OSI Model (Application Layer)

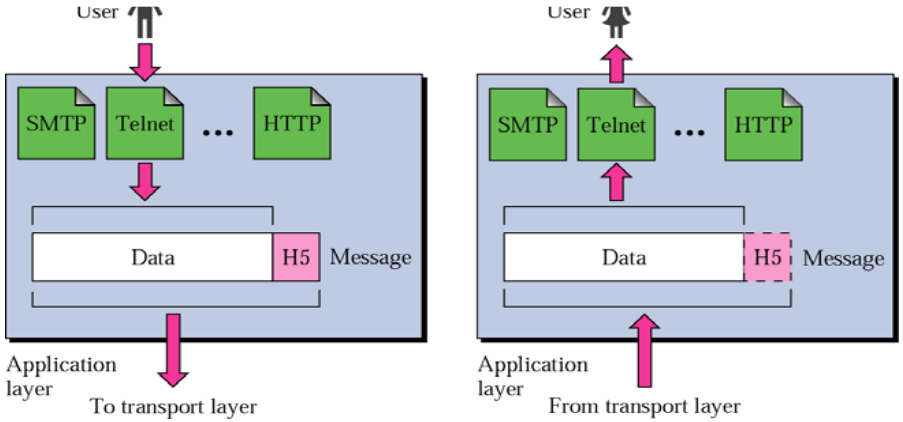
Application Layer (i.e. OSI Session + Presentation + Application Layer)

The application layer is responsible for providing the actual service to the user.

We want to send a big file to a system that occasionally crashes.

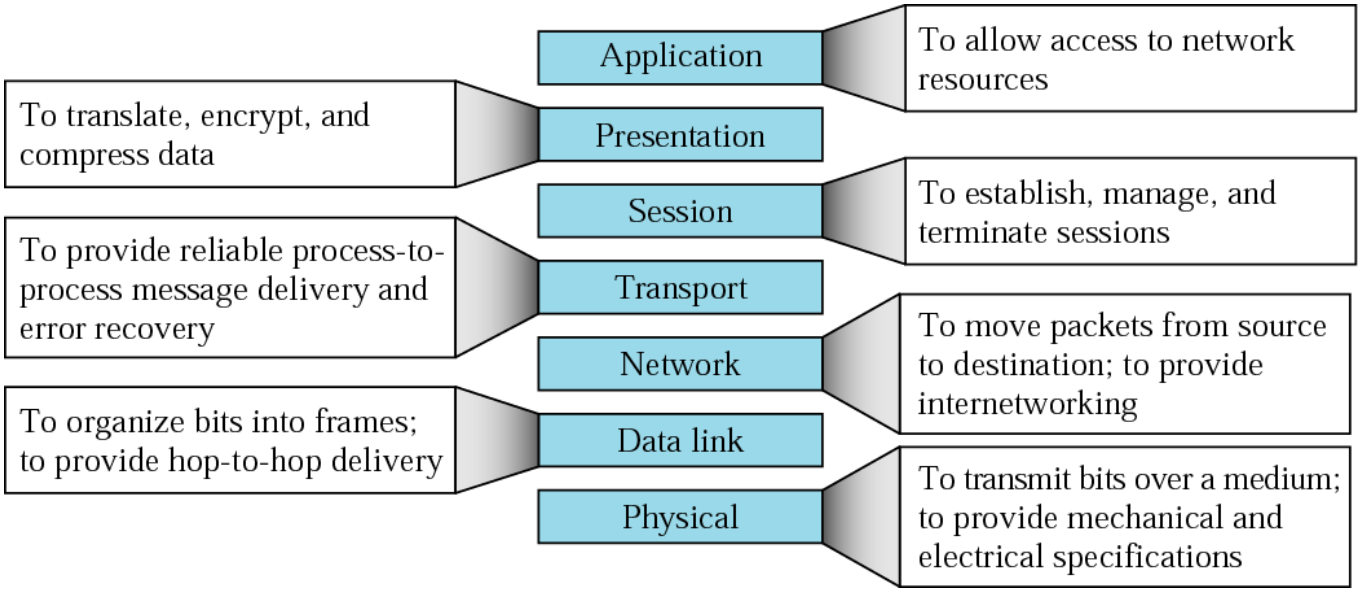
We want to send private data over third-party network.

We want to send multimedia/video data, but network capacity limited.



OSI Model (Summary)

Summary of Layers



Why 7 Layers?

- physical and application layer = bottom and top
- data link layer – bundles all link-dependent details
- network layer – responsible for hop-to-hop routing
- transport layer – responsible for end-to-end flow control
- session and presentation layer – provide some useful features; these can be easily provided in application layer

OSI Model (Summary)

Why did OSI Model Fail in Practice?

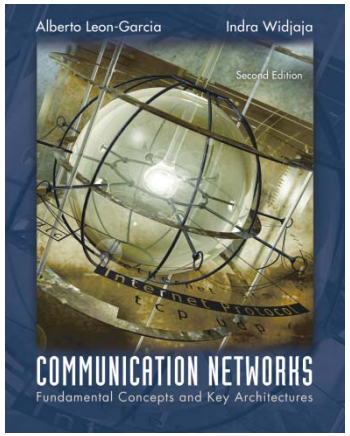
(1) Bad Timing

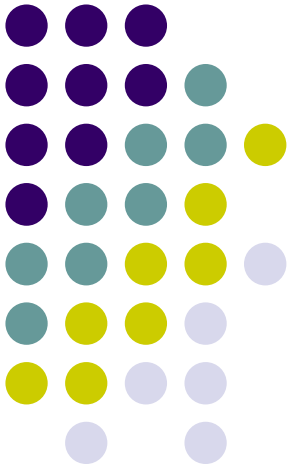
- although essential elements of OSI model were in place quickly, final standard (model + protocols) was not published until 1984
- by the time it took to develop OSI protocol standards, TCP/IP network architecture emerged as an alternative for open system interconnection
- free distribution of TCP/IP as part of Berkeley UNIX system ensured widespread use and development of numerous applications at various academic institutions

(2) Complexity and Inefficiency

- 7-layer OSI model was specified before there was much experience in designing large-scale OSI networks – several design choices were made in absence of concrete evidence of their effectiveness
- some functions, e.g. error control, appear in several layers (data link, transport, application) $\Rightarrow$ overall efficiency reduced

