Computer Networks

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

(§1.3.4, 6.1.2-6.1.4)

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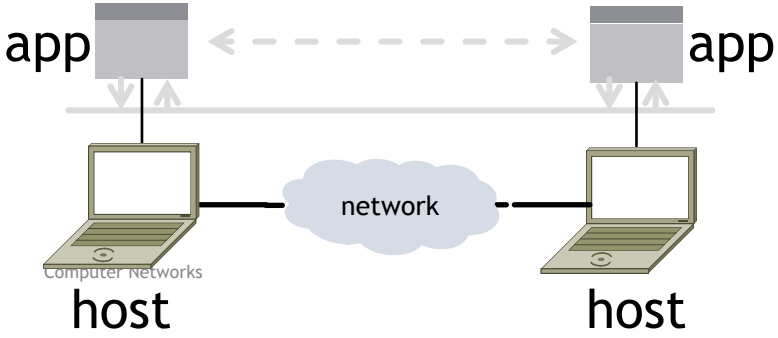
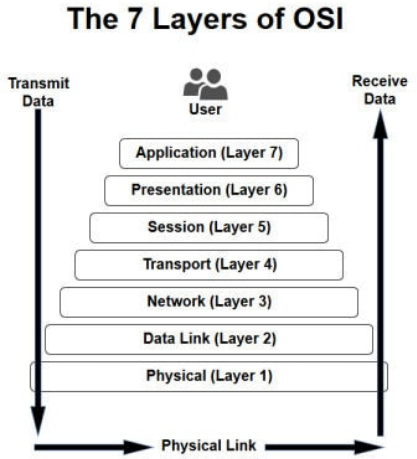
Network-Application Interface

- 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

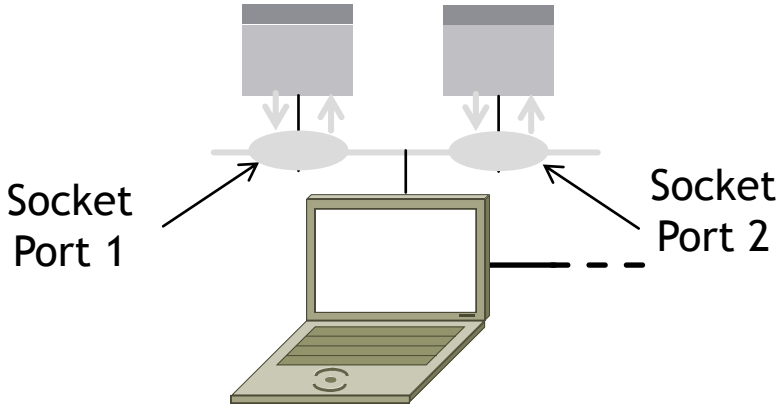
- This is the basis for many apps!
  - File transfer: send name, get file (§6.1.4)
  - Web browsing: send URL, get page
  - Echo: send message, get it back
- Let's see how to write this app …

