CS305 hw2

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> 1. List the four broad classes of services that a transport protocol can provide. For each of the service classes, indicate if either UDP or TCP (or both) provides such a service.

Solution:

1. Reliable transport: TCP
2. Flow control: TCP
3. Congestion control: TCP
4. Connection-oriented: TCP

> 2. Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that n DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT of RTT1, . . ., RTTn. Further suppose that the Web page associated with one HTML file, and the HTML file references eight very small objects on the same server. Let RTT0 denote the RTT between the local host and the server containing these objects. Assuming zero transmission time of the objects. Please calculate the time which elapses from when the client clicks on the link until the client receives the object under the following circumstance.
> a) Non-persistent HTTP with no parallel TCP connections?
> b) Non-persistent HTTP with the browser configured for 5 parallel connections?
> c) Persistent HTTP?

Solution:

The total time of geting the IP address is $\sum_{i=1}^{n} RRT_i = RTT_1 + RTT_2 + ... + RTT_n$.
When we know the IP address, we need $2RTT_0$ to set up the TCP connection and request and receive the small object.

a) Non-persistent HTTP means that we should set up TCP connection for each object.
No parallel TCP connections means that we should set up TCP connection one by one.

$$
\begin{aligned}
Time &= RTT_1 + RTT_2 + ... + RTT_n + 2RTT_0 + 8 \times 2RTT_0 \\
&= RTT_1 + RTT_2 + ... + RTT_n + 18 \times RTT_0
\end{aligned}
$$

b) Non-persistent HTTP means that we should set up TCP connection for each object.
The browser configured for 5 parallel connections means that we should set up 5 TCP connections together.

$$
\begin{aligned}
Time &= RTT_1 + RTT_2 + ... + RTT_n + 2RTT_0 + \lceil \frac{8}{5} \rceil \times 2RTT_0 \\
&= RTT_1 + RTT_2 + ... + RTT_n + 2RTT_0 + 2 \times 2RTT_0 \\
&= RTT_1 + RTT_2 + ... + RTT_n + 6 \times RTT_0
\end{aligned}
$$

c) Persistent HTTP is the idea of using a single TCP connection to send and receive multiple HTTP requests/responses, as opposed to opening a new connection for every single request/response pair.

$$
\begin{aligned}
Time &= RTT_1 + RTT_2 + ... + RTT_n + 2RTT_0 + RTT_0 \\
&= RTT_1 + RTT_2 + ... + RTT_n + 3 \times RTT_0
\end{aligned}
$$

> 3. Consider distributing a file of F bits to N peers using a client-server architecture. Assume a fluid model where the server can simultaneously transmit to multiple peers, transmitting to each peer at different rates, as long as the combined rate does not exceed us.
> a) Suppose that us/N ≤ dmin. Specify a distribution scheme that has a distribution time of NF/us.
> b) Suppose that us/N ≥ dmin. Specify a distribution scheme that has a distribution time of F/dmin.
> c) Conclude that the minimum distribution time is in general given by max {NF/us, F/ dmin}.

Solution:

a) There is a distribution that server sends the file to each client at a rate of u_s/N.
And the rate is less than clients' download rate because $u_s/N \leq d_{min}$.
So that each client receive the file at the rate of u_s/N.
The file is F bits.
Since the time of all the clients receive the file is $F/(u_s/N) = NF/u_s$.

b) There is a distribution that that server sends the file to each client in parallel at the rate of u_s.
The aggregate rate is Nd_{min} and it less than u_s because $u_s/N \geq d_{min}$.
The slowest client receive the file at rate of d_{min}, the time of the slowest client receive the file is F/d_{min}.
SO that all the clients receive the file is F/d_{min}.

c) Equation 1: $D_{cs} \geq max\{\frac{NF}{u_s}, \frac{F}{d_{min}}\}$

1. $u_s/N \leq d_{min}$, we have $D_{cs} \leq NF/u_s$. But we also have $D_{cs} \geq NF/u_s$ due to Equation 1, so that $D_{cs} = NF/u_s$ when $u_s/N \leq d_{min}$
2. $u_s/N \geq d_{min}$, we have $D_{cs} \leq F/d_{min}$. But we also have $D_{cs} \geq F/d_{min}$, so that $D_{cs} = F/d_{min}$ when $u_s/N \geq d_{min}$

   Combining 1 and 2, we can prove the minimum distribution time is in general given by $max\{NF/u_s, F/d_{min}\}$.

