...MAKE YOUR NETWORK SMARTER

TCP/IP

Per Flock, System architect

Revised by Torbjörn Söderberg

Data communication overview

- History
- General datacomms
- OSI reference model and layering
- Encapsulation
- Multiplexing

History

-776 Homing pigeons
1957 USSR launches Sputnik, US forms ARPA
1969 ARPANET formed
1972 First email sent
1983 TCP/IP mandated for ARPANET hosts
1980s Local networking explodes
1988 Internet worm hits hard
1992 WWW launched
1993 Cambridge Computer Lab Coffee Pot becomes the first webcam
1994 Order pizza online
2000 ~30 Pbyte/month on US backbone (compare ~50 Pbyte/month voice traffic)
2004 Google indexes 3.3 Gpages (one page may be an 800 page book on QFT)

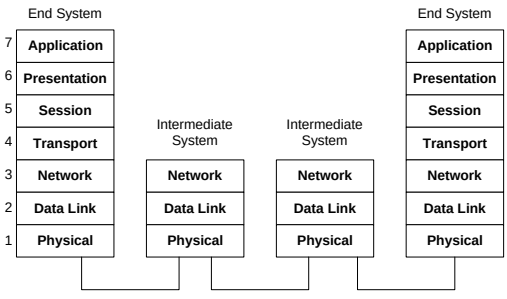
Communication is (really) hard

- Coordination: end-in-itself, caching
- Flow control
- Lossy channel
- Routing
- Addressing
- Multiplexing
- Node failures, link failures, address changes, load changes
- Performance: bandwidth, latency, jitter, node CPU and memory load
- Security & robustness: malevolence and error
- Quality of service differentiation
- Accounting

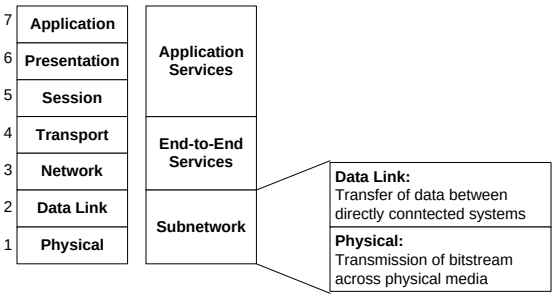
Illustrations

- Human communication and collective problem solving: Diplomacy
- Smoke signalling
- Optic telegraphs
- Postal system
- Phone system
- Taxi dispatch and inter-taxi communication
- Special problems in mobile and wireless comms