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

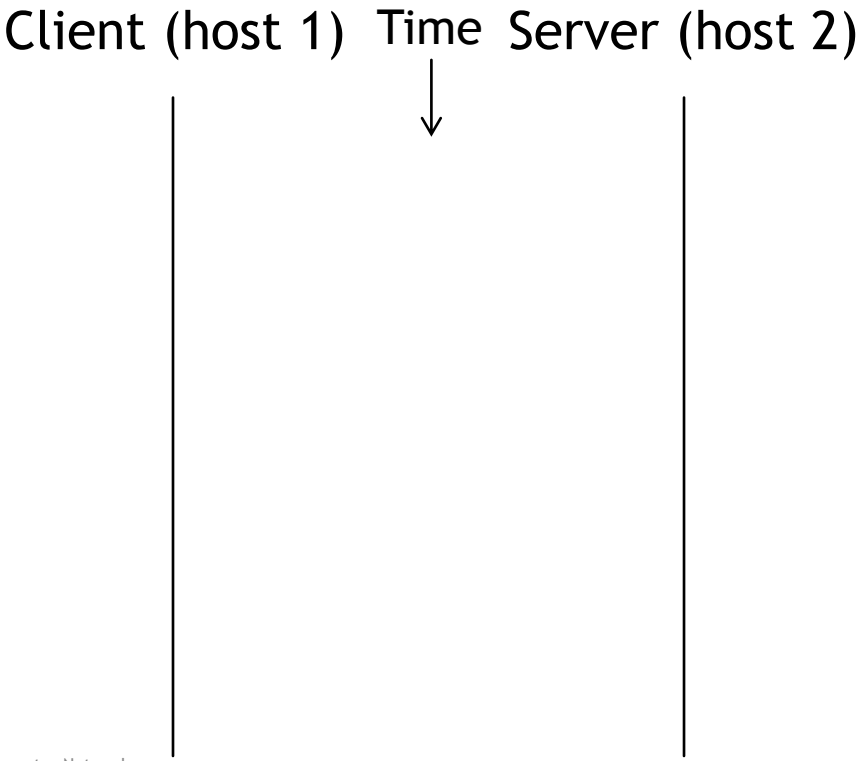


Socket API (3)

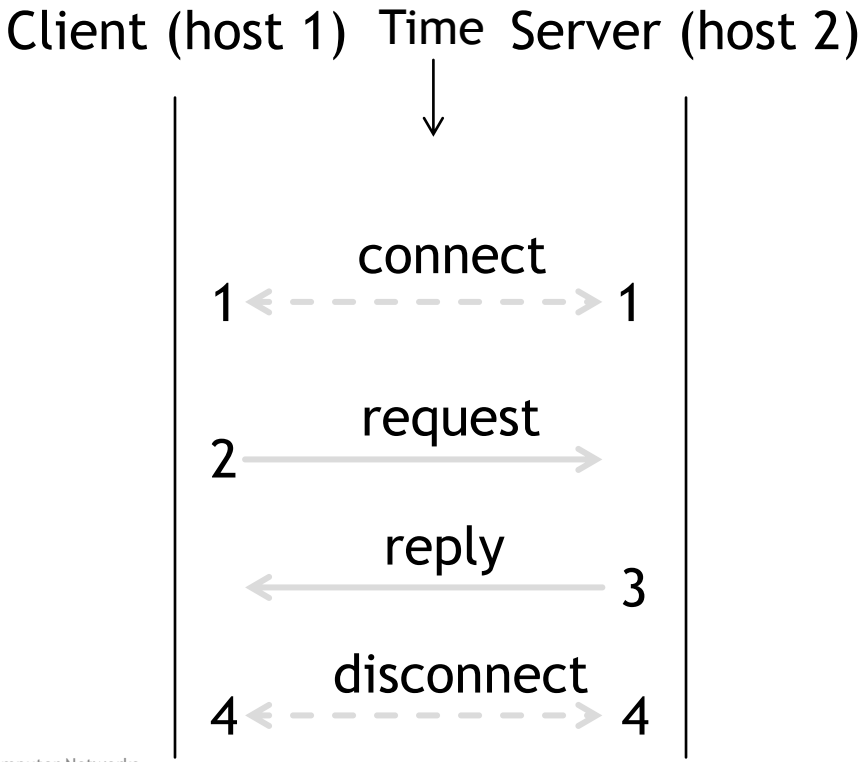
Primitive	Meaning
SOCKET	Create a new communication endpoint
BIND	Associate a local address (port) with a socket
LISTEN	Announce willingness to accept connections; (give queue size)
ACCEPT	Passively establish an incoming connection
CONNECT	Actively attempt to establish a connection
SEND	Send some data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

