Reference: Ece Güran Schmidt's EE444 lecture slides (Kurose Book)

APPLICATION LAYER

Application Layer Protocols :

1) Web and HTTP

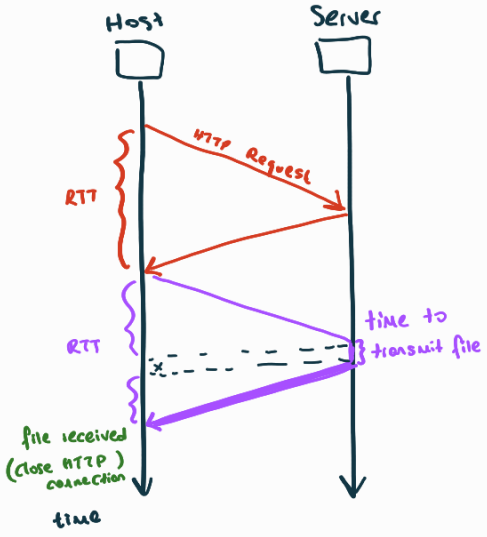
web page consists of objects
- HTML files (HyperText Markup Language)
- JPEG image, audio file...

Each object has URL (Uniform Resource Locator)

HTTP TCP Overhead

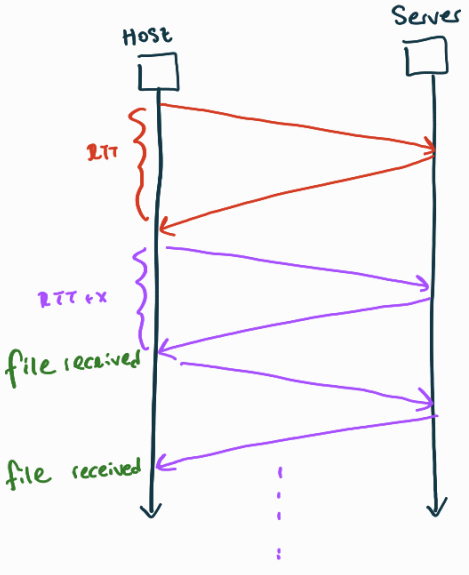
Client initiates TCP connection, port 80

Non-persistent HTTP



for N objects Response time = N * (2RTT + transmit time)

Persistent HTTP

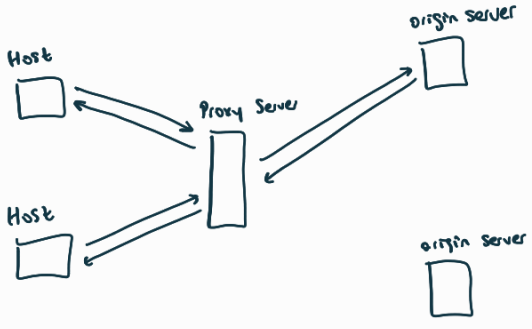


Response time = RTT + N * (RTT + transmit time)

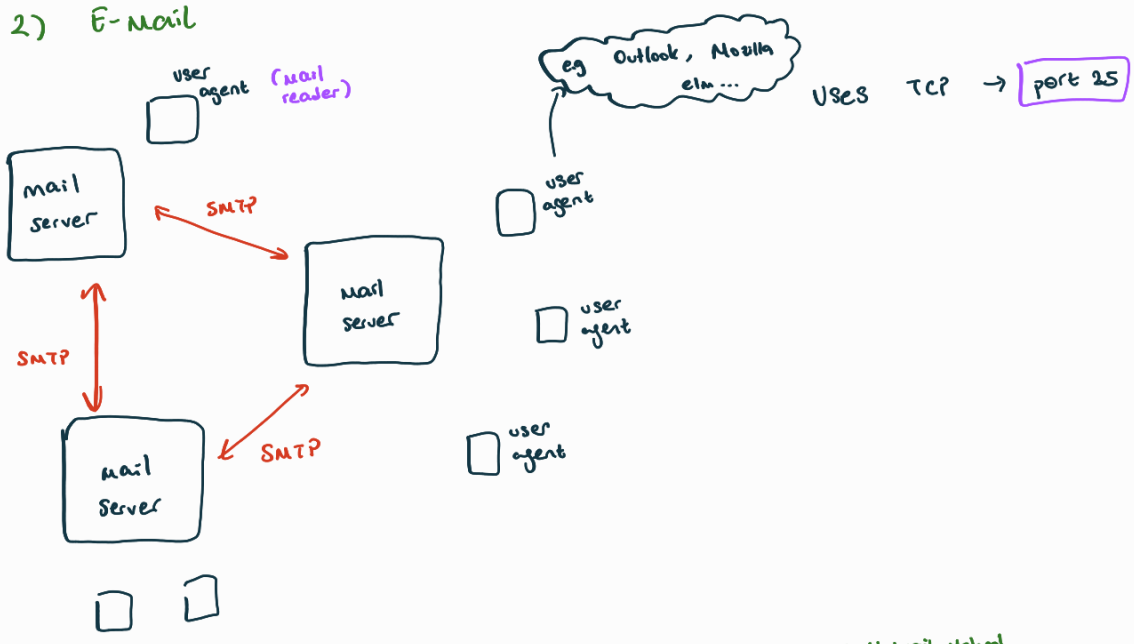
HTTP is "stateless" → server does not maintain info about past client requests