Chapter 2
Applications and Layered Architectures

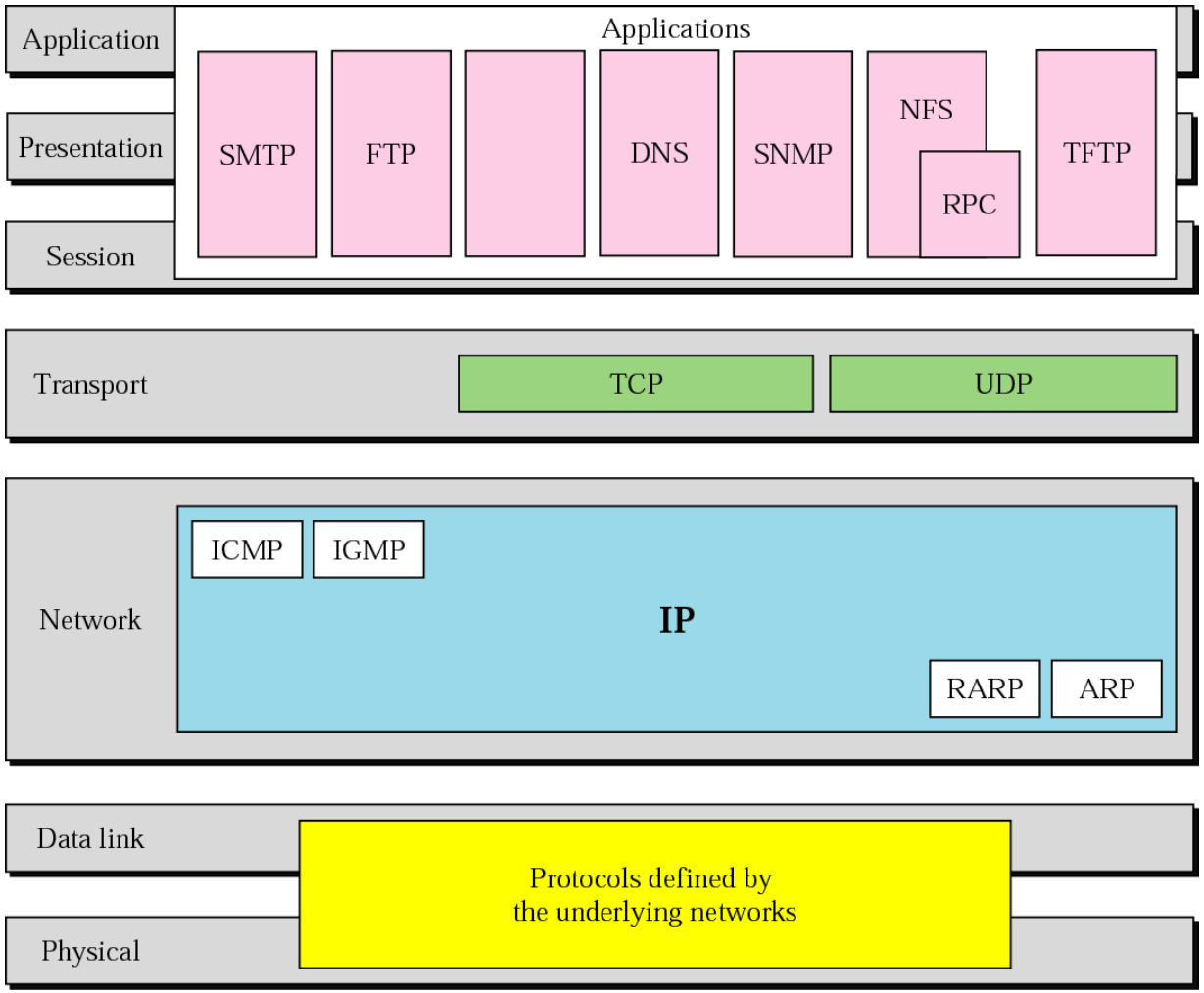




TCP/IP Architecture

How the Layers Work Together

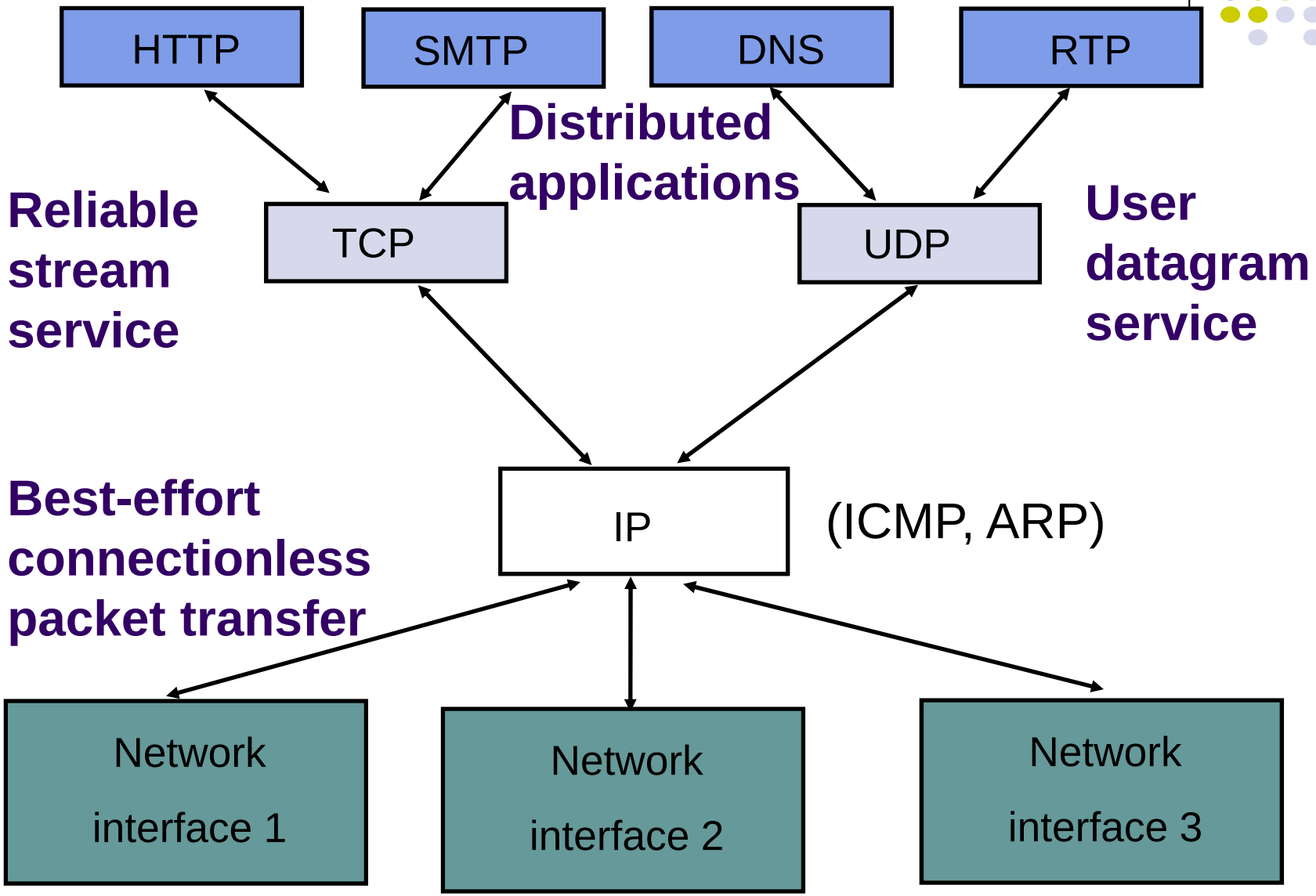
Internet Model



The operation of one single protocol at the network layer (IP protocol) over various networks provides independence from the underlying network technologies.

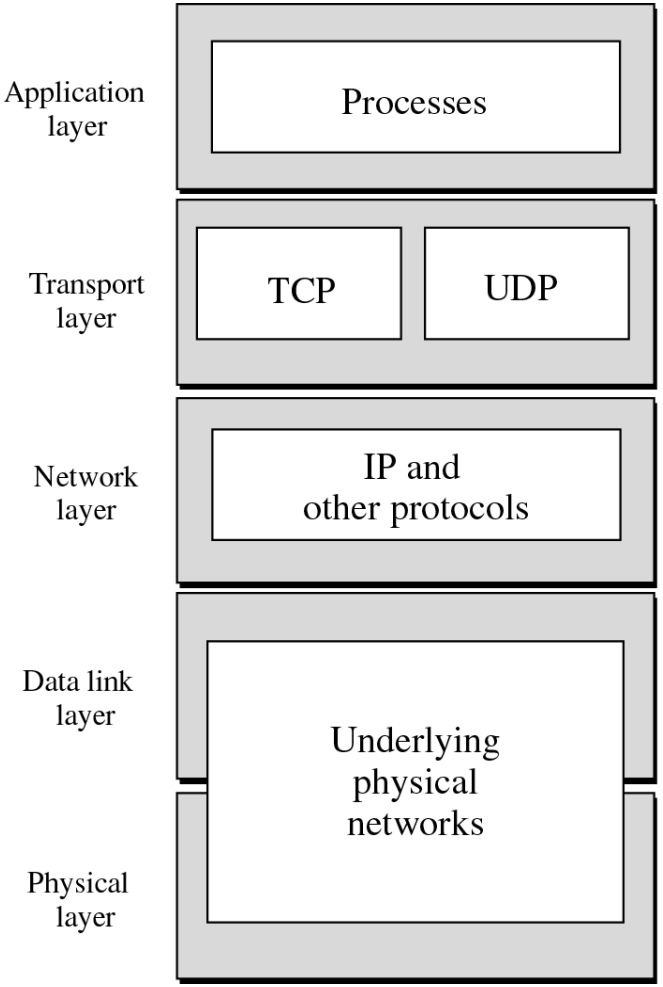
IP over anything, anything over IP!

TCP/IP Protocol Suite



TCP/IP Protocol Suite (Cont.)

Addresses in TCP/IP Model



0 – 65,535

Port address

- **locally unique** logical address used to differentiate between applications sharing the same IP address

130.63.92.157

IP address

- **globally unique** logical address used to located corresponding node in the entire Internet
- hierarchical addresses that can be easily aggregated in routing tables ⇒ **fast routing !**

00:07:E9:06:FD:2B

Physical address

- **globally unique** NIC address used to located corresponding node on a LAN
- each NIC on a subnetwork may have different manufactures ⇒ we cannot aggregate physical addresses in routing tables ⇒ **large networks cannot use these addresses to identify hosts !**

Internet Names & Addresses

Internet Names

- Each host a a unique name
  - Independent of physical location
  - Facilitate memorization by humans
  - Domain Name
  - Organization under single administrative unit
- Host Name
  - Name given to host computer

Internet Addresses

- Each host has globally unique *logical* 32 bit IP address
- Separate address for each physical connection to a network
- Routing decision is done based on destination IP address
- IP address has two parts:
  - *netid* and *hostid*
  - *netid* unique
  - *netid* facilitates routing
- Dotted Decimal Notation:

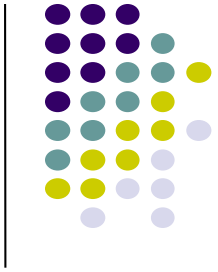
  int1.int2.int3.int4

  (intj = jth octet)

  128.100.10.13

DNS resolves IP name to IP address

Physical Addresses



- LANs (and other networks) assign physical addresses to the physical attachment to the network
- The network uses its own address to transfer packets or frames to the appropriate destination
- IP address needs to be resolved to physical address at each IP network interface
- Example: Ethernet uses 48-bit addresses
  - Each Ethernet network interface card (NIC) has globally unique Medium Access Control (MAC) or physical address
  - First 24 bits identify NIC manufacturer; second 24 bits are serial number
  - 00:90:27:96:68:07 12 hex numbers

