

UiO : Faculty of Mathematics and Natural Sciences
University of Oslo

Department of Informatics
Networks and Distributed Systems (ND) group

IN 3230 / IN 4230

Networks



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Organisational matters

- Physical attendance
  - 1 two-hour lecture per week
    1 two-hour common group exercise (not this week)
  - 1 oracle per week (also not this week)

- Theoretical knowledge
  - IN 3230: 70% of the grade
  - IN 4230: 60% of the grade
  - examined in a written 4-hour exam

- Practical knowledge
  - 1 mandatory assignment (must be passed for admission to written exam)
  - IN 3230: 1 home exam (30% of the final grade)
  - IN 4230: 2 home exams (40% of the final grade)

Course outline

Pensum

- All lectures
- All lecture slides
- All group lessons
- All mandatory assignments and home exams

Not pensum

- The recommended books

- **What does that mean?**
  - The books are recommended to improve understanding of the material that is pensum.
  - The books contain more topics.
    These are not part of the course's pensum.
  - In a few cases, the lecture is more up-to-date than the books.

Problem area and focus

- What today's networks really are
  - Why they are the way they are
  - How we could make them better

→ Critical thinking!

- Principles, concepts, and generality
  ...and learning by doing
  - Understand principles and concepts by building examples

Internet, previously:

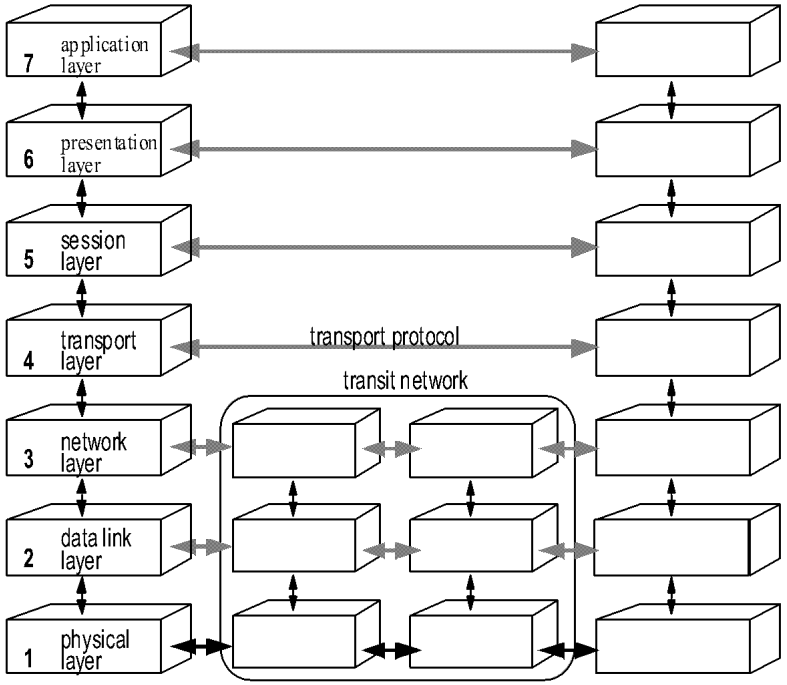


Internet, today:

