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## Part B: Application Layer (8 marks).

### 1. Browsers:

Suppose that within your Web browser you click on a link to obtain a Web page containing a small amount of HTML text, and that this text references  $N$  ( $< 5$ ) very small objects on the same server that must also be retrieved to present the page.

Denote the round-trip time between your computer and the server by  $R$ . Assuming that a DNS lookup is not necessary (the required IP address was obtained earlier and cached), and that transmission, queueing, and processing times are negligible compared to  $R$ , as functions of  $R$  and  $N$  how much time elapses with:

#### Non-persistent HTTP with no parallel TCP connections?

This would require multiple connections and sequential requests.

So, for each  $N$  request, it needs:  $R$  to get connection setup,  $R$  to send the request and get the response.

$$f(N, R) = 2 \times N \times R$$

#### Non-persistent HTTP with parallel connections?

This would require multiple parallel connections (1 time unit).

Ignoring the other overheads, assuming we do the  $n$  connections and  $n$  req/res parallelly.

We need first do connections first, then do the req/res.

$$f(N, R) = 2 \times R$$

#### Persistent HTTP with no parallel connections, and without pipelining?

This would require 1 connection with  $N$  req/res.

$$f(N, R) = R + N \times R$$

#### Persistent HTTP with no parallel connections, but with pipelining?

Since it's pipelined, all connections and req/res will be in 1 go.

so

$$f(N, R) = R$$