REVIEW OF THE BASICS: COMPUTER NETWORKS

Disclaimer: this is an oversimplified overview of a complex topic, distilled for what matters most for our cloud computing course

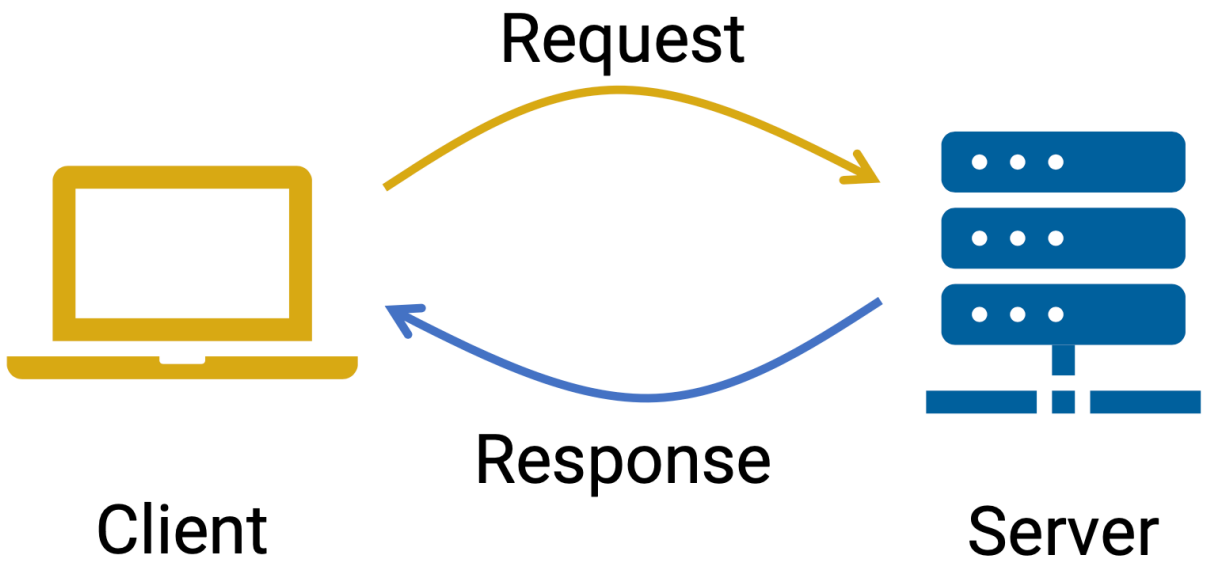
Definition

A computer network is an interconnection of two or more computers. It is done to enable the computers to communicate and **share available resources**.

The main global computer network is the **Internet**.

