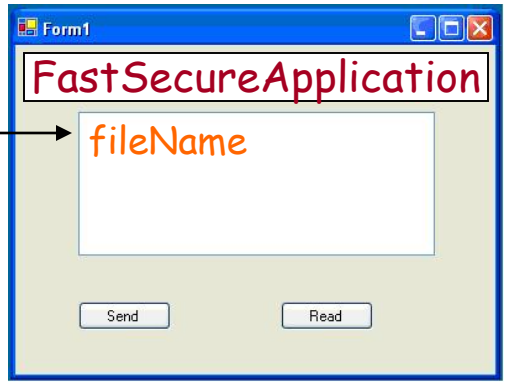
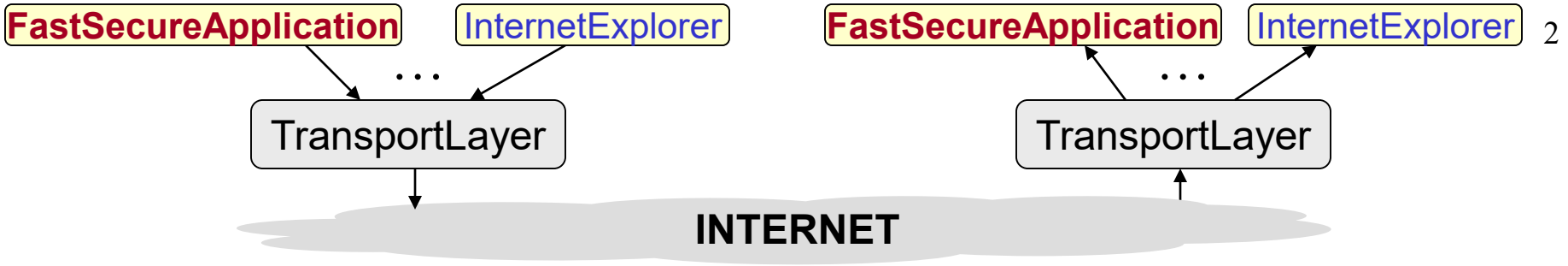
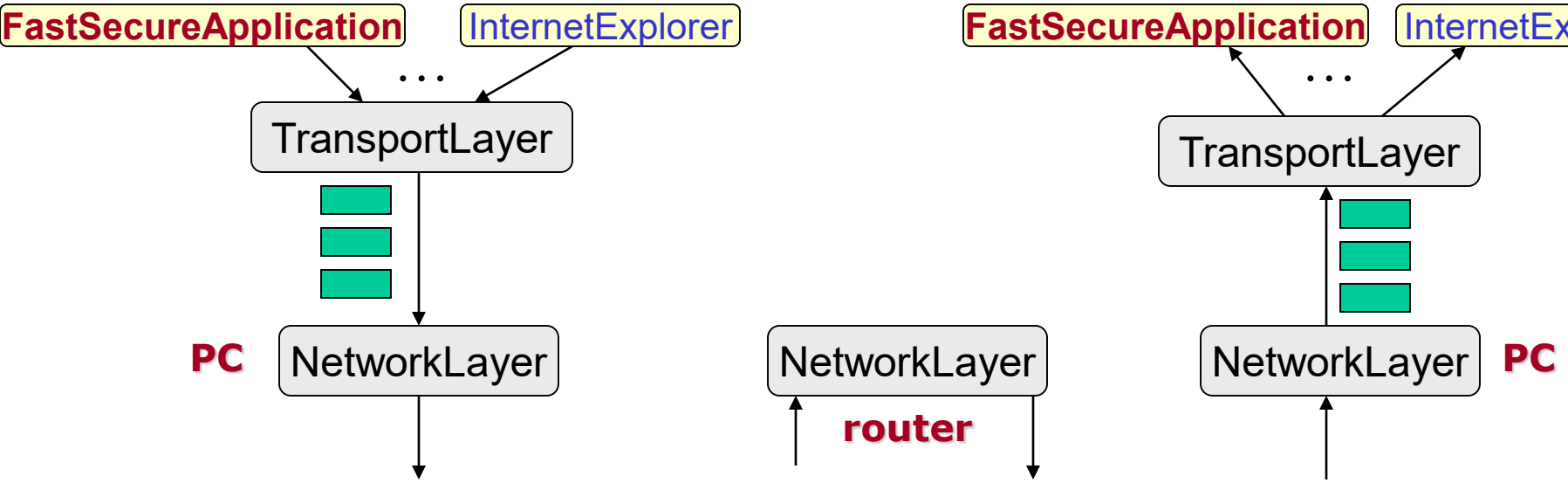



```
public void main(String[] args) {
    ...
    FastSecureApplication.send(file);
    ...
}
```

```
class FastSecureApplication {
    Object compress(Object file);
    Object encrypt(Object file);
    static void send(Object file);
    Object deCompress();
    Object deCrypt(Object file);
    Object receive();
    ...
    static void send(Object file) {
            Object compressedFile = compress(file);
            Object encryptedFile = encrypt(compressedFile);
            TransportLayer.send(encryptedFile);
    ...
}
```




```
class TransportLayer {
    int pickPortNumber();
    Packets[] reassemble(Object file);
    Packets[] addHeaders(Packets[] filePackets, int portNmb);
    static void send(Object applicationLayerFile);
    Object assemble();
    Packets[] removeHeaders(Object file);
    ...
    static void send(Object applicationLayerFile) {
       int portNmb = pickPortNumber();
       Packets[] filePackets = reassemble(applicationLayerfile);
       Packets[] packetsWithHeader = addHeaders(filePackets, portNmb);
       for (int i=1; i< packetsWithHeader.length; i++) {
            NetworkLayer.send(packetsWithHeader[i]);
          ...
       }
```

