

Basics to understand the mathematical terms with real life application:

Persistent HTTP:

Persistent HTTP, is a communication feature where a single TCP connection is reused to send and receive multiple HTTP requests and responses, reducing the overhead of establishing new connections.

Non-persistent HTTP:

Non-persistent HTTP is a communication method where a new TCP connection is established for each HTTP request and closed after the response is received, leading to increased connection overhead for multiple requests.

RTT (Round Trip Time):

time for a small packet to travel from client to server and back.

Propagation Delay:

Propagation delay is the time it takes for a signal to travel from the sender to the receiver across a communication medium.

Transmission Delay:

Transmission delay is the time required to push all the bits of a data packet onto the communication link, determined by the packet size and the transmission rate of the link.

Mathematical Terms:

Assume that you have a base HTML file with 30 embedded images, images & base file are small enough to fit in one TCP segment. How many RTT are required to retrieve base file & images under the following conditions:

(Assume RTT dominates all other time)

1. **Non-Persistent connection without parallel connection.**
2. **Non-Persistent connection with 10 parallel connections.**
3. **Persistent connection without pipelining.**
4. **Persistent connection with pipelining.**

Explanation:

2 RTT is the initial required connection, one for TCP connection and one for HTML base file.

Total time = 2 RTT + transmit time

1. Non-Persistent connection with no parallel connection:

For each image, 2 RTT are required—one for the TCP connection and one for the image to send.

So, transmit time for 30 images = $2 * (30 \text{ RTT}) = 60 \text{ RTT}$

Total time = 2 RTT + 60 RTT = 62 RTT

2. Non-persistent connection with 10 parallel connections:

Here, 10 images can be sent simultaneously.

So, for 30 images, it requires $\rightarrow 2 * (30 / 10) = 6 \text{ RTT}$

Total time = 2 RTT + 6 RTT = 8 RTT

3. Persistent connection without pipelining:

Here, the TCP connection is required again and again.

So, for 30 images, it requires $\rightarrow 30 \text{ RTTs}$

Total time = 2 RTT + 30 RTT = 32 RTT

4. Persistent connection with pipelining:

Since it is a persistent connection, the TCP connection is not required again and again. Pipelining means in one packet only images that can fit can be sent.

In a pipelining connection, we can send all images in 1 RTT.

Total time = 2 RTT + 1 RTT = 3 RTT.

Real Life Application with Mathematical Terms:

Suppose a website contains 1 HTML file, 10 CSS files, and 5 JavaScript files.

File Type	Size
HTML	100 KB
CSS	30 KB
JavaScript	50 KB

The RTT required for connection setup is 0.3 sec. The bandwidth between the server and the client is 0.5 Gbps. The distance between the client and the server is 5 km. Propagation speed is 200 m/microsec.

Now, calculate the response time required to retrieve the base files and images under the following conditions:

1. Non-persistent HTTP without parallel connection.

2. Persistent HTTP without pipelining.

Solution:

1. Non-persistent HTTP without parallel connection:

RTT = 0.3 sec

Transmission Rate = 0.5×10^9 bps

Propagation Delay = $(5 \times 10^3) / (2 \times 10^8) = 2.5 \times 10^{-5}$ sec

For HTML = $((2 \times 0.3) + ((100 \times 10^3) / (0.5 \times 10^9))) \times 1 = 0.6002$ sec

For CSS = $((2 \times 0.3) + ((30 \times 10^3) / (0.5 \times 10^9))) \times 10 = 6.0006$ sec

For JS = $((2 \times 0.3) + ((50 \times 10^3) / (0.5 \times 10^9))) \times 5 = 3.0005$ sec

So, Non-persistent HTTP without parallel connection response time

= $((2 \times 0.3) + (2.5 \times 10^{-5}) + 0.6002 + 6.0006 + 3.0005) = 10.201$ sec

2. Persistent HTTP without pipelining:

RTT = 0.3 sec

Transmission Rate = 0.5×10^9 bps

Propagation Delay = 2.5×10^{-5} sec

For HTML = $(0.3 + ((100 \times 10^3) / (0.5 \times 10^9))) \times 1 = 0.3002$ sec

For CSS = $(0.3 + ((30 \times 10^3) / (0.5 \times 10^9))) \times 10 = 3.0006$ sec

For JS = $(0.3 + ((50 \times 10^3) / (0.5 \times 10^9))) \times 5 = 1.5005$

So, Persistent HTTP without pipelining response time

= $(0.3 + (2.5 \times 10^{-5}) + 0.3002 + 3.0006 + 1.5005) = 5.101$ sec

From the above topic, it covers the differences between persistent and non-persistent HTTP connections, focusing on how they handle multiple file transfers in a webpage. It explains key networking terms like RTT, propagation delay, and transmission delay. Through mathematical examples, it shows how non-persistent HTTP incurs more delays by opening separate connections for each file, while persistent HTTP improves efficiency by reusing connections. It then applies these concepts to calculate the response times for a website containing HTML, CSS, and JavaScript files, illustrating the performance differences between the two connection types.

