Computer Networks

The Socket API (Project 1) & Traceroute (HW 1)

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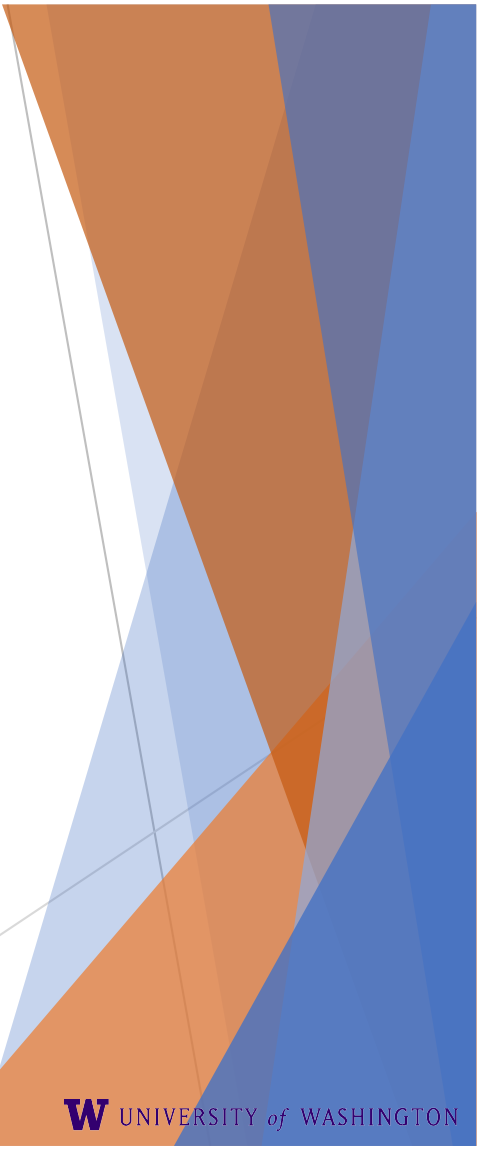
Outline

- Administrivia
- Project 1 and Socket API
- Traceroute

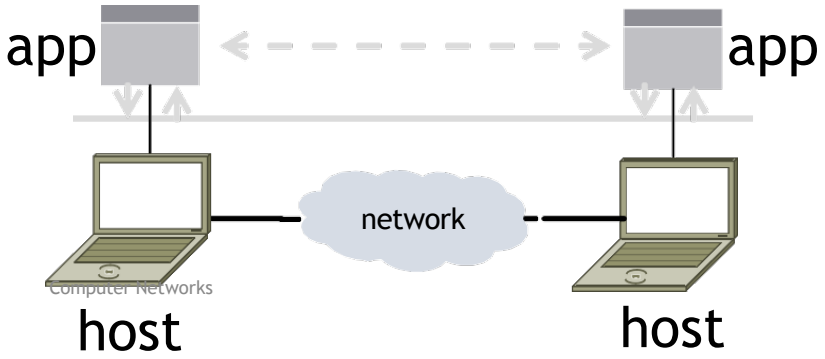


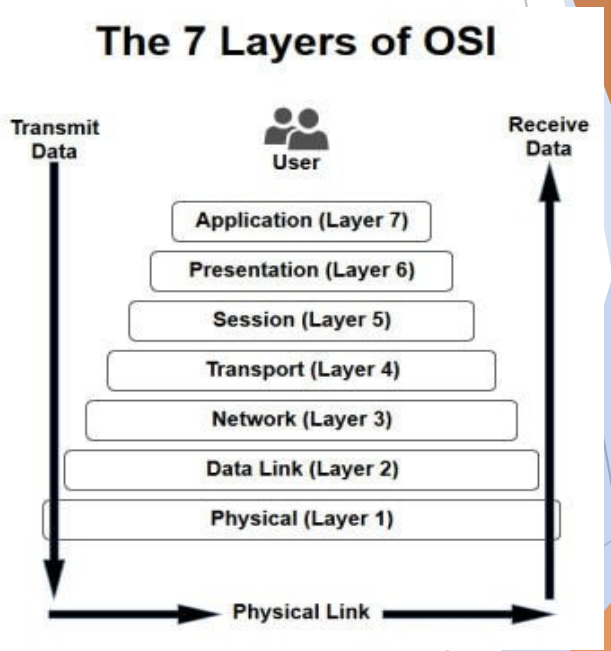
Administrivia

- Sections will be recorded
- HW1 & Traceroute Experiment due tomorrow
- HW2 due Jan 21st (next Friday)
- Project 1 due on Jan 25th (the Monday after next)