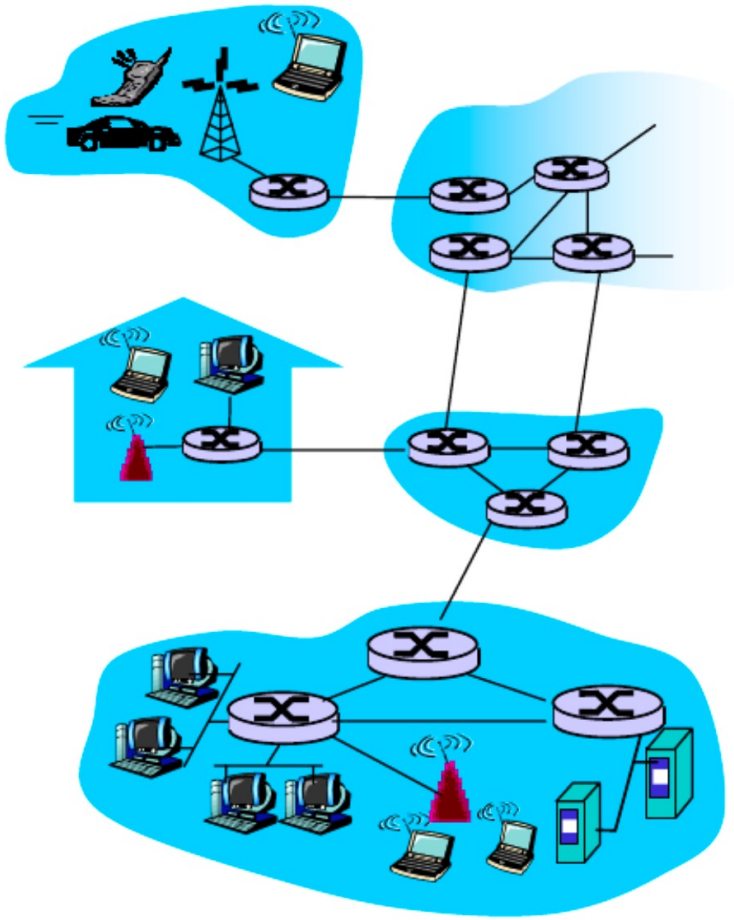
Client-server model

Client–server model is a distributed application structure that partitions tasks or workloads between the **providers of a resource or service, called servers**, and **service requesters, called clients**.



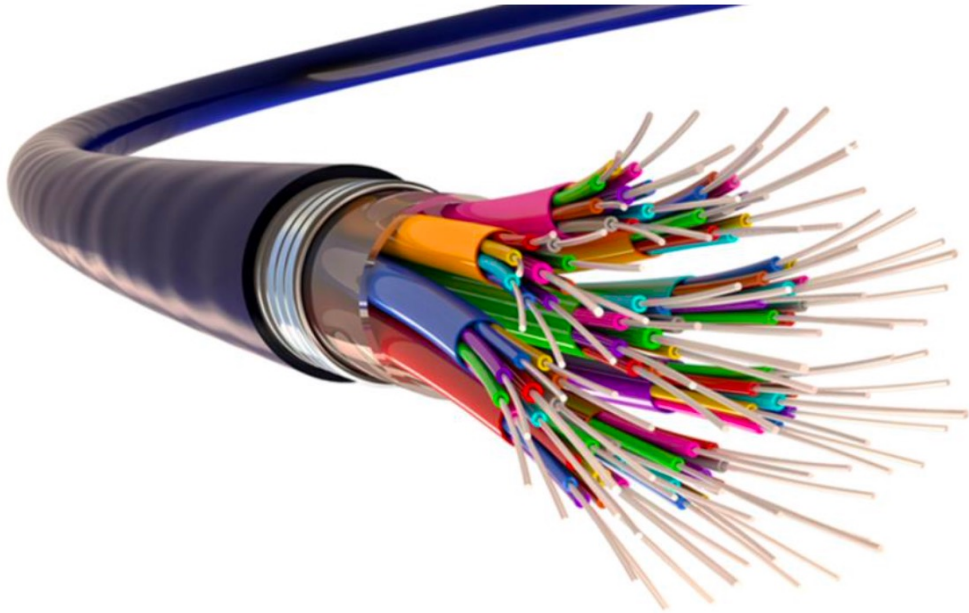
Internet

- The Internet is a network that connects computers all over the world
- These computers are various: PC, smartphone, cars, web servers, ...
- All those devices are called **host** or **end systems**



