Chapter 2 : Application layer

Internet protocol stack:

$$\begin{tikzcd}
\boxed{\text{application}} \arrow[d] \arrow[r, Rightarrow] & \text{IMAP, SMTP, HTTP, FTP} \\
\boxed{\text{Transport}} \arrow[d] \arrow[r, Rightarrow] & \text{TCP, UDP} \\
\boxed{\text{Network}} \arrow[d] \arrow[r, Rightarrow] & \text{IP, routing protocols} \\
\boxed{\text{link}} \arrow[d] \arrow[r, Rightarrow] & \text{Ethernet, WiFi, PPP} \\
\boxed{\text{physical}} \arrow[r, Rightarrow] & \text{wire}
\end{tikzcd}$$

- server - client paradigm :
  - server => always on , fixed IP
  - client => intermittently connected , dynamic IP
  - ex: HTTP, IMAP, FTP

- peer - peer achitecture
  - no always on server
  - end systems communicate directly
  - peers request & provide services from each other
  - ex: p2p file sharing

- Process : Program running within a host.
- inter-process communication : how to processes in the same host communicate.
- processes on different hosts communicate by exchanging messages

- client processes : process that initiates communication.
- server process : process that waits to be contacted.

} p2p has both

- socket : process sends / recieves messages to / from its socket.

- identifier of a process is both $\boxed{\text{IP address}}$ & $\boxed{\text{port number}}$
  - ↳ 32 bit

- port of HTTP server is 80 & mail server is 25

	TCP	UDP
reliability	✓	X
flow control	✓	X
congestion control	✓	X
connection oriented	✓	X
timing, minimum throughput, security	X	X

- then why is there UDP ?? because its simple & doesn't need setup, so when we don't need reliable transport we use it

- Vanilla TCP & UDP sockets:
  - No encryption
  - clear text passwords sent into socket traverse internet in clear text

- TLS (transport layer security)
  - encrypted TCP conn. - data integrity - end point authentication
  - in application layer (apps use TLS libraries)

HTTP (hypertext transfer protocol)

- web's application layer protocol
- client / server
- TCP used ⇒ ① client initiates TCP conn. & creates socket to port 80.
  ② server accepts TCP
  ③ HTTP messages exchanged between browser & webserver.
  ④ TCP connection closed
- stateless → server has no history about past client requests
- Types :-

HTTP

Non persistent
- parallel
- non parallel

a TCP connections is used for requesting one object.

persistent (HTTP 1.1)
- pipelining
- non piplined

multiple objects can be requested with one TCP connection.

- RTT : time for a packet to travel from client to server & back.
- HTTP response time (per project)

non persistent
2RTT + file transmit time
→ issues :- 1) 2 RTTs per project
2) OS overhead for each TCP conn.

solution : parallel TCP conn.

persistent
→ $(n+1)RTT + \sum_{i=1}^{N} FTT$
→ non pipelined : client sends a request & waits for the response before sending another request
→ piplined : client send multiple requests to server without waiting for previous response
→ $3RTT + \sum_{i=1}^{N} FTT$

HTTP messages

① HTTP request message

ASCII

- request line → Get html - - - - .
- header lines start
  ⋮
  end

⇒ \r\n in a line alone mean the end of header lines.

- body

types :

ⓐ post method :- user input

ⓑ Get method :- (for data sending to a server after url & ?)

ⓒ head method :- requests only headers that would be returned if specified URL were requested with an HTTP Get method .

ⓓ put method :- uploads new file (object) to server

② HTTP response message :-

- status line (protocol , status code , status phrase)
- header lines ⇒ end with line \r\n
- data requested

status codes :-

I. 200K
object request succeeded its in this message

II. 301 moved permenantly
requested object moved, new location in this message (field)

III. 400 Bad request
request message not understood by servers.

IV. 404 Not found
requested object not on this server

V. 505 HTTP version not supported

- stateful protocol :: client makes to changes to x or none at all

- cookies are used to maintain user/server state between transactions.

cookie components ⇒ 1) cookie header line of HTTP response message.
2) cookie = = in next HTTP request message
3) cookie file kept on user's host managed by user's browsers
4) back-end database at website.