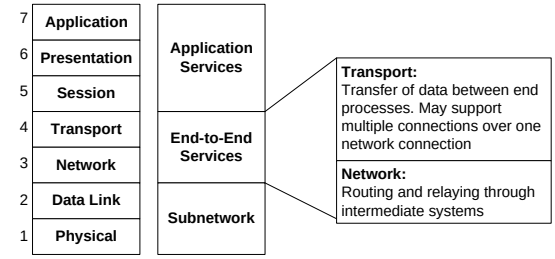
OSI Reference Model



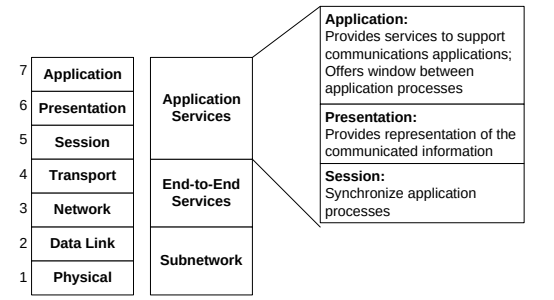
Subnetwork Layers



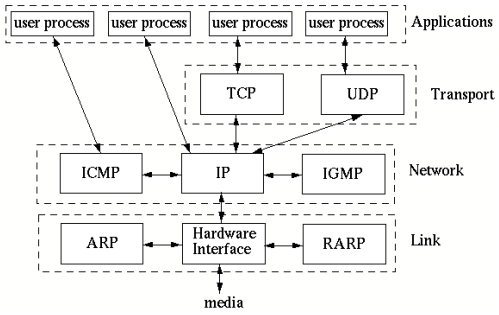
End-to-End Service Layers



Application Service Layers



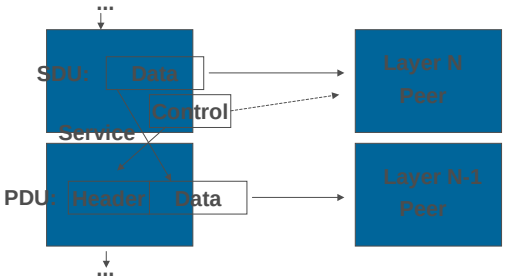
TCP/IP Layers



Network vs. Transport level services

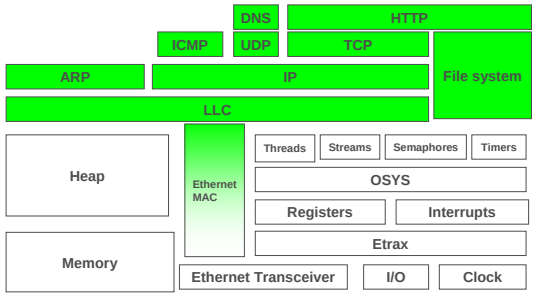
- The link layer gives a connection between two network interfaces on the same physical cable
- The network layer gives a connection between two machines across interconnected networks
- The transport layer provides end-to-end connections