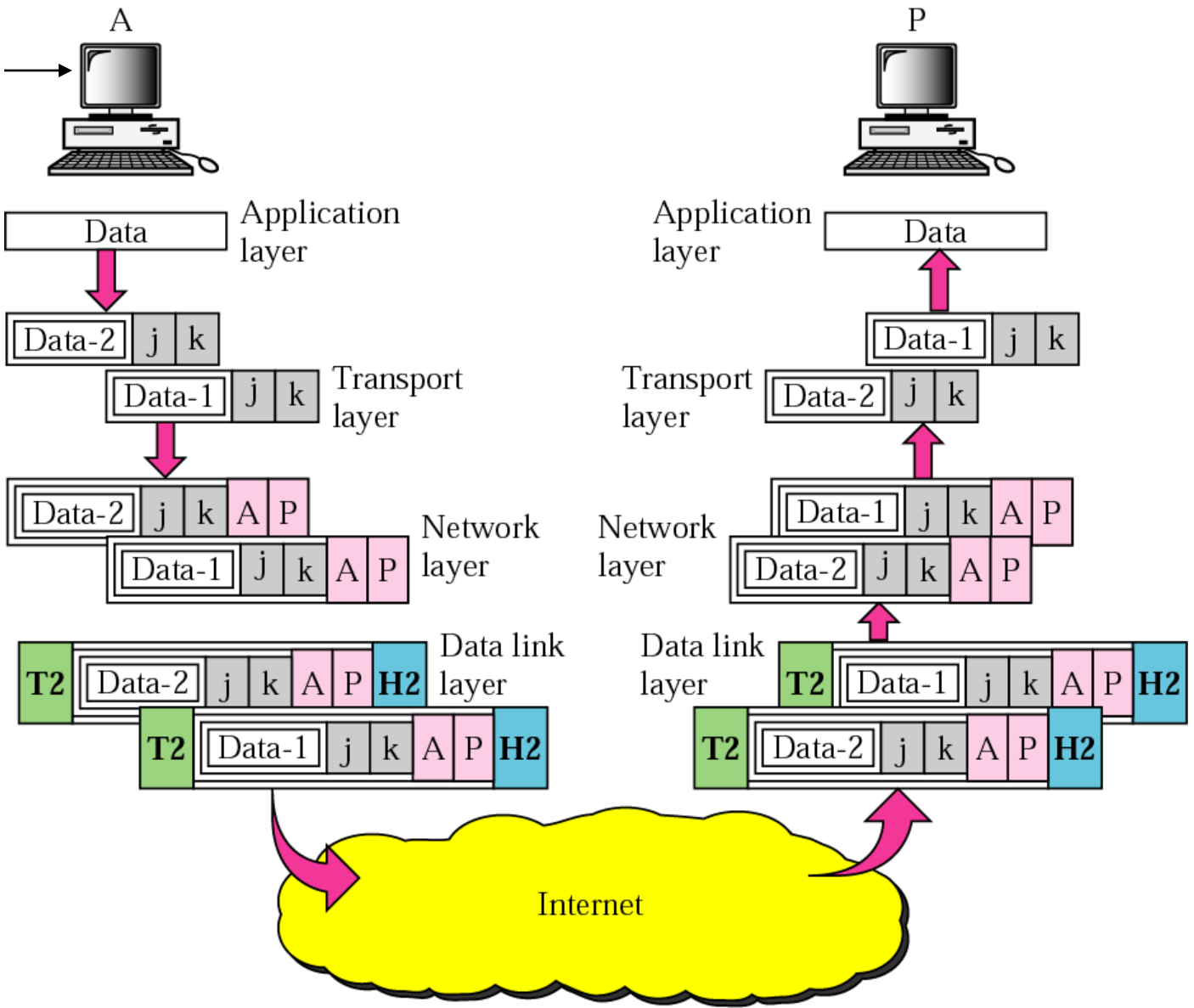



```
class NetworkLayer {
    …
    static void send(Object trsportLayerPaket) {
        Packet IPPacket = addHeader(trsportLayerPacket, IPAddress, etc.);
        DataLinkLayer.send(IPPacket);
        ….        }

     static void sendRouter(Object IPPacket) {
        … findNextHop(IPPacket);
        DataLinkLayer.send(IPPacket);
        …        }
```