Network-Application Interface

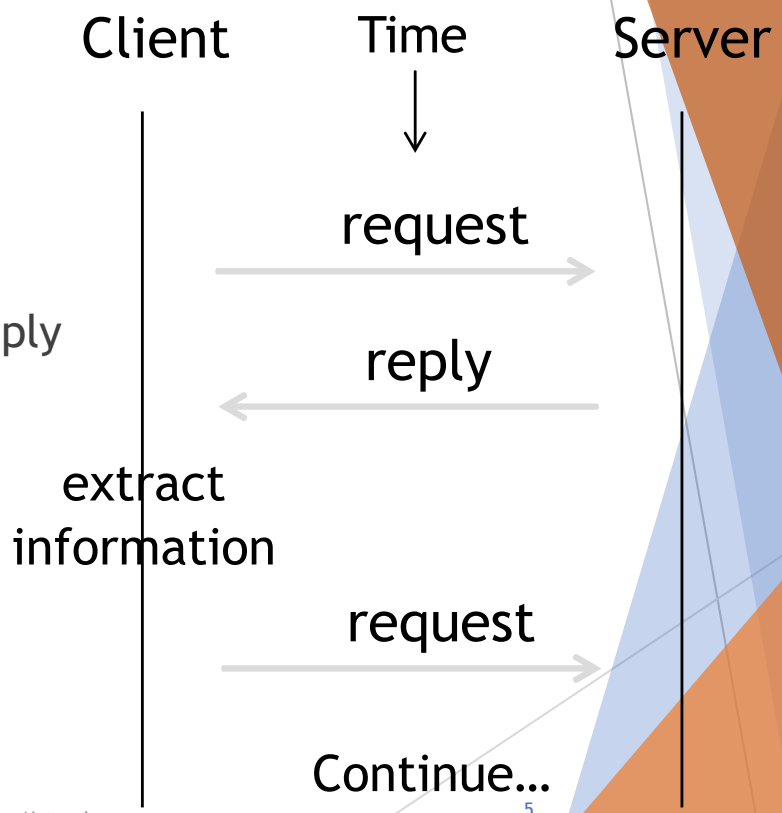
- Defines how apps use the network
  - Application Layer APIs
  - Lets apps talk to each other
  - hides the other layers of the network





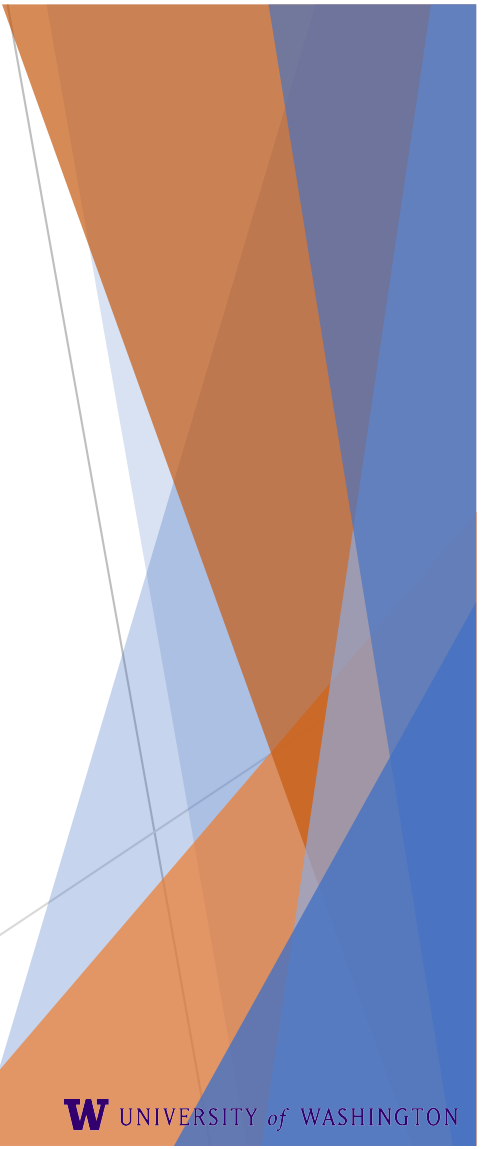
Project 1

- Simple Client
  - Send requests to attu server
  - Wait for a reply
  - Extract the information from the reply
  - Continue…
- Simple Server
  - Server handles the Client requests
  - Multi-threaded



Project 1

- This is the basis for many apps!
  - File transfer: send name, get file
  - Web browsing: send URL, get page
  - Echo: send message, get it back
- Let's see how to write this app …



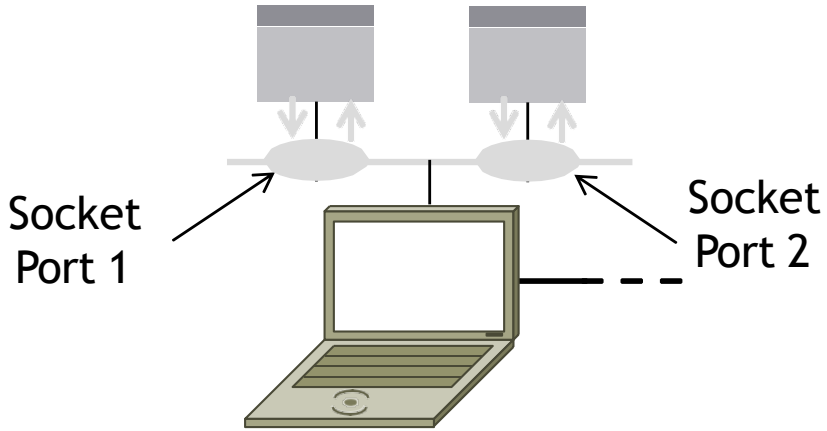
Socket API (Generalized)

- Simple application-layer abstractions (APIs) to use the network
  - The network service API used to write all Internet applications
  - Part of all major OSes and languages; originally Berkeley (Unix) ~1983

- Two kinds of sockets
  - Streams (TCP): reliably send a stream of bytes
  - Datagrams (UDP): unreliably send separate messages

Socket API (2)

- Sockets let apps attach to the local network at different ports
  - Ports are used by OS to distinguish services/apps using internet

