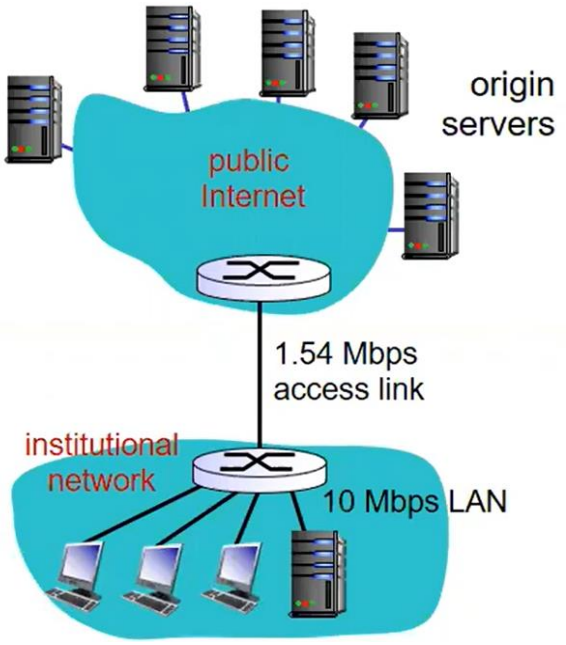

Assumptions:	**Consequences:**
avg object size: 100K bits avg request rate from browsers to origin servers:15/sec avg data rate to browsers: 1.50 Mbps RTT from institutional router to any origin server: 2 sec (Internet delay) Access link rate: 1.54 Mbps	LAN utilization: 15% Access link utilization = 99% Total delay = Internet delay + access delay + LAN delay = 2 sec + minutes + usecs

Consequences elaboration:

Traffic Intensity on LAN Utilization =15%?

15 rec/sec * (100,000 bits/req) / 10,000000 bits/sec = 0.15 = 15% [Note: 10 Mbps LAN = 10,000000 bps]

Traffic Intensity on Access Link utilization = 99% (approximately)?

15 rec/sec * (100,000 bits/req) / 1540000 bits/sec = 0.9740 = 97% [i.e. close to 99%] (approximately) [Note: 1.54 Mbps Access link = 1540000 bps]

Since the access link is being utilized around 97-99%, there will be a congestion, hence delay will be more.

Total delay = Internet delay (2 sec) + Access delay (since intensity is 97-99%, which is high, it will be in order of minutes, which is also a larger delay in networking (NOT OK)) + LAN delay (typically is milliseconds (OK))

= ~ 2 seconds ++

SOLUTIONS:

1. We can upgrade the access link. If updated with a larger bandwidth, it will reduce the traffic intensity on the access link and consequently delay will be reduced in the access link.

Let us, increase the bandwidth of access link from 1.54 Mbps to **154 Mbps**.

The access link intensity becomes = 15 rec/sec * (100,000 bits/req) / 154000000 bits/sec = 0.09740 = 9.7%.

Access Link utilization is reduced.

Total delay = Internet delay (2 sec) + Access delay (since intensity is 9.7%, which is low, it will be in order of milliseconds (OK)) + LAN delay (typically is milliseconds (OK))

= ~ 2 seconds ++

However, increasing access link bandwidth is **COSTLY.** Since, we need to pay for this large bandwidth every month.

2. We can install Web cache (proxy server) in the institutional network.

Suppose after installing the proxy server in the LAN, the cache-hit rate is 0.4 (40%), 60% requests are satisfied at origin servers.

Now 60% of requests use the access link, instead of 97-99%.

Data rate to browsers over the access link = 0.6*1.50 Mbps = 0.9 Mbps

Hence, access link utilization becomes = 0.9/1.54 Mbps = 0.584 = 58.4% (reduced than original 97-99%)

Now, Total delay = 0.6 * (delay from origin servers) + 0.4 *(delay when satisfied at web cache) = 0.6* 2.01 + 0.4* (~ milliseconds) = ~ 1.2 seconds (which is lower than the delay with increased bandwidth of 154 Mbps also (VERY GOOD-CHEAPER- FASTER)).