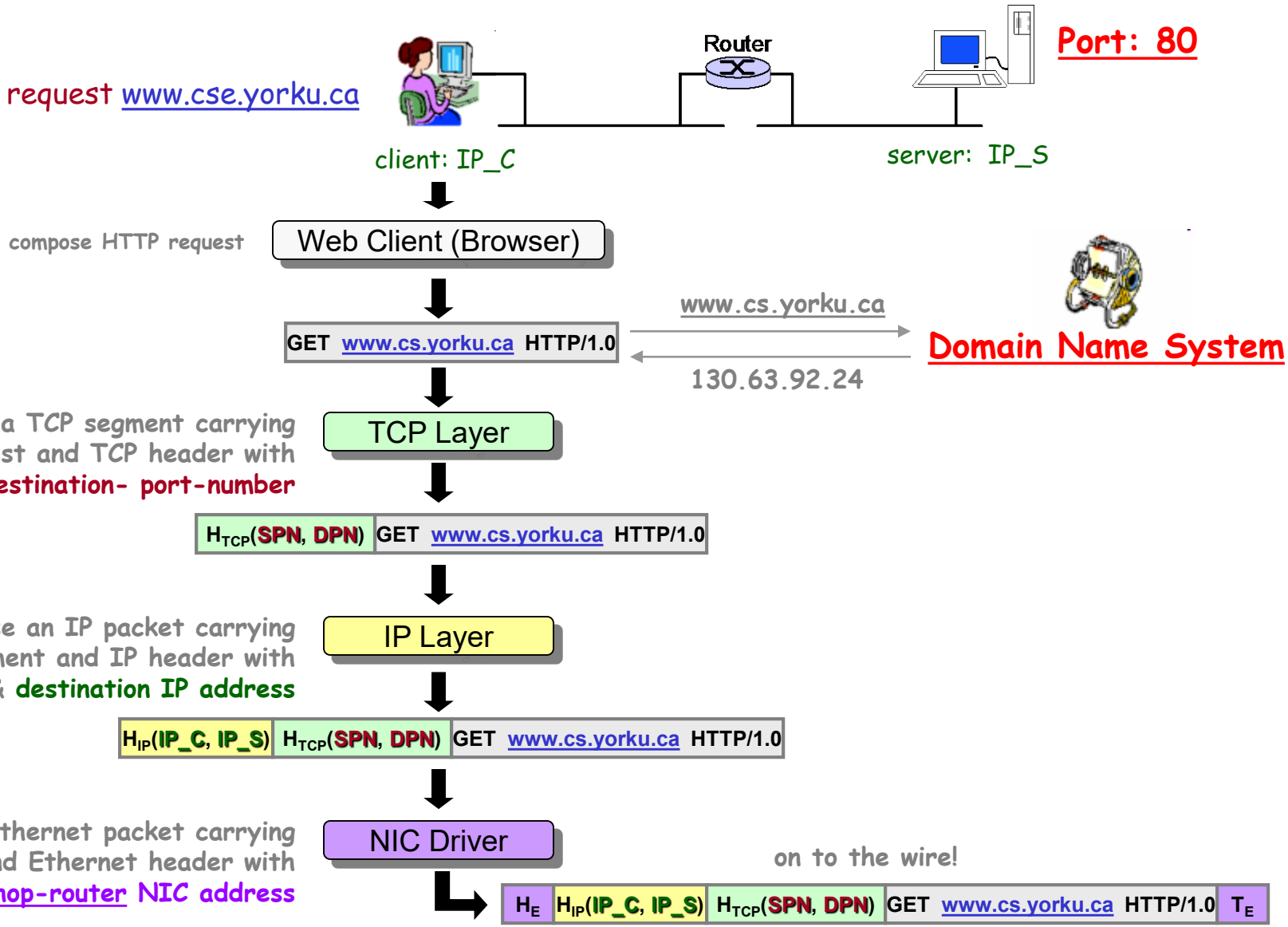
Example

Assume we want to exchange an image between computers A and P. The image, after being compressed, occupies 1000 bytes. The maximum packet size is 500 bytes.