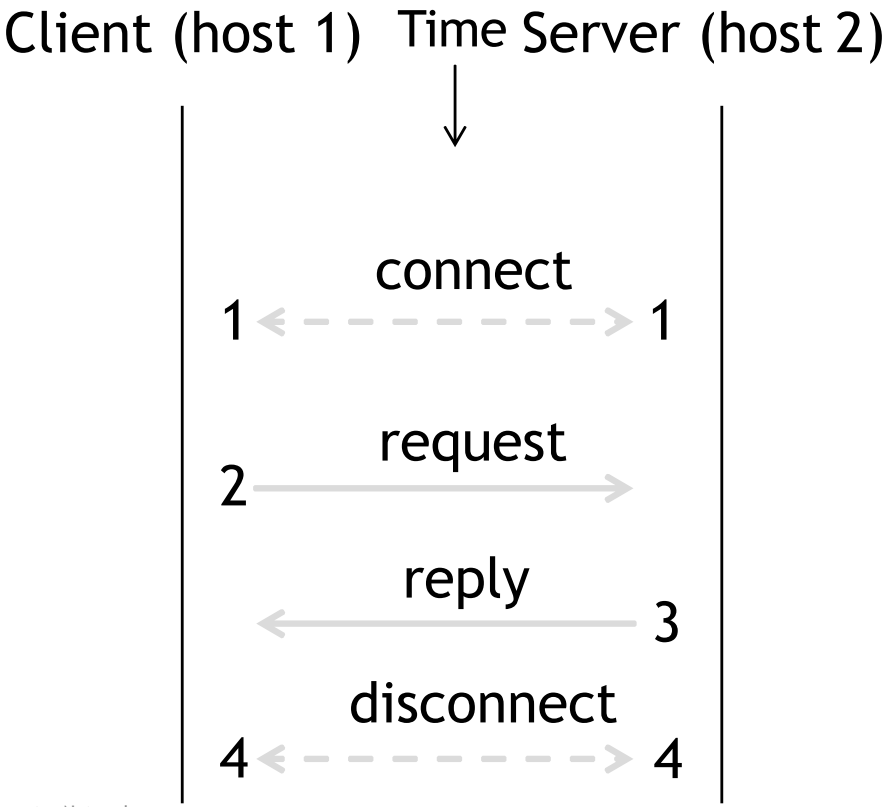


Socket API (3)

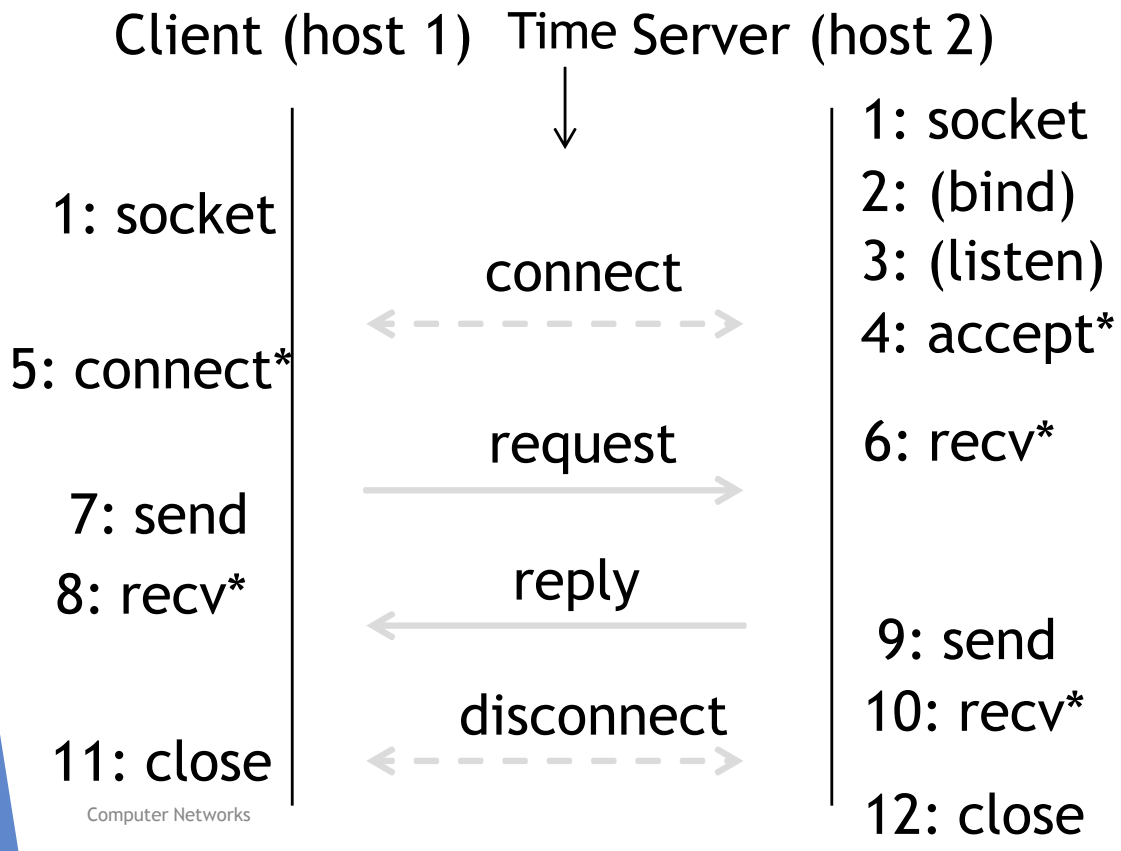
Primitive	Meaning
SOCKET	Create a new communication endpoint
BIND	Associate a local address (port) with a socket
LISTEN	Announce willingness to accept connections; (give queue size)
ACCEPT	Passively establish an incoming connection
CONNECT	Actively attempt to establish a connection
SEND	Send some data over the connection
RECEIVE	Receive some data from the connection
CLOSE	Release the connection

https://docs.oracle.com/javase/8/docs/api/java/net/Socket.html
https://docs.oracle.com/javase/8/docs/api/java/net/ServerSocket.html