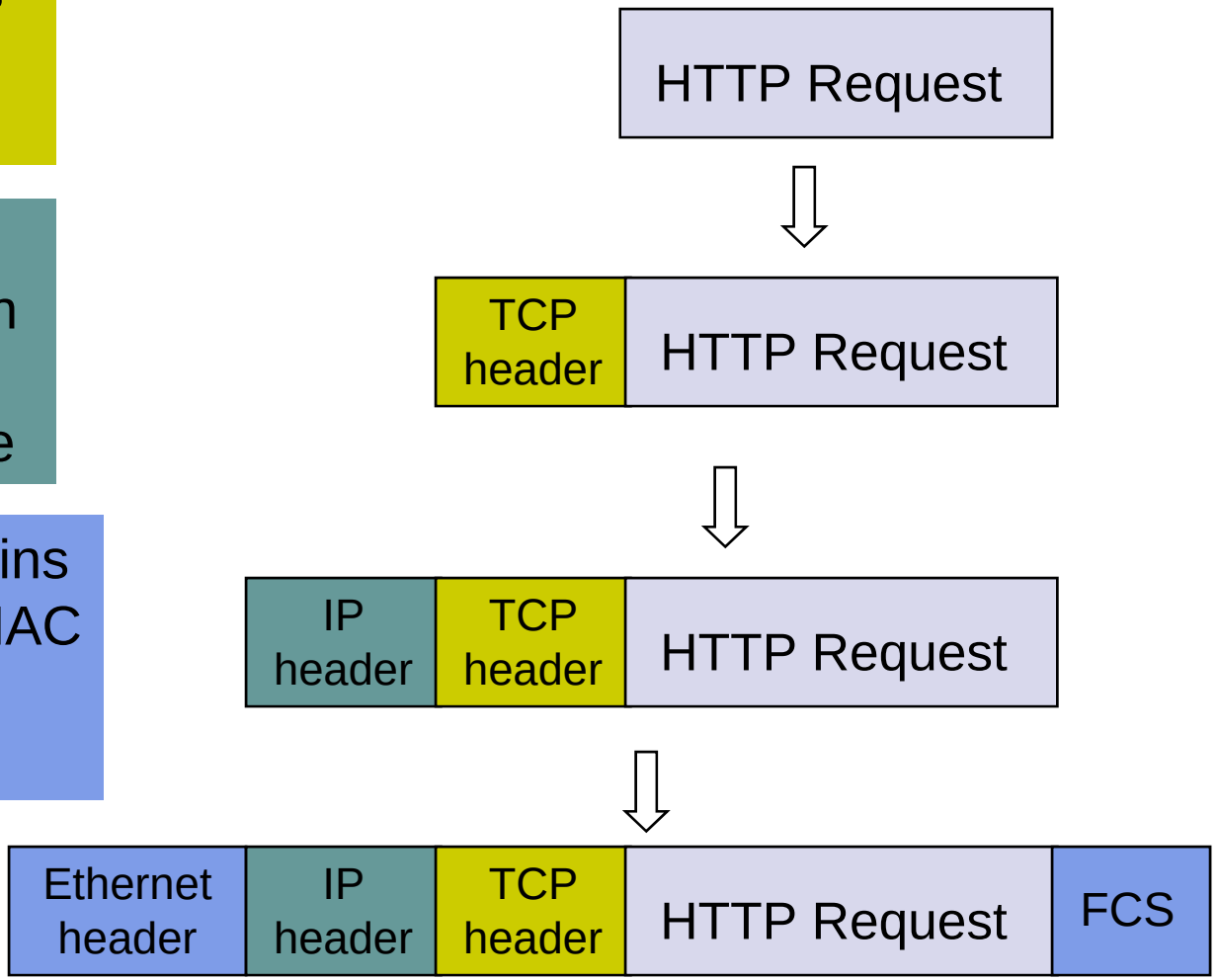
    Intel

Encapsulation

TCP Header contains source & destination port numbers

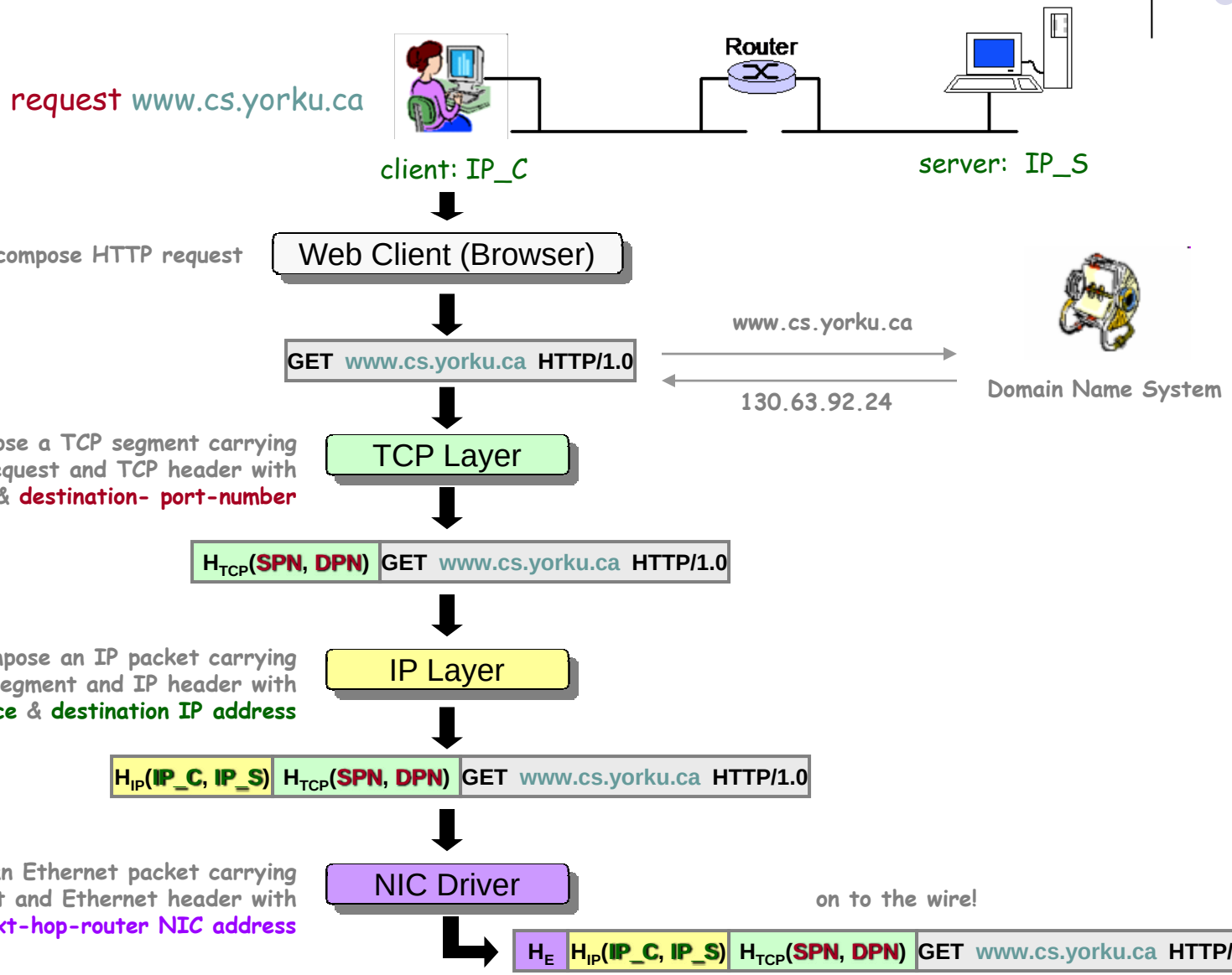
IP Header contains source and destination IP addresses; transport protocol type