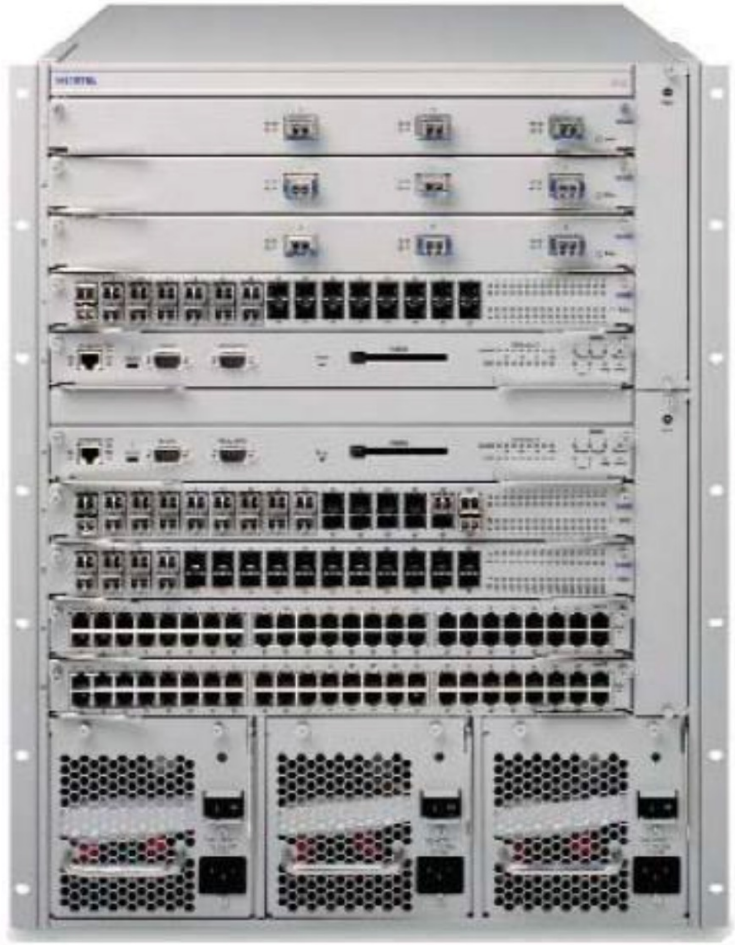
Communication links

- Hosts are connected by communication links
- Communications links are various:
  - Coaxial cables
  - Optical fiber
  - Radio
- Metrics: bandwidth = bit-rate (*bit/s)



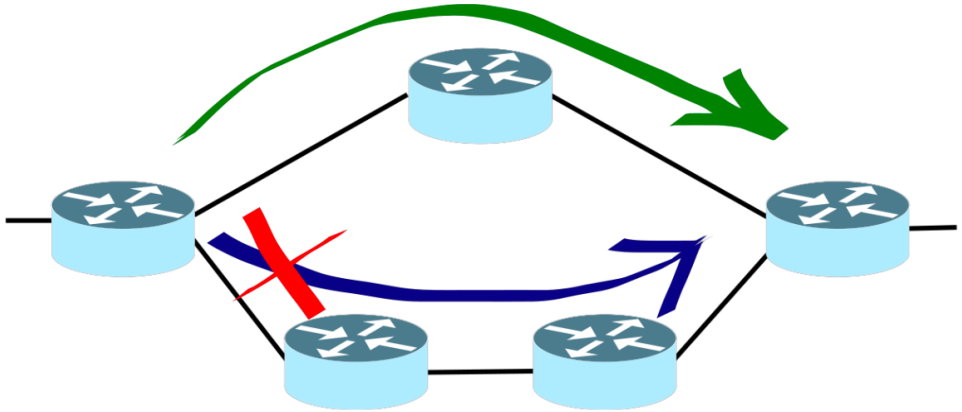
Router

- Usually, two hosts are not directly connected
- They are connected through communication devices called **routers**
- A router takes a piece of information that comes from a communication link and redirects it to another communication link
- This piece of information is called **packet**



