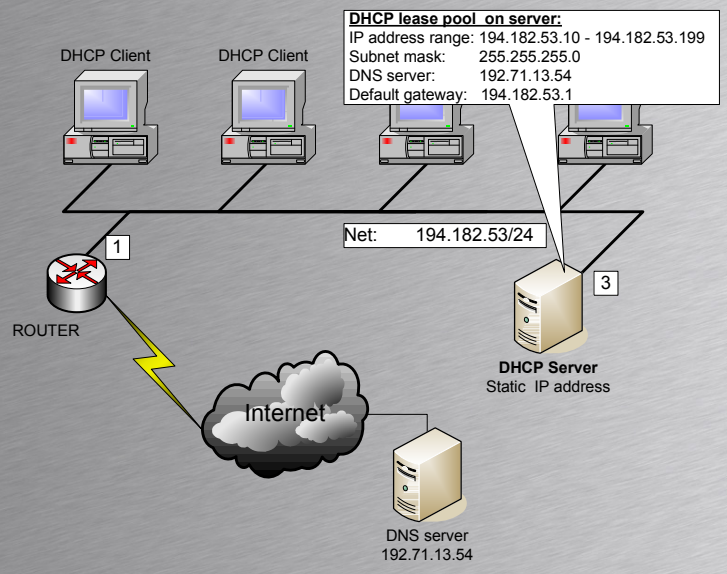
- A DHCP server leases IP addresses to DHCP Clients
- The DHCP server keeps track on leased addresses
- Easy to change – if new IP address plan nessesary
- The DHCP server offer full IP configuration to the client
  - IP Address
  - Subnet mask
  - Default gateway IP address
  - DNS server IP address
  - Additional information needed on site. For example VoIP server

How DHCP works

1. When a client need to lease a IP address it will broadcast a DHCP-Discover packet on the network.
2. A listening DHCP server will locate a free IP address from its pool of IP addresses and send a DHCP-offer packet to the client
3. If the DHCP client accept the DHCP-offer it will send a DHCP-request packet to the DHCP server requesting the offer.
4. The DHCP server sends a DHCP-Acknowledge to confirm the lease



DHCP example



DNS

DOMAIN NAME SYSTEM

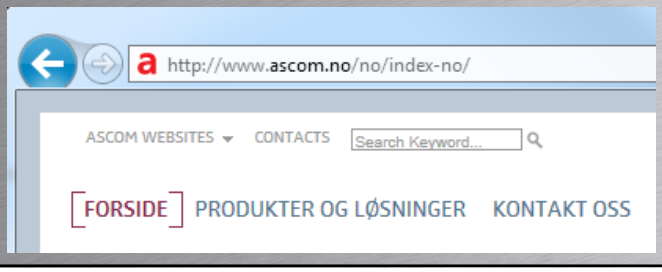
DNS Service

- Domain Name System (DNS) is a system that translates between domain names and IP addresses
  - For example from www.ascom.no to 195.191.133.67
- Makes it possible to assign new IP addresses to servers as the domain name is the same.
- DNS uses UDP port 53

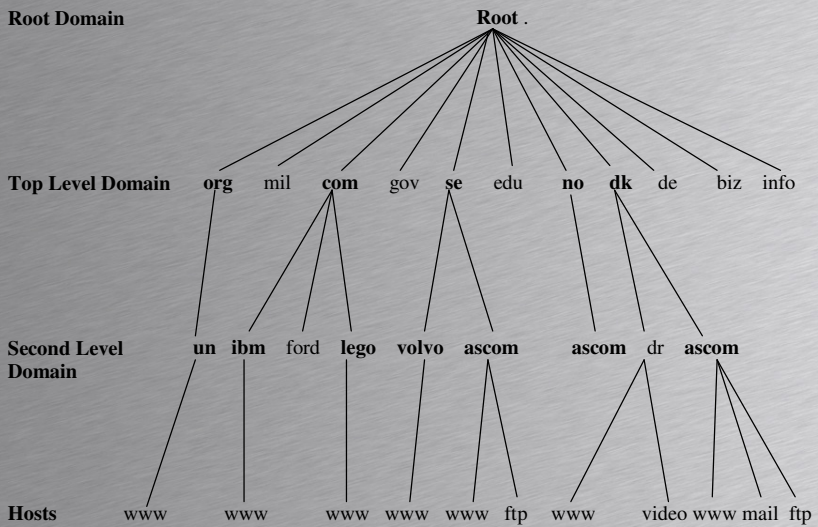
```
Command Prompt
C:\temp>nslookup www.ascom.no
Server:  sagembox.home
Address:  192.168.1.1

Non-authoritative answer:
Name:    www.ascom.no
Address:  195.191.133.67
```

DNS

- DNS is a hierarchical distributed naming system.
- Domain names consists of two parts www.ascom.no
  - A host name: www
    - A specific webserver located at ascom.no
  - A domain name: ascom.no
- A full domain name is also called a FQDN.
  - Fully Qualified Domain Name (FQDN).