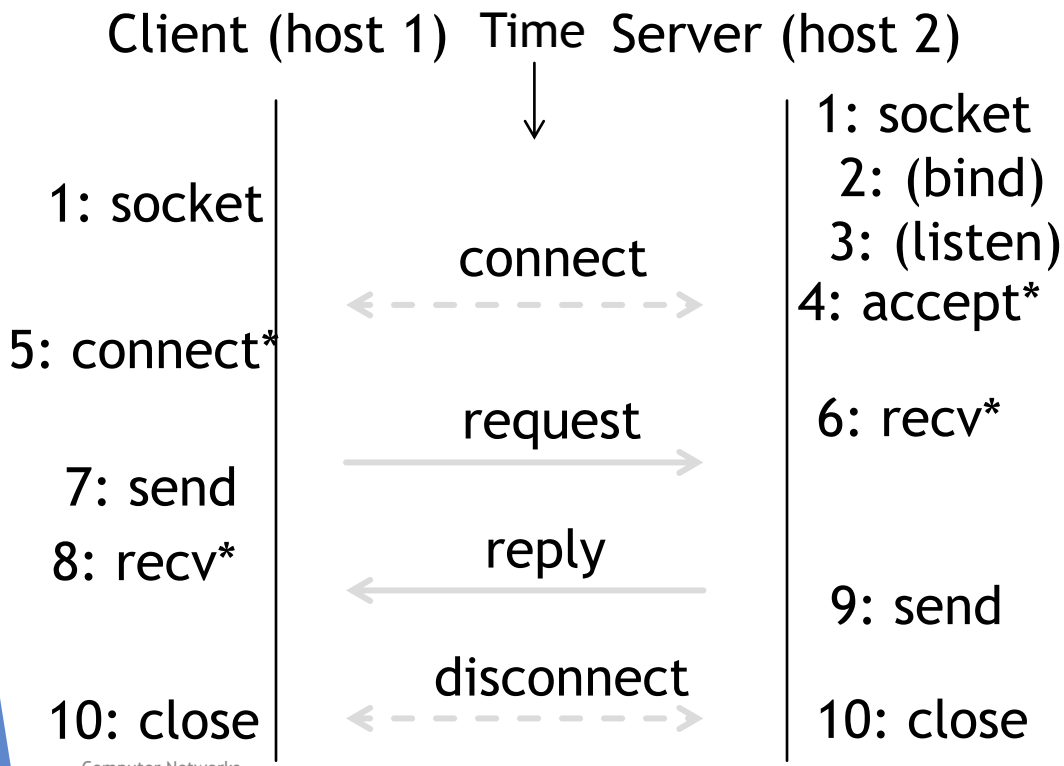
Using Sockets



Using Sockets (2)



Using Sockets (3)



*= call blocks

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
…
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();
    }
```

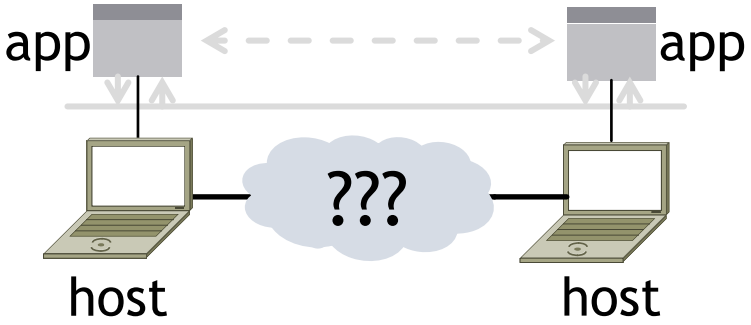
- Client

```
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

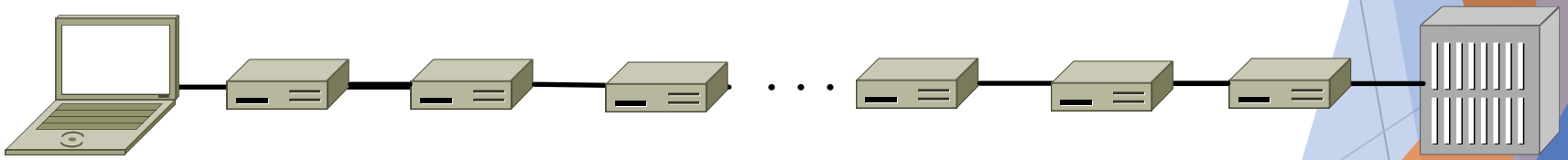
- Widely used command-line tool to let hosts peek inside the network
  - On all OSes (tracert on Windows)
  - Developed by Van Jacobson ~1987
  - Uses a network-network interface (IP) in ways we will explain later

Van Jacobson

: Credit: Wikipedia (public domain)