Packet switching

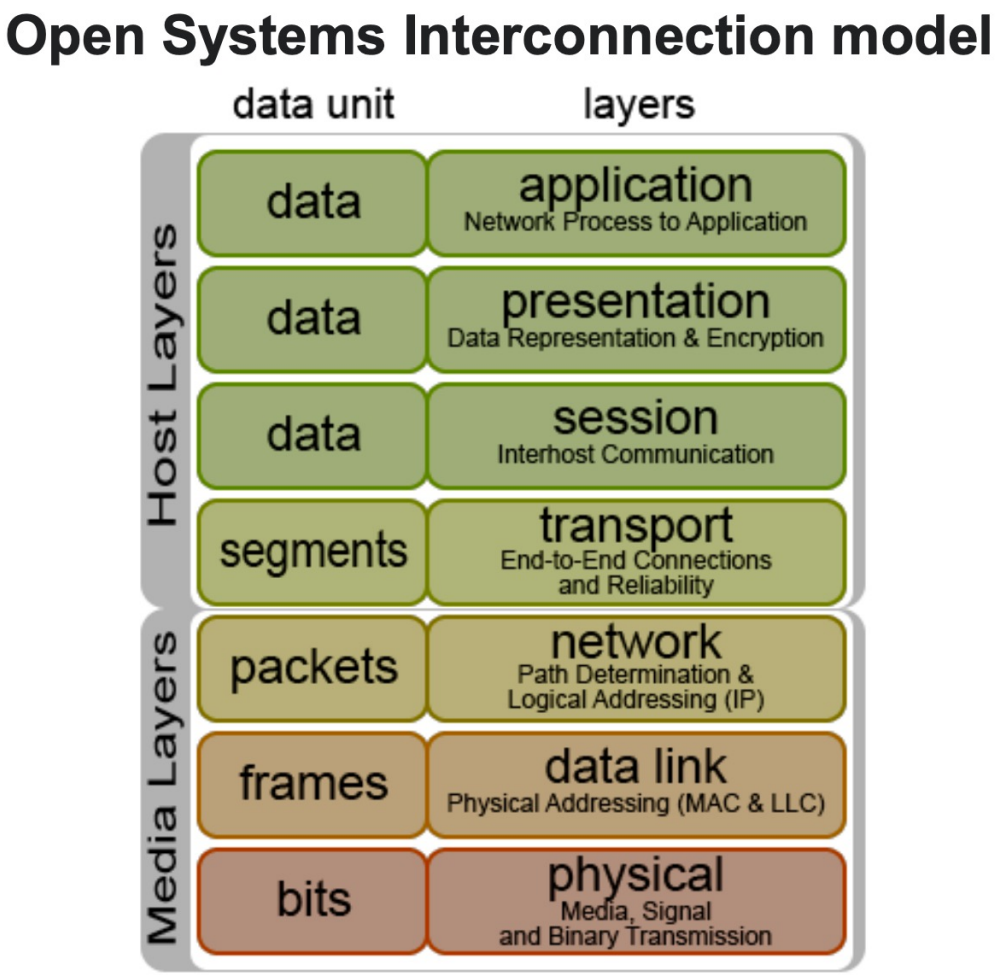
- **Packet switching** is a method of grouping data that is transmitted over a digital network into packets
- Packets are made of a header and a payload.
- Data in the header is used by networking hardware to direct the packet to its destination, where the payload is extracted and used by application software.
- Paths made in the network by two packets with the same origin and the same destination may differ



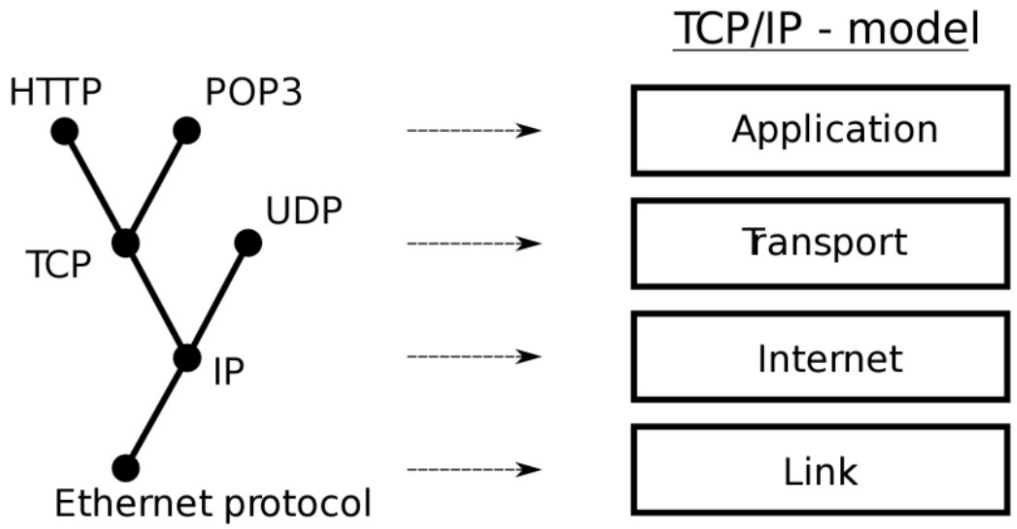
Communication protocol

- A **communication protocol** is a **system of rules** that allow two or more entities of a communications system to transmit information via any kind of variation of a physical quantity.
- The protocol defines the rules, syntax, semantics and synchronization of communication and possible error recovery methods.
- Protocols may be implemented by hardware, software, or a combination of both

ISO/OSI Reference Model



Internet protocol suite



Internet protocol suite

Application layer

BGP · DHCP · DNS · FTP · HTTP · HTTPS · IMAP · LDAP · MGCP · MQTT · NNTP · NTP · POP · PTP · ONC/RPC · RTP · RTSP · RIP · SIP · SMTP · SNMP · SSH · Telnet · TLS/SSL · XMPP · *more...*