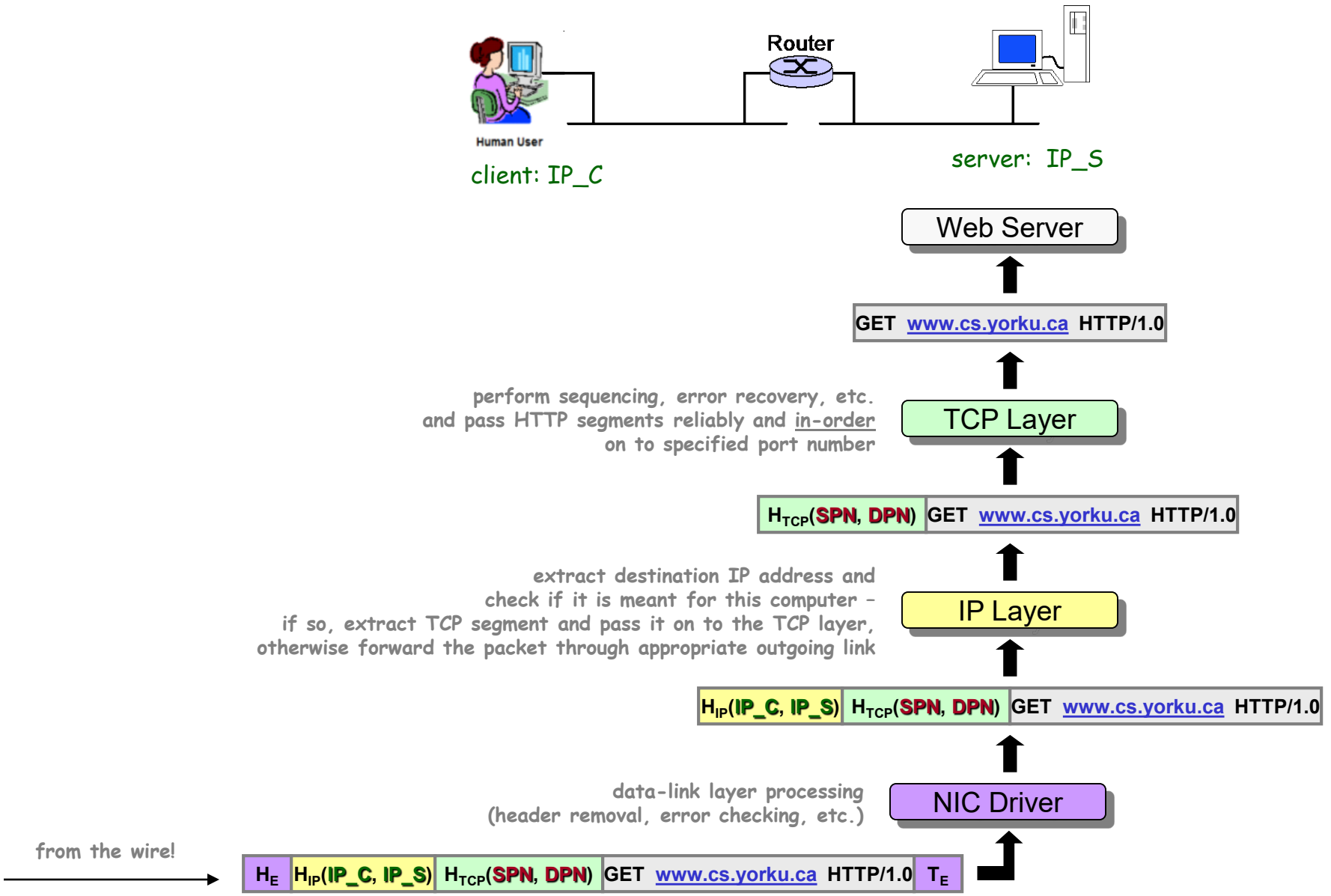


TCP/IP Protocol: How the Layers Work Together

Example [web-page retrieval – assumption: TCP connection established!]



TCP/IP Protocol: How the Layers Work Together (cont.)