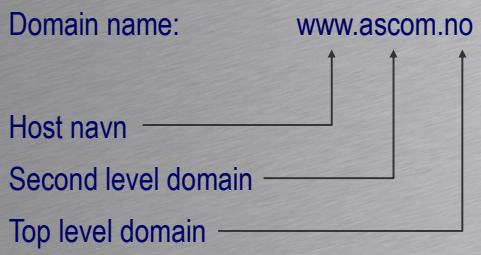


DNS zones



DNS zones

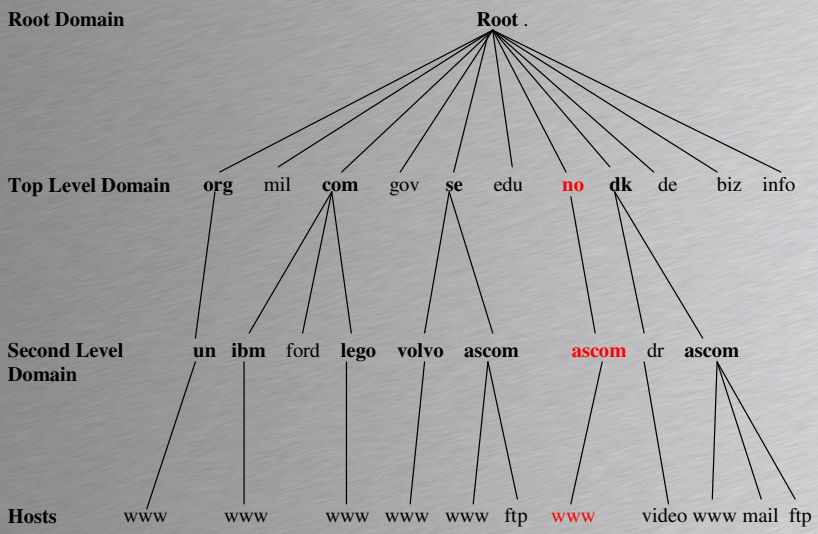
- A domain name is read from the right side to the left side
- Dots (.) divides the domain name in sections
- A dot means authority is delegated to a operator.
  - The TLD no is operated by by the company norid (www.norid.no)
  - Norid delegates control of ascom.no to Ascom in norway.
  - Ascom in norway operates a DNS servers with an entry stating that that the IP address of www.ascom.no is 195.191.133.67



DNS zones

- There are 13 root-servers named a to m.
  - a.root-servers.net
  - …
  - m.root-servers.net
- The 13 root-servers has well known IP addresses
- The root-servers are the top level of the hierarchical distributed database.