Using TCP Sockets (2)

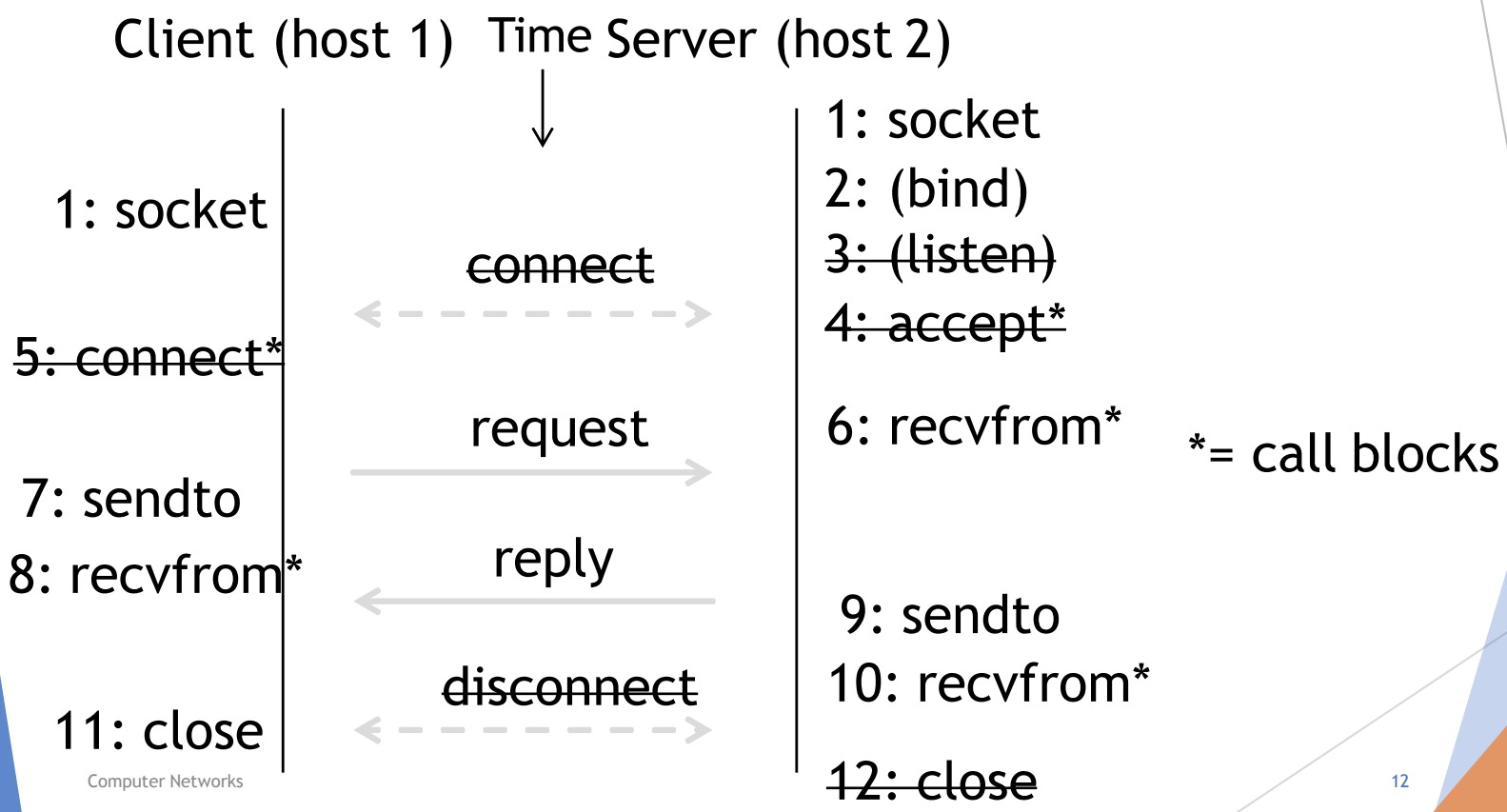


Using TCP Sockets (3)



*= call blocks

Using UDP Sockets



Client Program (outline)

```
socket()        // make socket
getaddrinfo()   // server and port name
          // www.example.com:80
connect()   // connect to server [block]
…
send()      // send request
recv()      // await reply [block]
…         // do something with data!
close()     // done, disconnect
```

Server Program (outline)

```
socket()        // make socket
getaddrinfo()       // for port on this host
bind()          // associate port with socket
listen()        // prepare to accept connections
accept()        // wait for a connection [block]
...
recv()          // wait for request [block]
...
send()          // send the reply
close()         // eventually disconnect
```

Java Examples with Socket & ServerSocket

- Server

```
ServerSocket listener = new ServerSocket(9090);
        try {
            while (true) {
                Socket socket = listener.accept();
                try {
                    socket.getInputStream();
                } finally {
                    socket.close();
                }
            }
        }
        finally {
            listener.close();
        }
```