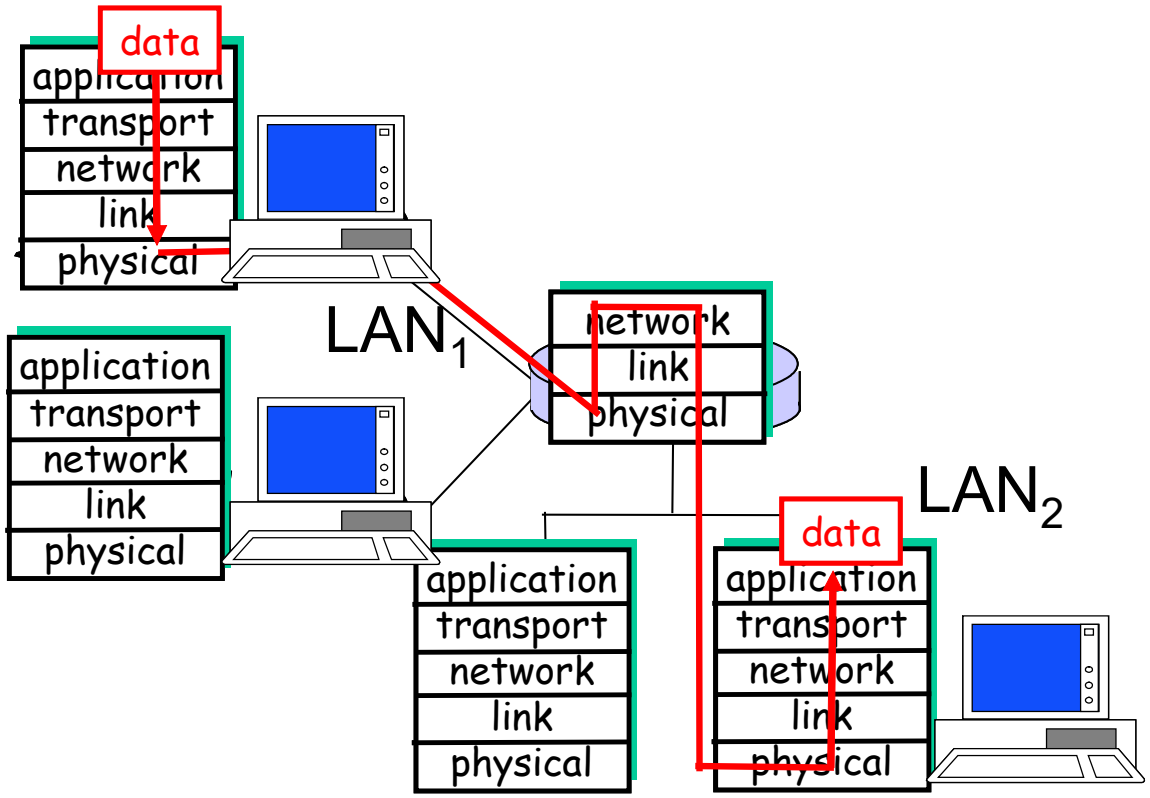


TCP/IP Protocol: How the Layers Work Together (cont.)

Bonus Question [layering – encapsulation]

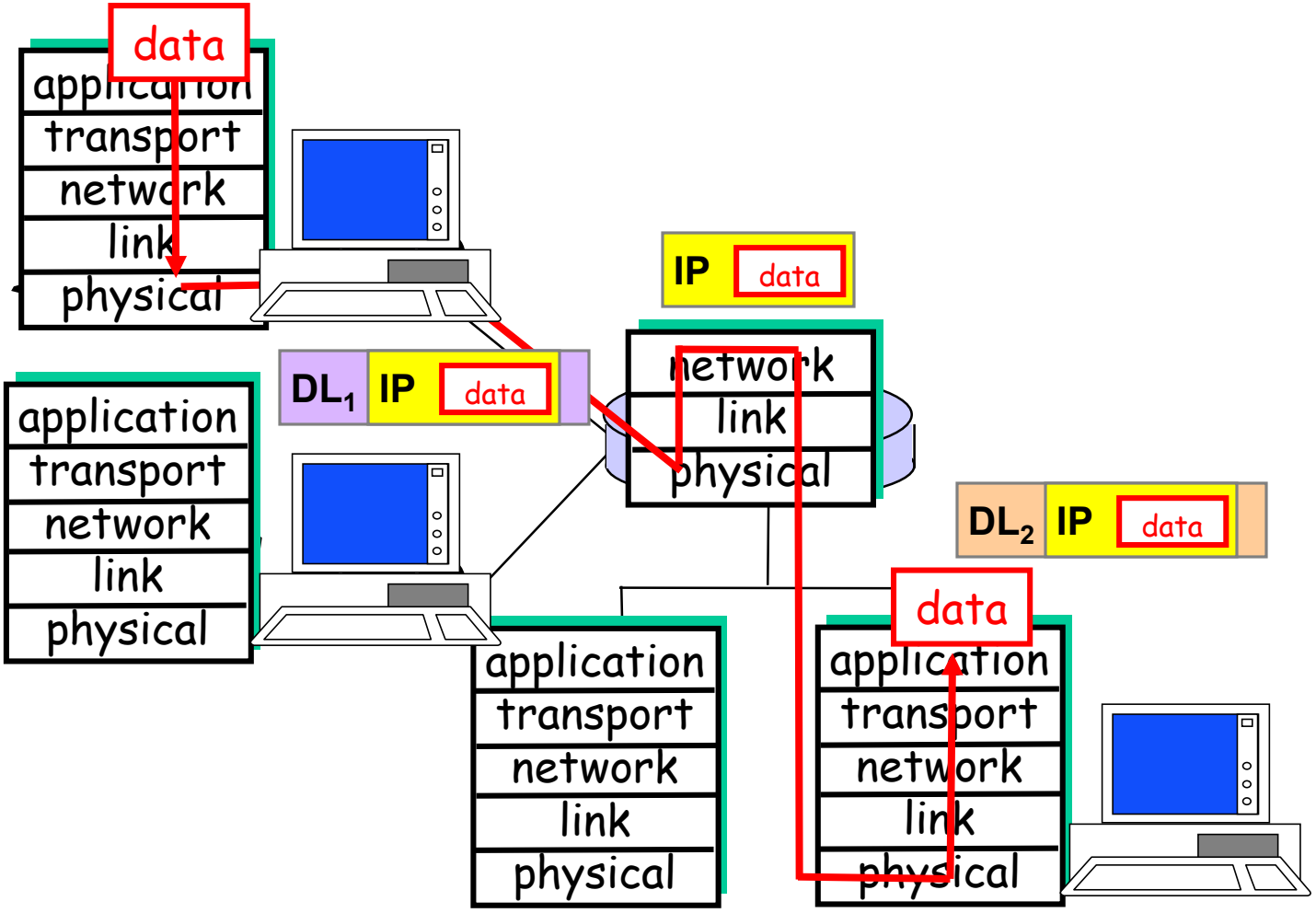
Assume two computers, situated on two distant LANs - with <u>different</u> data-link technologies, communicate with each other over the Internet.