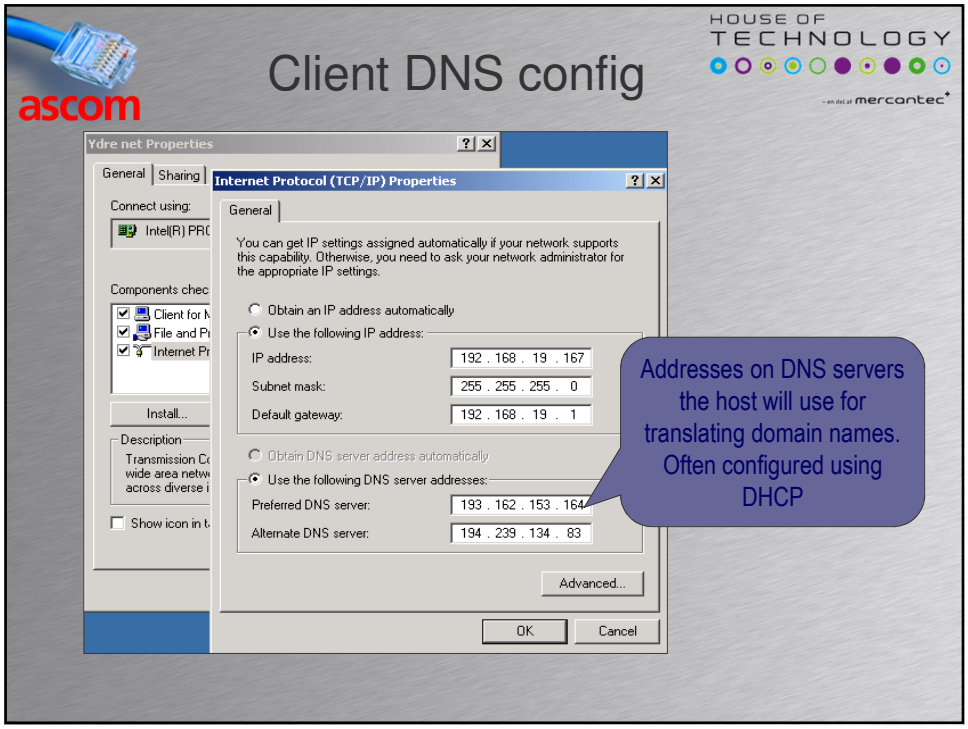
www.ascom.no



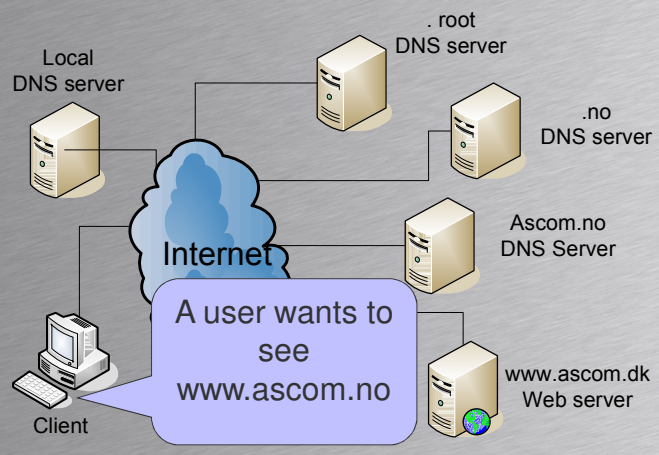
DNS name rules

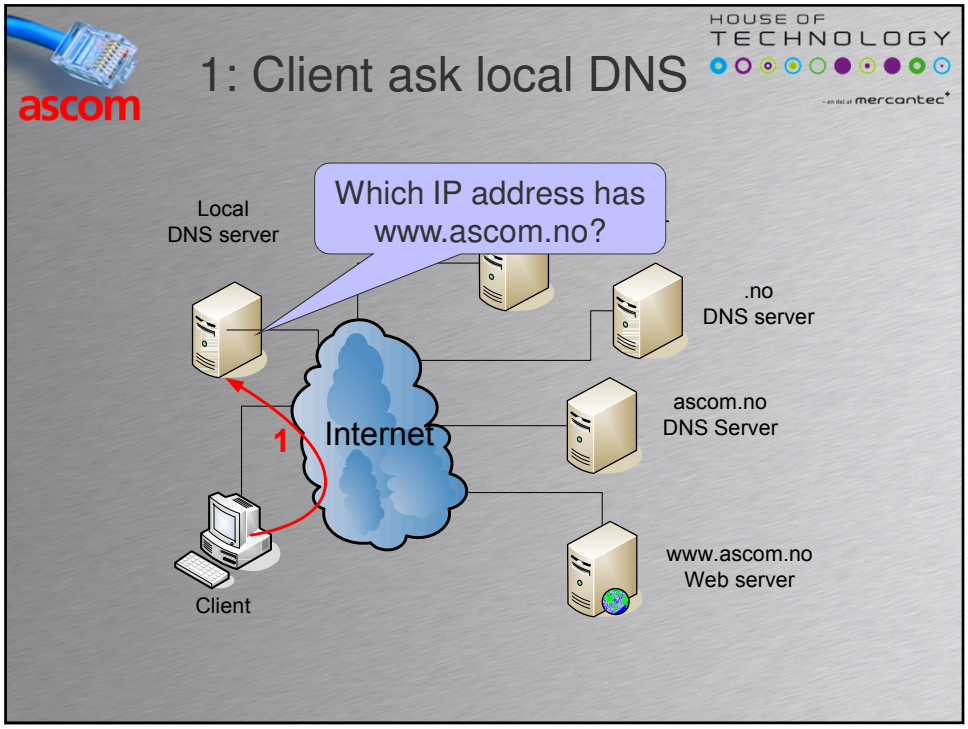
- Domain names maximum length is 63 characters including dots.
- The maximum length of FQDN names is 255 characters.
- No distingtion between upper or lower case in letters

