CS314-11-32

Summing up: How the Internet Works

Important protocols we haven't got time for

We haven't said nearly enough about security

How things fit together

Guiding principles

Questions?

314 s2c Exam, 2011

Exam Date: Thursday 27 October 2011

Time: 2:15 - 4:30 p.m.

8 short-answer questions

- 100 marks total
- 12 for part 1

Material covered includes

- All the lecture slides
- Assignments

Other infrastructure topics

Background slide

PPP (point-to-point protocol)

EAP, RADIUS, DIAMETER

Authentication, authorisation

IPSec, IKE (Shay 11.3)

Applies to IPv4 *or* IPv6

VPN (virtual private networks)

NAT

Network address translation

Firewalls

SOCKS (firewall traversal)

Multicast (Shay 11.2)

Mobile IP, mobility in general

SASL (simple auth & security)

SLP (service location)

RSVP (Shay 11.2)

ROHC (header compression)

iSCSI (SCSI over IP)

RDMA (remote DMA)

Other application topics

Background slide

MIME (multimedia formats)

SIP, ENUM

standards for voice over IP

Video over IP

PGP, S/MIME (secure email)

Internationalised email

Anti-spam solutions

LDAP (directory)

NTP (network time protocol)

IPP (Internet printing protocol)

NFS, AFS

Remote file systems

NNTP (network news)

RSS, ATOMPUB (feeds)

Instant messaging

Language tags

Web Services

XML-based distributed computing over SOAP+HTTP

Peer to Peer protocols

Grid computing protocols

The kitchen sink - a list of topics

Background slide

This is only to illustrate the complexity and richness of Internet protocols; don't learn it ...

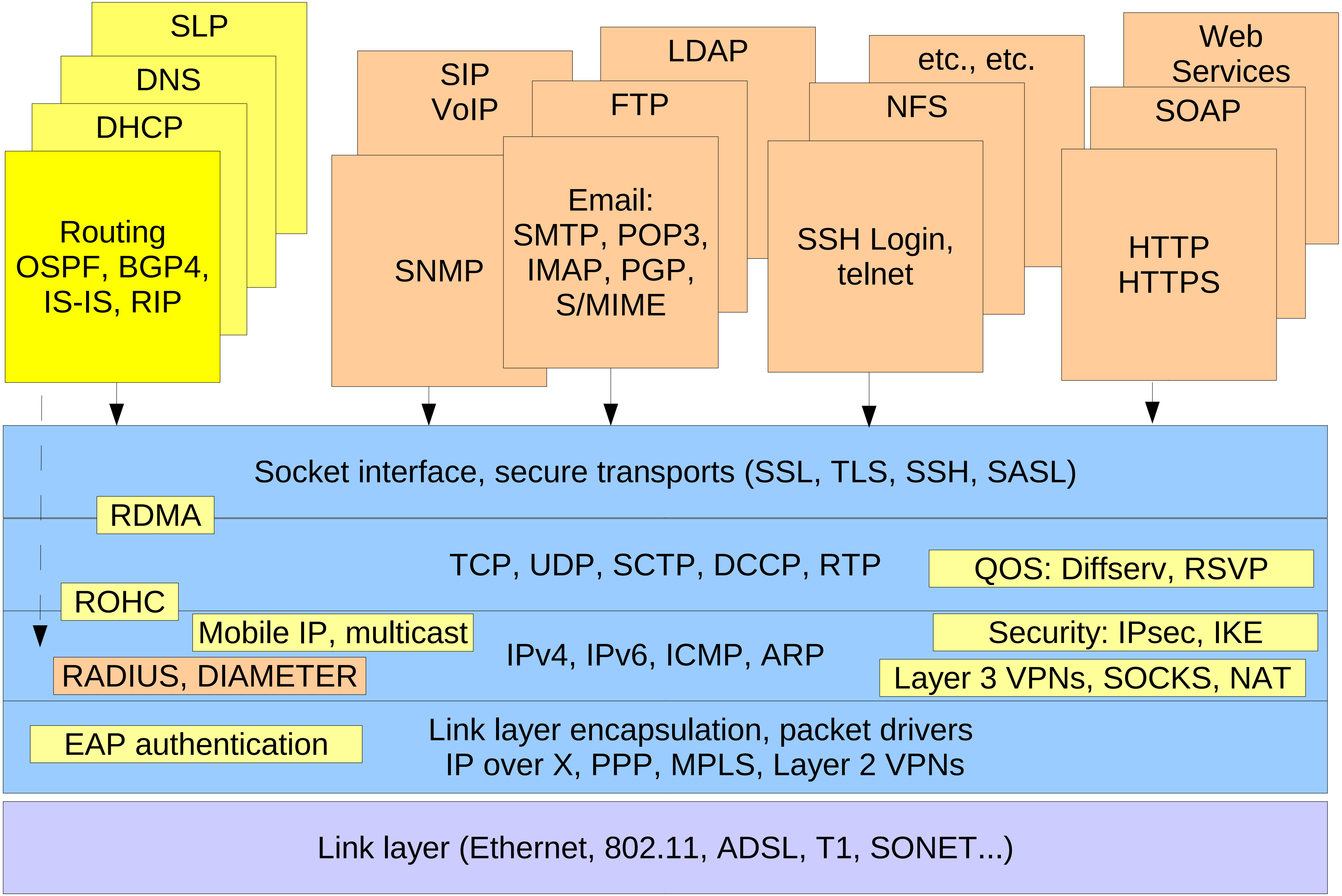
ACAP
APEX
ATOM
BEEP
CALSCH
CIP
DKIM
DNS
EDIINT
Email and MIME
ENUM
FAX
FTP
GEOPRIV
HTTP
Instant messaging
IPP
LDAP
Language Tags
Multimedia
NFS
NNTP
NTP
OPES
RSERPOOL
SEAMOBY
SIP, SIPPING, PPSIP
SLP
TELNET
TFTP
TIP