Transport layer

TCP · UDP · DCCP · SCTP · RSVP · *more...*

Internet layer

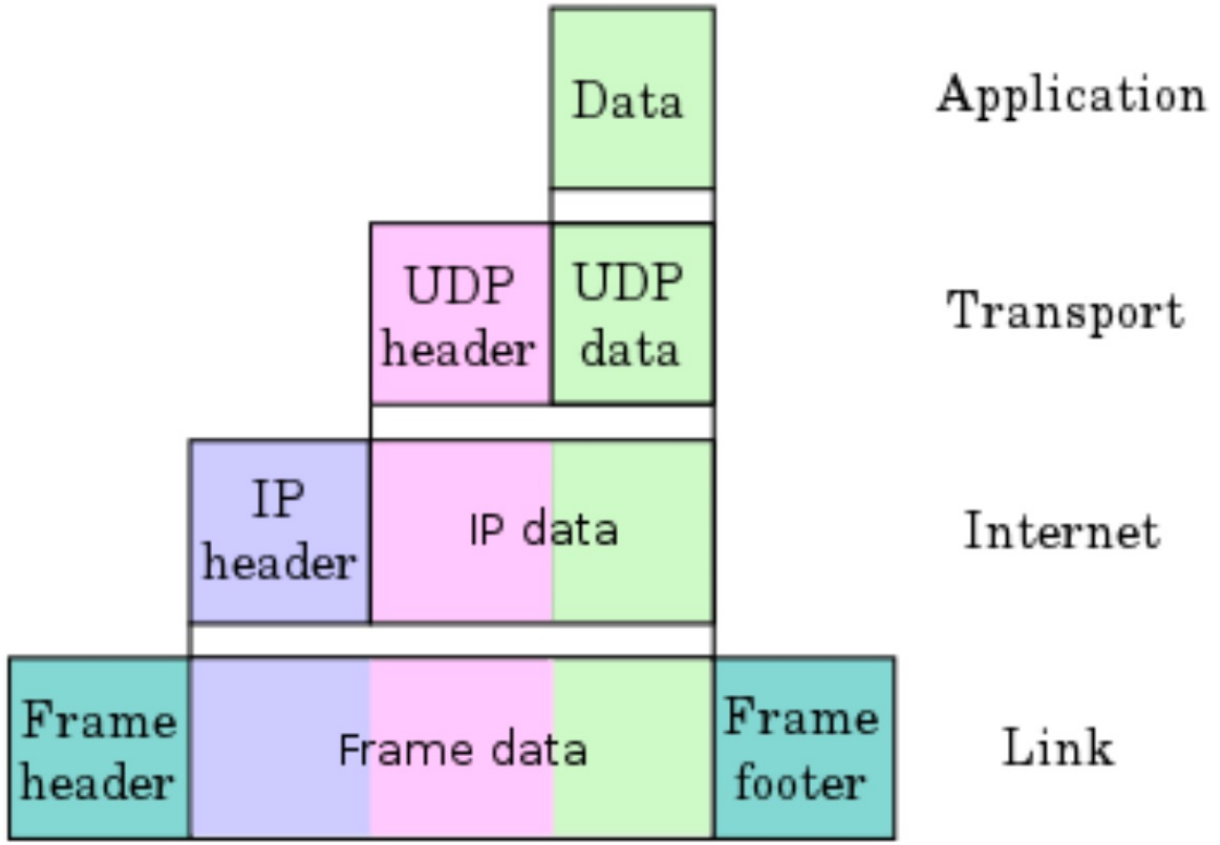
IP (IPv4 · IPv6) · ICMP · ICMPv6 · ECN · IGMP · IPsec · *more...*