Does each of these computers have to be aware of the data-link technology / protocol run in the LAN of the other computer?



(Source: Kurose & Ross)

TCP/IP Protocol: How the Layers Work Together (cont.)

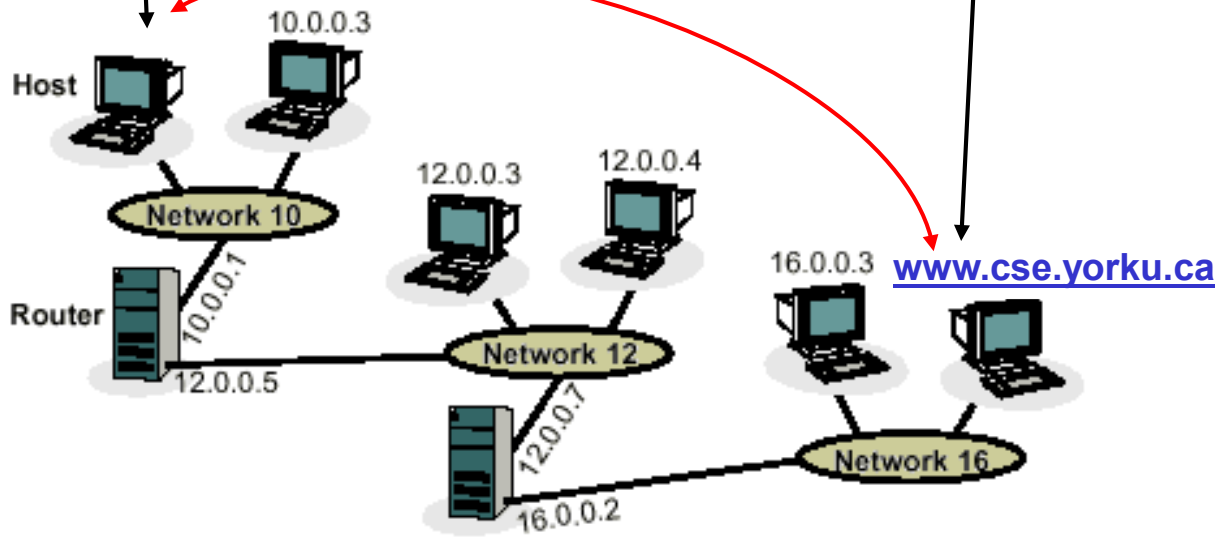


(Source: Kurose & Ross)

How to determine own IP & MAC address(es)?

How to determine the number and identity of intermediate routers?

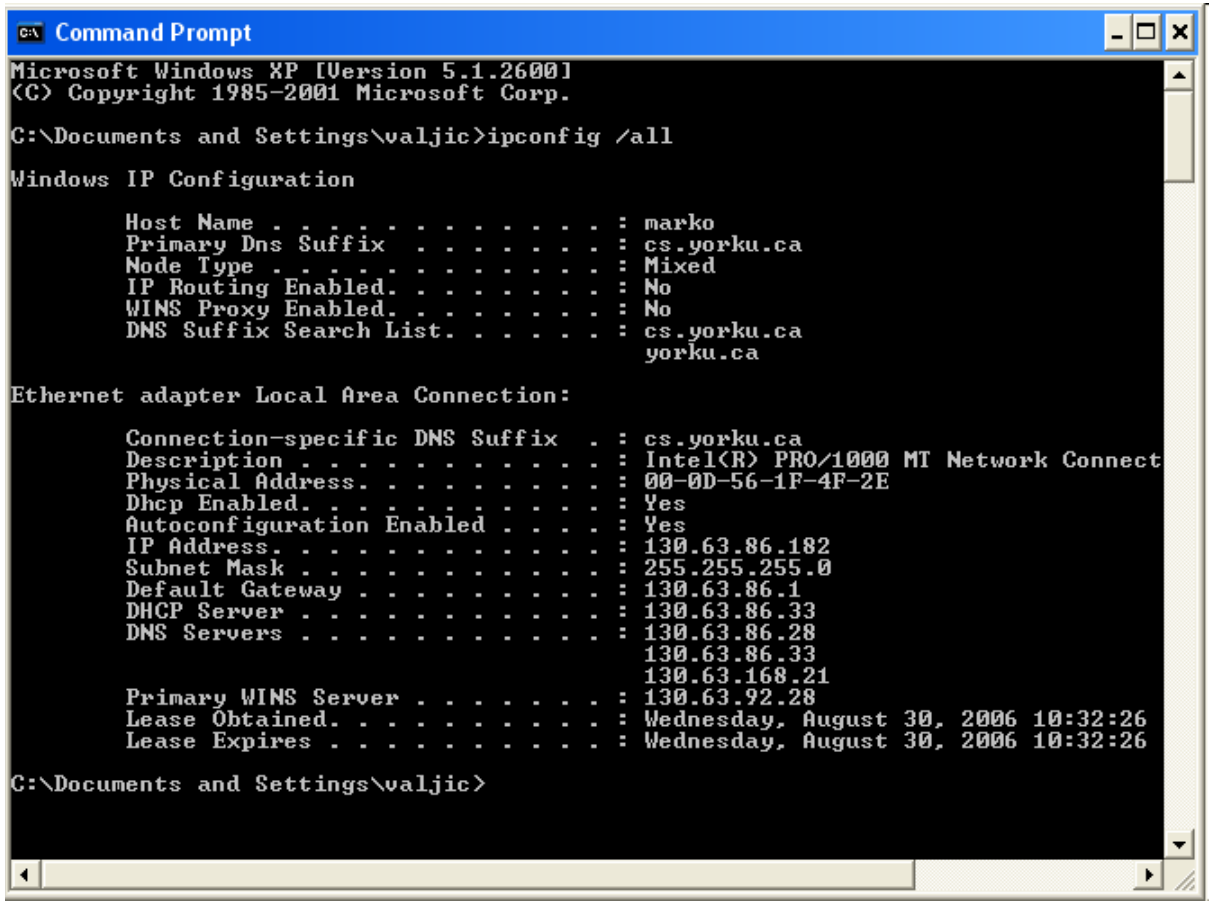
How to determine IP address of another remote machine?