TN3270
URI, URL, URN issues
VoIP
WEBDAV
WIDEX
FECFRAME
iSCSI, iFCP
MIDCOM, STUN
ONCRPC
RDDP
ROHC
RMT
RTP, RTSP, SDP
SCTP
TCP
UDP
BEHAVE
BFD
BGP
DHCP
DIFFSERV, PCN
FORCES
GROW
HIP
ICMP
IPv4
IPv6
IPMTUD iscovery
IP multicast
IS-IS
L2VPN, L3VPN

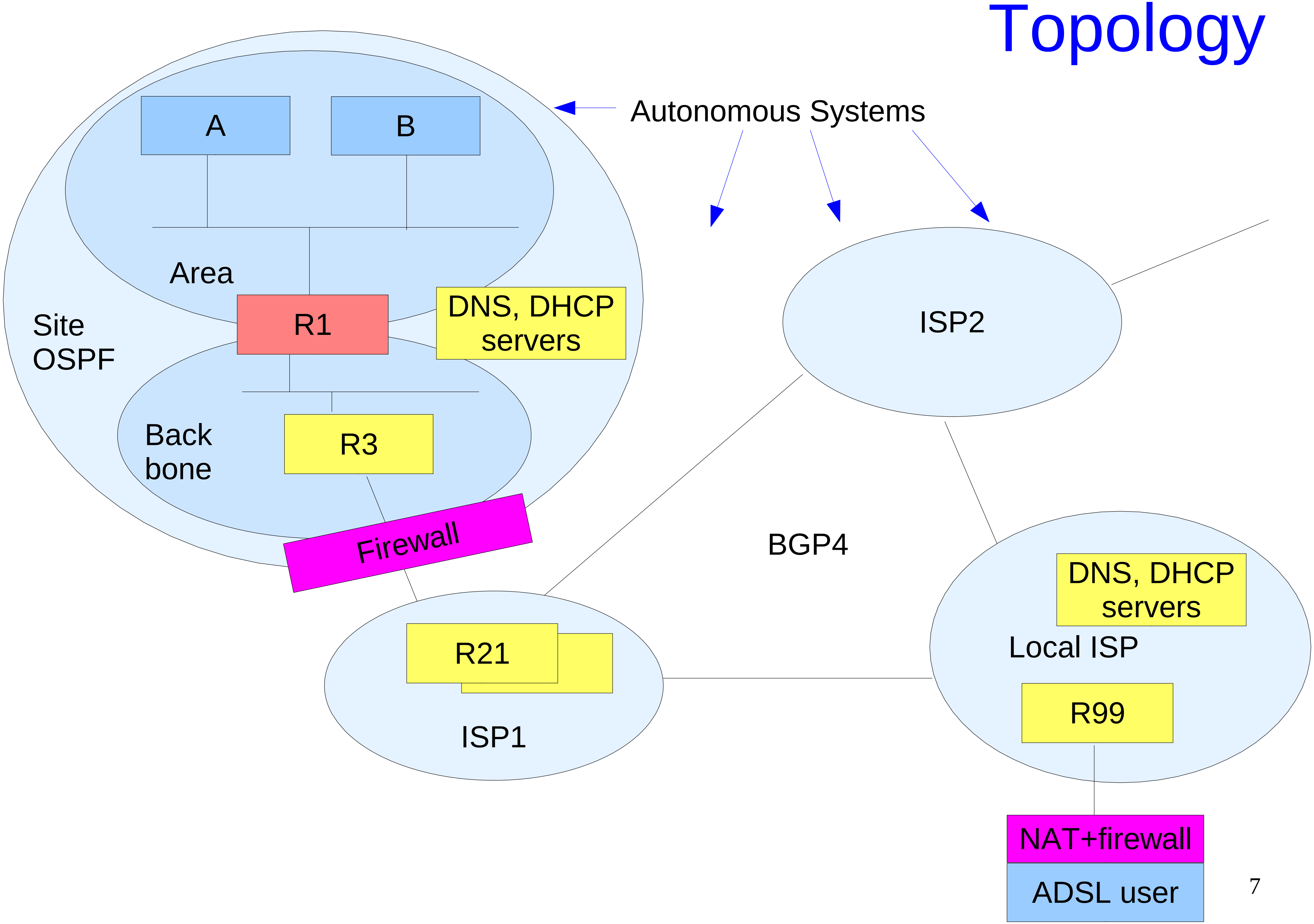
MANET/AUTOCONF
MobileIP
NEMO
NETLMM
OSPF
PPP
PTOMAINE
PWE
RIP
Router Discovery
RSVP, IntegratedServices, NSIS
SOFTWIREs
UDLR
VRRP
ZEROCONF
16ng (IP over IEEE 802.16)
6lowpan (IPv6 over 802.15.4)
GMPLS
IP over X
IPoIB
IMSS
MPLS
TRILL
ANCP
BMWG
CAPWAP
COPS
GSMP
IPFIX, PSAMP
IPPM
MIBs