Traceroute

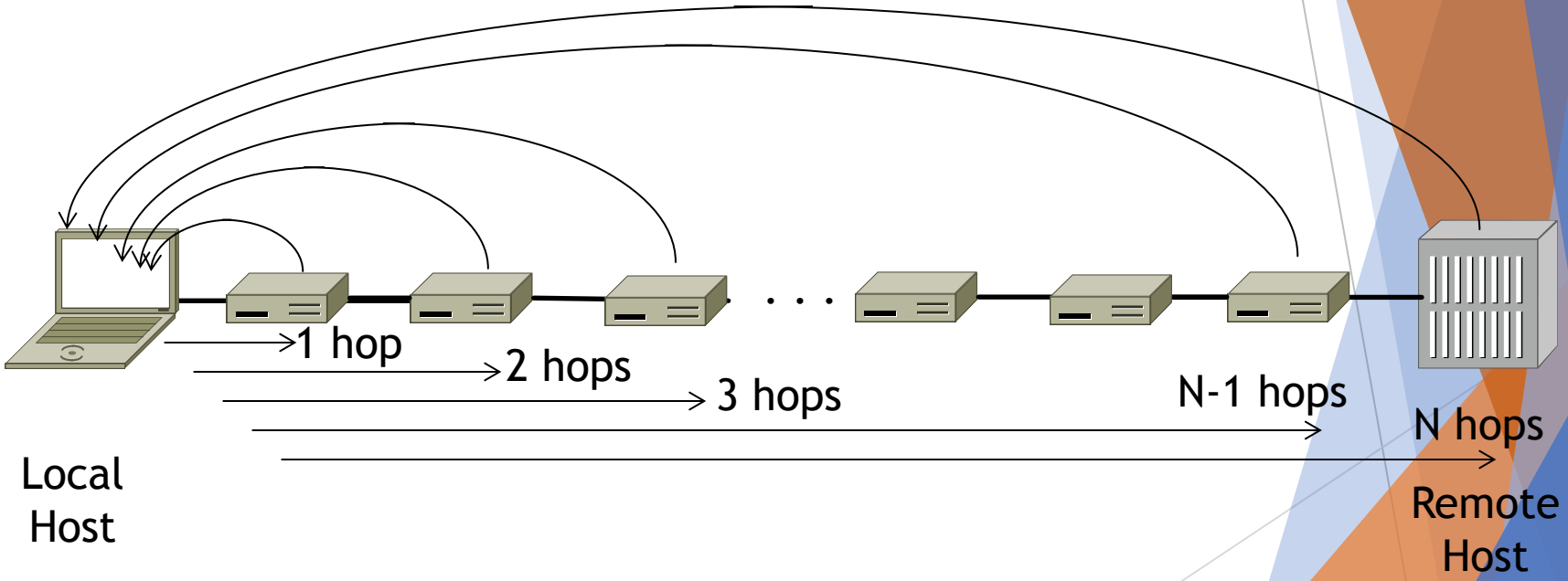
- Probes successive hops to find network path
- TTL: time-to-live