Packets: layer interaction

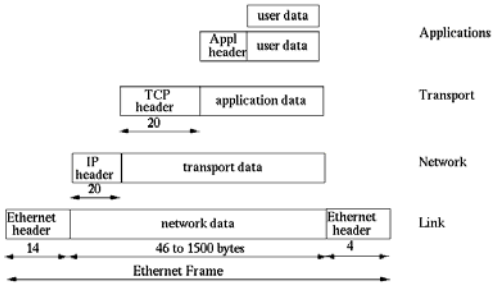


- A layer helps upper layer
- A layer may have to talk to peer on its own

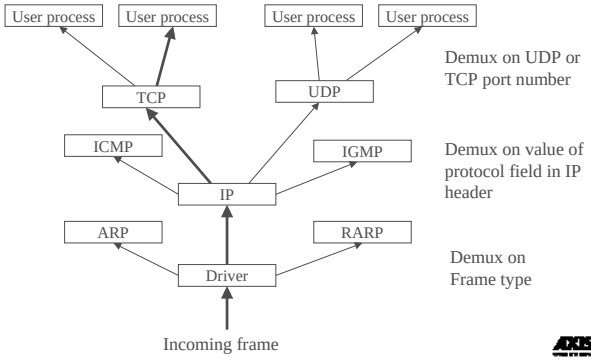
Internet Inside



Encapsulation



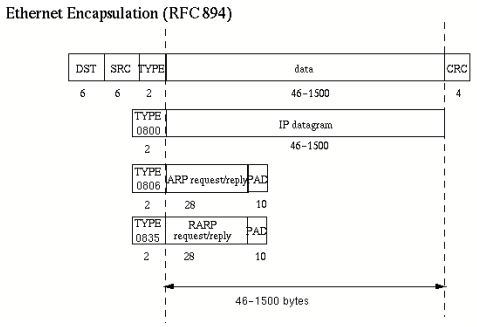
(De-)multiplexing



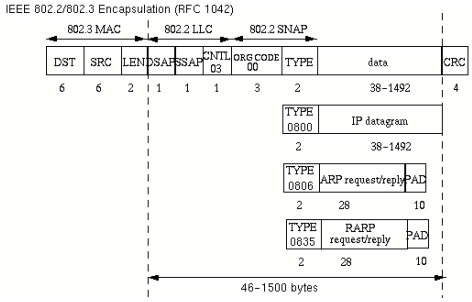
Link Layer

- Ethernet Encapsulation
- IEEE 802.3 Encapsulation
- Request For Comments

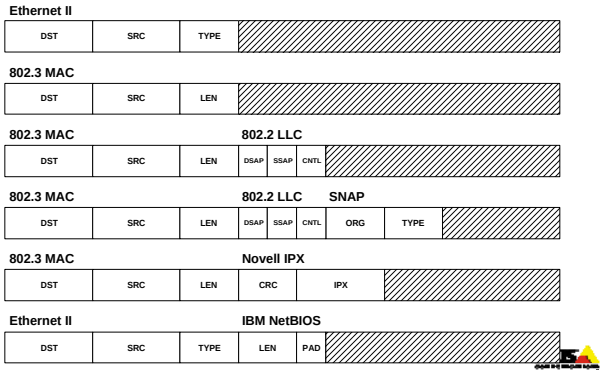
Ethernet encapsulation



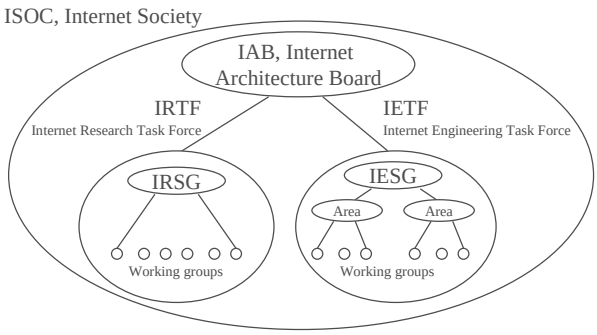
IEEE 802.3 Encapsulation (SNAP)



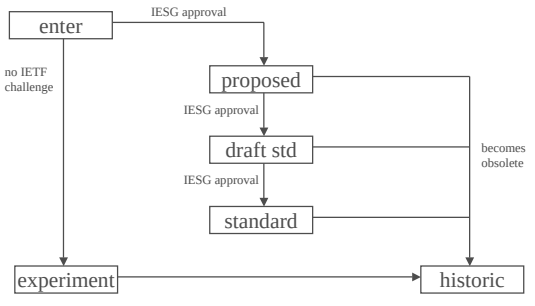
Possible Maximum Transmission Units



Internet Architecture Board



Request For Comments, RFC

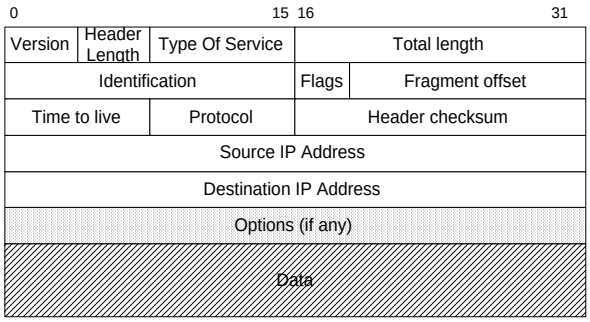


Internet Protocol, IP

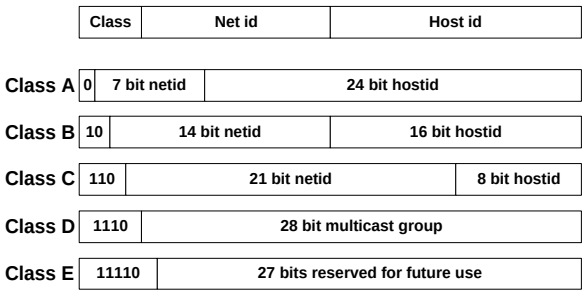
Connectionless Unacknowledged Network Service

- IPv4 [RFC 791]
- IP addresses
- Fragmentation
- Ping of death
- Domain Name System
- Routing

IPv4 [RFC 791]



IP Addresses



Classless routing and the subnet mask

Subnet mask 255.255.255.0	All one's		All zero's
140	252	1	1
Different subnets			
140	252	4	5

Special case IP Address

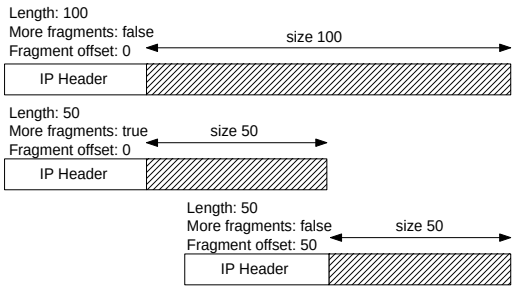
IP Address			Can appear as		Description
NetID	SubnetID	hostID	Source	Destination	
0		0	Ok	Never	This host on this net
0		hostID	Ok	Never	Specified host on this net
127		anything	Ok	Ok	Loopback address
255		255	Never	Ok	Limited broadcast
NetID		255	Never	Ok	Net-directed broadcast
NetID	SubnetID	255	Never	Ok	Subnet-directed broadcast
NetID	255	255	Never	Ok	All-subnets-dir. broadcast

IP Address to Link Address

- Dynamic mapping, Address Resolution Protocol (ARP)
- ARP Cache

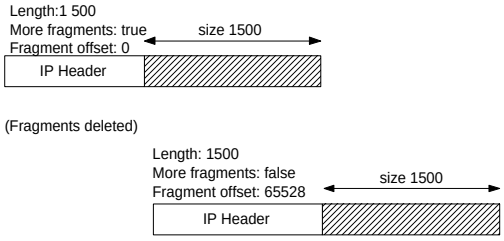
Importance of MTU

IP Fragmentation



Ping of Death

- IP MTU is 65535 bytes
- Consider the following IP fragments



- Total length is 67028!