IP Utilities

IPCONFIG – **Microsoft Windows OS tool used to display TCP/IP information about the host - UNIX/Linux equivalents: ifconfig, ip addr**

- **in simplest form returns IP address, subnet mask, default gateway**

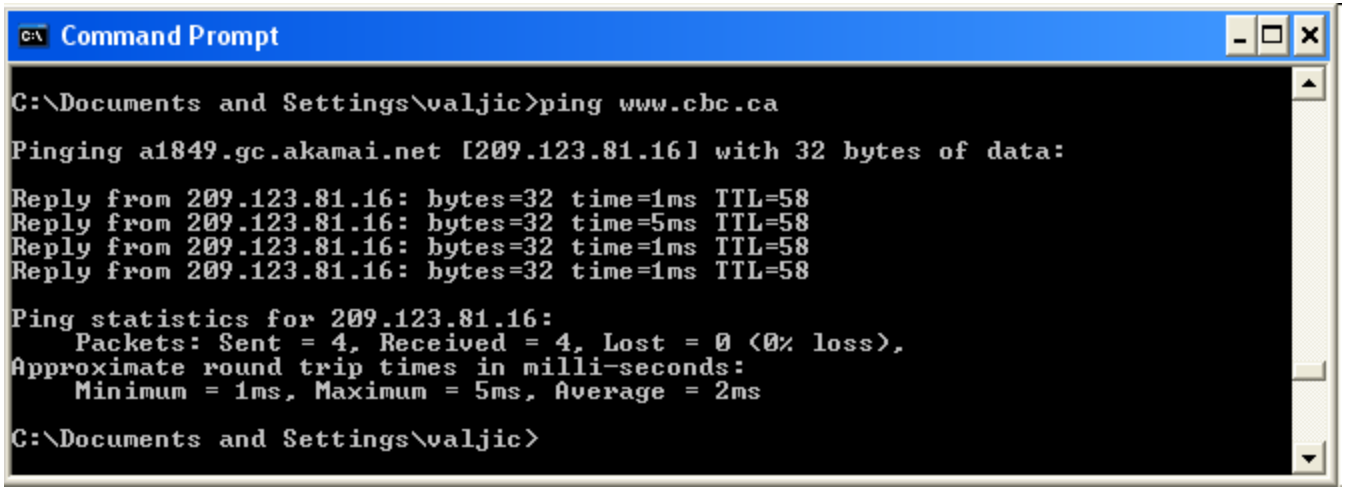


IP Utilities (cont.)

PING – **standard troubleshooting tool (available on most OS) used to determine**

1) **whether a remote computer is currently "alive"**
2) **round trip delay – max, min, average**

- **Windows *ping* sends 4 32-bit packets to destination and reports**
  a) **how many packets reached another computer**
  b) **roundtrip delay for each**
- ***ping* makes use of ICMP messages**
- **if host names used instead of IP addresses, ping relies on DNS service to obtain respective IP address**



IP Utilities (cont.)