- Client

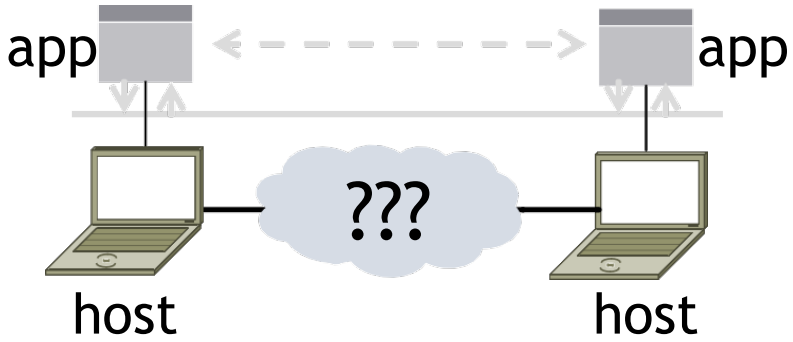
```
Socket socket = new Socket(server, 9090);
out =
        new PrintWriter(socket.getOutputStream(), true);
socket.close();
```

- http://cs.lmu.edu/~ray/notes/javanetexamples/
- https://docs.oracle.com/javase/tutorial/networking/datagrams/clientServer.html
- https://docs.oracle.com/javase/tutorial/networking/sockets/index.html

Traceroute

- Apps talk to other apps with no real idea of what is inside the network
  - This is good! But you may be curious …

- Peeking inside the Network with Traceroute



Traceroute

- Widely used command-line tool to let hosts peek inside the network
  - On all OSes (tracert on Windows)
  - Developed by Van Jacobson ~1987
  - Uses a network-network interface (IP) in ways we will explain later

Van Jacobson

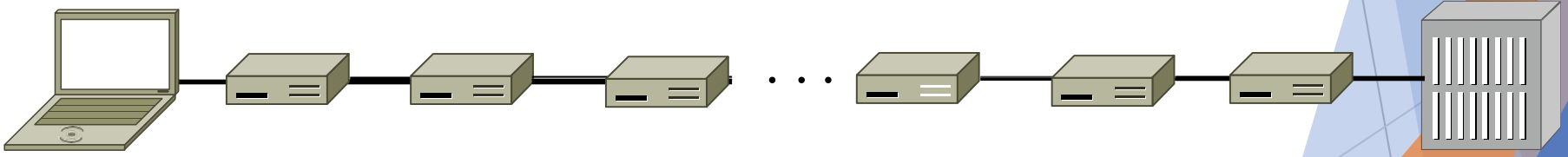
: Credit: Wikipedia (public domain)

Traceroute

- Probes successive hops to find network path
- Core mechanism: Time-To-Live(TTL)
  - TTL == 0?