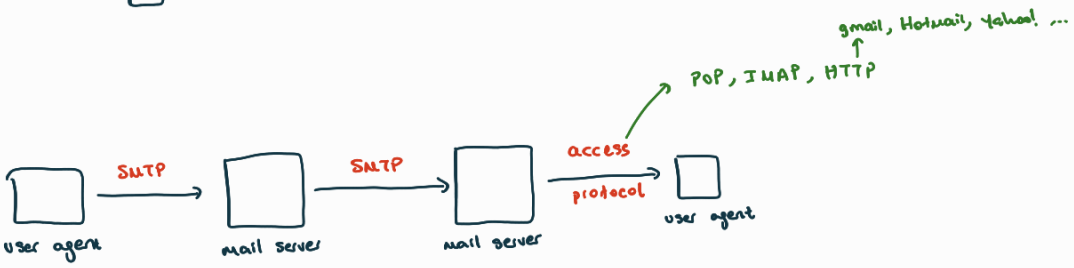
To keep state → use cookies

Web Caching = Proxy Servers



2) E-Mail



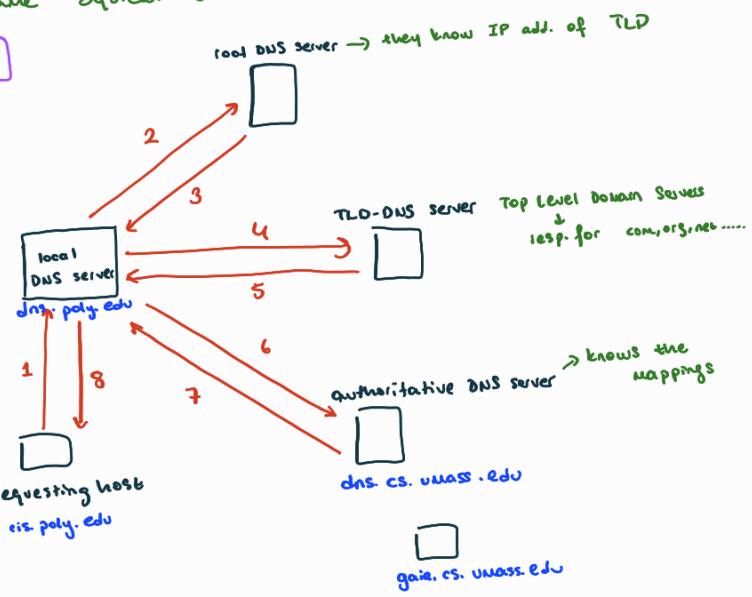


3) Domain Name System (DNS)