Ethernet Header contains source & destination MAC addresses; network protocol type

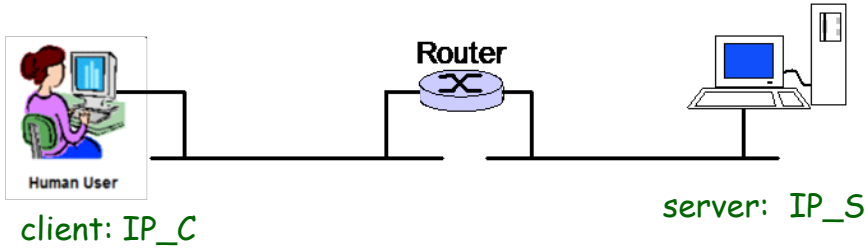


TCP/IP Protocol: How the Layers Work Together

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



TCP/IP Protocol: How the Layers Work Together



Web Server

GET www.cs.yorku.ca HTTP/1.0

perform sequencing, error recovery, etc.
and pass HTTP segments reliably and in-order
on to specified port number

TCP Layer

H_{TCP}(SPN, DPN) | GET www.cs.yorku.ca HTTP/1.0

extract destination IP address and
check if it is meant for this computer –
if so, extract TCP segment and pass it on to the TCP layer,
otherwise forward the packet through appropriate outgoing link

IP Layer

H_{IP}(IP_C, IP_S) | H_{TCP}(SPN, DPN) | GET www.cs.yorku.ca HTTP/1.0

data-link layer processing
(header removal, error checking, etc.)

NIC Driver

from the wire!

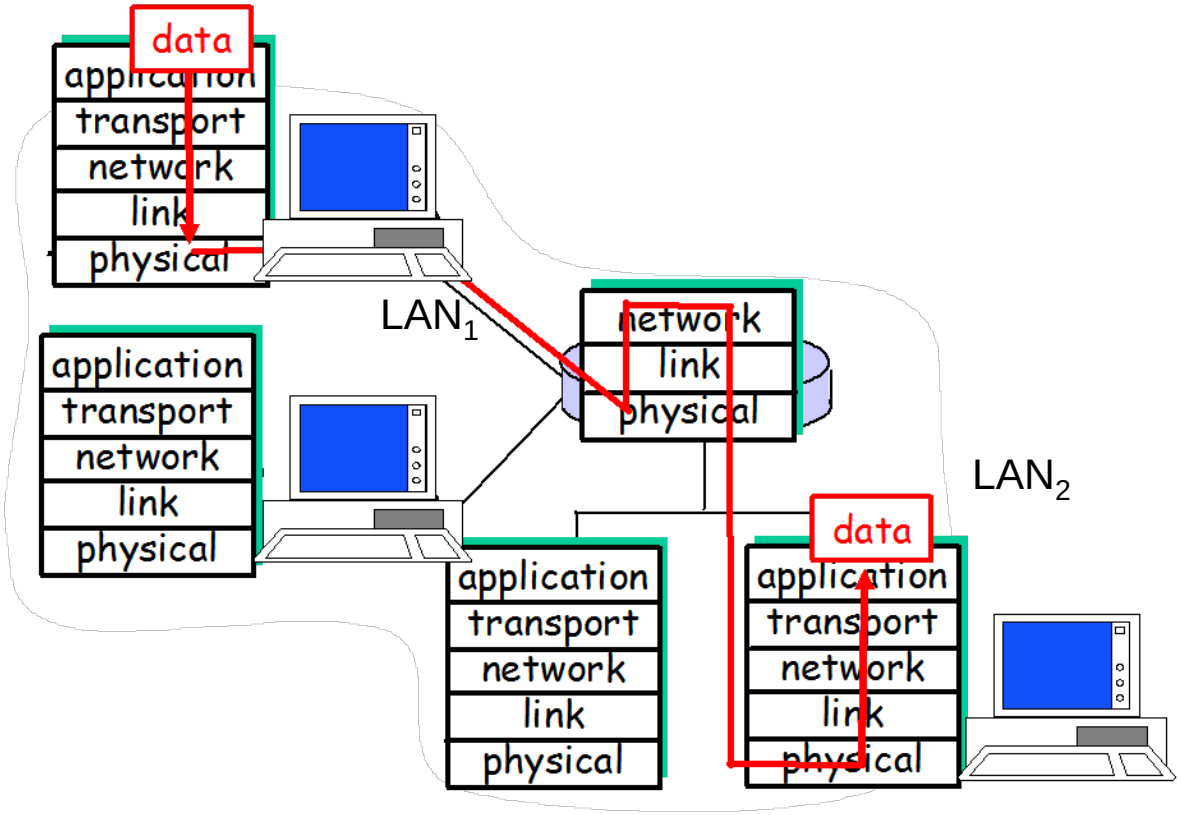
H_E | H_{IP}(IP_C, IP_S) | H_{TCP}(SPN, DPN) | GET www.cs.yorku.ca HTTP/1.0 | T_E

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

Bonus Question [layering – encapsulation]