Link layer

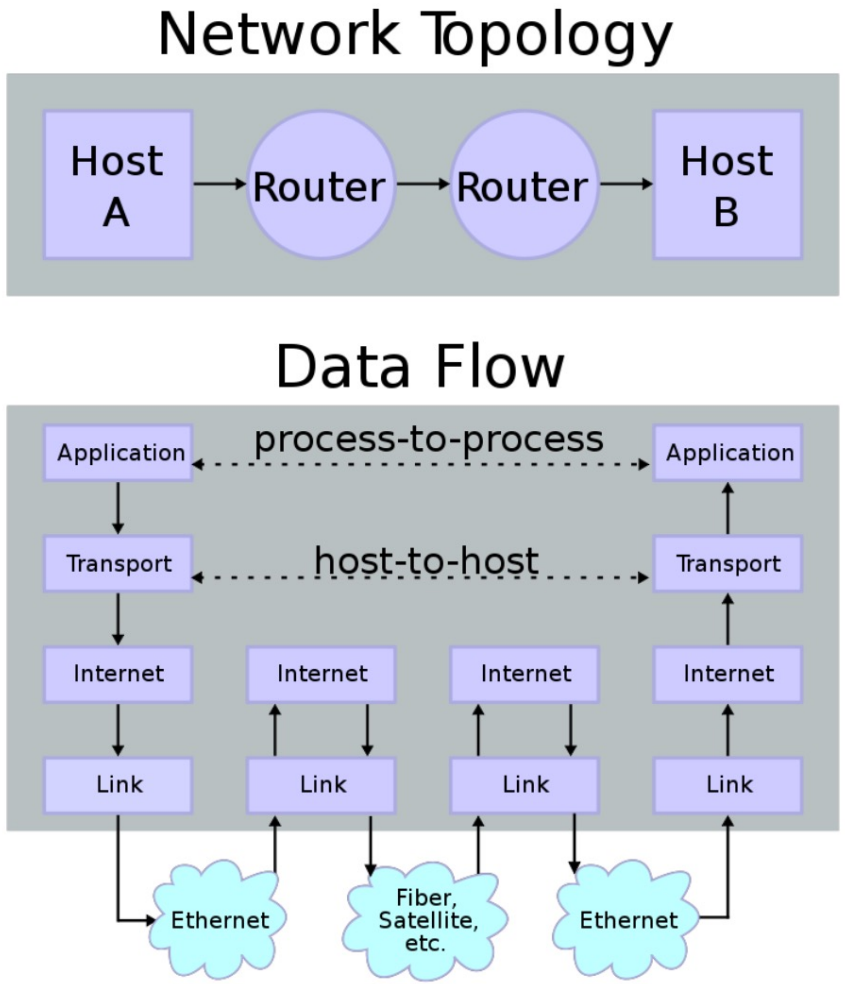
ARP · NDP · OSPF · Tunnels (L2TP) · PPP · MAC (**Ethernet** · Wi-Fi · DSL · ISDN · FDDI) *more...*

V · T · E

Encapsulation



Data flow


Network Topology
Host A
Router
Router
Host B
Data Flow
Application
process-to-process
Application
Transport
host-to-host
Transport
Internet
Internet
Internet
Internet
Link
Link
Link
Link
Ethernet
Fiber, Satellite, etc.
Ethernet

