

record that contains the IP address (64.233.169.105) for www.google.com. (assuming that it is currently cached in the DNS server). Recall that this cached data originated in the **authoritative DNS server** (Section 2.5.2) for google.com. The DNS server forms a **DNS reply message** containing this hostname-to-IP-address mapping, and places the DNS reply message in a UDP segment, and the segment within an IP datagram addressed to Bob's laptop (68.85.2.101). This datagram will be forwarded back through the Comcast network to the school's router and from there, via the Ethernet switch to Bob's laptop.

17. Bob's laptop extracts the IP address of the server www.google.com from the DNS message. *Finally*, after a *lot* of work, Bob's laptop is now ready to contact the www.google.com server!

5.7.4 Web Client-Server Interaction: TCP and HTTP

18. Now that Bob's laptop has the IP address of www.google.com, it can create the **TCP socket** (Section 2.7) that will be used to send the **HTTP GET** message (Section 2.2.3) to www.google.com. When Bob creates the TCP socket, the TCP in Bob's laptop must first perform a **three-way handshake** (Section 3.5.6) with the TCP in www.google.com. Bob's laptop thus first creates a **TCP SYN** segment with destination port 80 (for HTTP), places the TCP segment inside an IP datagram with a destination IP address of 64.233.169.105 (www.google.com), places the datagram inside a frame with a destination MAC address of 00:22:6B:45:1F:1B (the gateway router) and sends the frame to the switch.
19. The routers in the school network, Comcast's network, and Google's network forward the datagram containing the TCP SYN towards www.google.com, using the forwarding table in each router, as in steps 14–16 above. Recall that the router forwarding table entries governing forwarding of packets over the inter-domain link between the Comcast and Google networks are determined by the **BGP** protocol (Section 4.6.3).
20. Eventually, the datagram containing the TCP SYN arrives at www.google.com. The TCP SYN message is extracted from the datagram and demultiplexed to the welcome socket associated with port 80. A connection socket (Section 2.7) is created for the TCP connection between the Google HTTP server and Bob's laptop. A TCP SYNACK (Section 3.5.6) segment is generated, placed inside a datagram addressed to Bob's laptop, and finally placed inside a link-layer frame appropriate for the link connecting www.google.com to its first-hop router.
21. The datagram containing the TCP SYNACK segment is forwarded through the Google, Comcast, and school networks, eventually arriving at the Ethernet card in Bob's laptop. The datagram is demultiplexed within the operating system to the TCP socket created in step 18, which enters the connected state.
22. With the socket on Bob's laptop now (*finally!*) ready to send bytes to www.google.com, Bob's browser creates the HTTP GET message (Section 2.2.3) containing the URL to be fetched. The HTTP GET message is then written into the socket, with the