> 4. Consider distributing a file of F bits to N peers using a P2P architecture. Assume a fluid model. For simplicity assume that dmin is very large, so that peer download bandwidth is never a bottleneck.
> a) Suppose that us ≤ (us + u1 + ... + uN)/N. Specify a distribution scheme that has a distribution time of F/us.
> b) Suppose that us ≥ (us + u1 + ... + uN)/N. Specify a distribution scheme that has a distribution time of NF/(us + u1 + ... + uN).
> c) Conclude that the minimum distribution time is in general given by max {F/us, NF/(us + u1 + ... + uN)}.

Solution:

a) We suppose that $u = u_1 + u_2 + ... + u_N$
So that $u_s \leq (u_s + u)/N$
We divide the file into N parts, the i^{th} part has size $(u_i/u)F$.
The server transmits the i^{th} part to peer i at rate of $r_i = (u_i/u)u_s$.
$r_1 + r_2 + ... + r_N = u_s$, so that the aggregate rate doesn't over the limit rate of server.
And each peer need to forward the bits it receives to each of the $N - 1$ peers.
The aggregate rate is $(N-1)r_i = (N-1)(u_s u_i)/u \leq u_i$.
In this distribution: peer i receives bits at the aggregate rate of $r_i + \sum_{j!=i,1<=j<=N} r_j = u_s$.
So that each peer receives the file at rate of F/u_s.

b) We suppose that $u = u_1 + u_2 + ... + u_N$
So that $u_s \geq (u_s + u)/N$
We divide the file into $N + 1$ parts.
The server transmits the i^{th} part to peer i(0<=i<=N>) at rate of r_i.
And each peer need to forward the bits it receives to each of the $N - 1$ peers.
And The server transmits the $(N+1)^{th}$ part to each peer at rate of r_{N+1}.
$r_1 + r_2 + ... + r_N + Nr_{N+1} = u/(N-1) + u_s - u/(N-1) = u_s$, so that the aggregate rate doesn't over the limit rate of server.
The aggregate rate is $(N-1)r_i = u_i$
So that the aggregate rate doesn't over the limit rate of each peer.
In this distribution: peer i receives bits at the aggregate rate of $r_i + r_{N+1} + \sum_{j!=i,1<=j<=N} r_j = u/(N-1) + (u_s - u/(N-1))/N = (u_s + u)/N$
So that each peer receives the file at rate of $F/(u_s + u)/N = FN/(u_s + u_1 + ... + u_N)$

c) We suppose that $u = u_1 + u_2 + ... + u_N$
$D_{P2P} >= max\{F/u_s, NF/(u_s + u)\}$
And combining a) and b),
a) each peer receives the file at rate of F/u_s
b) each peer receives the file at rate of $FN/(u_s + u_1 + ... + u_N)$
We get the result when we do a)'s or b)'s distribution.

> 5. Consider a DASH system for which there are N video versions (at N different rates and qualities) and N audio versions (at N different rates and qualities). Suppose we want to allow the player to choose at any time any of the N video versions and any of the N audio versions.
> a) If we create files so that the audio is mixed in with the video, so server sends only one media stream at given time, how many files will the server need to store (each a different URL)?
> b) If the server instead sends the audio and video streams separately and has the client synchronize the streams, how many files will the server need to store?

Solution:

a) If we match N video with N audio, we have $N \times N = N^2$ different files, we fix them first, then send one file to client.

b) We just send N video and N audio to client. They are $N + N = 2N$ different files, and client will fix them together.