NETCONF
POLICY
SNMP
Traffic Engineering
DIAMETER
EAP
IDX
IEPREP, ECRIT
INCH
IPSEC, IKE
KERBEROS and GSS-API
KEYPROV
LTANS
NEA
OPENPGP
OPSEC
OTP
PANA
PKI
RADIUS
RPSEC, SIDR
SACRED
SASL
SEND
SOCKS
SSH
SSL/TLS and HTTPS
SYSLOG
S/MIME
XMLDSIG

Protocol stack


SLP
DNS
DHCP
Routing OSPF, BGP4, IS-IS, RIP
SIP VoIP
LDAP
FTP
SNMP
Email: SMTP, POP3, IMAP, PGP, S/MIME
etc., etc.
NFS
SSH Login, telnet
Web Services
SOAP
HTTP HTTPS
Socket interface, secure transports (SSL, TLS, SSH, SASL)
RDMA
TCP, UDP, SCTP, DCCP, RTP
QOS: Diffserv, RSVP
ROHC
Mobile IP, multicast
IPv4, IPv6, ICMP, ARP
Security: IPsec, IKE
RADIUS, DIAMETER
Layer 3 VPNs, SOCKS, NAT
EAP authentication
Link layer encapsulation, packet drivers
IP over X, PPP, MPLS, Layer 2 VPNs
Link layer (Ethernet, 802.11, ADSL, T1, SONET...)

Topology


Autonomous Systems
A
B
Area
Site
OSPF
R1
DNS, DHCP servers
Back bone
R3
Firewall
ISP2
BGP4
ISP1
R21
DNS, DHCP servers
Local ISP
R99
NAT+firewall
ADSL user

The end-to-end principle (1)

Background slide

Note how TCP works - it *assumes* that packets may be lost, delayed, corrupted or delivered out of order. The two ends of a TCP connection cooperate to overcome this

Note how SSH works - it *assumes* that messages may be intercepted and that attackers may try to insert false messages. The two ends of an SSH connection cooperate to overcome this

Note how DNS works - if a DNS (UDP) message is lost, no harm results except a delay.

These are all examples of the end-to-end principle at work

The end-to-end principle* (2)

Background slide

Certain required end-to-end functions can only be performed correctly by the end-systems themselves

Any network, however carefully designed, will be subject to failures of transmission at some statistically determined rate. The best way to cope with this is to give responsibility for the integrity of communication to the end systems. A similar argument applies to intrusions

No solution buried inside the network can give the same level of assurance as the end systems

For example, *end-to-end* encryption is intrinsically safer than *router-to-router* encryption

** see References*

Other principles (1)

Background slide

Heterogeneity by design

Avoid duplicate solutions

Scaleable designs

Performance and cost must be considered as well as functionality

KISS (keep it simple, stupid!)

Modularity is good

Good enough is enough (don't seek perfection)

Minimise use of options

Be strict when sending and tolerant when receiving

Other principles (2)

Background slide

Be parsimonious with unsolicited packets, especially multicasts and broadcasts

Circular dependencies must be avoided

Objects should be self-describing (type and size)

Nothing gets fully standardised until there are multiple instances of running code

Avoid design that requires hard coded addresses

Addresses must be unambiguous (NAT breaks this!)

Designs should be fully international

All protocols need strong security (early ones didn't!)

References

Background slide

RFC 1958: Architectural principles of the Internet

End-to-end principle paraphrased from "End-To-End Arguments in System Design", J.H. Saltzer, D.P.Reed, D.D.Clark, ACM TOCS, Vol 2, Number 4, 1984

“Why the Internet only just works” by Prof. Mark Handley, University College London

http://www.cs.ucl.ac.uk/staff/
M.Handley/papers/only-just-works.pdf

Questions?

What haven't you understood in this course?