Data flow

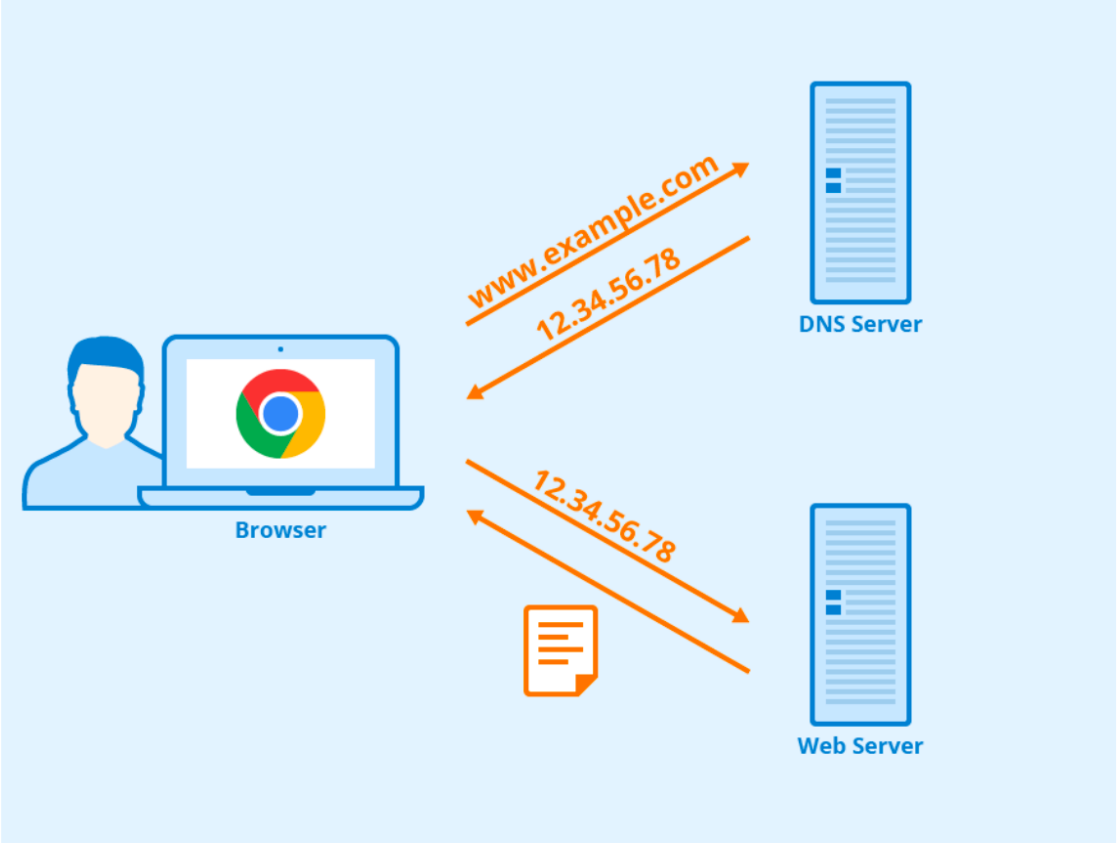
- Ethernet is one the protocol of the data link layer
- No routing at this level
- As with other IEEE 802 LANs, adapters come programmed with globally unique 48-bit MAC address so that each Ethernet station has a unique address, that reference the physical card unique identifier
- MAC (Medium Access Control) address example: 00:24:E8:F4:A6:44

IP (Internet Protocol)

- The Internet Protocol is responsible for addressing host interfaces, encapsulating data into datagrams
- (including fragmentation and reassembly) and routing datagrams from a source host interface to a destination host interface across one or more IP networks
- Each host connected to the Internet as an **IP address**
- IPv4 address examples: 216.27.61.137 or 192.168.0.1
- IPv6 address examples: 2607:F0D0:1002:0051:0000:0000:0000:0004 = 2607:F0D0:1002:51::4

DNS

- Domain Name System translates domain names to numerical IP addresses



TCP and UDP

- **TCP** (Transmission Control Protocol) provides reliable, ordered, and error-checked delivery of a stream of octets (bytes) between applications running on hosts communicating via an IP network
- **UDP** (User Datagram Protocol) uses a simple connectionless communication model with a minimum of protocol mechanisms

HTTP

- Hyper-Text Transfer Protocol (relies on TCP connection)
- Example

Request:

```
GET /wiki/Pagina_principale HTTP/1.1
Connection: Keep-Alive
User-Agent: Mozilla/5.0 (compatible; Konqueror/3.2; Linux) (KHTML, like Gecko)
Accept: text/html, image/jpeg, image/png, text/*, image/*, */*
Accept-Encoding: x-gzip, x-deflate, gzip, deflate, identity
Accept-Charset: iso-8859-1, utf-8;q=0.5, *;q=0.5
Accept-Language: en
Host: it.wikipedia.org
```

Response:

```
HTTP/1.0 200 OK
Date: Mon, 28 Jun 2004 10:47:31 GMTHTTP/1.0 200 OK
Date: Mon, 28 Jun 2004 10:47:31 GMT
Server: Apache/1.3.29 (Unix) PHP/4.3.4
X-Powered-By: PHP/4.3.4
Vary: Accept-Encoding,Cookie
Cache-Control: private, s-maxage=0, max-age=0, must-revalidate
Content-Language: it
Content-Type: text/html; charset=utf-8
Age: 7673
X-Cache: HIT from wikipedia.org
Connection: close
```

Other important application-level protocols

- HTTPS: Hypertext Transfer Protocol Secure
- FTP: File Transfer Protocol
- SSH: Secure Shell
- SMTP: Simple Mail Transfer Protocol
- IMAP: Internet Message Access Protocol
- POP: Post Office Protocol
- TLS/SSL: Transport Layer Security / Secure Sockets Layer

Questions?