Domain Name System (DNS)

- Hostname to IP Address

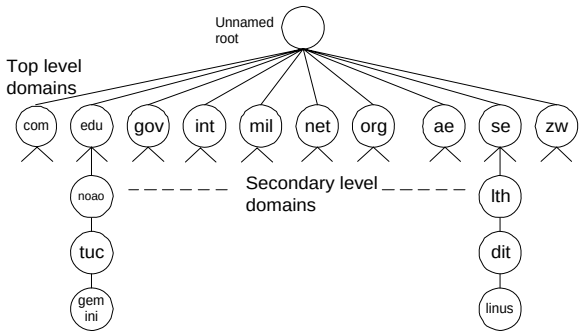
  linus.dit.lth.se ⇔ 130.235.17.242

- IP Address to host name

DNS names

- domain name: list of labels from a root, i.e., linus.dit.lth.se
- Fully Qualified Name (FQDN): a domain name ending in "." - there are no further labels
- leaves are managed **locally** through delegation of authority (to a *zone*) **not** centrally, this allows scaling
- if a name server does not know the answer it asks other name servers, every name server **must** know how to contact a **root server**

Zones



Internet Blackout!

- Full cause of massive Internet redirection still unclear (ComputerWorld, Jan 24 2001)
  - DNS table misconfiguration
  - DNS lookup strategy error
- Microsoft Sites Suffer Large-Scale Blackout (The industry standard, Jan 24 2001)
  - 60 million Hotmail users worldwide could not access their e-mail
  - microsoft.com, msnbc.com, windowsupdate.com, passport.com etc
  - Reasons proposed
    - MS: Router configuration + subsequent DOS attack
    - All MS DNS servers on the same network
    - Bug (since downtime was outage was ~ 1 day)

Routing

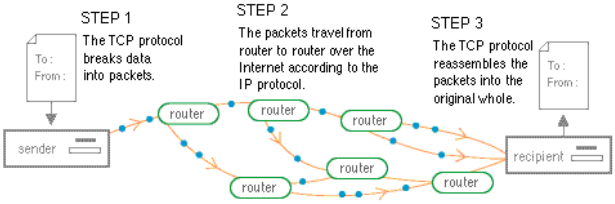
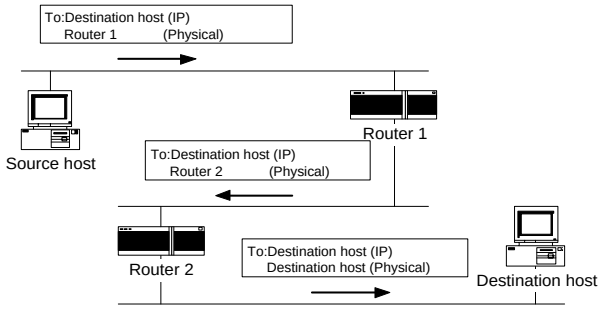


Figure 2. How data travels over the Net.

Routing

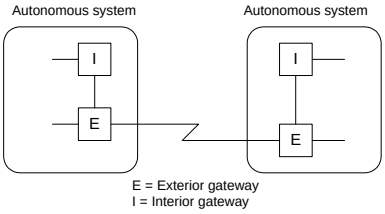
Subnet mask 255.255.255.0	**All one's**		**All zero's**
140	**252**	**1**	**1**
Same Class B netid		Different subnets	
140	**252**	**4**	**5**

Routing

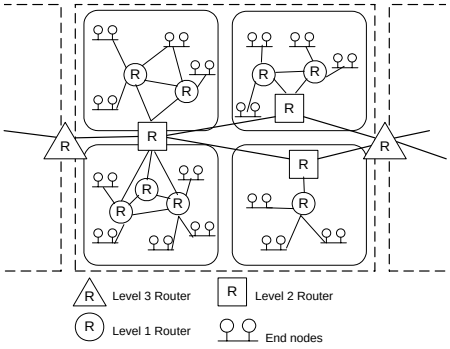


Dynamic routing

- Autonomous systems
- Interior Gateway Protocols (IGP)
- Exterior Gateway Protocols (EGP)