DNS name resolution

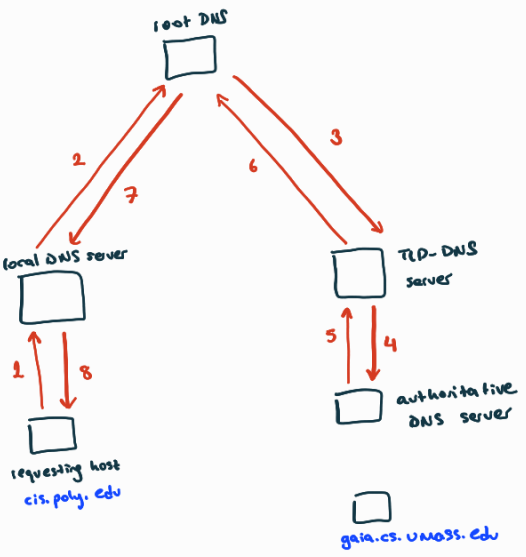
Iterated Query

Ex Host @ cis.poly.edu wants IP address for gaia.cs.umass.edu



Recursive Query

Host @ cis.poly.edu wants IP address for gaia.cs.umass.edu

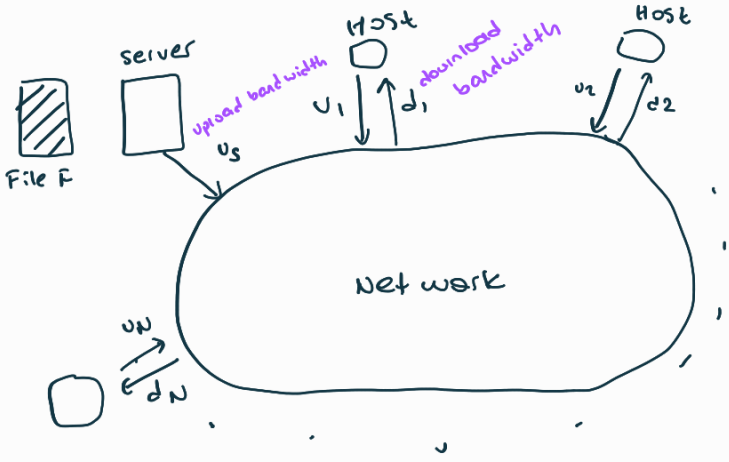


In general, DNS responses are cached

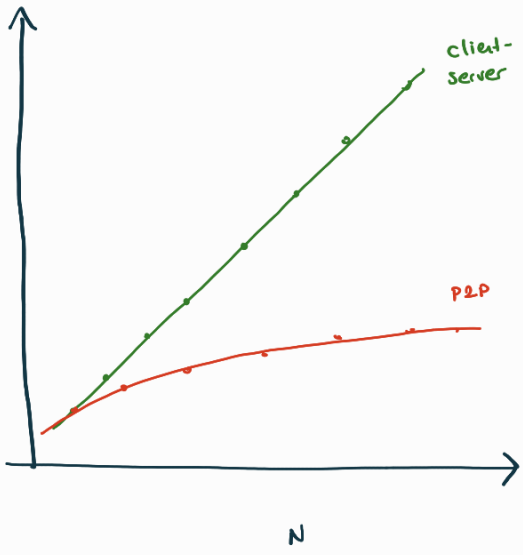
- TLD servers typically cached in local name servers (thus root name servers not often visited)

4) Peer to Peer (P2P)

In server-client system:



Min. Distribution Time



Time distribute F to N clients $= \max\left\{ \frac{NF}{u_s}, \frac{F}{\min(d_i)} \right\} = d_{cs}$

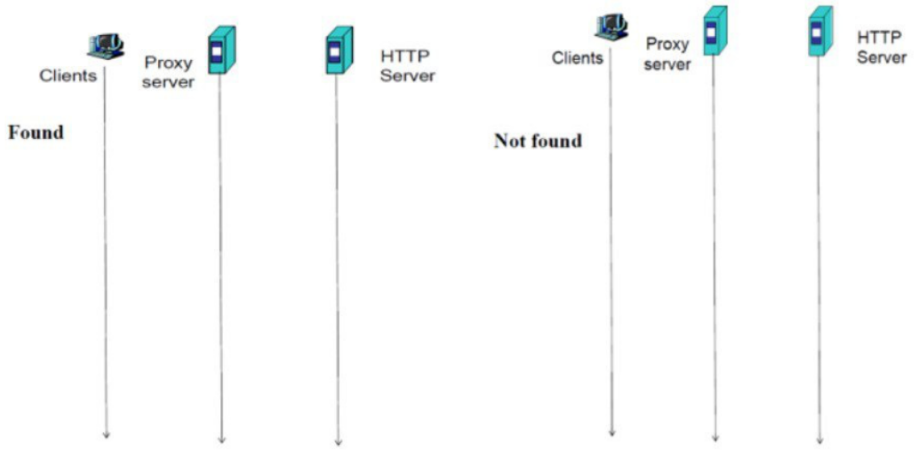
$$d_{p2p} = \max\left\{ \frac{F}{u_s}, \frac{F}{\min(d_i)}, \frac{NF}{(u_s + \Sigma u_i)} \right\}$$

QUESTIONS

2 objects

Q1] A web server hosts web pages that consist of a base html file and a single jpeg. The web service company employs a proxy server to give better service to the clients a campus network. Persistent HTTP is used. The RTT between campus clients and the proxy server is RTT_{CP}=100msec. The RTT between campus clients and the web server is RTT_{CS}=500msec. The RTT between the proxy server and the web server is RTT_{PS}=500msec.

