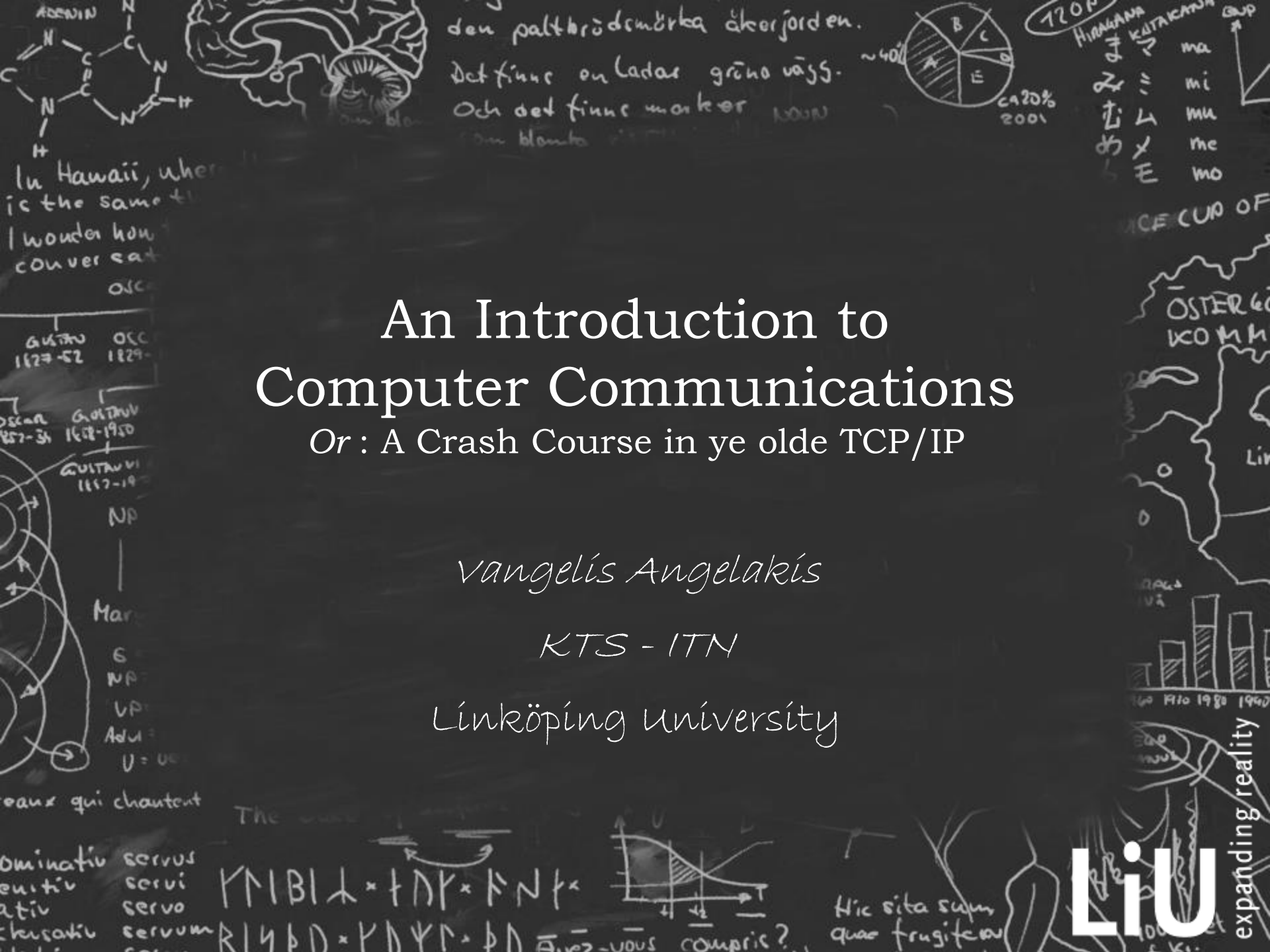
An Introduction to Computer Communications

Or : A Crash Course in ye olde TCP/IP

Vangelis Angelakis

KTS - ITN

Linköping University

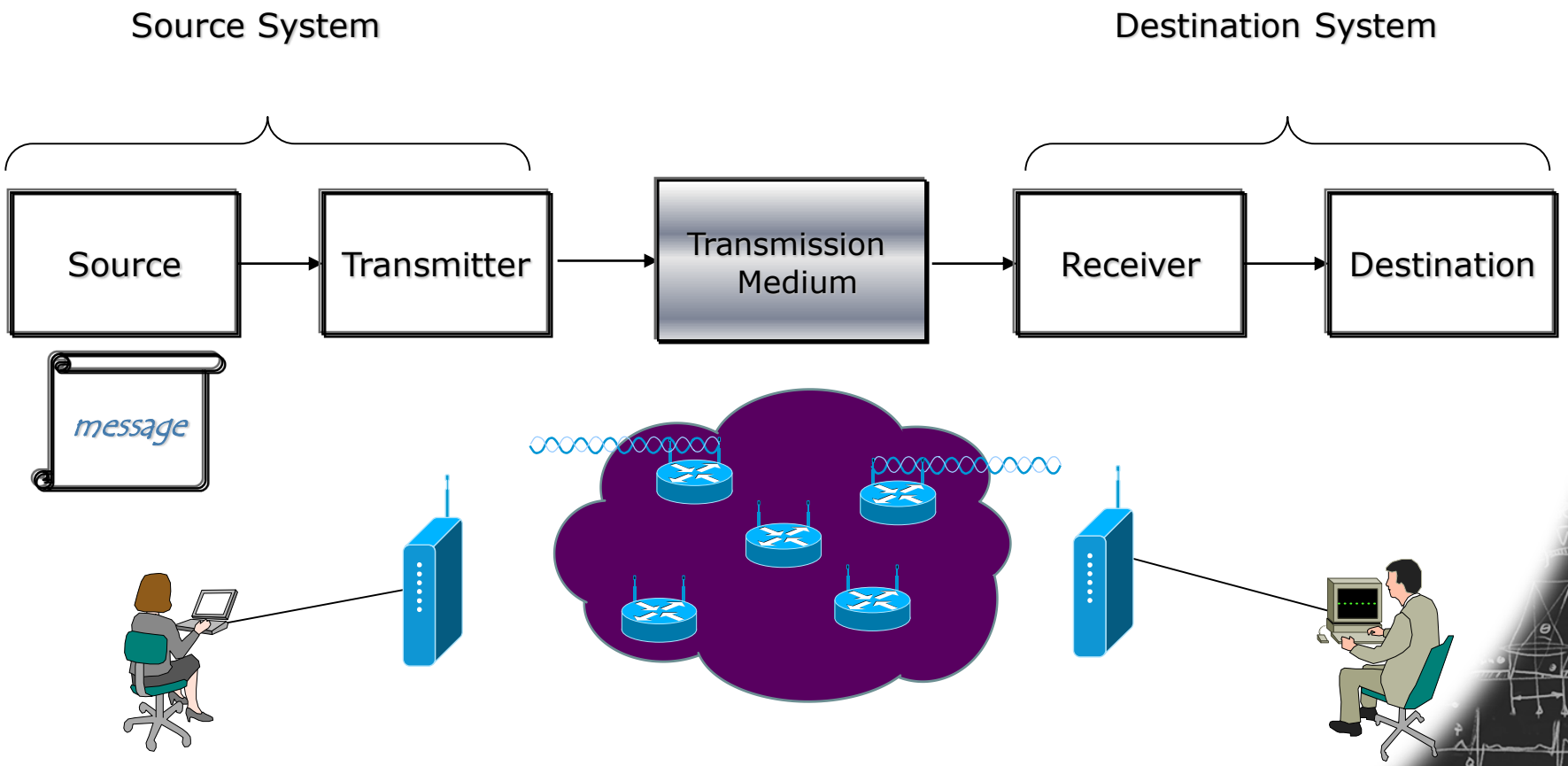


Background

- TNM031 Network Programming and Security
  - Security issues in data communication networks
  - To understand security aspects, we need some basic knowledge in computer communications

- What is needed to make people communicate?

Ye olde Communications model



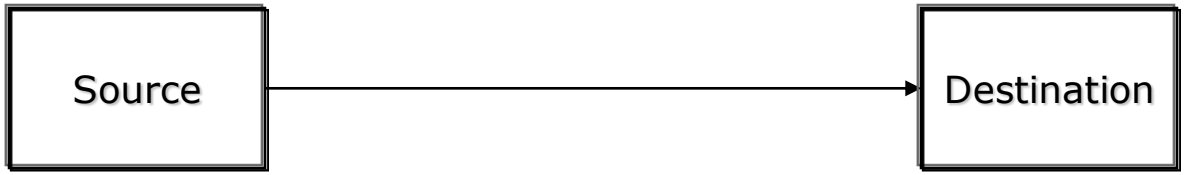
Outline

- Communication architectures
- Packets and addressing
- Client-server paradigm
- Internet

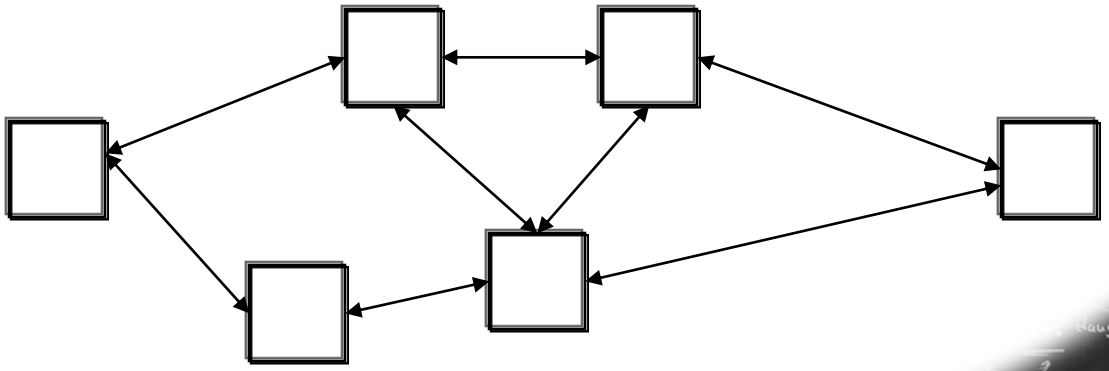
- Want to know more?
  - TNK108 Computer Networking
  - TNK080 Wireless Communication Systems

“Data communications” vs. “Networking”

- Data Communication: a “single hop” problem

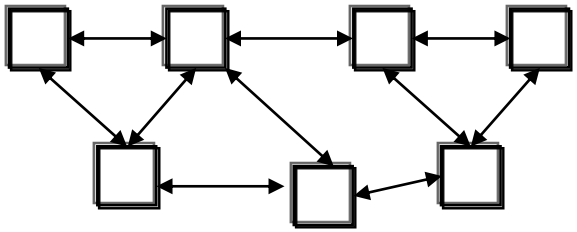


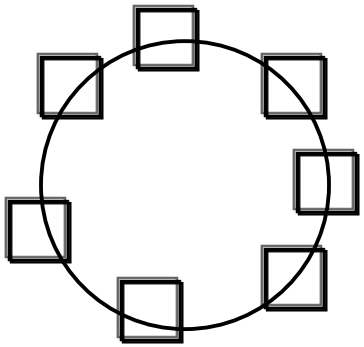
- Networking: addresses issues of more nodes



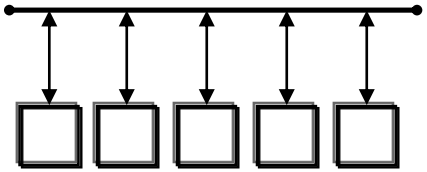
Types of Networks

- Topological Taxonomy
  - p2p / d2d / m2m



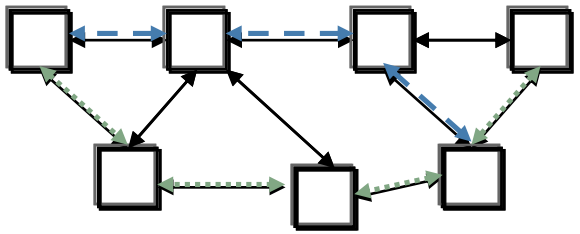


  - Broadcast

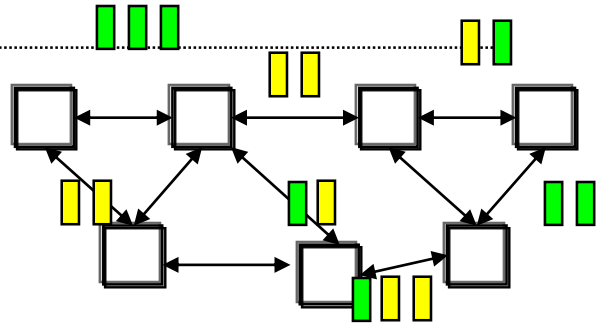


Types of Networks

- Switching Taxonomy
  - Circuit Switching
    - **Dedicated path** between two stations
      - Connected sequence of links between nodes
      - E.g POTS (telephone network)
    - Communication involves 3 phases
      - Circuit establishment
      - Data transfer
      - Circuit disconnection