Traceroute – utility (tool) that traces packet from *host_1* to *host_2*, showing number of hops between hosts and how long each hop takes

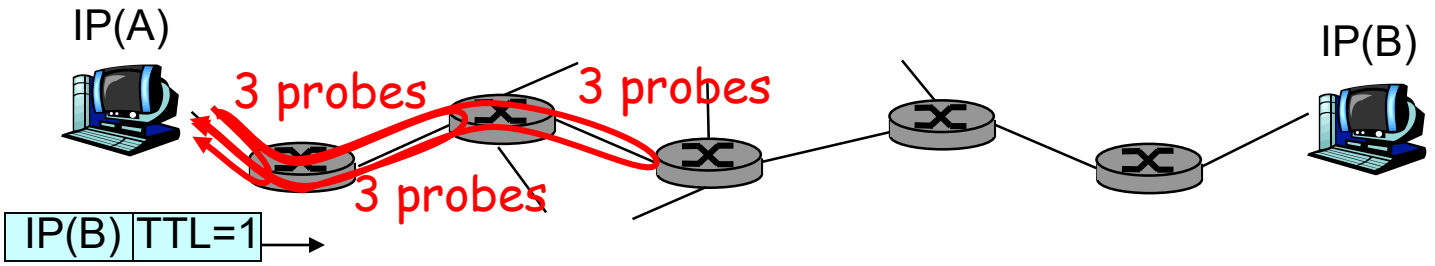
- works by sending UDP packets with low TTL fields – TTL specifies how many hops packet is allowed to pass before being discarded

  (1) sender first sends a UDP datagram with TTL=1 as well as an invalid port number to destination host

  (2) 1st router to see datagram sets TTL=0, discards datagram, and sends an ICMP Time Exceeded message to sender – this info enables sender to identify 1st machine in route and associated roundtrip delay

  (3) traceroute continues to identify remaining machines by sending datagrams with successively larger TTLs

- traceroute repeats above experiment 3 times ⇒ source actually sends 3*N packets to destination (N=number of hops)



IP Utilities (cont.)

Traceroute Origin – traceroute is a UNIX utility, but nearly all platforms have something similar

- Windows includes a traceroute utility called **tracert** – you can run tracert from MS-Dos Window, by entering tracert followed by domain name, e.g.

  tracert www.cs.yourku.ca

- tracert implementation is different from traceroute !!!

Traceroute Use – traceroute is generally used:

(1) as network debugging tool by pinpointing network connectivity problems

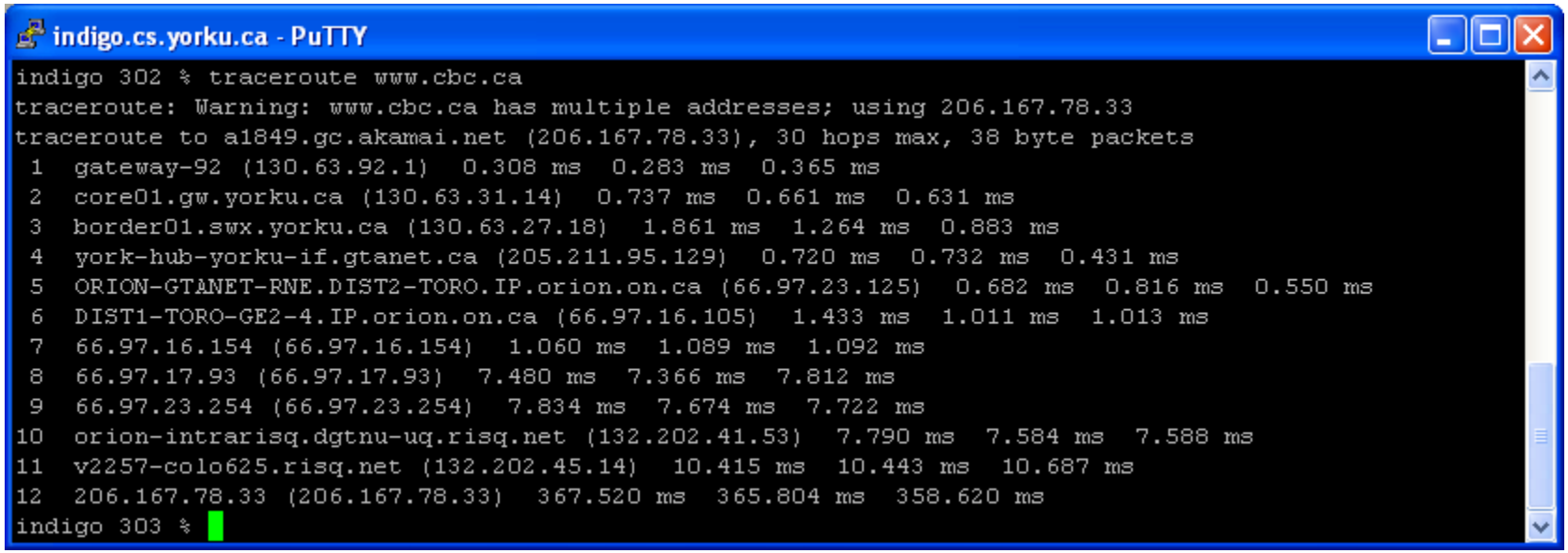
(2) for identifying IP addresses

Example [traceroute]

If you are visiting a Web site and pages are appearing slowly, you can use traceroute to figure out where the longest delay(s) are occurring.

IP Utilities (cont.)

Example **[traceroute www.bbc.co.uk]**



IP Utilities (cont.)

Open Visual Trace Route for Internet Performance:
https://visualtraceroute.net/