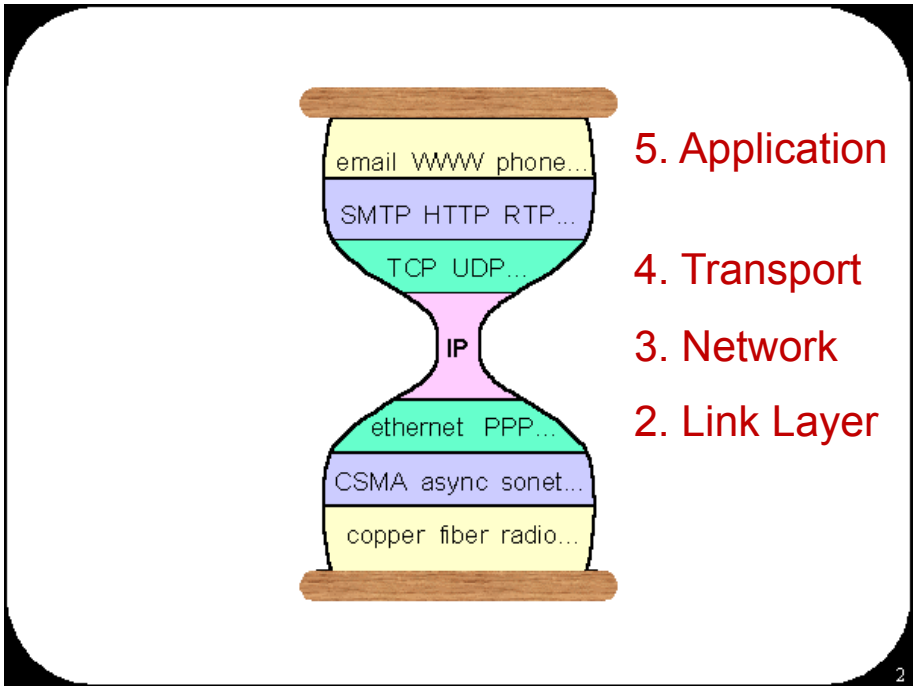


Theory

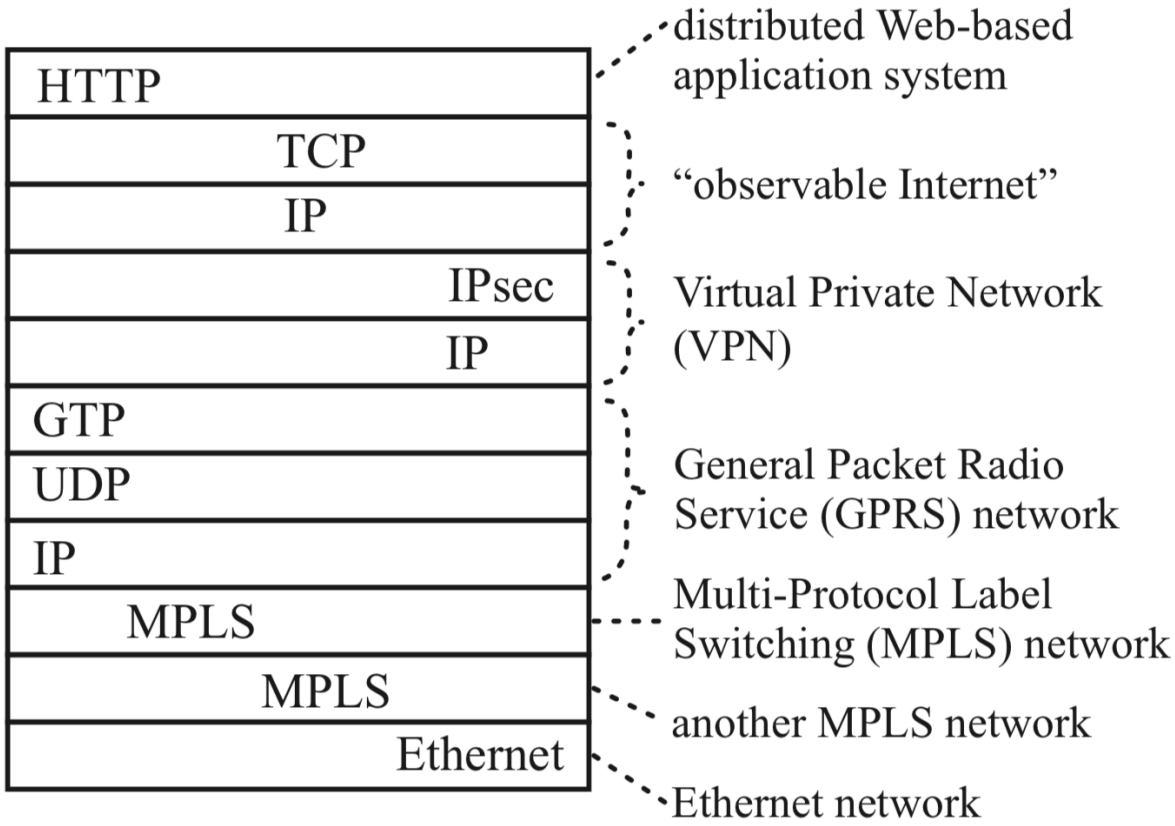
ISO/OSI model



DoD model



Reality



Typical packet from AT&T backbone network

Pamela Zave and Jennifer Rexford. 2019. The compositional architecture of the internet. Commun. ACM 62, 3 (February 2019), 78-87. DOI: https://doi.org/10.1145/3226588

Example problem 1: IP fragmentation

- IP must get all fragments of a packet to reassemble
  => What if a fragment is lost?
  - Early 70's: IP was split from TCP => TCP's retransmissions are distinct, not recognized by IP
  - Must hold fragments for a long time, in vain
    => wastes buffer space

- Fix: Path MTU Discovery
  - Disable fragmentation & find the largest possible packet that can be sent: start big, reduce size upon incoming ICMP error
    - Actually this doesn't work either: many nets filter ICMP
    - Solution: PAcketization Layer PMTUD (PLPMTUD): start small, assume ok when ACKs arrive

    ...can you see problems with this?

Example problem 2: multi-path transfer

- TCP makes many assumptions
  (little re-ordering, almost no loss, ..)
  - IP tries to be neutral; yet, new in-network mechanisms must not break TCP's assumptions
- Multi-path data transfer
  - Network layer; routers should not look at transport header
  - Per-packet operation creates re-ordering for TCP
  - Mechanisms like Equal-Cost Multi-Path (ECMP) or Link Aggregation Group (LAG) divide per-connection
  - Need to track connections, need functions per transport protocol
  - IPv6 flow label could help... but ECMP/LAG rules in RFCs allow hashing on transport header
    - Maybe some router vendors want this?

SCTP, UDP, ...
QUIC?

Non-technical reasons for these problems

- Compromises
  - Standards: often "group 1 demands X, group 2 demands Y, so let's have both X and Y !"



- Opposing incentives
  - Google, Cisco, Netgear, Akamai, Telenor, Apple, Microsoft, ...







Conclusion

- The Internet is quite different from “theory”
  - Layers are often neither OSI nor DoD
  - Not much real theory until quite recently
    - Recursive architectures offer a "cleaner" look
- You will learn what the Internet really is like
  - You should learn to appreciate good vs. bad design
  - Hopefully deeper understanding than public press or some tech blogs!

Thank you!

Questions?