Types of Networks

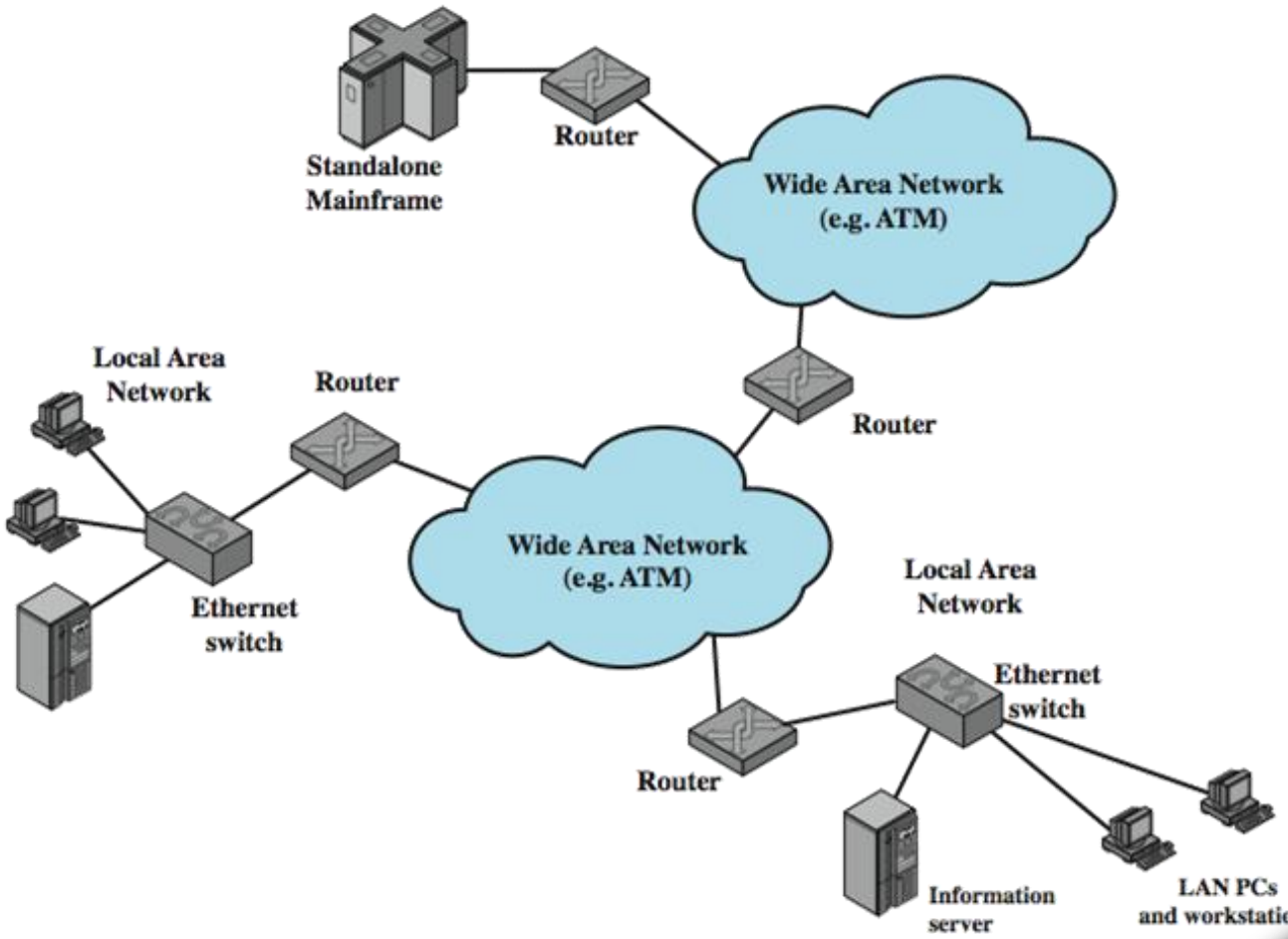


- Switching Taxonomy
  - Packet Switching
    - Data are transmitted in short blocks: ***packets***
    - Typical upper bound (used to be) 1000 Bytes…
    - Longer messages broken up (fragmented) into series of packets
      - Each packet contains part (or all for short message) of user's data **plus** some **control information**
      - Control information includes network **routing information**
      - At each intermediate node, packet is received, stored briefly, and passed on to the next node
    - Transmitting computer sends message as sequence of packets
    - Packet includes control information including destination station
    - Packets sent to node to which sending station attaches
    - Node stores packet briefly, determines next leg of route, and queues packet to go out on that link
    - When link is available, packet is transmitted to next node
    - All packets eventually work their way through network

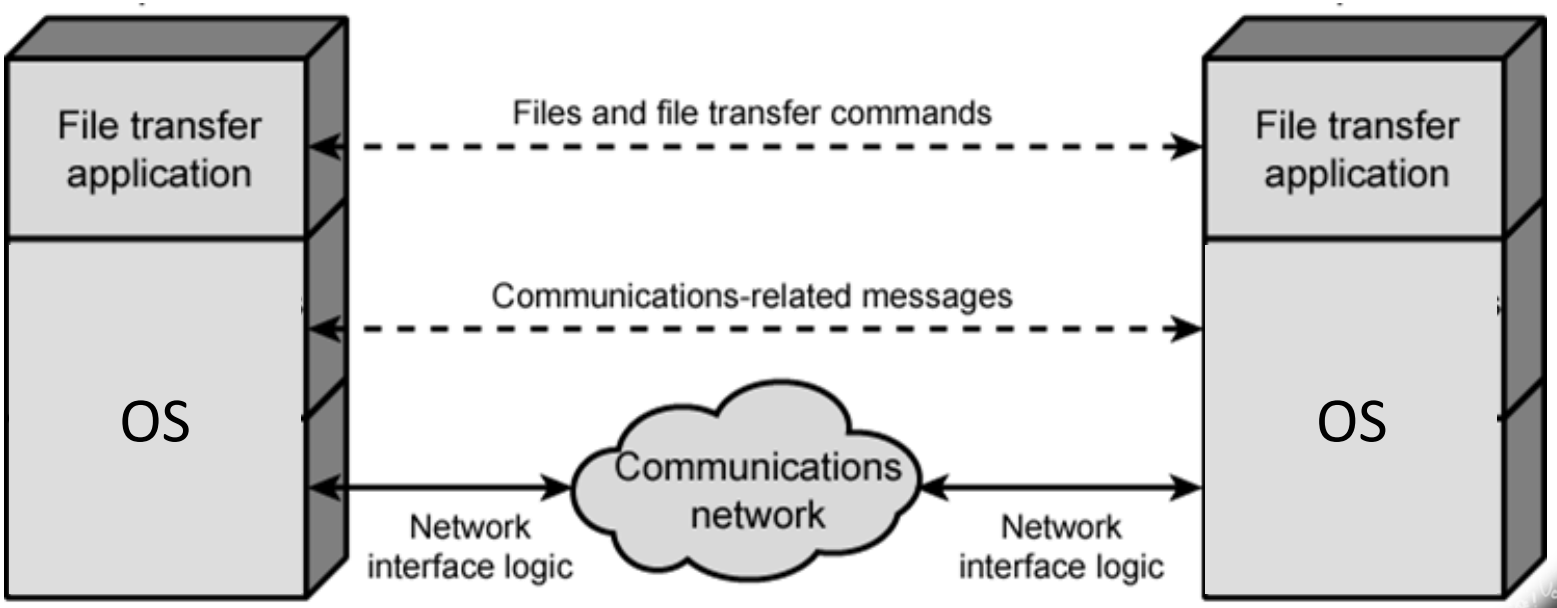
Types of Networks

- Area Taxonomy
  - LANs
    - < 1 Km
    - Typically under Single owner
  - Metropolitan
    - 1Km – 50 Km
  - WAN
    - >50km
  - Enterprise (Ethernet/wifi LANs /3-4G)
  - Telecom
    - Access (Ethernet/wifi LANs /3-4G)
    - Metro
    - Core (ATM FDDI)

The Internet Elements



Simplified Communication Architecture

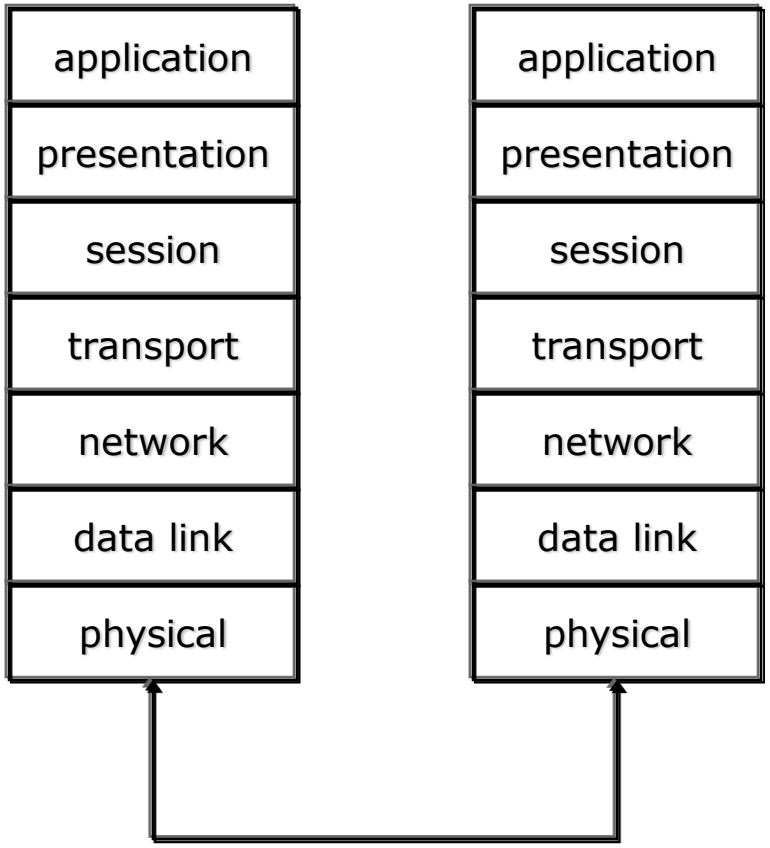


The OSI 7 layer model

- OSI = Open System Interconnection
  - Open➔ two systems should be able to communicate ***independently of manufacturer***
- **Not a protocol**, but a **framework** for designing and understanding communication systems
- Developed by ISO during 1977-1984, tested first time 1987
- Practically *never* used, why still important?
  - Helps us to understand and structure the large number of functions included in most communication systems
  - Support for designing all functionalities

(although not always as a separate layer)

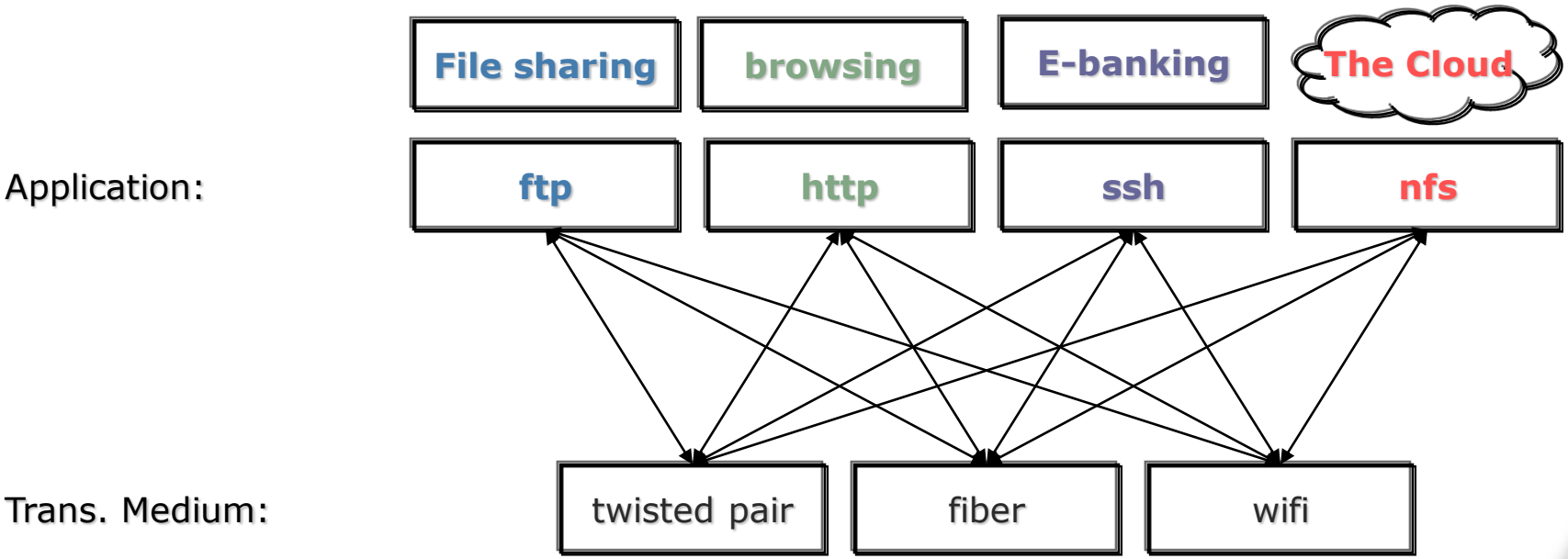
The OSI 7 layer model



- Produced by ISO and CCITT (Now ITU)
- ISO Reference Model
- A general, open standard (interoperability)
- Heavily referenced, but
- Rarely implemented
- What is so magical about these 7 layers after all ???

Why layering ?