- use of cookies :-
• authorization • shopping carts • recommendations • user session state.

* Web Caches (proxy servers)
⇒ satisfy client request <u>without</u> involving origin server.
⇒ they act like both client & server, client when they request sth from origin server & server when they response to an existing response.

⇒ an object allowable of caching is in response header:
cache-control: max-age = <seconds>
no-cache
⇒ cache is installed by ISP

* conditional get is used so an object is not sent if cache has up to date version
cache:- if modified since: < date >
server :- no object if up to date
HTTP / 1.0 304 Not Modified

HTTP 1.1 ⇒ multiple piplened gets over a TCP connection.
⇒ FCFS responds by server to get requests.
⇒ loss recovery stalls object transmition.

HTTP 2 ⇒ methods, status codes, header fields same as HTTP 1.1
⇒ transmission order of objects is By priority
→ divides objects to frames to lessen HoL Blocking
⇝ same as HTTP 1.1 in loss recovery & no security over vanilla TCP connection.

HTTP 3 → added security

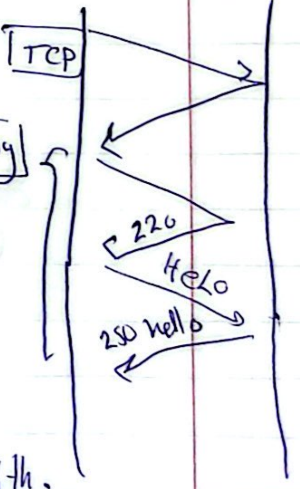
* Email components
  → user agents
  → mail server → mailbox :- contains incoming messages for user
    → message queue : outgoing messages
  → SMTP
    ↓
    between mail servers to exchange messages

① client sends their message to their mail server.
② client mail server of SMTP opens TCP conn. with server mail.
③ SMTP client sends message over TCP
④ message is put in SMTP server in mailbox.

SMTP RFC (5321) ⇒ uses TCP, Port 25
① TCP ③ transfer
② handshaking ③ closure of SMTP
- commands : ASCII
- response : status code & phrase.
↳

220	SMTP ready
221	service closing
250	Request completed
354	start message input & end with .

MAIL FROM DATA
RCPT TO QUIT



- SMTP : protocol for exchanging email messages defined in RFC ~~#~~ 5321
- HTTP, is defined in RFC 7281
- RFC 2822 defines syntax for email like html defines syntax web browsers.
- IMAP (Mail access protocol) :- retrieval from server (RFC 3501)

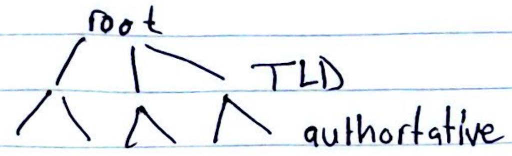
DNS

- IP 32 bit
- name

DNS is used to map between IP address & name.

$$\begin{tikzcd} & \text{DNS} \arrow[dl] \arrow[dr] & \\ \text{Distributed base in name servers} & & \text{Application layer protocol} \end{tikzcd}$$

- why not centralize DNS??
  - single point of failure
  - traffic
  - maintenance.
  - distant



- Local DNS : ⇒ Does not belong to hierarchy
  ⇒ each ISP has one

DNS: distributed database storing resource records.
RR format (name, value, type, ttl)

- RR types :-

① A
(host name, IP, A, ttL)

② NS
(domain, hostname of authortative name server for this domain, NS, ttl)

③ CNAME
(alias, canonical, CNAME, ttl)

④ MX
(~~alia~~ domain, canonical, MX, ttl)

* DNS → reply
  → query

identification 16 bit
flags 16 bit

- query 0 reply 1
- recursion desired
- recursion avilable
- reply is authortative