    Discard data, error (ICMP) report to sender

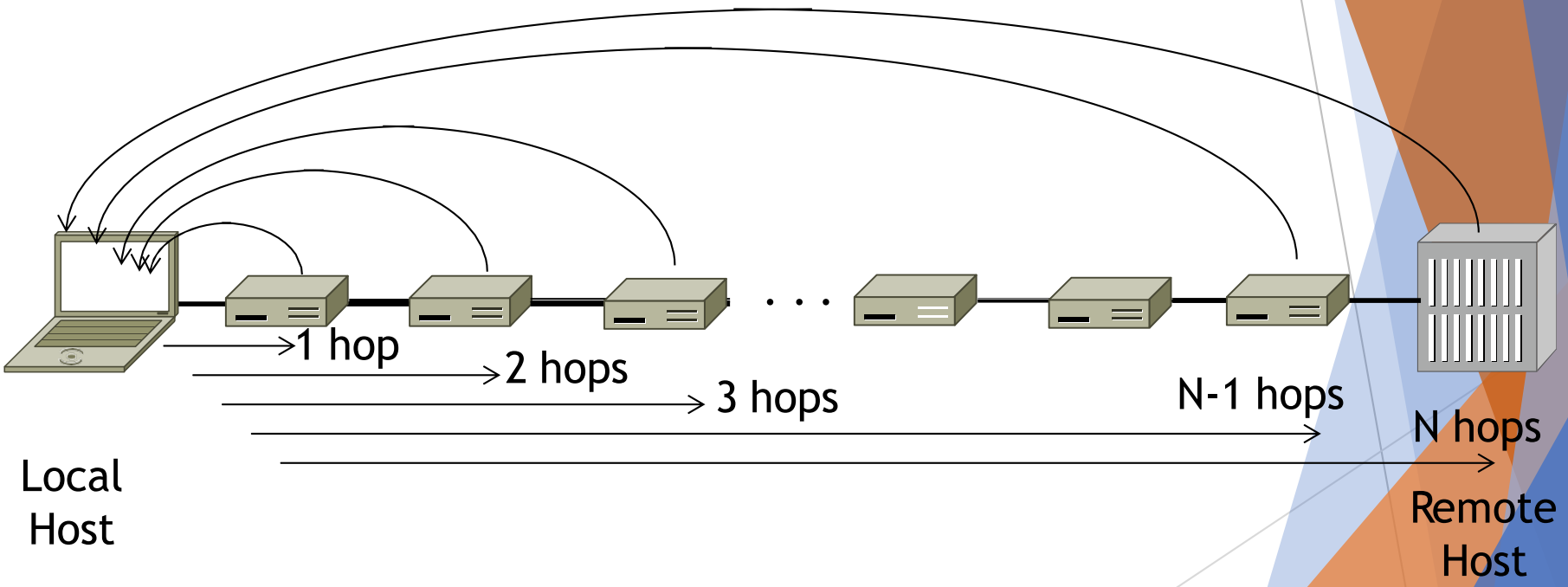
    Continue with TTL-1



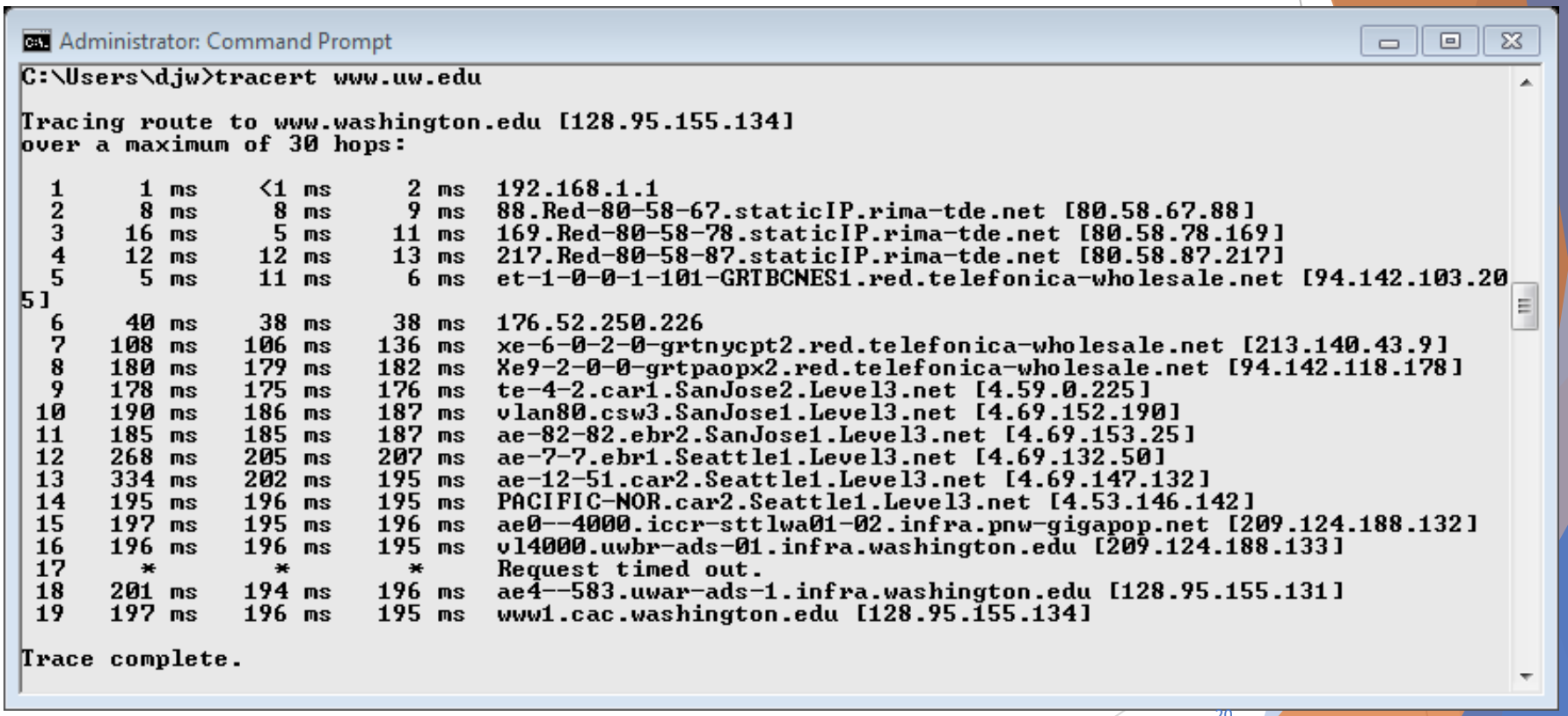
Local Host

Remote Host

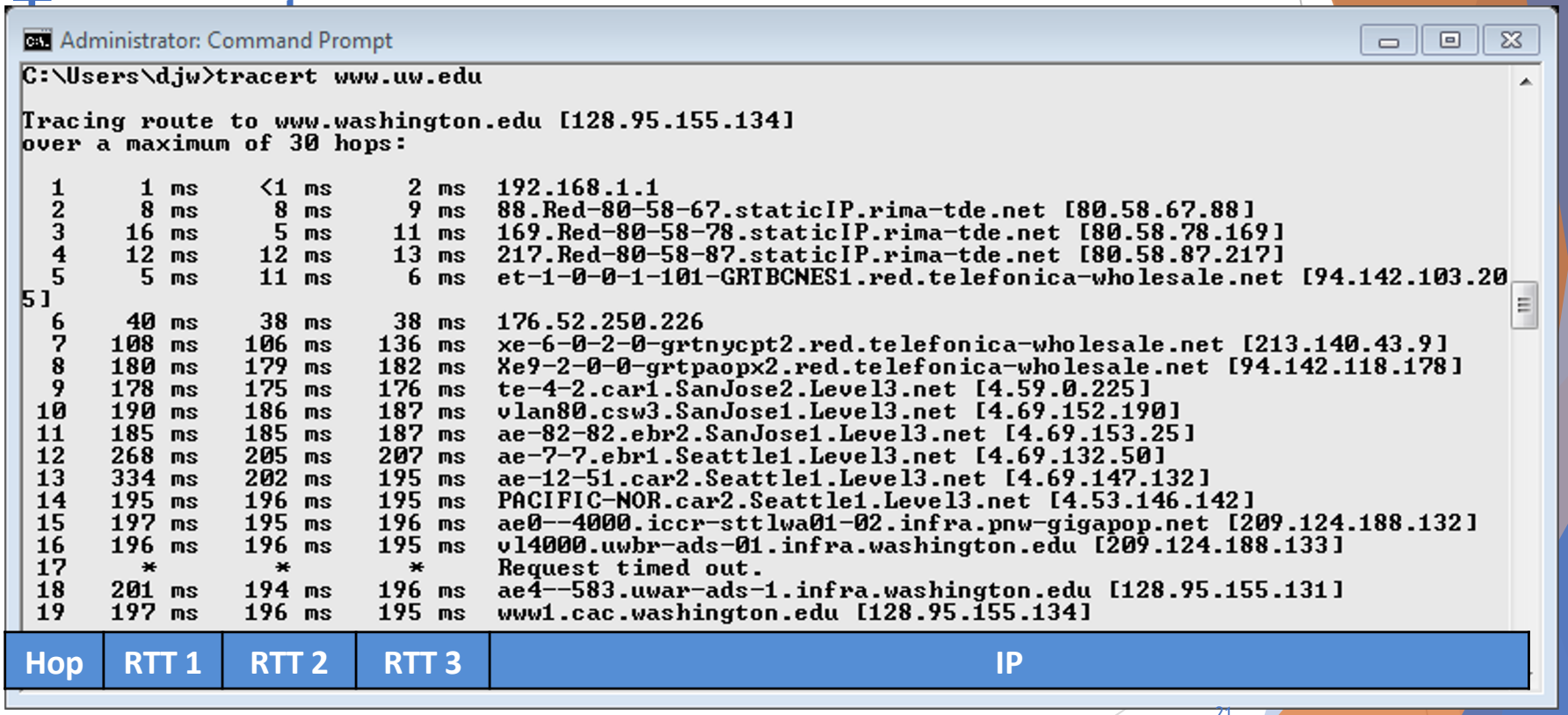
Traceroute



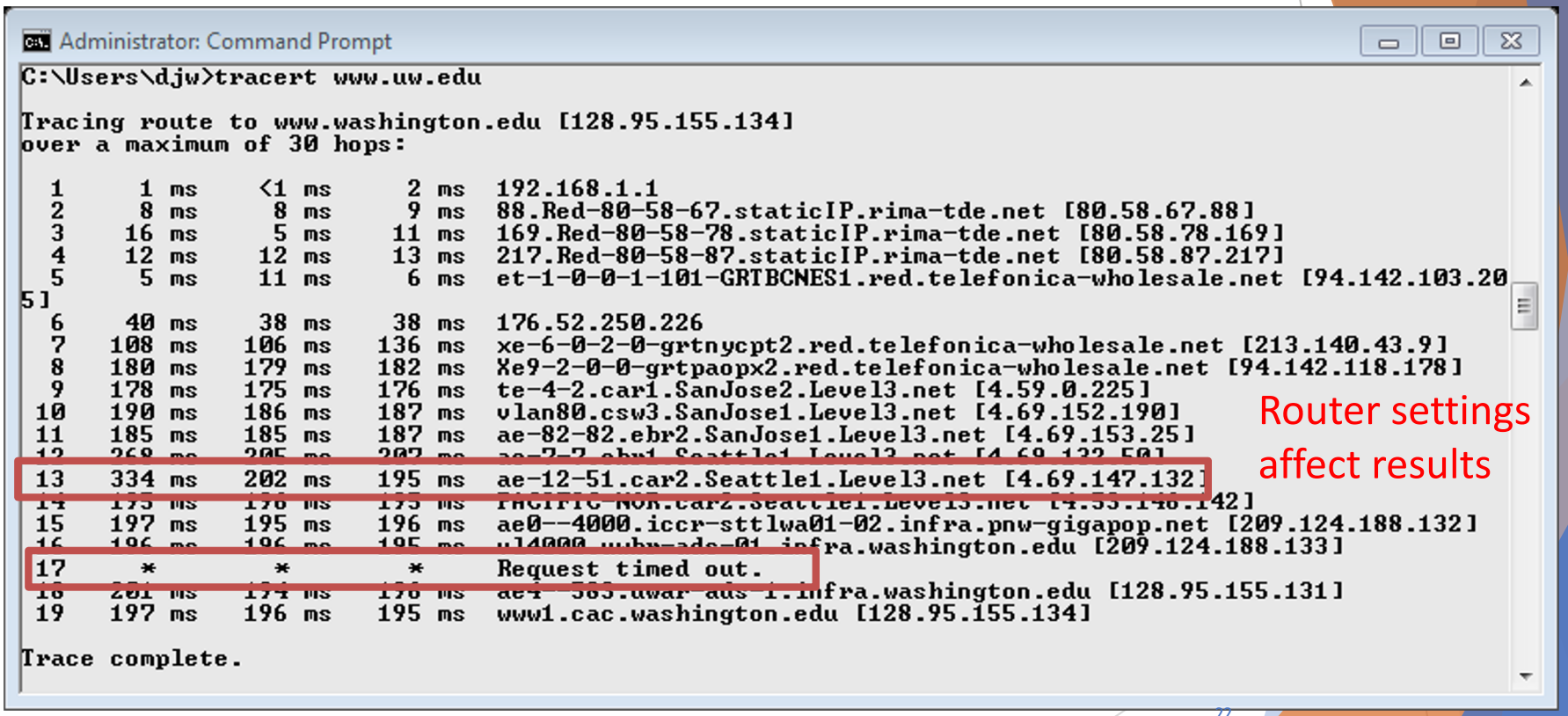
Using Traceroute



Using

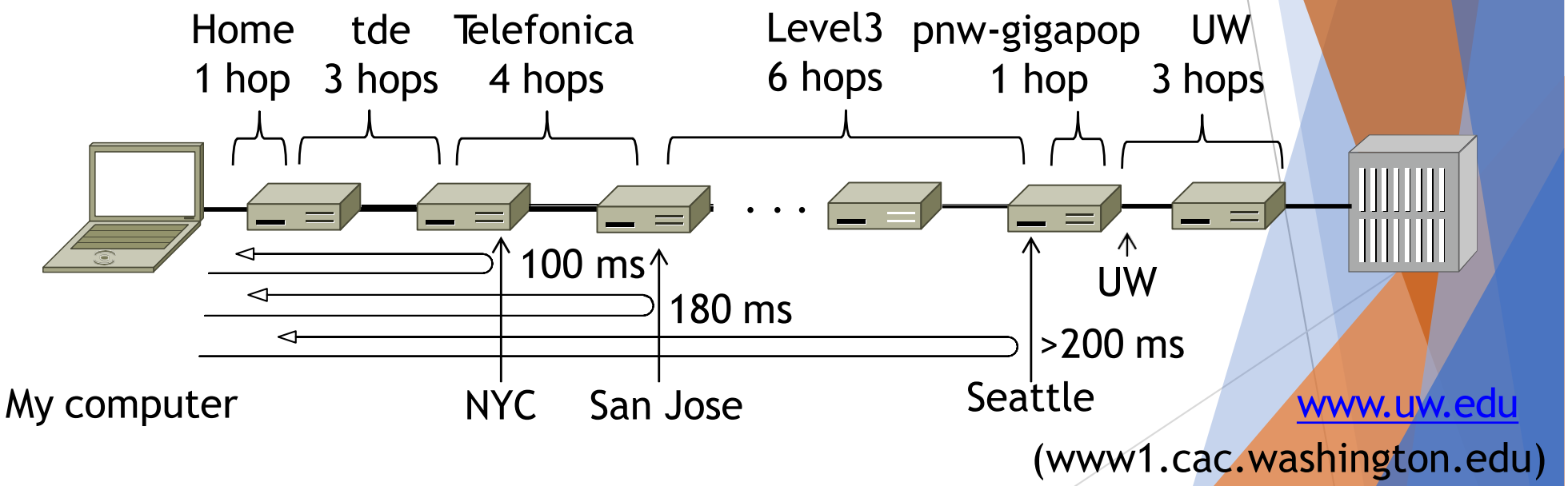

Administrator: Command Prompt
C:\Users\djw>tracert www.uw.edu
Tracing route to www.washington.edu [128.95.155.134]
over a maximum of 30 hops:
1 1 ms <1 ms 2 ms 192.168.1.1
2 8 ms 8 ms 9 ms 88.Red-80-58-67.staticIP.rima-tde.net [80.58.67.88]
3 16 ms 5 ms 11 ms 169.Red-80-58-78.staticIP.rima-tde.net [80.58.78.169]