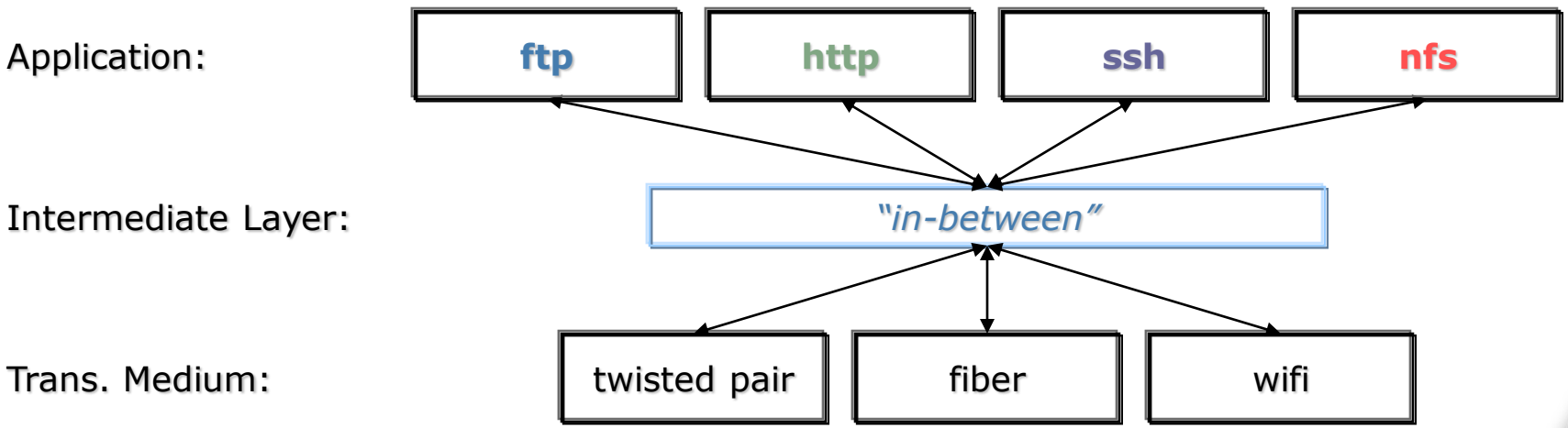
- Without layering :



- Each *networking application* would need to be:
  - implemented for every *existing* networking technology
  - **re-**implemented for every *new* networking technology!

Introducing an intermediate layer

- provides a unique abstraction for various network technologies
- uses abstractions to hide complexity



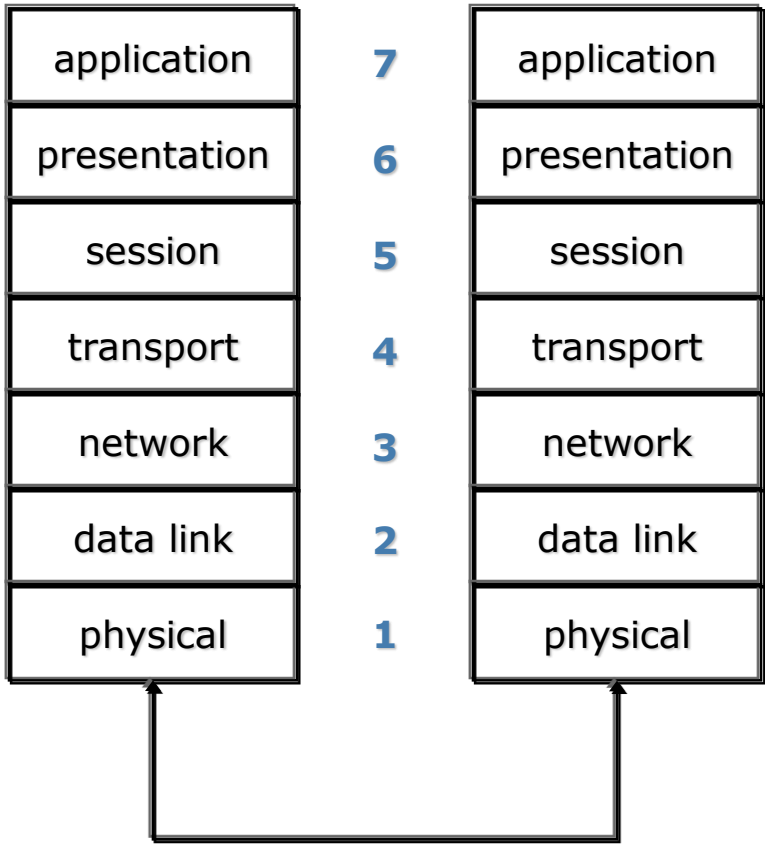
Such abstractions naturally lead to ***multilevel layering***:

a service of layer L uses only *services* of layer L-1

Layering

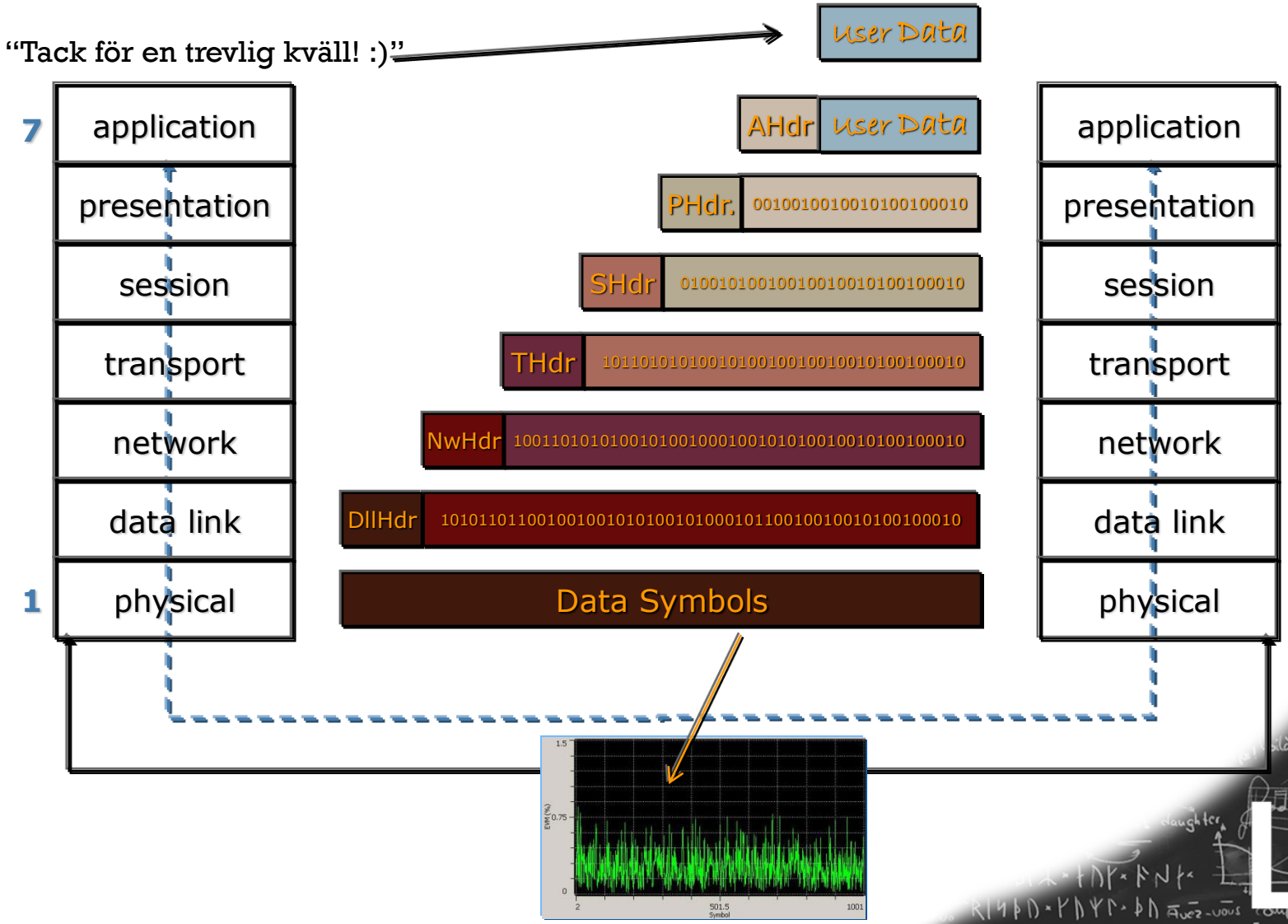
- Advantages
  - Modularity:
    - protocols easier to manage & maintain
  - Abstract functionality
    - lower layers can be changed without affecting the upper layers
  - Reusability:
    - upper layers can reuse the functionality provided by lower layers
  - Disadvantages
    - Information hiding
      - inefficient implementations

OSI Model Concepts

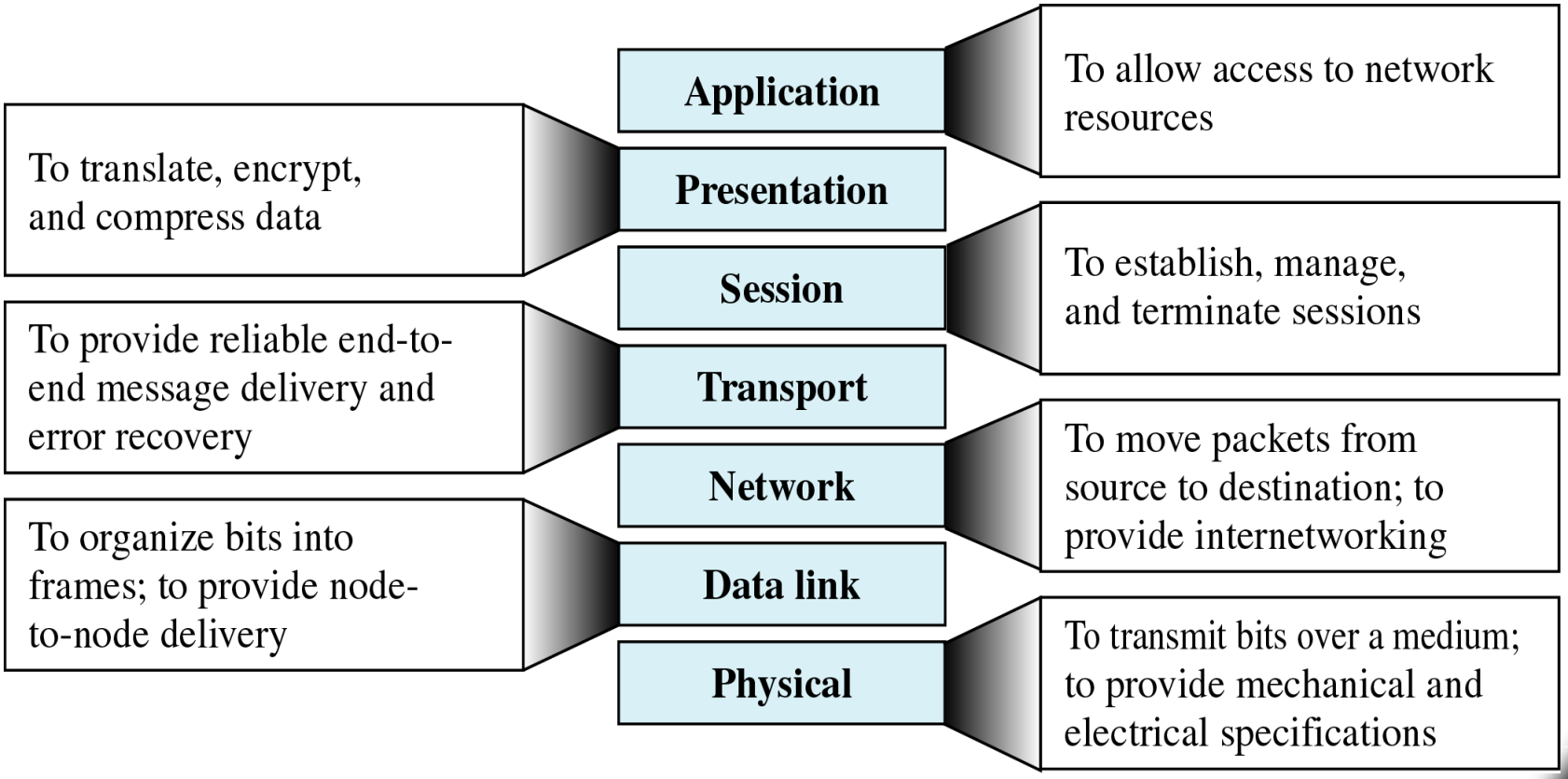


- Service
  - **what** a layer provides
- Interface
  - **how** a service can be accessed
- Protocol
  - how the service is **implemented**
  - a set of **rules** and **formats** that govern the communication between two peers