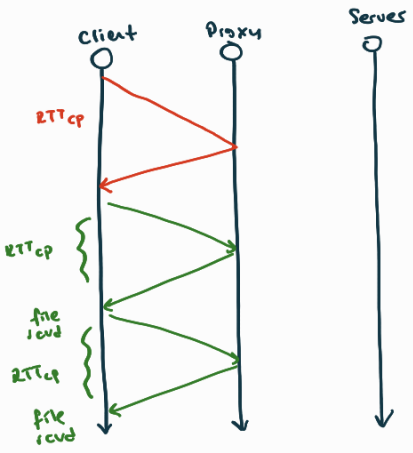
√ i)Draw the transmissions and compute the response time when the web page requested by a client is found on the proxy server and when it is not found on the proxy server.



V ii)What is the minimum probability P_{find} that the proxy server has the requested file such that using the Proxy Service has better average response time than directly downloading from the web server.

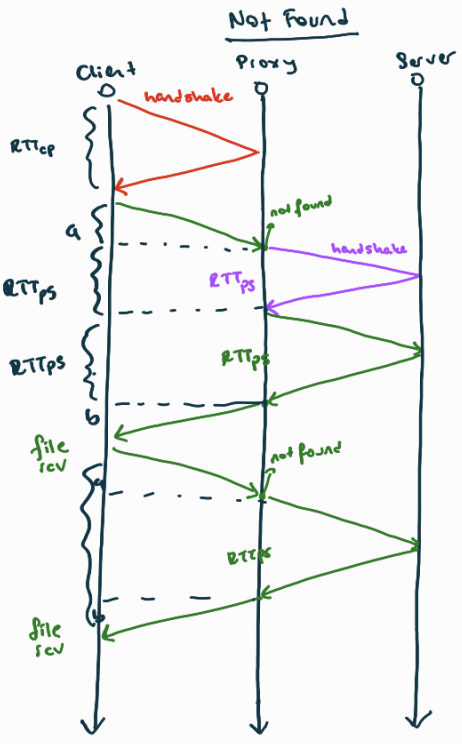
$3RTT_{CS} = 3 \times 500 = 1500$

i) Found



$3x\ RTT_{cp} = 3x\ 100\ msec = 300\ msec$

Not Found



$3RTT_{ps} + 3RTT_{cp} = 1800$ ($RTT_{ps} = 500$, $RTT_{cp} = 100$)

ii) Avg. response time

$$P_{find} \times 300 + (1-P)1800 < 3 \cdot RTT_{cs} = 1500 \quad (RTT_{cs} = 500)$$

$$300P + 1800 - 1800P < 1500$$

$$300 < 1500P$$

$$\frac{1}{5} < P \rightarrow P_{min} = 20\%$$

Q2

- A bit torrent user A has a file of 4 GBytes and makes it available for sharing. 3 other users (C1, C2, C3) start to download concurrently at t=0sec. The bandwidth parameters of the hosts are as follows:
- A: upload rate=10 Mbps, download rate =10Mbps →
- C1: upload rate=100 Mbps, download rate =100Mbps
- C2: upload rate=10 Mbps, download rate =10Mbps } min(di)
- C3: upload rate=100 Mbps, download rate =10Mbps
- What is the minimum bound on the time spent for all C1, C2, C3 complete the download?

C1 → $u_1 = 100$ Mbps $d_1 = 100$ Mbps

C2 → $u_2 = 10$ Mbps $d_2 = 10$ Mbps

C3 → $u_3 = 100$ Mbps $d_3 = 10$ Mbps

$$d_{p2p} = \max\left\{ \frac{F}{u_s}, \frac{F}{\min(d_i)}, \frac{NF}{u_s + \sum u_i} \right\}$$

$\frac{4GB}{10\ Mbps} = \frac{4 \times 10^9 \times 8\ bits}{10 \times 10^6\ bits/sec} = 3200$

$\frac{32 \times 10^9}{10\ Mbps} = 32 \times 10^2$

$\frac{3x\ 32 \times 10^9}{10 + 210} = \frac{96 \times 10^9}{220}$ (max)

Q3)

- Given the following host and DNS server configurations (TLD: Top Level Domain). The local DNS server has caching capability. The web server of cnn.com employs a proxy server with IP address of IP4. The proxy server knows the IP address of the original cnn.com server. Host A and Host B are two computers in the same room.