4 12 ms 12 ms 13 ms 217.Red-80-58-87.staticIP.rima-tde.net [80.58.87.217]
5 5 ms 11 ms 6 ms et-1-0-0-1-101-GRTBCNES1.red.telefonica-wholesale.net [94.142.103.205]
6 40 ms 38 ms 38 ms 176.52.250.226
7 108 ms 106 ms 136 ms xe-6-0-2-0-grtnycpt2.red.telefonica-wholesale.net [213.140.43.9]
8 180 ms 179 ms 182 ms Xe9-2-0-0-grtpaopx2.red.telefonica-wholesale.net [94.142.118.178]
9 178 ms 175 ms 176 ms te-4-2.car1.SanJose2.Level3.net [4.59.0.225]
10 190 ms 186 ms 187 ms vlan80.csw3.SanJose1.Level3.net [4.69.152.190]
11 185 ms 185 ms 187 ms ae-82-82.ebr2.SanJose1.Level3.net [4.69.153.25]
12 268 ms 205 ms 207 ms ae-7-7.ebr1.Seattle1.Level3.net [4.69.132.50]
13 334 ms 202 ms 195 ms ae-12-51.car2.Seattle1.Level3.net [4.69.147.132]
14 195 ms 196 ms 195 ms PACIFIC-NOR.car2.Seattle1.Level3.net [4.53.146.142]
15 197 ms 195 ms 196 ms ae0--4000.iccr-sttlwa01-02.infra.pnw-gigapop.net [209.124.188.132]
16 196 ms 196 ms 195 ms vl4000.uwbr-ads-01.infra.washington.edu [209.124.188.133]
17 * * * Request timed out.
18 201 ms 194 ms 196 ms ae4--583.uwar-ads-1.infra.washington.edu [128.95.155.131]
19 197 ms 196 ms 195 ms www1.cac.washington.edu [128.95.155.134]
Hop
RTT 1
RTT 2
RTT 3
IP

Using Traceroute



Using Traceroute (2)

- ISP names and places are educated guesses



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