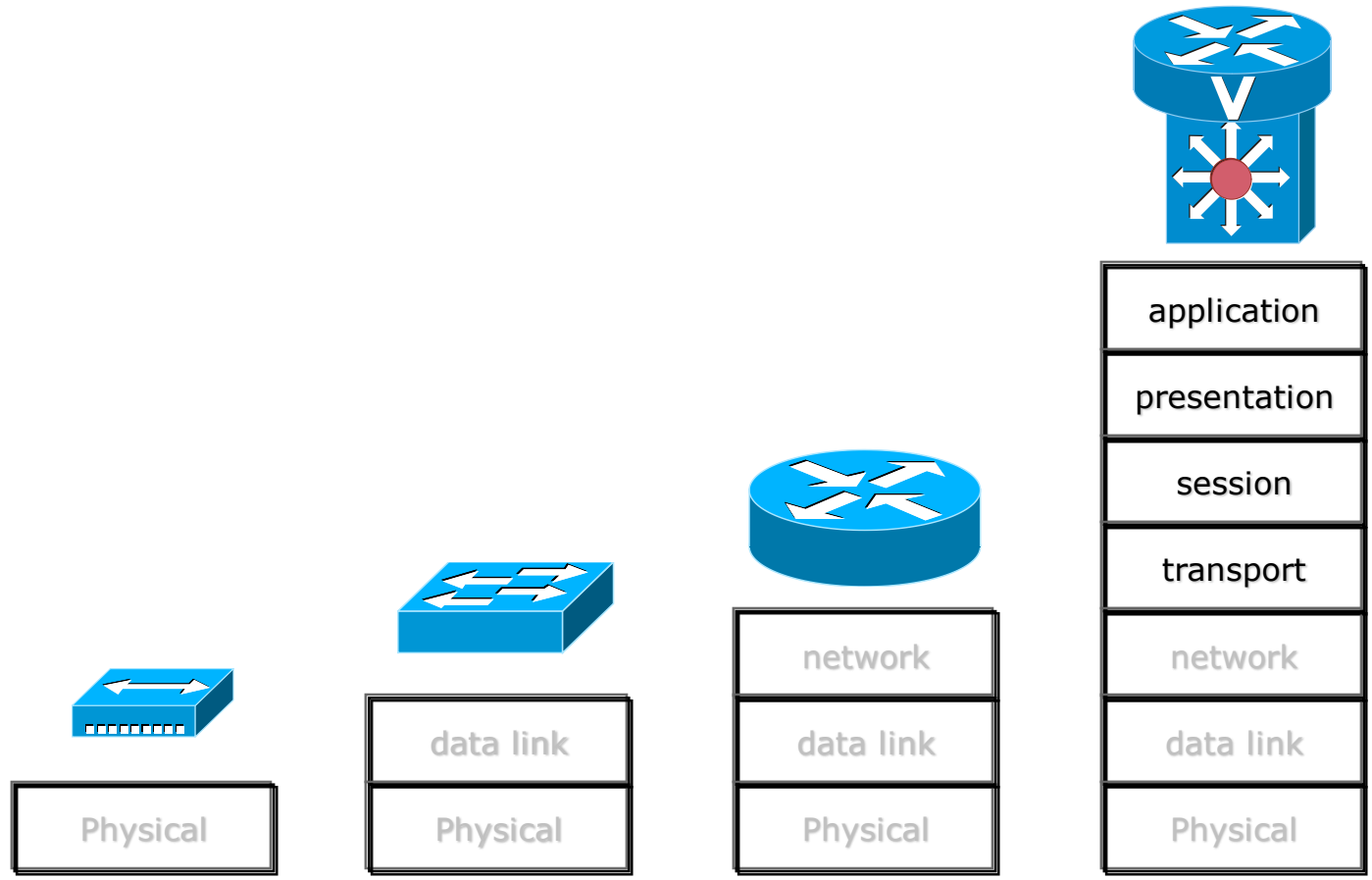
Information exchange & encapsulation



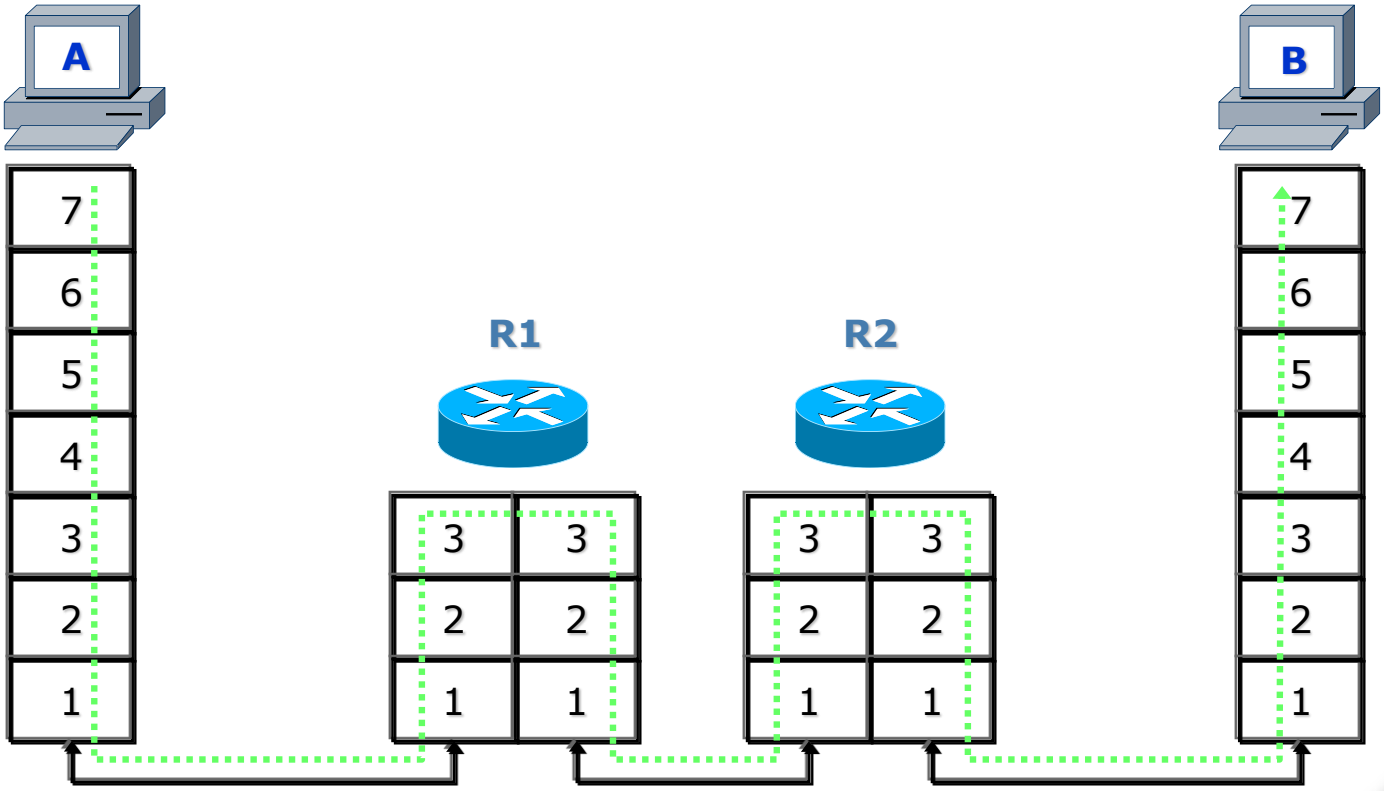
The layers in a nutshell



Intermediate Nodes



What does a Router do?

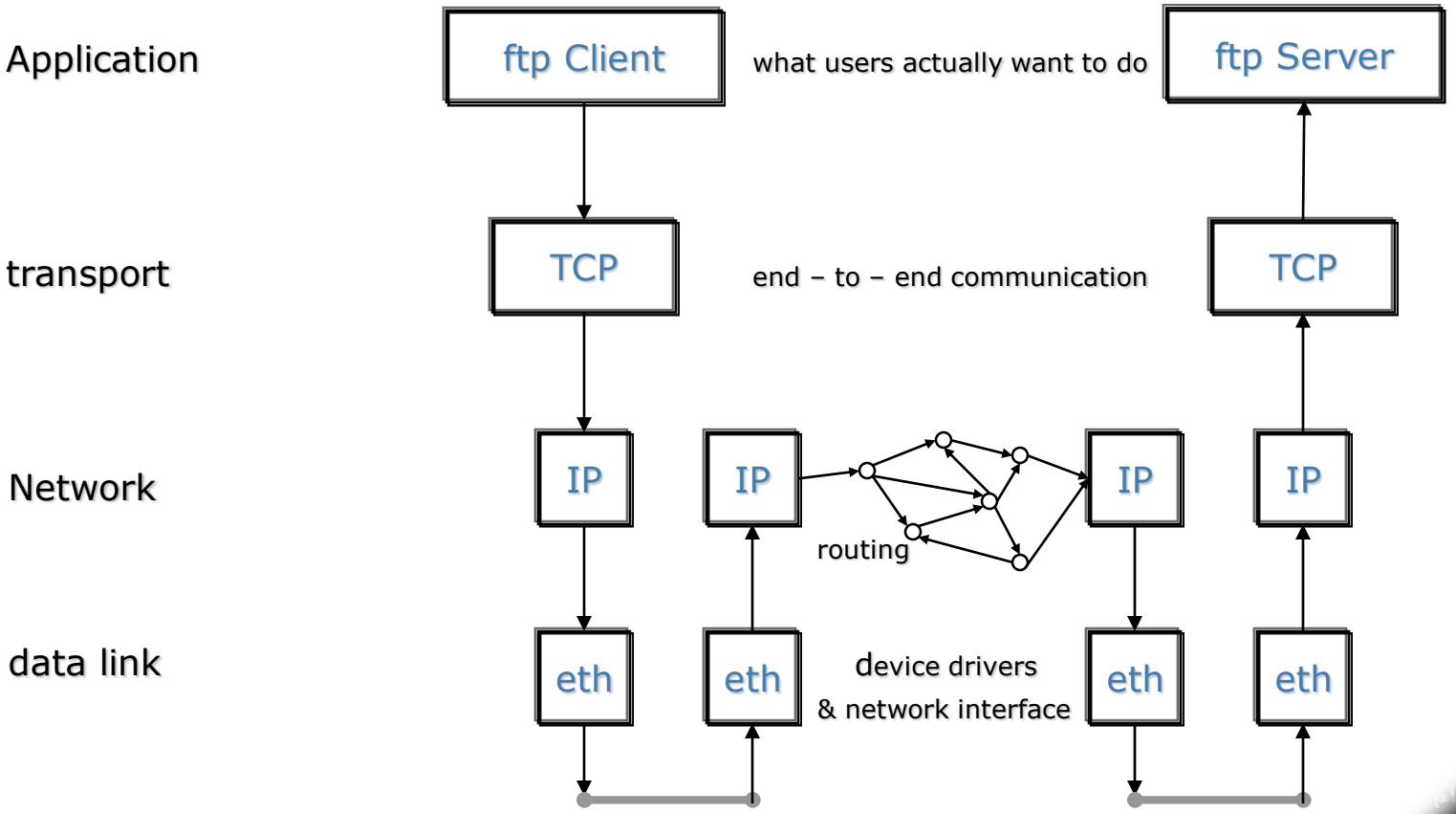


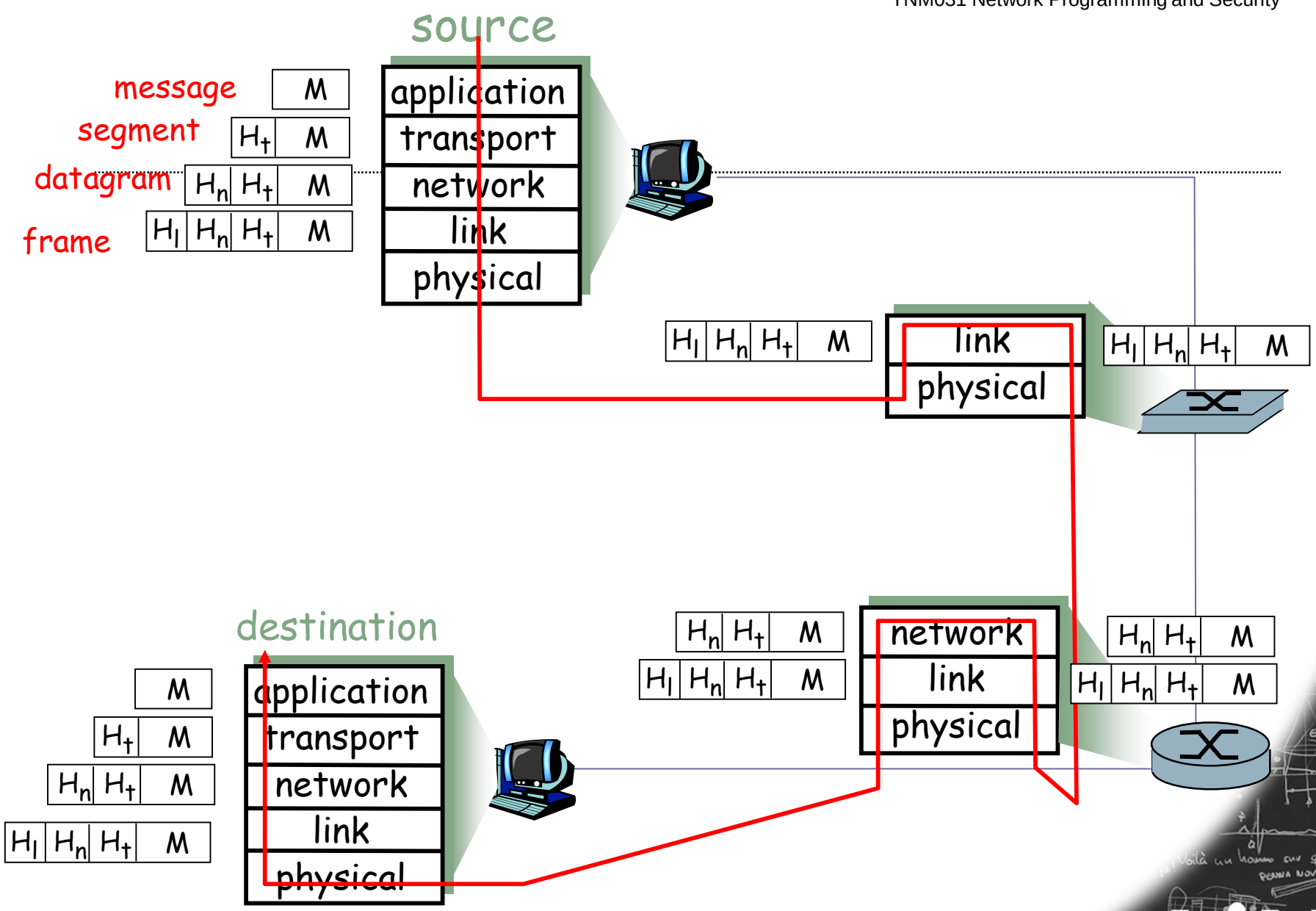
The TCP/IP Protocol suite

- Considers ***four*** layers
- Forms the basis for the Internet
- An Open System since:

  the definition of the protocol suite and many of its implementations are publicly available
- Outline of the main protocols
  - Internet Protocol (IP)
  - User Datagram Protocol (UDP)
  - Transmission Control Protocol (TCP)
- Brief sketch of “helper protocols”:
  - ARP, RARP, ICMP, IGMP…