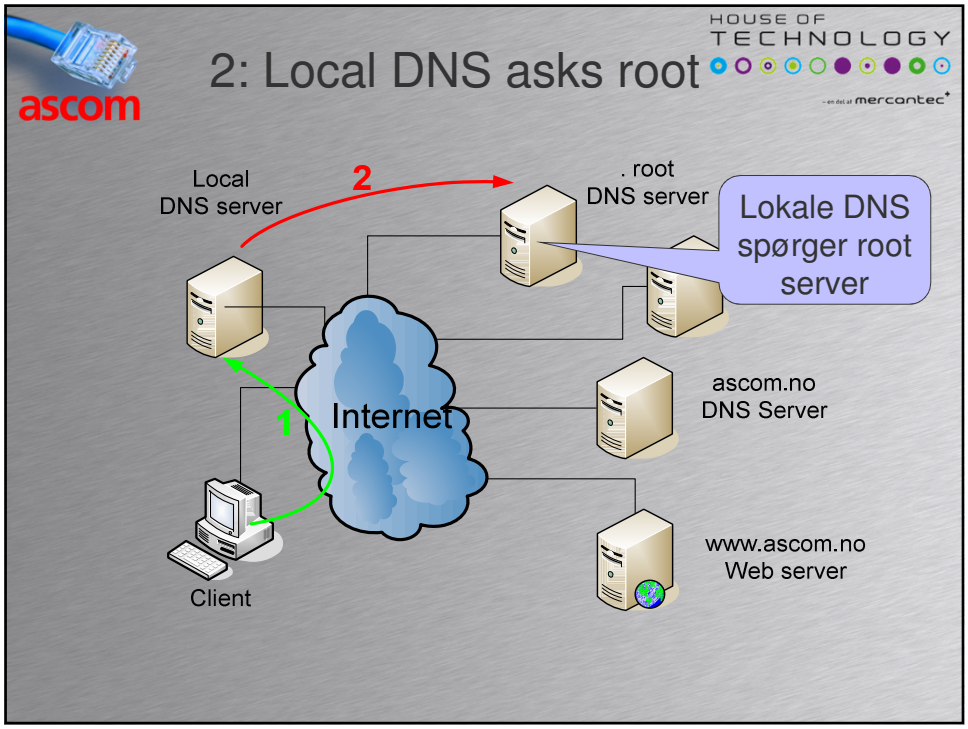
Client DNS config

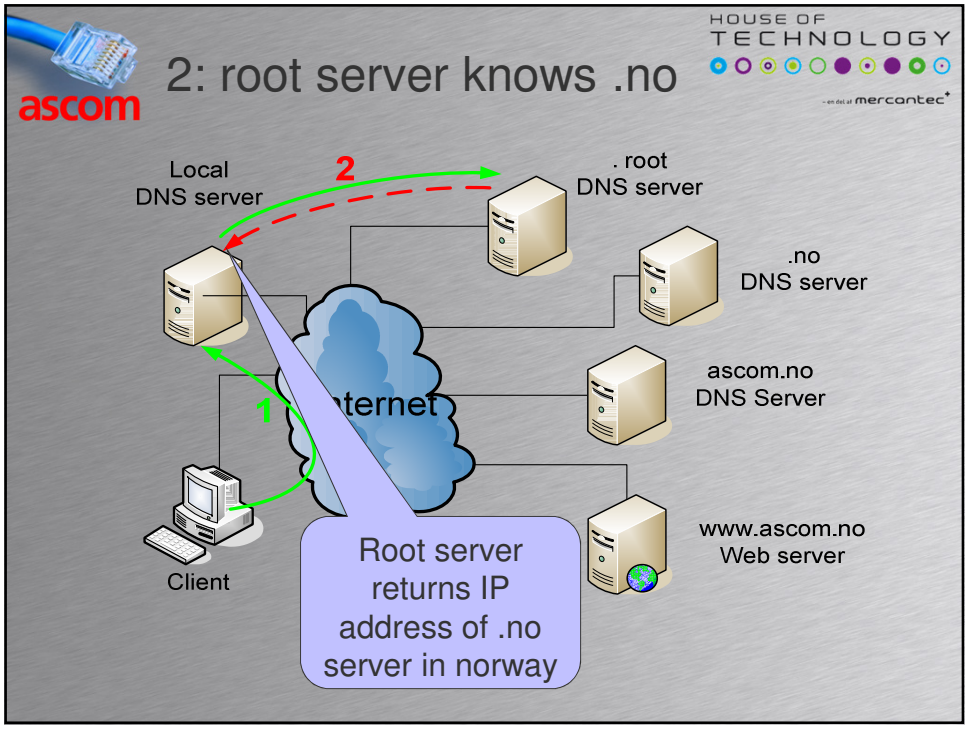


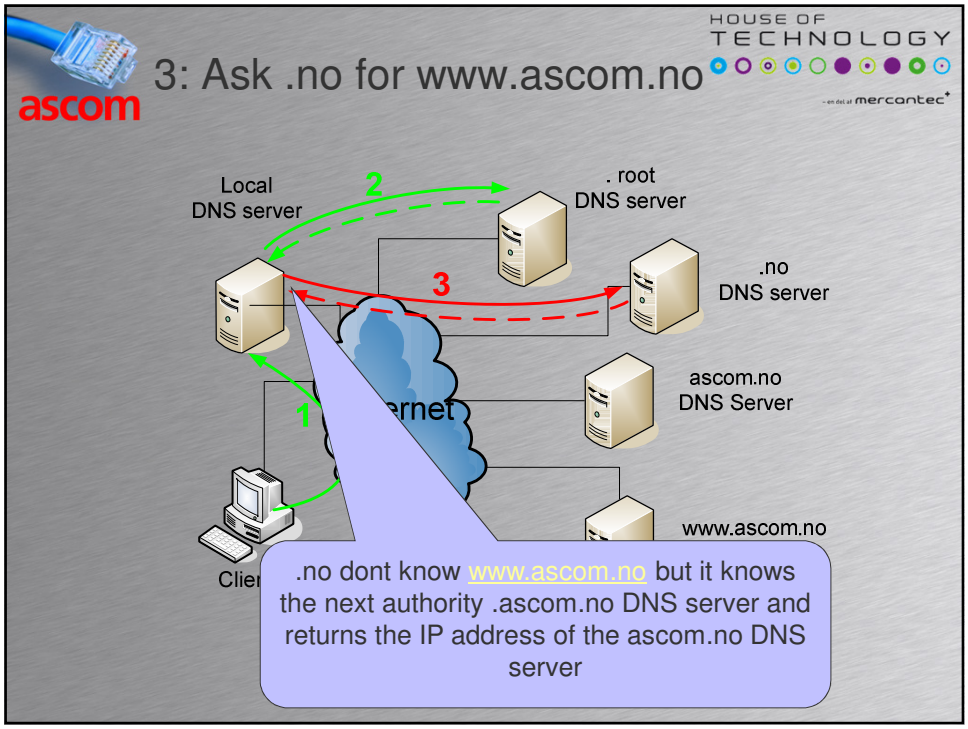
DNS- Example



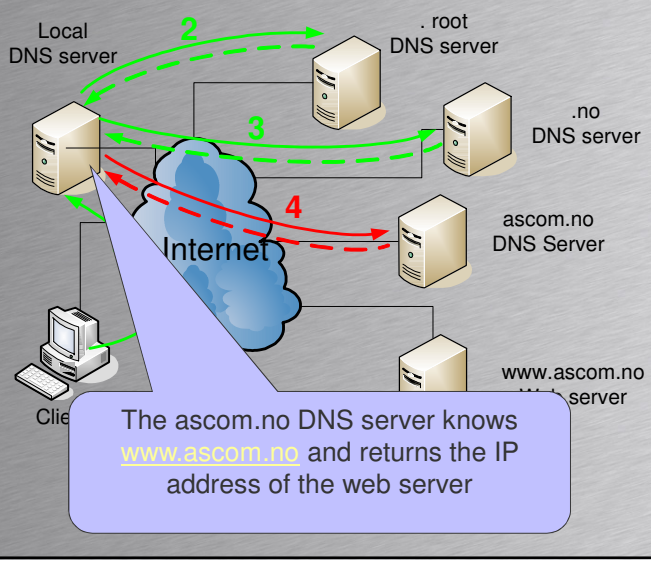

ascom
HOUSE OF TECHNOLOGY
1: Client ask local DNS
Which IP address has www.ascom.no?
Local DNS server
.no DNS server
ascom.no DNS Server
Internet
1
Client
www.ascom.no Web server