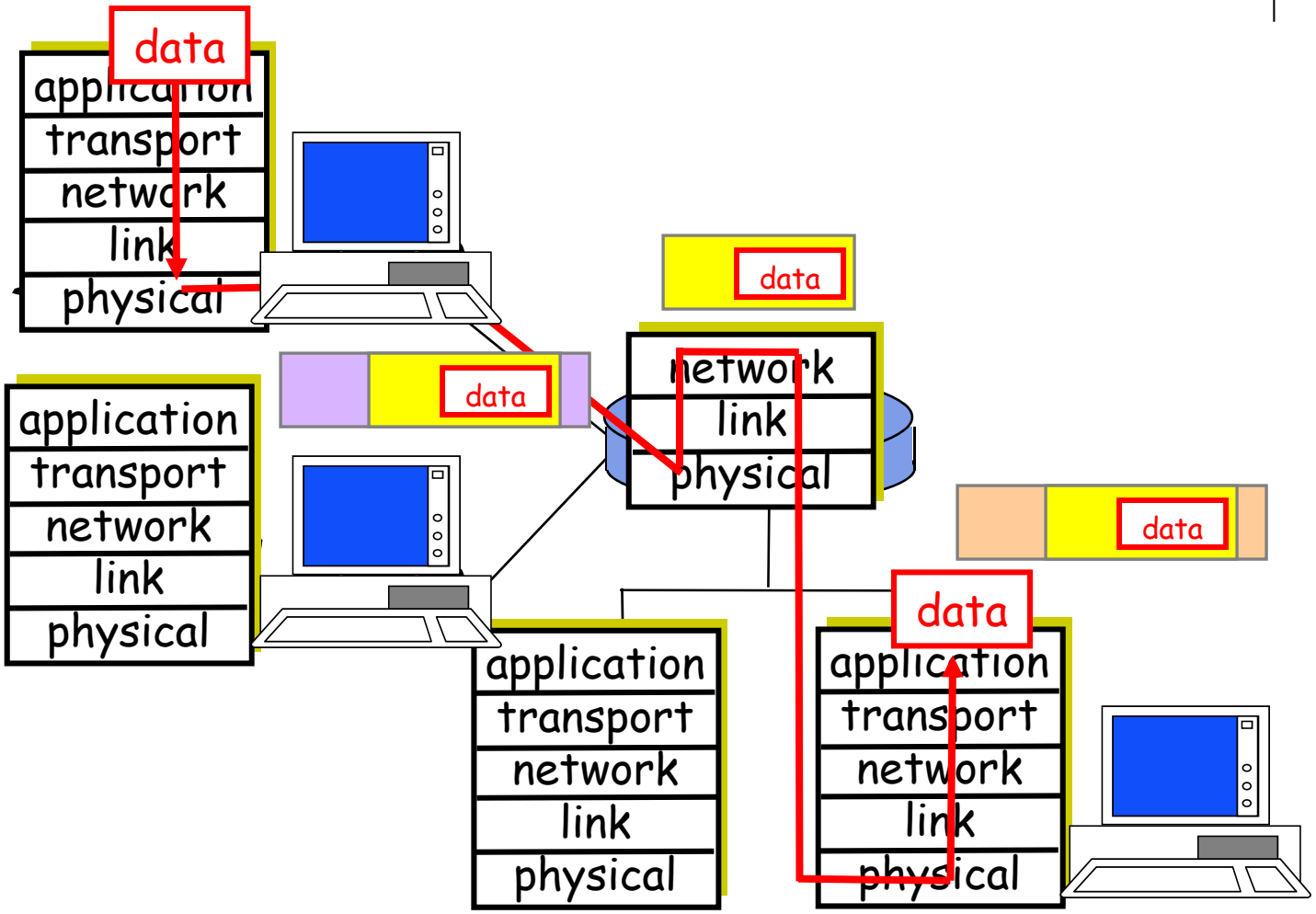
Assume two computers, situated on two distant LANs - with different data-link technologies, communicate with each other over the Internet.

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.)

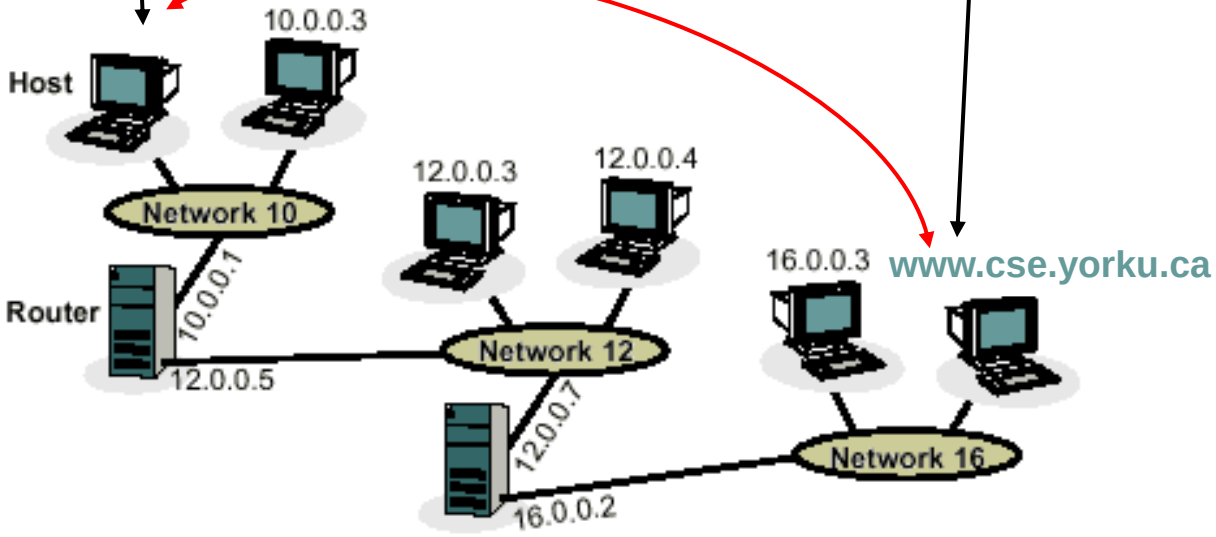


(Source: Kurose & Ross)

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

How to determine the number and identity of intermediate routers?