The TCP/IP Protocol suite



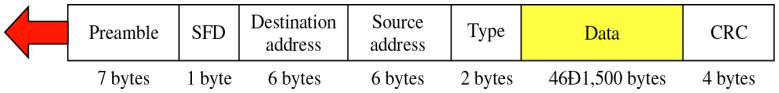


Packets

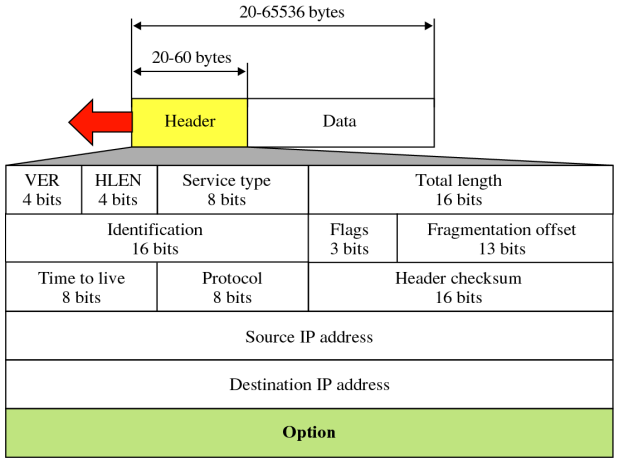
- Named differently depending on which layer it belongs to
- Application layer
  - **Message**
- Transport layer
  - UDP: **datagram**
  - TCP: **segment**
- Network layer
  - **Datagram**
- Data link layer
  - **Frame**

Packets

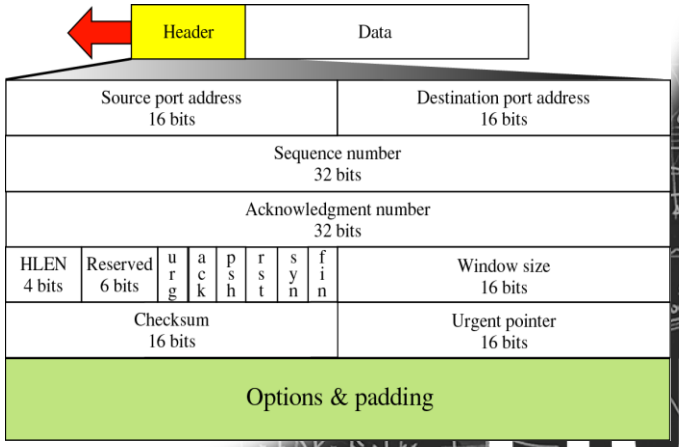
- Layer-2 packet (Ethernet)



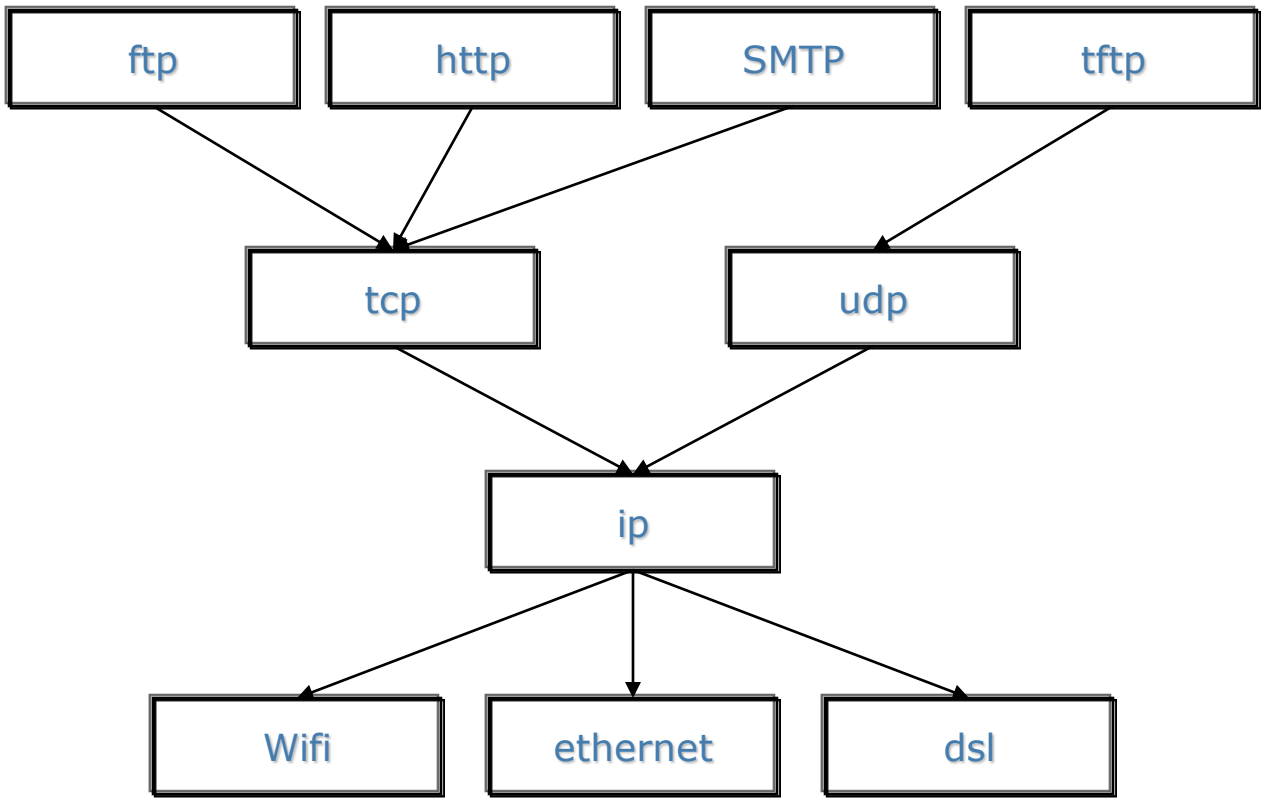
- Layer-3 packet (IP)



- Layer-4 packet (TCP)



The TCP/IP hourglass notion



OSI vs TCP/IP

#12: *In protocol design,*

perfection has been reached

not when there is nothing left to add,

but when there is nothing left to take away.

RFC 1925

The Twelve Networking Truths

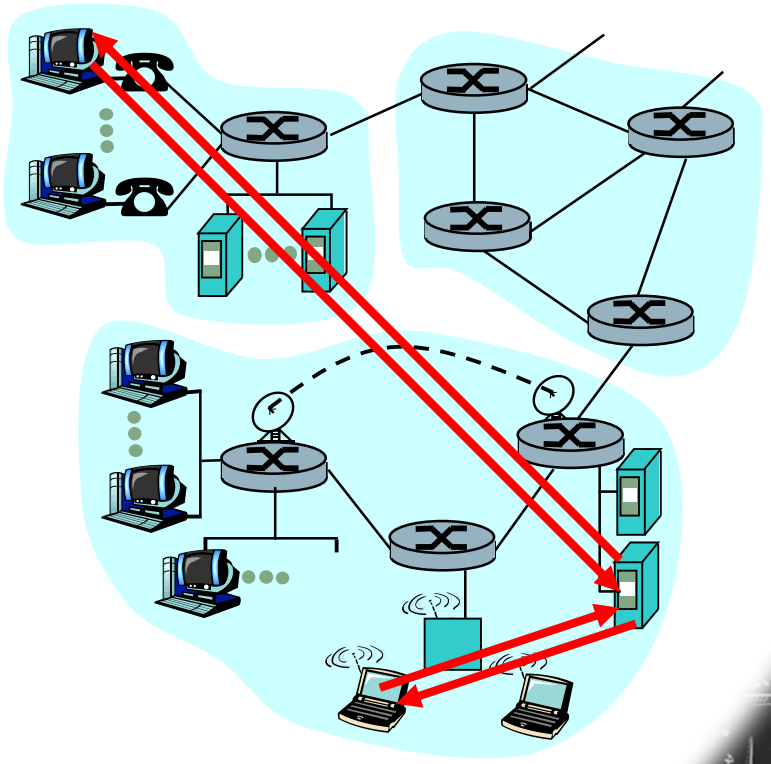
1 April 1996

Internet Standardization

- Internet Engineering Task Force (IETF) responsible for Internet standardization
- Standardization documents
  - Internet Draft (ID)
    - RFC suggestion
  - Request For Comments (RFCs)
    - Official document (http://www.ietf.org/rfc.html)
    - IP: RFC 0791, TCP: RFC 0793 (bl.a.)
  - Internet Standard

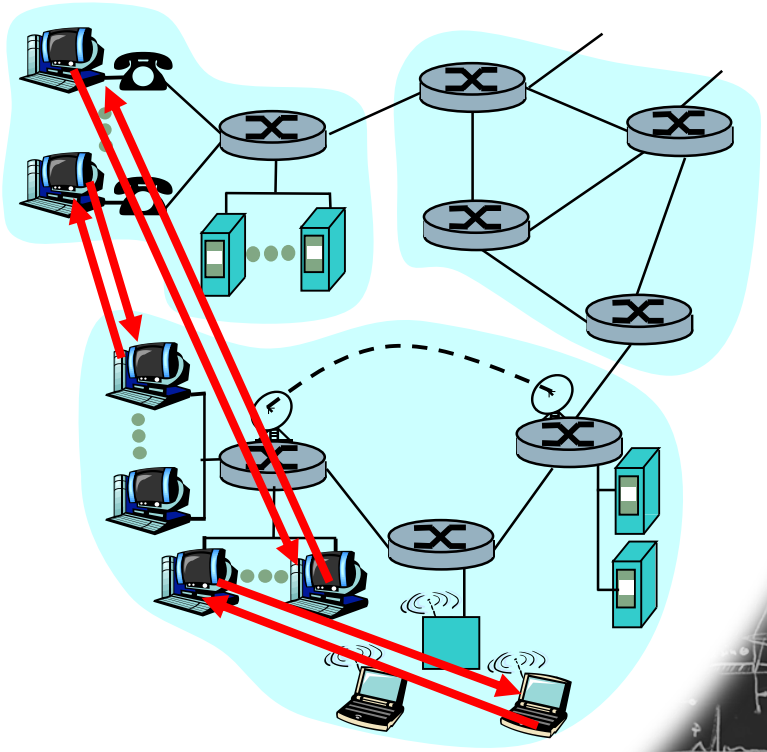
Client-server Paradigm

- What is a client?
- Client
  - A process that executes on a local computer
  - Has limited time activity
- Server
  - A process that offers services to clients
  - Executes continuously
  - “Permanent” IP-address
- Clients do not talk directly to each other



Peer-to-peer (M2M Communication)

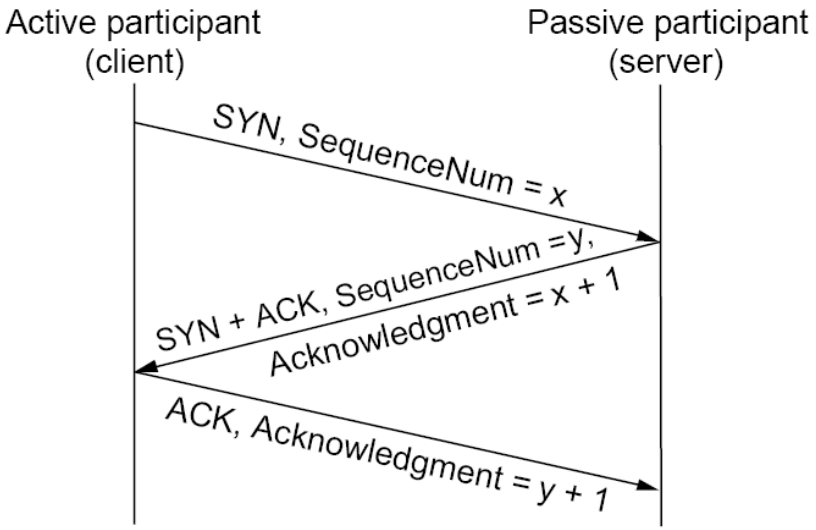
- End systems communicate directly with each other
  - All nodes act as both client and server
  - Torrents
  - Skype
- P2P-hybrids
  - msn



Transport Services

- Transport layer in TCP/IP offer two kinds of communication services to the application layer
  - Connection oriented: TCP
  - Connectionless: UDP
- TCP (guaranteed in order delivery)
  - Receiver needs to confirm before starting transmission and give feedback during data transfer
  - Flow control, congestion control, packet order control, error control
- UDP (best effort)
  - Address + checksum

The TCP 3-way handshake



TCP sender & receiver establish a “connection” before exchanging data segments

Need to initialize TCP variables:

- Sequence Numbers
- buffers,
- flow control info (e.g. RcvWindow)