requesting host B

URL	IP
www.cnn.com	UNKNOWN
local name server	IP1

requesting host A

URL	IP
www.cnn.com	UNKNOWN
local name server	IP1

local name server

URL	IP
www.cnn.com	UNKNOWN
TLD name server	IP2

TLD name server iterative queries

URL	IP
www.cnn.com	UNKNOWN
authoritative name server	IP3

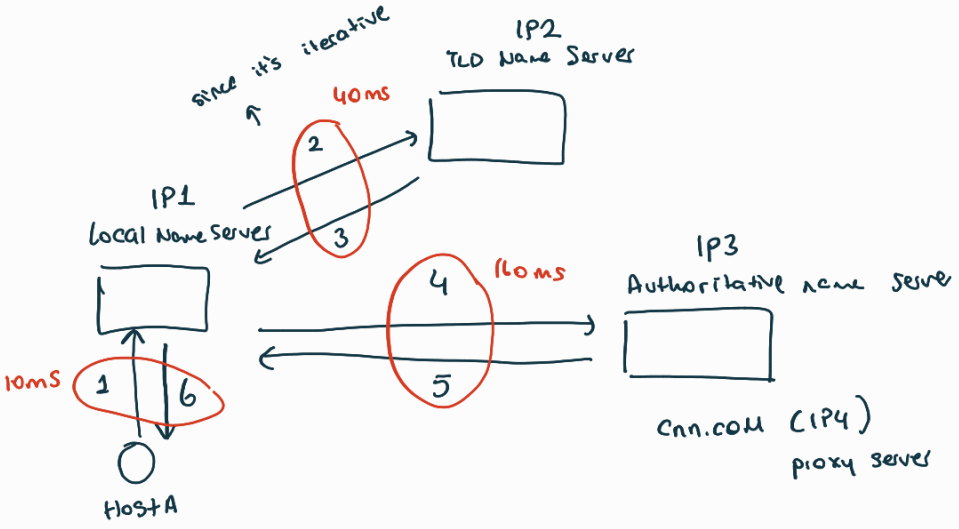
Authoritative name server

URL	IP
www.cnn.com	IP 4

- Host A wants to browse a web page on cnn.com that consists of a single small base html file. This page does not exist on the Proxy server. Show the sequence of all packet sending events until the page is displayed on the screen of Host A by drawing arrows on the following diagram and clearly numbering the arrows in sequence

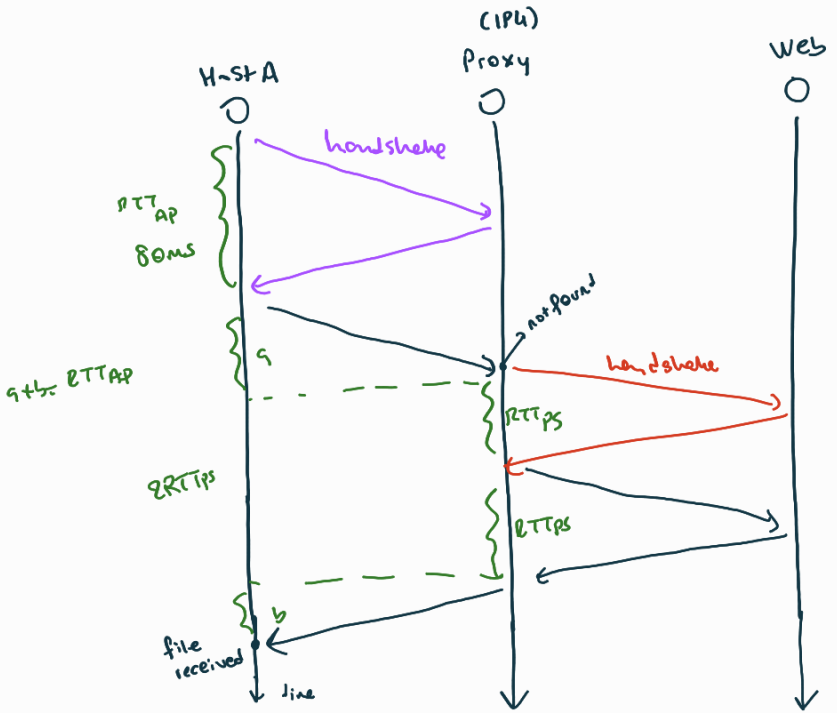
- The RTTs (sum of two directions) between all pairs of hosts are given in the table below. Compute the total time spent in part a.

Host A/B-local name server:	10 ms ✓	Host A/B - TLD name server:	50 ms	Host A/B-Proxy Server:	80ms ✓
Local name server-TLD name server:	40 ms ✓	Host A/B - Authoritative name server:	150 ms	Host A/B-cnn.com Server:	240ms
TLD name server-Authoritative Name server:	60 ms	Local name server-Authoritative Name server:	160 ms ✓	Proxy Server-cnn.com server:	120ms ✓



Time passed to reach IP4:

10+40+160 = 210 ms



$2RTT_{AP} + 2RTT_{PS} = 160 + 240 = 400$ (80, 120)

Total time = 210 + 400 = 610 ms