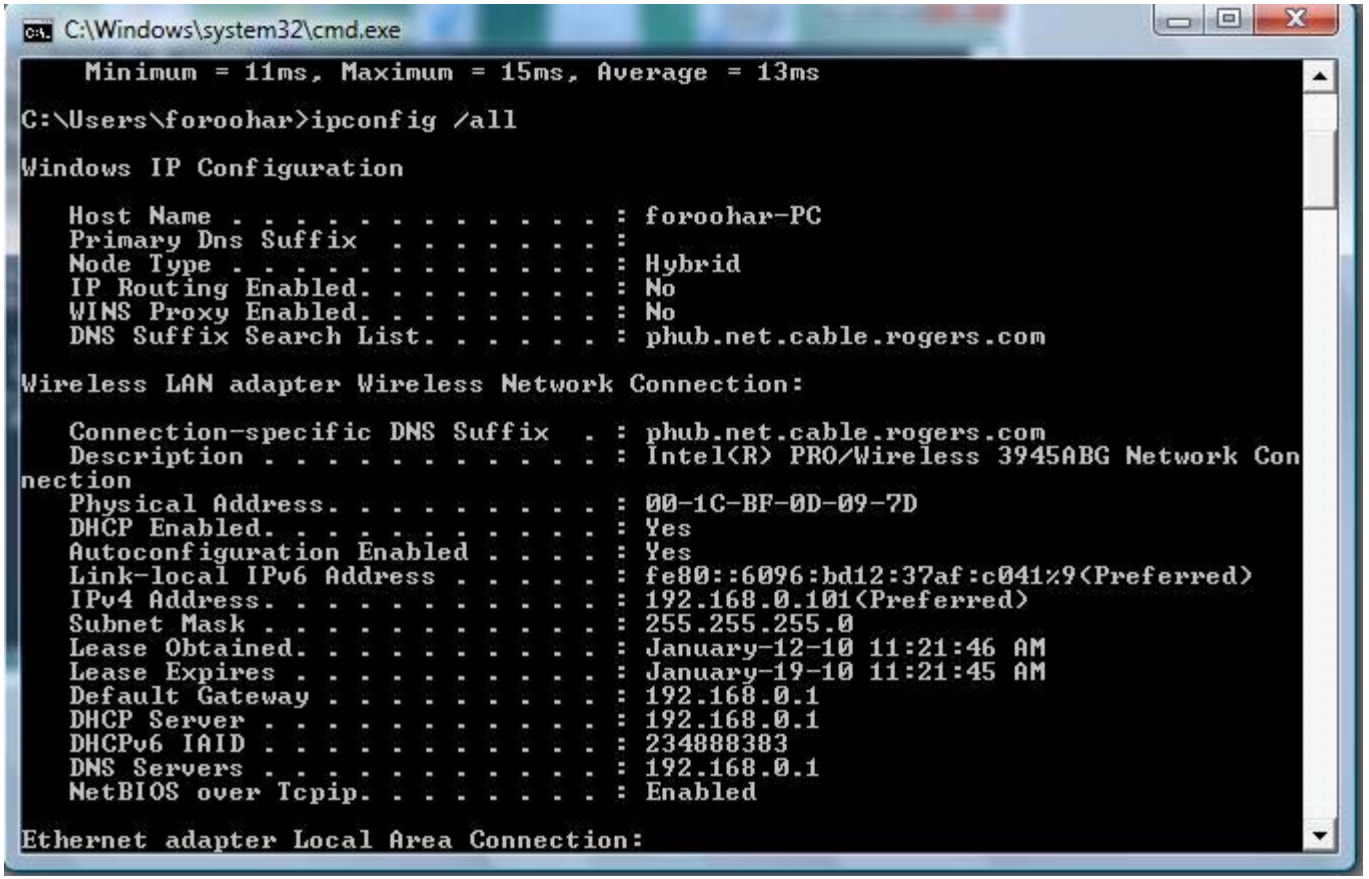
How to determine IP address of another remote machine?



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.)

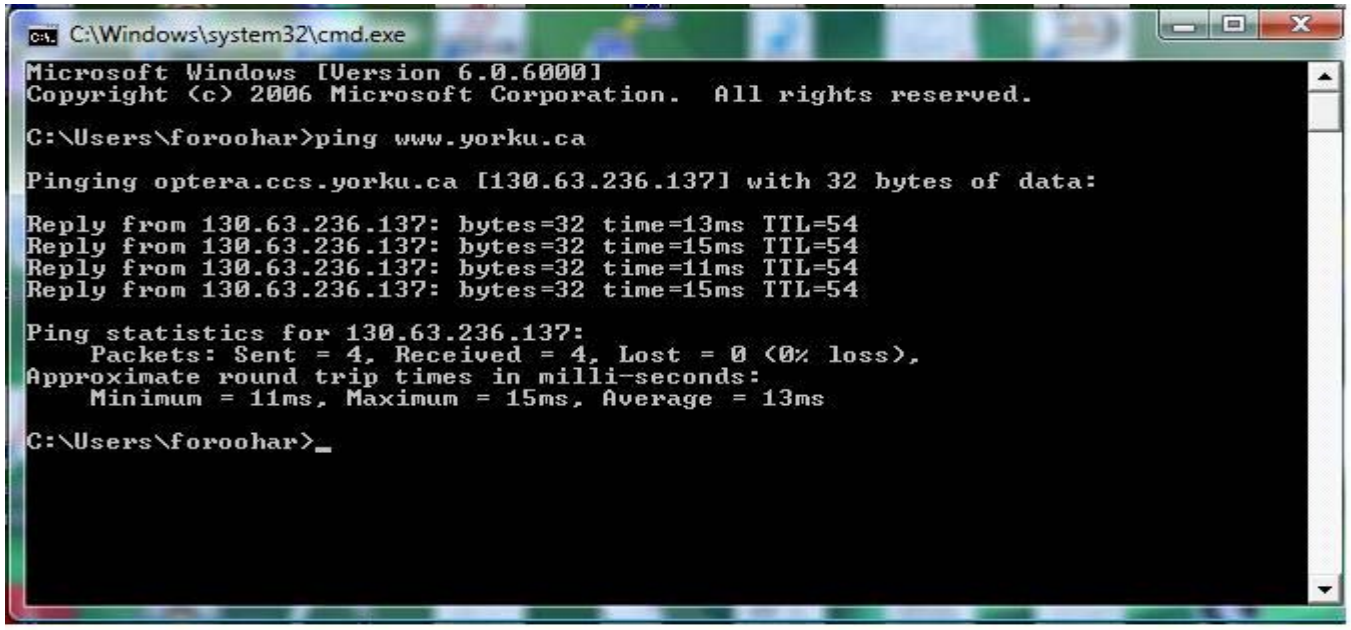
PING – standard troubleshooting tool (available on most OS) used to determine

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 are used instead of IP addresses, ping relies on DNS service to translate that name into corresponding IP address ⇒ additional delay!