Step 1:

client host sends TCP_SYN segment to server

- Specifies initial sequenceNum Carries no data

Step 2:

server host receives SYN, replies with SYN_ACK segment

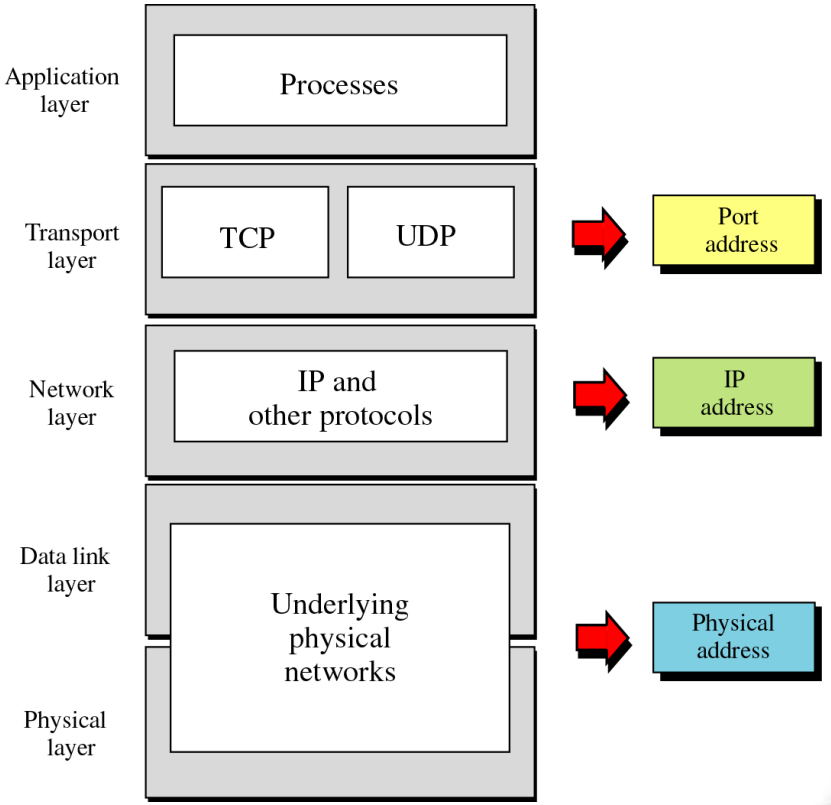
- server allocates buffers
- specifies server initial sequenceNum

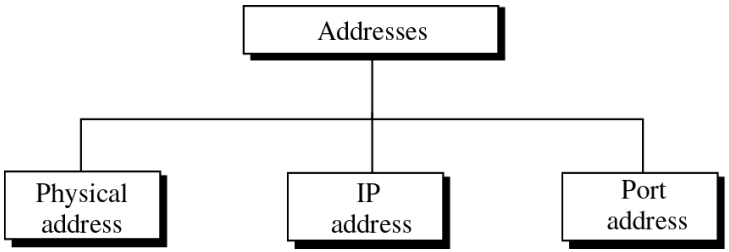
Step 3:

client receives SYNACK, replies with ACK segment, which may contain data

Addressing

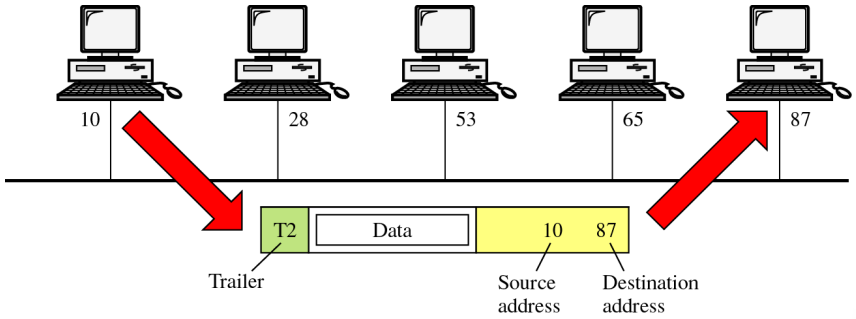
- Normally, three different levels of addresses are used
- Each belongs to a specific layer in the system architecture





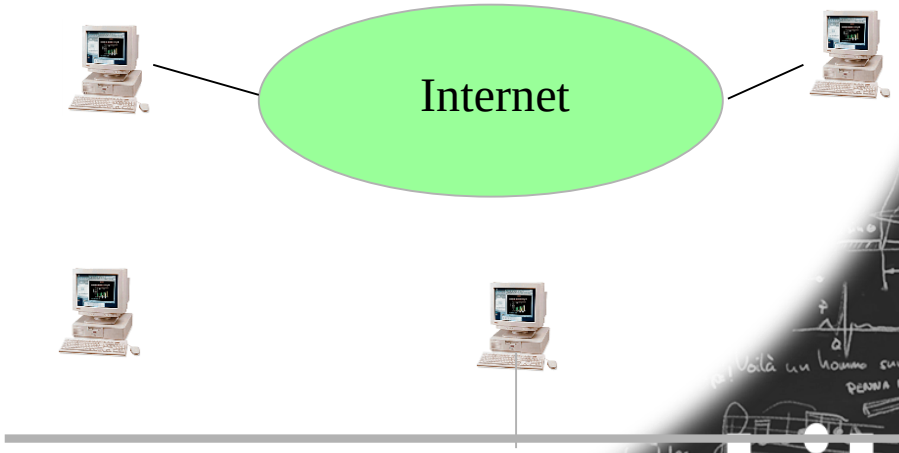
Physical Address

- Points out the physical device (e.g., 08005A5903DA)
- Used only locally



I wish to access a computer via the Internet. Does my computer know the physical address of that computer?

What if the two computers are in the same local network?

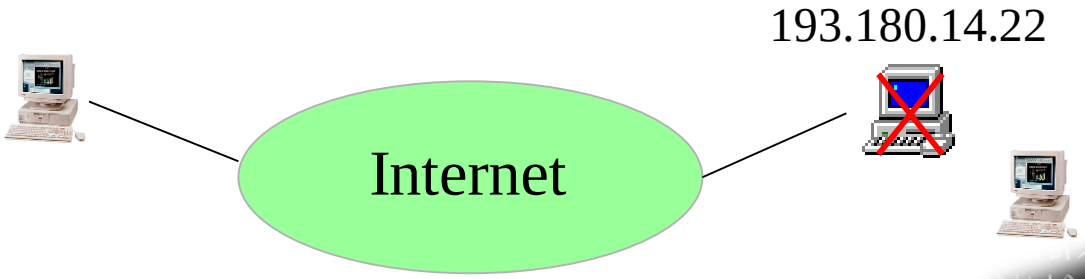


Network Address

- Usually is the Internet address, or IP address (e.g. 192.236.133.152)
- Uniquely identifies a host (more precisely: *N/W interface*) connected to the Internet

I wish to access a server via the Internet.
The server has the physical address: 08:00:5A:59:03:D0,
and IP address: 193.180.14.22

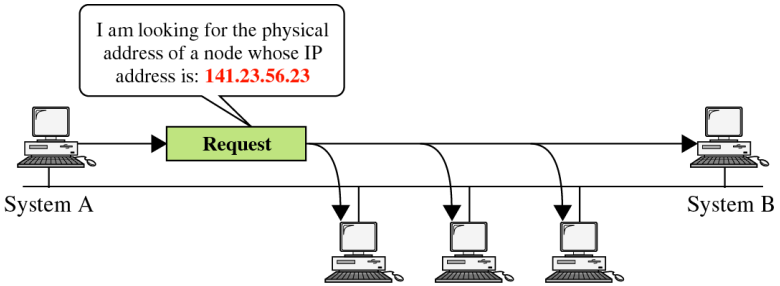
- ***Suppose the server is replaced by another machine***
  - ***Will the physical address change?***
  - ***Will the IP address change?***
  - ***Does my computer need to know the changes?***



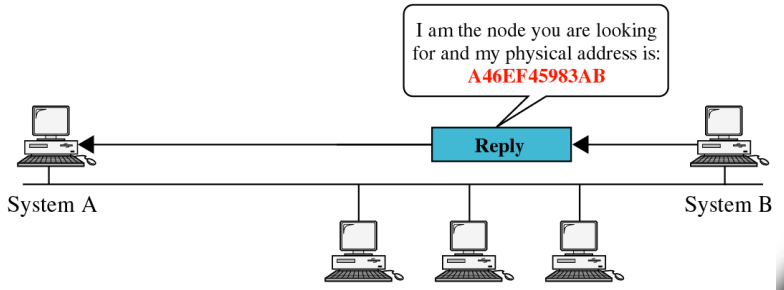
Address Resolution Protocol (ARP)

- Connecting Physical and Network addresses

How can a host find out the physical address of another host on the same network?



a. ARP request is broadcast

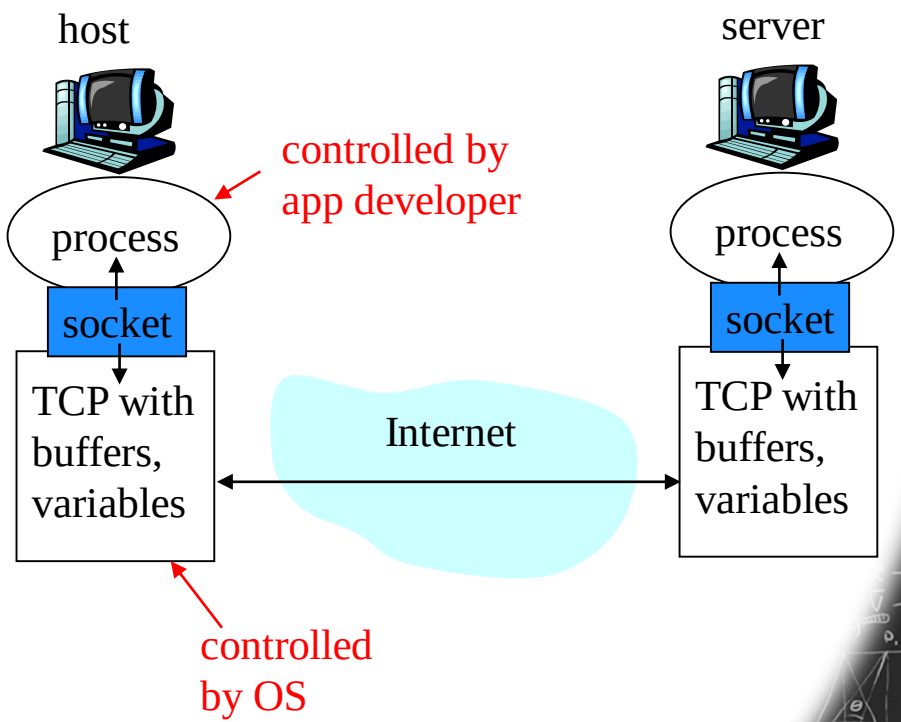


b. ARP reply is unicast

…If the final destination is outside the local network?

Sockets

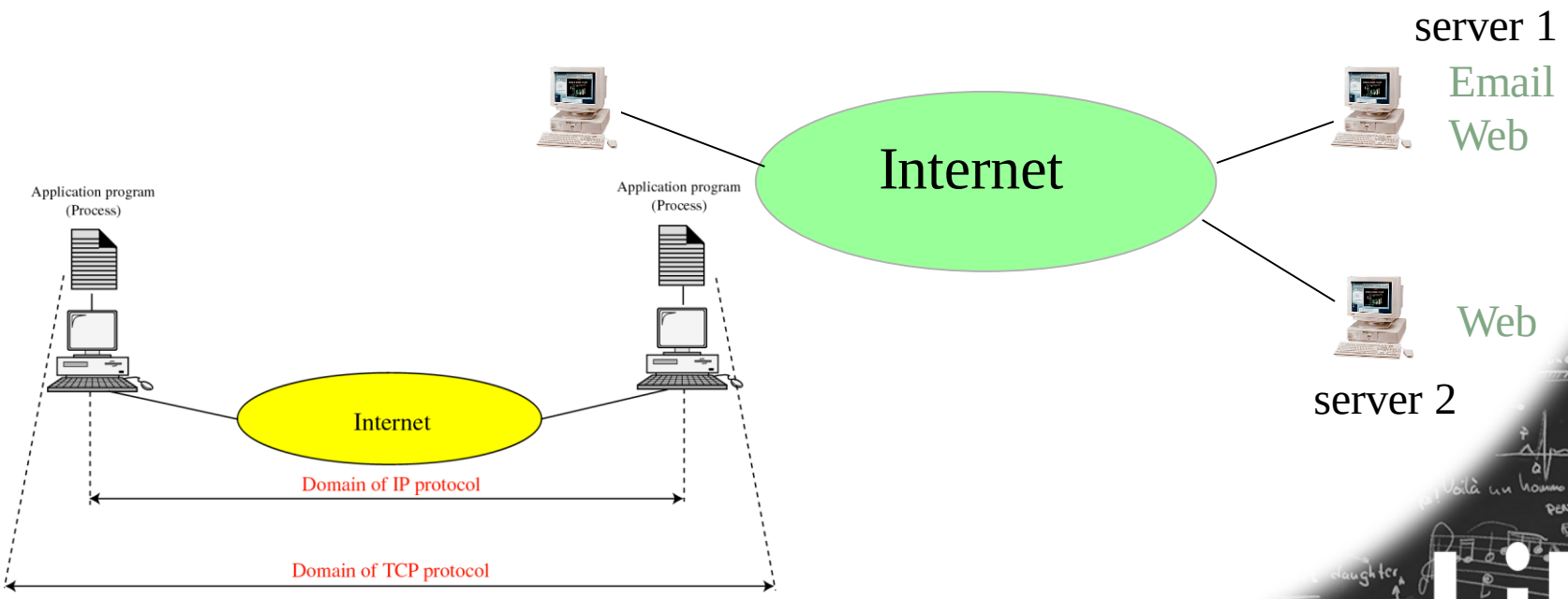
- A process on one computer can communicate with a process on another computer through sockets
- Find the right process to communicate with:
  - Computer: **IP-number**
  - Process type on that computer: **port number**
  - Port and socket nr. define the **correct** process.
- Applications communicate through sockets



Port & socket numbering

My computer is communicating with two **web servers** at the same time using **several browser windows**

- How does my operating system distinguish data for the different browser windows, different servers and the different services



How to Communicate?