Autonomous systems



Routing

traceroute (www.traceroute.org)

```
Traceroute from 202.14.102.1 (Computer Services, Auckland, New Zealand, AS9303)
traceroute to www.sunet.se (192.36.125.18), 30 hops max, 40 byte packets
 1  C7507 (202.14.102.14)  0.594 ms  0.415 ms  0.391 ms
 2  C7507-2 (202.14.102.13)  1.495 ms  0.999 ms  0.925 ms
 3  gw-clearnet.kc.net.nz (202.27.202.222)  17.241 ms  5.053 ms  6.124 ms
 4  cs2-e-4-1-acld.auckland.clix.net.nz (203.97.81.206)  3.504 ms  2.985 ms  3.486 ms
 5  jcore1-ge-0-2-0-acld.auckland.clix.net.nz (203.97.2.246)  5.708 ms  5.785 ms  8.056 ms
 6  jb2-at-0-0-0-200-wils.losangeles.clix.net.nz (203.97.7.70)  204.902 ms  201.714 ms  208.372 ms
 7  us-ca-la-corel-s5-1.rtr.concentric.net (206.111.43.35)  213.604 ms ge9-0.dist1.lax-ca.us.xo.net (64.220.2.82)  204.906 ms  221.954 ms
 8  ge1-0.edge1.lax-ca.us.xo.net (64.220.0.85)  242.082 ms  211.858 ms  207.267 ms
 9  us-ca-la-qwest.gx.concentric.net (206.111.14.14)  254.379 ms  253.356 ms  221.017 ms
10  lax-core-01.inet.qwest.net (205.171.19.37)  221.187 ms  206.448 ms  219.661 ms
11  sjo-core-03.inet.qwest.net (205.171.5.155)  254.918 ms  269.245 ms  244.268 ms
12  sjo-core-01.inet.qwest.net (205.171.22.10)  264.913 ms  279.222 ms  273.862 ms
13  sfo-core-02.inet.qwest.net (205.171.5.123)  227.421 ms sjo-core-01.inet.qwest.net (205.171.22.10)  233.609 ms  246.642 ms
14  sfo-core-02.inet.qwest.net (205.171.5.123)  213.574 ms  275.23 ms  247.506 ms
15  jfk-core-02.inet.qwest.net (205.171.230.2)  292.996 ms  373.762 ms  375.769 ms
16  jfk-berk-02.inet.qwest.net (205.171.230.21)  351.778 ms  295.855 ms  306.406 ms
17  Nyk-cr02.NY.US.kpnqwest.net (205.171.30.146)  327.209 ms  430.612 ms  405.362 ms
18  r1-PO6-0.obl-KQ1.NL.kpnqwest.net (134.222.229.233)  459.129 ms  387.948 ms  457.756 ms
19  r2-Se2-0-0.0.ledn-KQ1.NL.kpnqwest.net (134.222.96.33)  399.988 ms  373.789 ms  360.558 ms
20  r1-Se0-0-0.0.ledn-KQ1.NL.kpnqwest.net (134.222.230.1)  359.968 ms  360.073 ms  369.728 ms
21  r1-Se0-1-0.0.hmbg-KQ1.DE.kpnqwest.net (134.222.230.18)  392.972 ms  371.261 ms  397.548 ms
22  r2-Se1-1-0-0.Sthm-KQ1.SE.KPNQwest.net (134.222.230.150)  397.496 ms  390.751 ms  390.579 ms
23  r4-Se7-0-0-0.Sthm-KQ1.SE.KPNQwest.net (134.222.119.246)  430.112 ms  399.548 ms  393.58 ms
24  s-gw.nordu.net (134.222.119.241)  391.868 ms  393.143 ms  391.191 ms
25  stockholm1-PO86-0.sunet.se (193.10.252.182)  391.444 ms  393.286 ms  391.441 ms
26  KTHNOC-1-SRP4.sunet.se (130.242.94.1)  394.218 ms  388.706 ms  387.279 ms
27  www.sunet.se (192.36.125.18)  401.51 ms  389.551 ms  392.439 ms
```