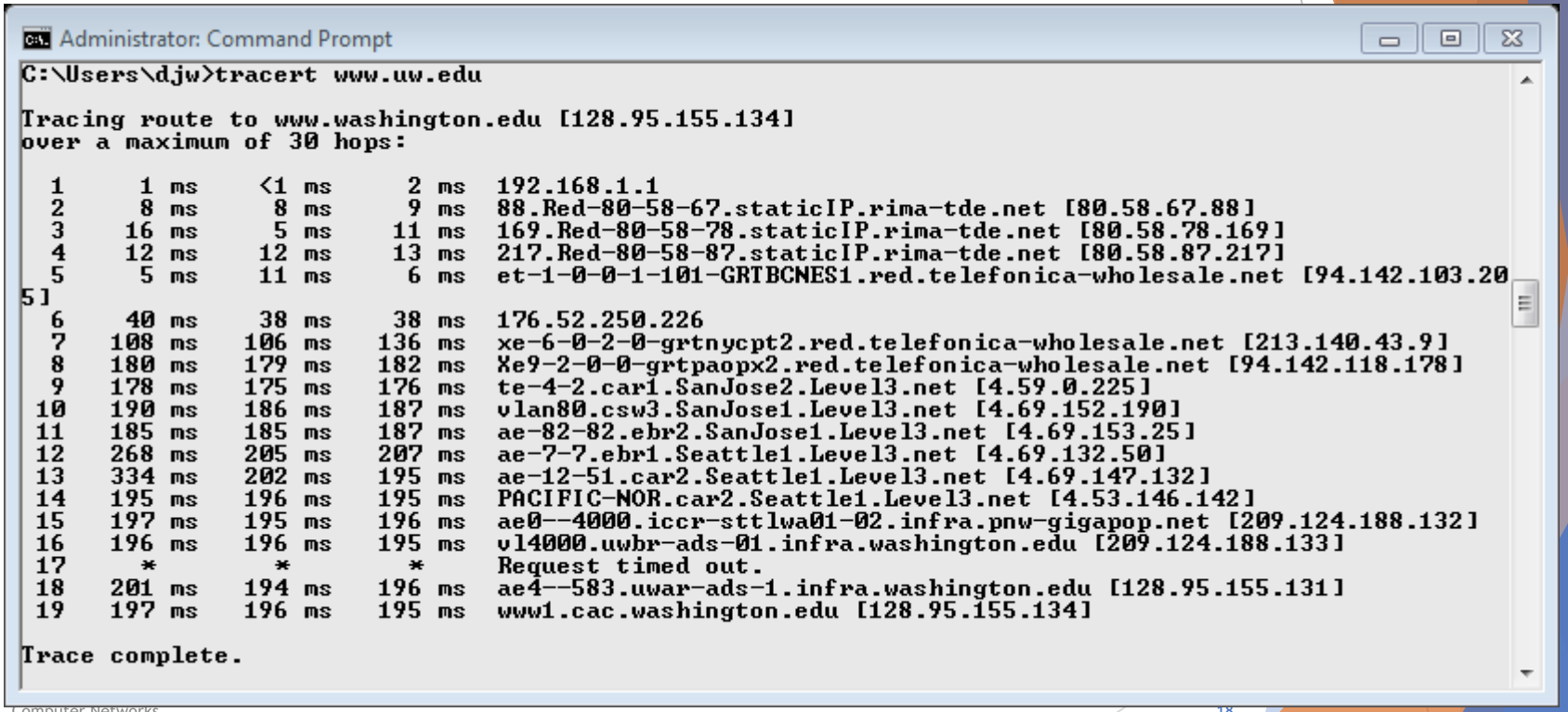
Local Host

Remote Host

Traceroute

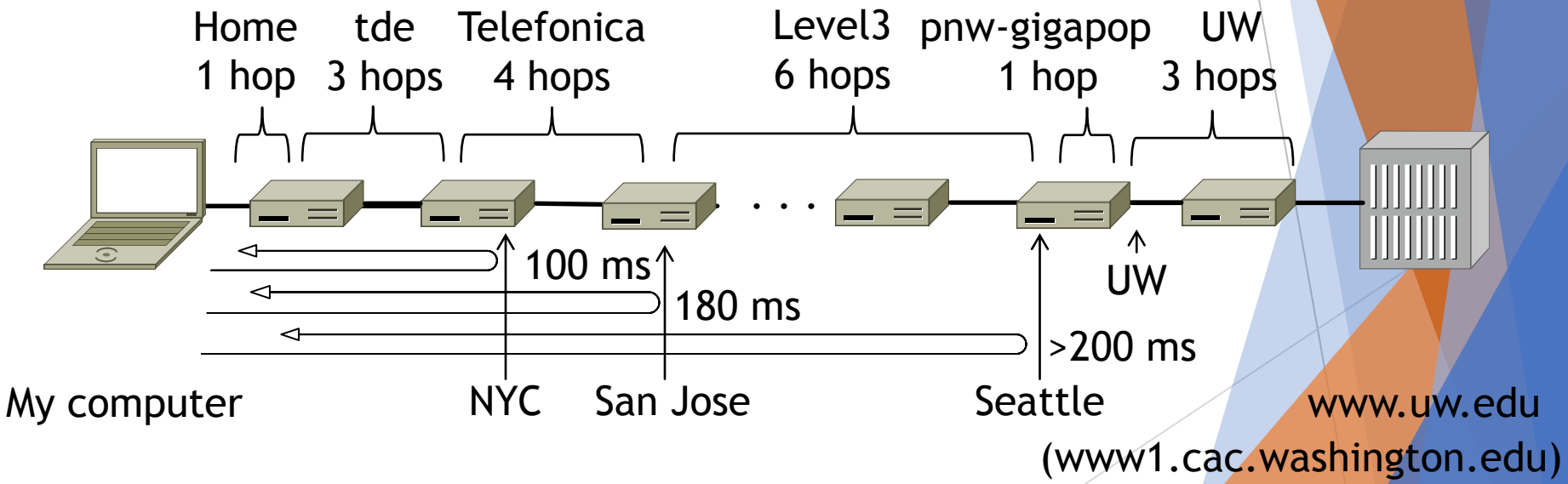


Using Traceroute



Using Traceroute (2)

- ISP names and places are educated guesses



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