- What information is required by the operating system in order to connect to the Internet?
  - An IP-address
  - A subnet mask
  - A default router
  - A DNS-server

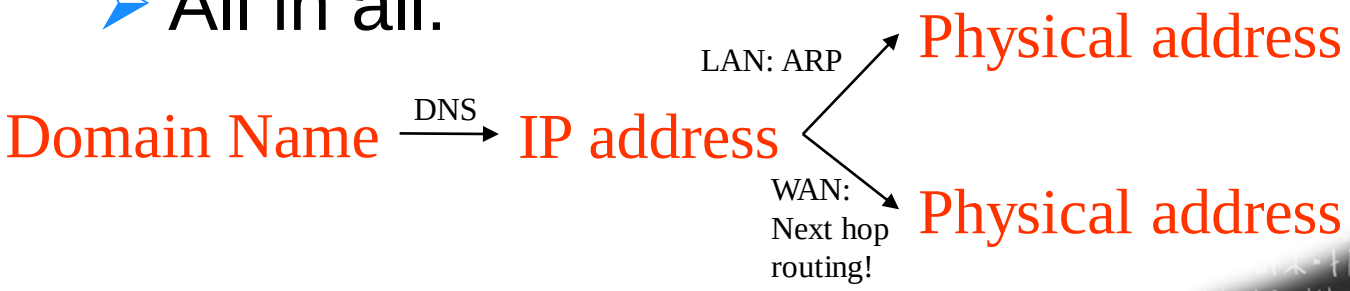
Example

IP. 130.236.132.119
Subnet mask 255.255.254.0
Default gateway. . . .130.236.133.1
DNS server 130.236.132.4

- Have *you* ever assigned this information when connecting to the Internet?
  - DHCP!
  - Bootstrap problem

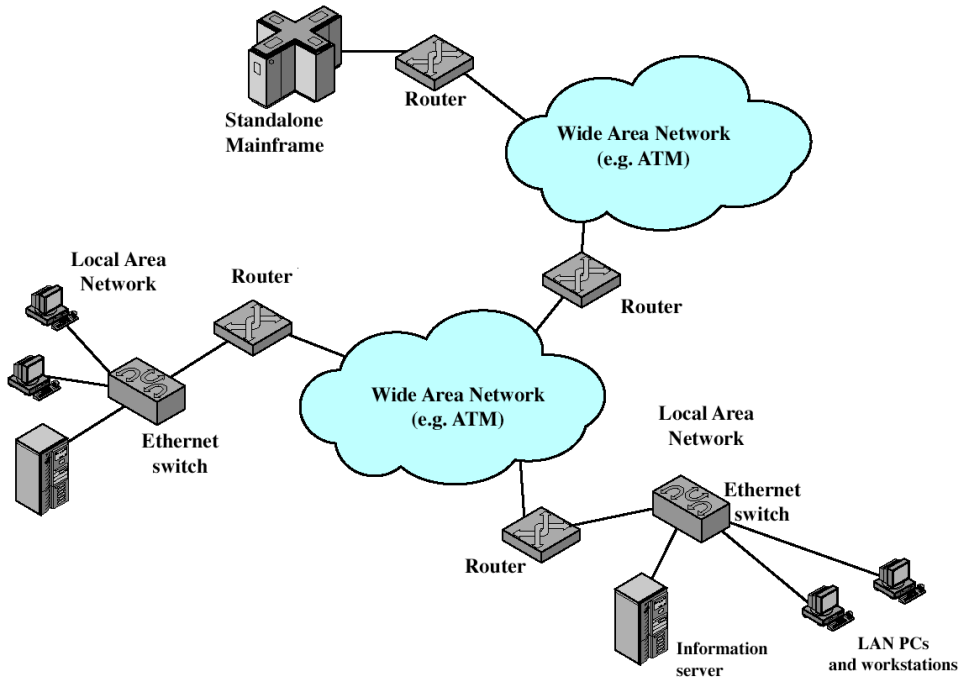
Example

- In order to request a web page from a web server we need to know the IP address of that web server
- What is the IP address of the facebook web server?
  - We don't know!
  - The solution is Domain Name System (DNS)
    - Translates domain names into IP addresses
- All in all:



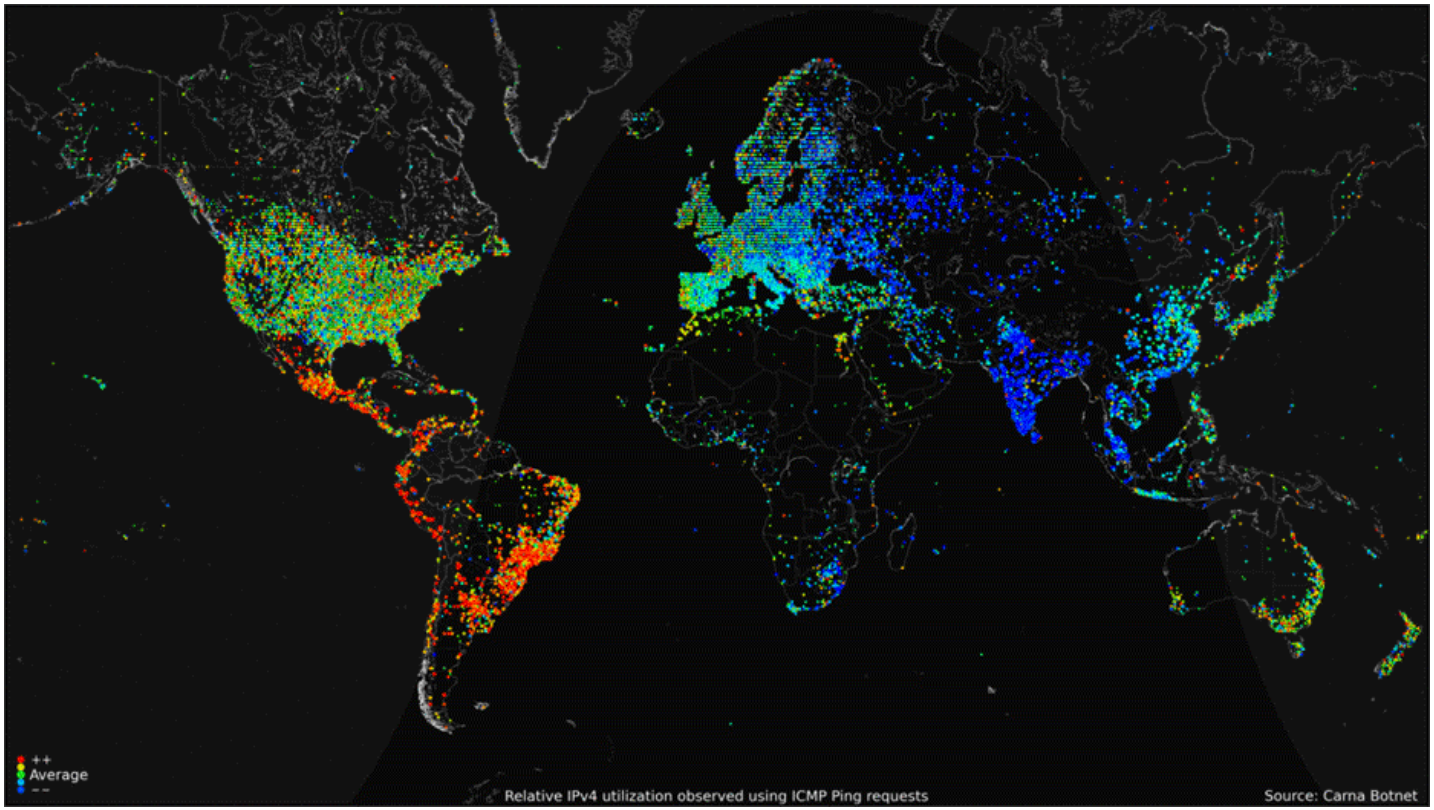
Internet

- internet = short for **inter**connected **net**works
- Internet = a specific interconnected network with billions of users…