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

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.cbc.ca]**

indigo.cs.yorku.ca - PuTTY

```
indigo 302 % traceroute www.cbc.ca
traceroute: Warning: www.cbc.ca has multiple addresses; using 206.167.78.33
traceroute to a1849.gc.akamai.net (206.167.78.33), 30 hops max, 38 byte packets
 1  gateway-92 (130.63.92.1)  0.308 ms  0.283 ms  0.365 ms
 2  core01.gw.yorku.ca (130.63.31.14)  0.737 ms  0.661 ms  0.631 ms
 3  border01.swx.yorku.ca (130.63.27.18)  1.861 ms  1.264 ms  0.883 ms
 4  york-hub-yorku-if.gtanet.ca (205.211.95.129)  0.720 ms  0.732 ms  0.431 ms
 5  ORION-GTANET-RNE.DIST2-TORO.IP.orion.on.ca (66.97.23.125)  0.682 ms  0.816 ms  0.550 ms
 6  DIST1-TORO-GE2-4.IP.orion.on.ca (66.97.16.105)  1.433 ms  1.011 ms  1.013 ms
 7  66.97.16.154 (66.97.16.154)  1.060 ms  1.089 ms  1.092 ms
 8  66.97.17.93 (66.97.17.93)  7.480 ms  7.366 ms  7.812 ms
 9  66.97.23.254 (66.97.23.254)  7.834 ms  7.674 ms  7.722 ms
10  orion-intrarisq.dgtnu-uq.risq.net (132.202.41.53)  7.790 ms  7.584 ms  7.588 ms
11  v2257-colo625.risq.net (132.202.45.14)  10.415 ms  10.443 ms  10.687 ms
12  206.167.78.33 (206.167.78.33)  367.520 ms  365.804 ms  358.620 ms
indigo 303 %
```

IP Utilities (Cont.)

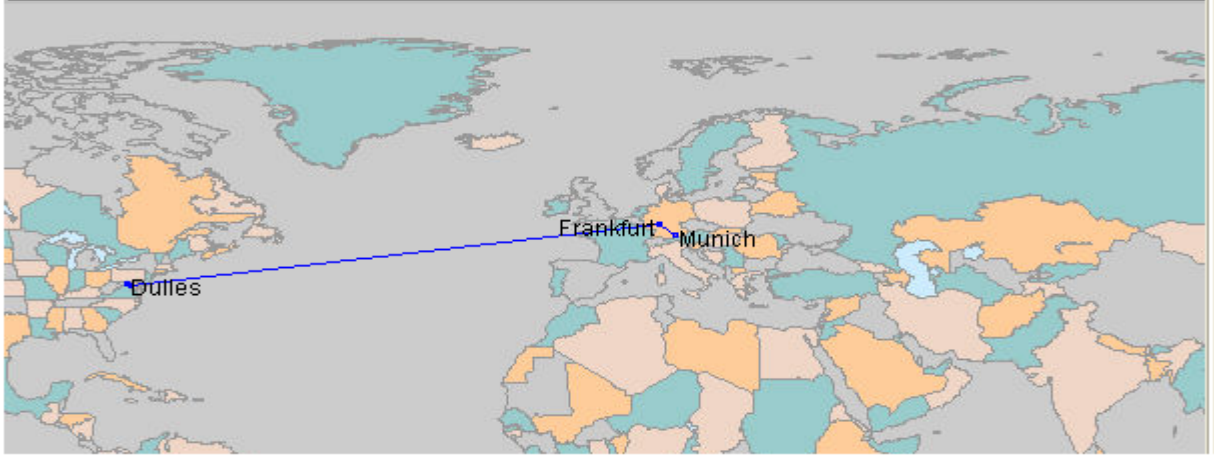
VisualRoute for Internet Performance:

http://visualroute.visualware.com/

Report for www.tu-muenchen.de [129.187.39.10]

Analysis: 'www.tu-muenchen.de' [w3proj5.ze.tum.de] was found in 12 hops (TTL=244). It is a HTTP server (running Apache/1.3.26 (Unix) PHP/4.2.2 AuthMySQL/2.20).

Hop	%Loss	IP Address	Node Name	Location	Tzone	ms	Graph	Network
0		161.58.180.11	WIN10115.visu	Dulles, VA, USA	-05:00		0 110	Verio, Inc. VRIO-161-058
1		161.58.176.12	-	Englewood, CO		0		Verio, Inc. VRIO-161-058
2		161.58.156.14	-	Englewood, CO		0		Verio, Inc. VRIO-161-058
3		129.250.28.20	xe-1-2-0-3.r20.	Ashburn, VA, USA	-05:00	0		Verio, Inc. VRIO-129-250
4		129.250.2.35	p64-0-0-0.r21.a	Ashburn, VA, USA	-05:00	0		Verio, Inc. VRIO-129-250
5		208.51.6.33	-	Phoenix, AZ, USA	-07:00	0		Global Crossing GBLX-6I
6		67.17.65.54	so5-0-0-2488M	Frankfurt, Germany	+01:0(	78		Global Crossing GBLX-1
7		208.48.23.142	Dante-Frankfu	Frankfurt, Germany	+01:0(	88		Global Crossing GBLX-6A
8		188.1.18.25	cr-muenchen1	Munich, Germany	+01:0(	94		IP networking on DFN's G
9		188.1.74.2	ar-muenchen1	Munich, Germany	+01:0(	99		IP networking on DFN's G
10		188.1.37.14	csrwan.lrz-mue	(Germany)	+01:0(	93		IP networking on DFN's G
11		129.187.1.244	csrkb1.lrz-mue	Munich, Germany	+01:0(	98		Leibniz-Rechenzentrum (
12		129.187.39.10	www.tu-muenc	Munich, Germany	+01:0(	93		Leibniz-Rechenzentrum (



http://www.visualware.com/resources/tutorials/tracert.html

CCNA Questions

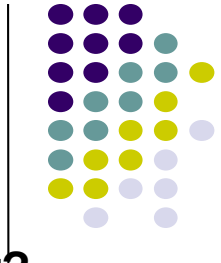
Q.1Which layer provides logical addressing that routers will use for path determination?

Q.2 Which layer is responsible for converting data packets into electrical signal?

Q.3Which layer combines bits into bytes and bytes into frames, uses MAC addressing, and provides error detection?

Q.4 Which layer is used for reliable communication between end nodes over a WAN and controlling the flow of information?

CCNA Questions (Cont.)



Q.5Which fields are contained within an IEEE Ethernet frame header?

(a) Source and destination MAC address.

(b) Source and destination network (IP) address.

(c) Source and destination MAC address and source and destination network (IP) address.

Q.6 When data is encapsulated, which is the correct order?

(a) Data, frame, packet, segment, bit.

(b) Segment, data, packet, frame, bit.

(c) Data, segment, packet, frame, bit.

(d) Data, segment, frame, packet, bit.