ascom
HOUSE OF TECHNOLOGY
2: Local DNS asks root
Local DNS server
2
. root DNS server
Lokale DNS spørger root server
ascom.no DNS Server
Internet
1
Client
www.ascom.no Web server

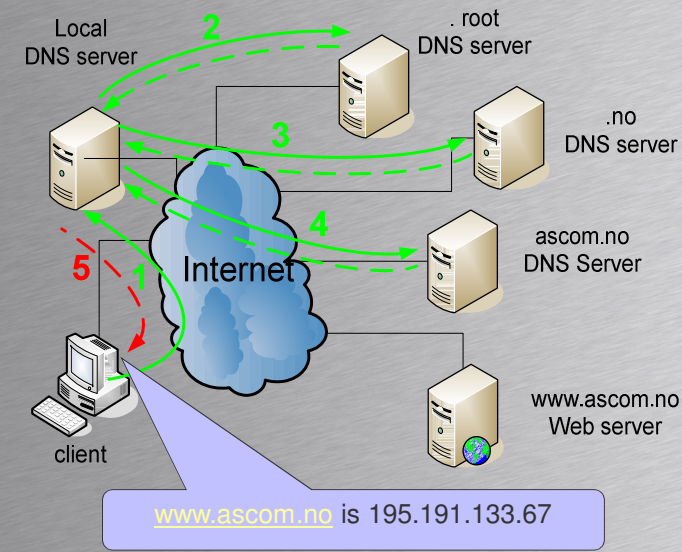

ascom
2: root server knows .no
HOUSE OF TECHNOLOGY
Local DNS server
2
. root DNS server
.no DNS server
ascom.no DNS Server
1
Client
www.ascom.no Web server
Root server returns IP address of .no server in norway


ascom
3: Ask .no for www.ascom.no
HOUSE OF TECHNOLOGY
Local DNS server
2
. root DNS server
3
.no DNS server
ascom.no DNS Server
1
www.ascom.no
.no dont know www.ascom.no but it knows the next authority .ascom.no DNS server and returns the IP address of the ascom.no DNS server

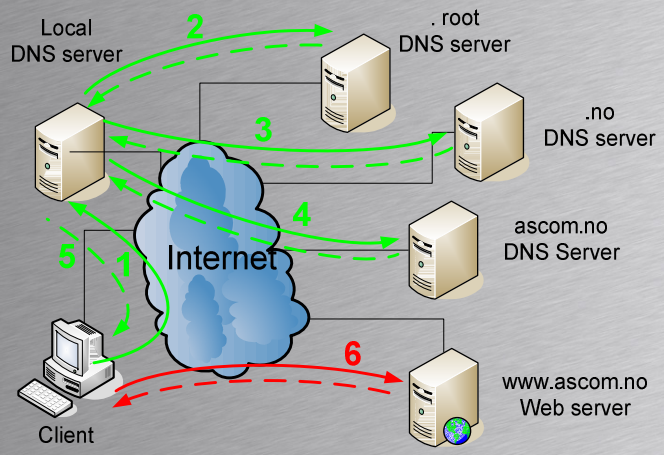
4: Then ask ascom.no



5: The client get the answer



6: Get the web-page



The local DNS server will normally be a caching DNS server meaning it will remember what it learns reducing traffic and decreasing respond time. All information has a time-to-live. The information will be deleted when time-to-live expires.

Caching DNS information

- My computer – Windows 7 caches the information it learns from the DNS system
- Uses time-to-live to timeout the information

```
Command Prompt
C:\Users\Henrik thomsen>ipconfig/displaydns

Windows IP Configuration

    www.ascom.no
    ----------------------------------------
    Record Name . . . . . : www.ascom.no
    Record Type . . . . . : 1
    Time To Live  . . . . : 295
    Data Length . . . . . : 4
    Section . . . . . . . : Answer
    A (Host) Record . . . : 195.191.133.67
```