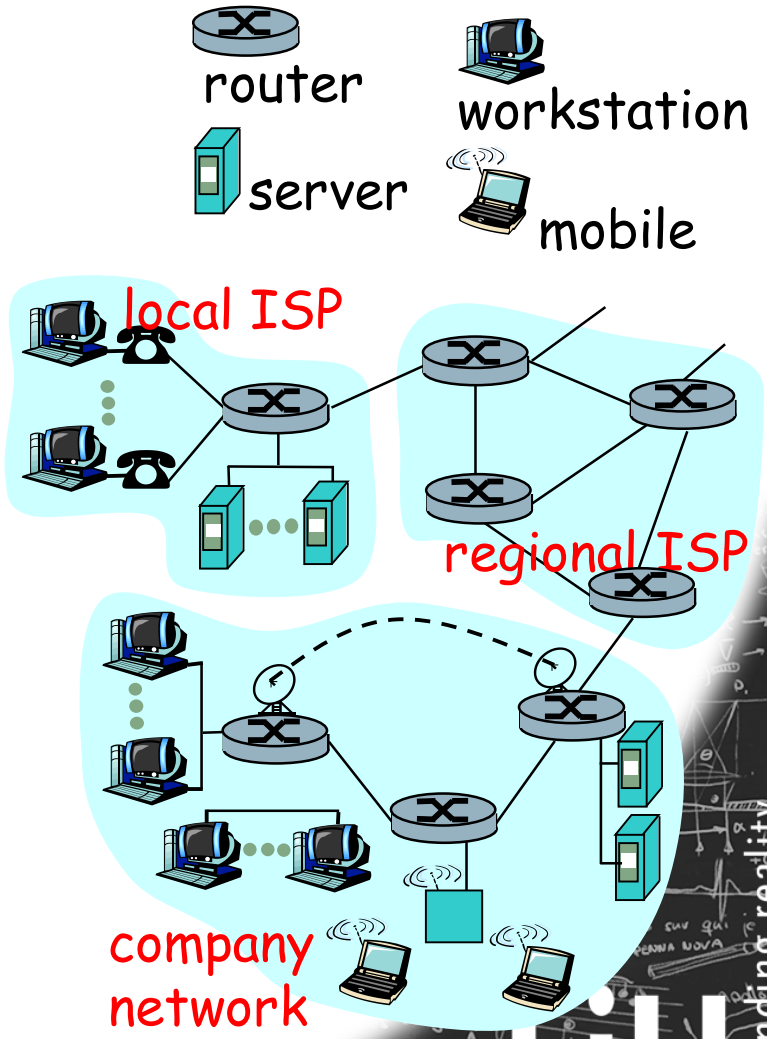
Internet

- http://internetcensus2012.bitbucket.org/paper.html

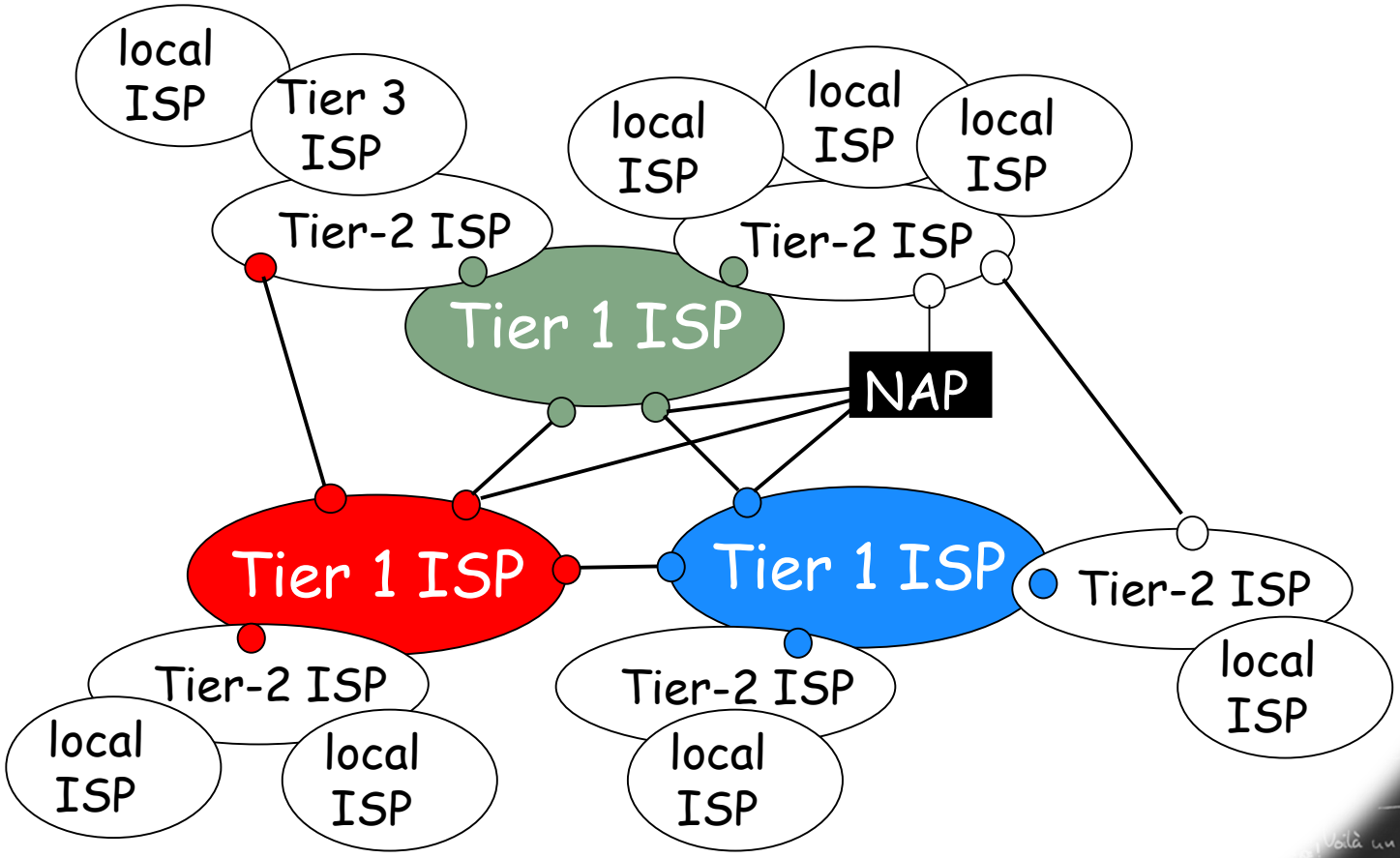


Internet

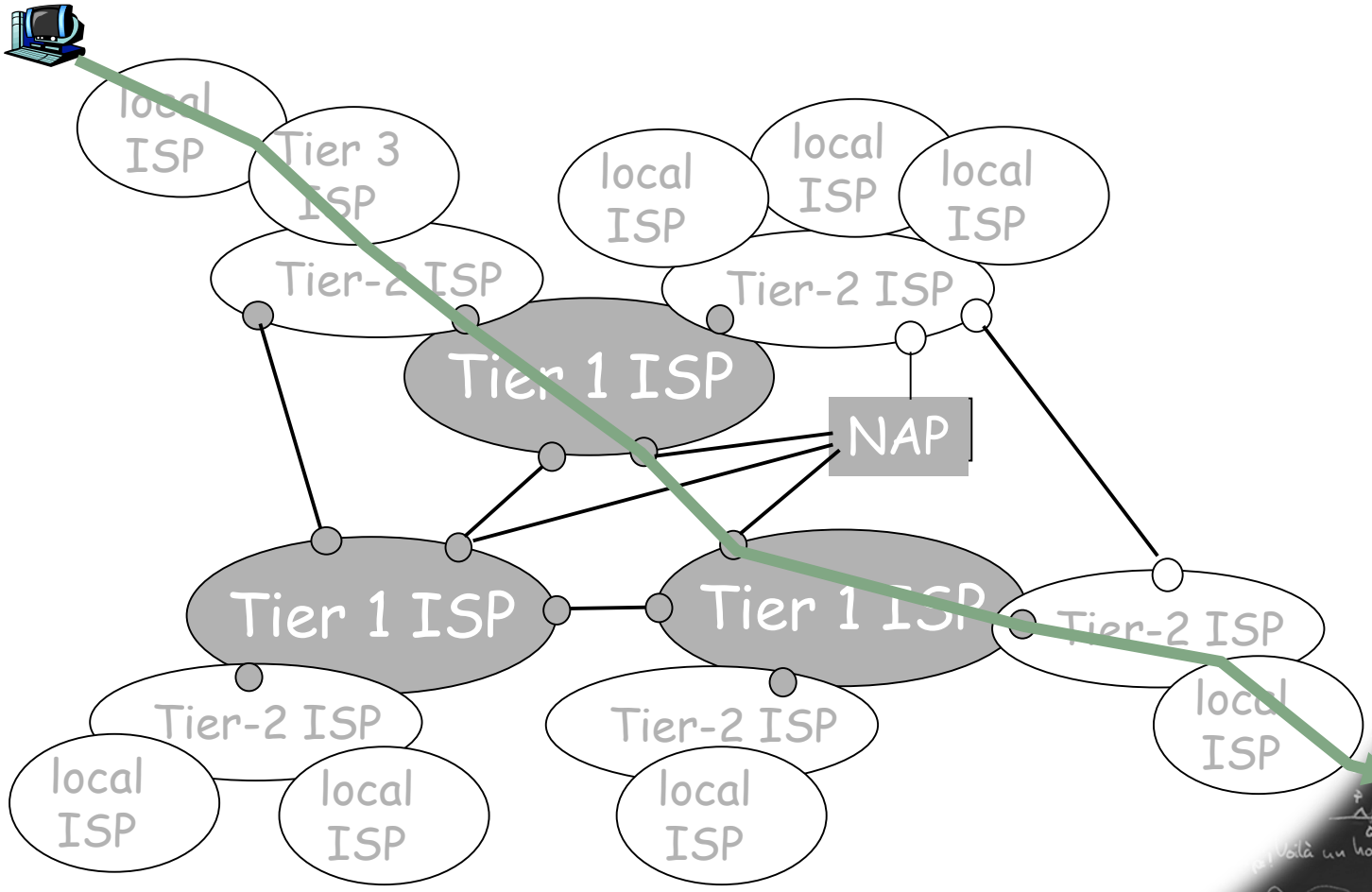
- Hierarchical structure
- Links can consist of different transmission media
  - Copper wire
  - Optical fibre
  - Radio link
  - Satellite
  - …
- On top of these different communication technologies and protocol stacks are implemented

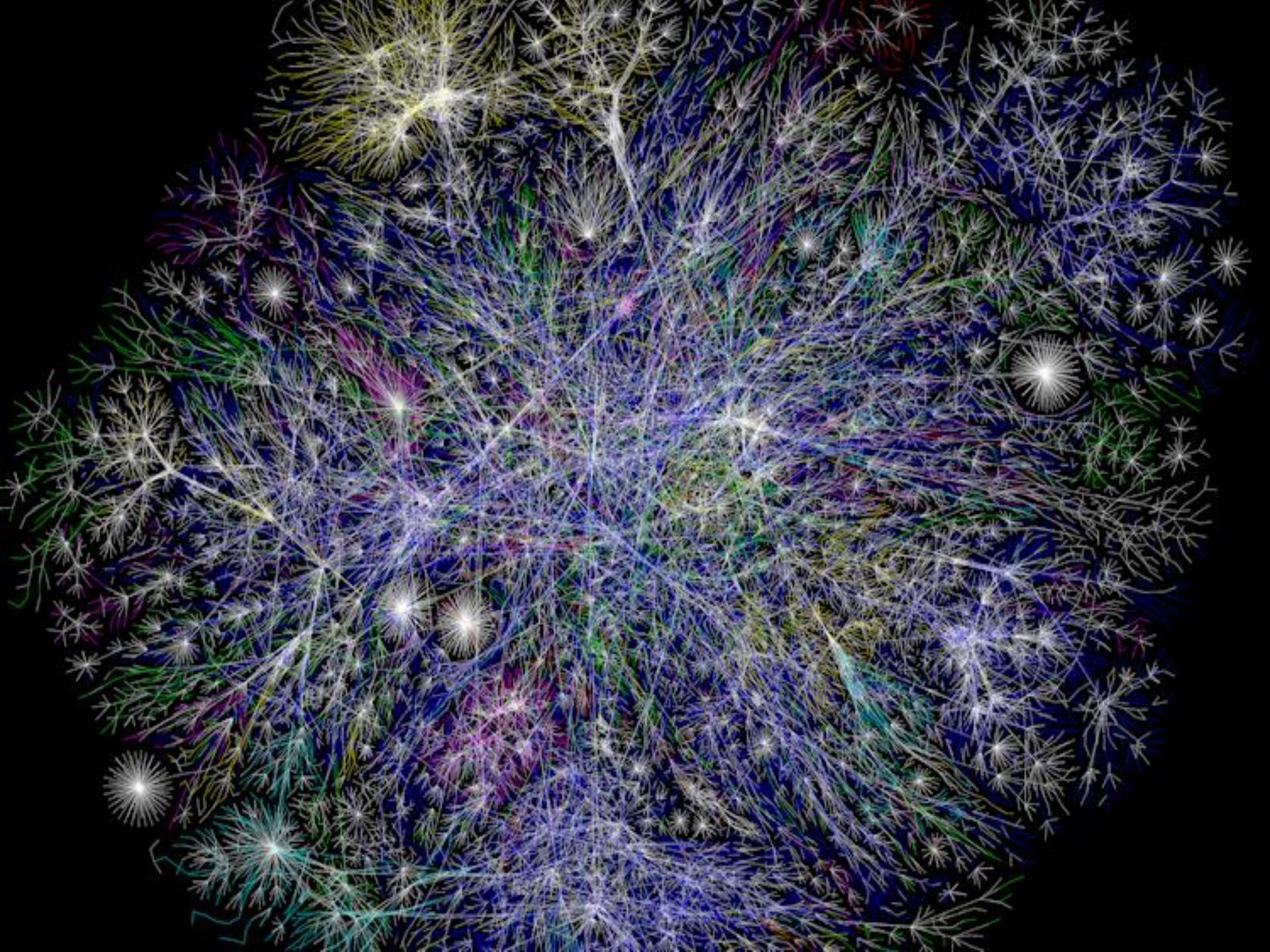


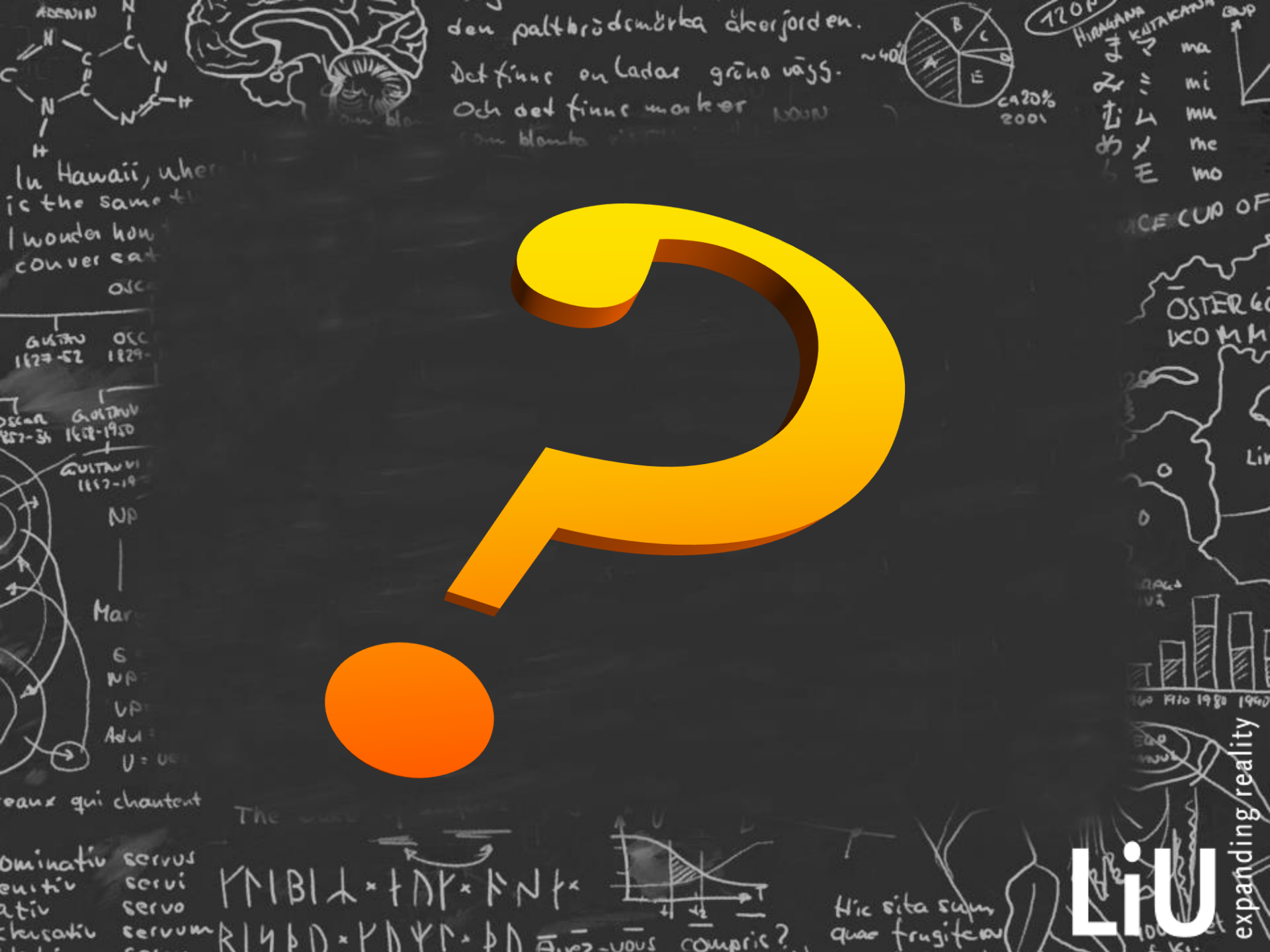
Internet


local ISP
Tier 3 ISP
local ISP
local ISP
local ISP
Tier-2 ISP
Tier-2 ISP
Tier 1 ISP
NAP
Tier 1 ISP
Tier 1 ISP
Tier-2 ISP
Tier-2 ISP
local ISP
Tier-2 ISP
local ISP
local ISP
local ISP
local ISP

Internet






LiU
expanding reality