7. Cross layer: Routing, UDP/TCP, DNS/HTTP

Consider the network shown below. In the figure, AA is the Authoritative DNS server for Web Servers A and B, and LC is the local DNS server for Client C. Client C wishes to see a webpage on Server A. The IP address of Server A is not cached in the client. The address resolution is done iteratively, i.e., all levels of DNS servers (root, TLD, and AA) should be consulted.

Assume that the one-way delay through each link inside AS1, and one-way delay through each AS outside AS1 is labeled in the figure, in ms. We assume that all dashed links have zero delay. For example, the one-way delay from Router C to AA is 30 ms. The one-way delay from Router E to Root via AS4 AS5 is 45 ms. OSPF routing protocol is used within AS1 (link cost is equivalent to one-way delay inside AS1). BGP is used among the ASes.

After resolving the IP address, Client C can visit Server A. After obtaining the main page, Client C finds that there are 2 objects to be fetched. One object is stored in Server A, but the other object is stored in Server B. Unfortunately, Client C does not know the IP address of Server B, so that Client C has to resolve the IP again.

The size of the main web page is small. It fits into 1 TCP segment. Each object is also small and fits into 1 TCP segment. No packet is lost. Persistent HTTP is used.

Assumption 1: All inter-AS paths are allowed, and these inter-AS paths have been known by all routers in all ASes.

Assumption 2: All levels of DNS servers should be consulted iteratively for address resolution.

Assumption 3: Client C starts to request the IP address of object 2 when object 1 has been successfully downloaded.

Assumption 4: TCP termination delay is ignored.

Question: How long in total does it take for Client C to successfully obtain the webpage (including: DNS of main paper, download of main page, download of object 1, DNS of object 2, and download of object 2).