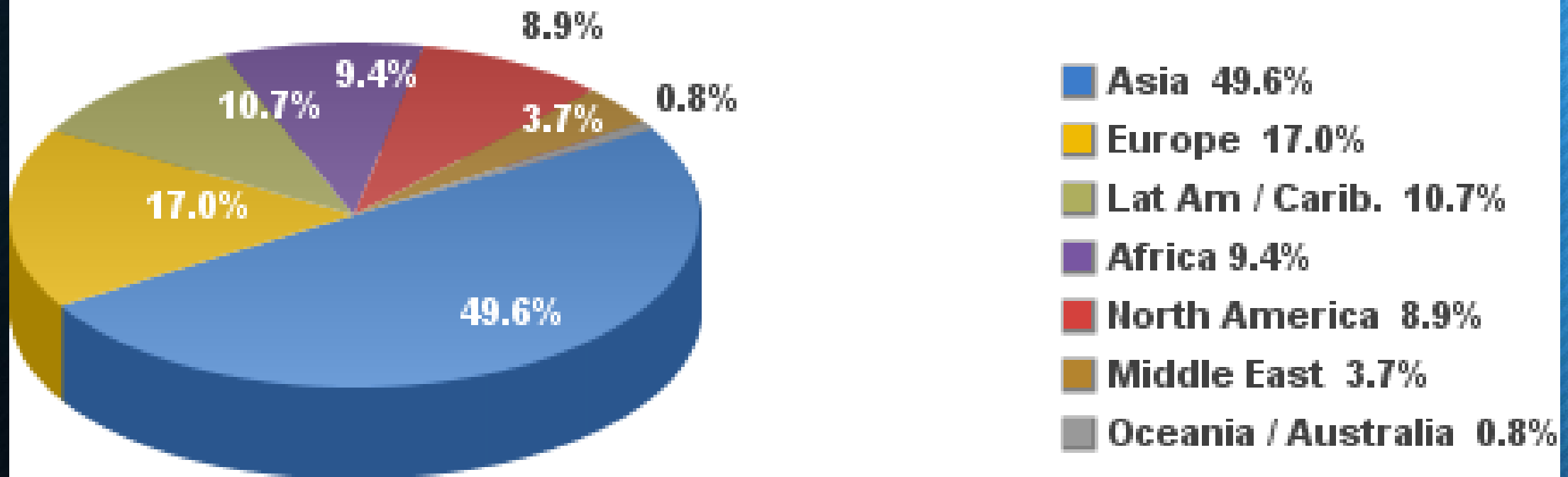


# Internet: Architecture and The Internet Protocol Suite

## Some Facts

### **Internet Users in the World by Regions June 2016**



Source: Internet World Stats - [www.internetworldstats.com/stats.htm](http://www.internetworldstats.com/stats.htm)

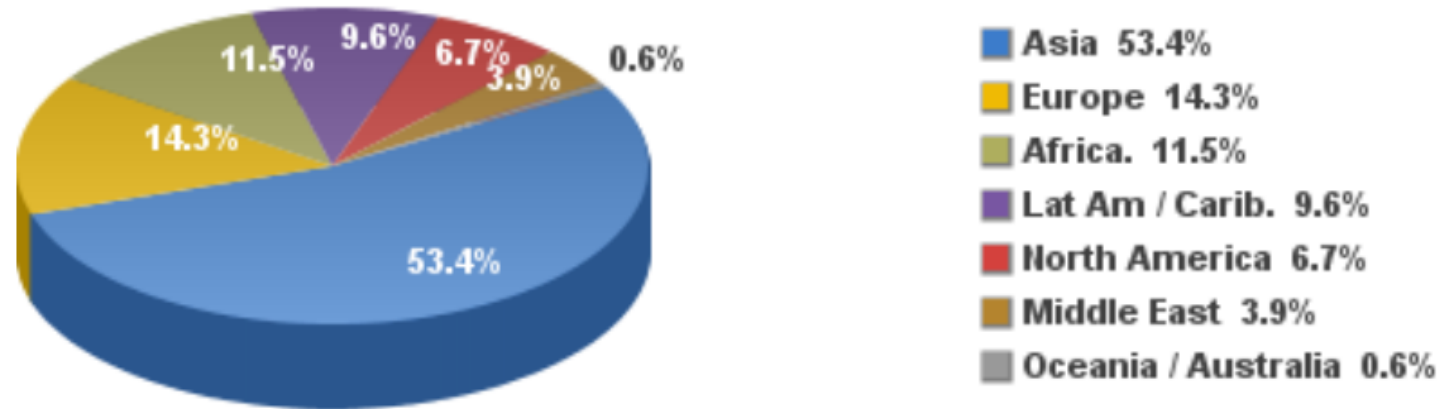
Basis: 3,611,375,813 Internet users on June 30, 2016

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# Some Facts

## Internet Users Distribution in the World - 2021



Source: Internet World Stats - [www.internetworldstats.com/stats.htm](http://www.internetworldstats.com/stats.htm)

Basis: 5,168,780,607 Internet users in March 31, 2021

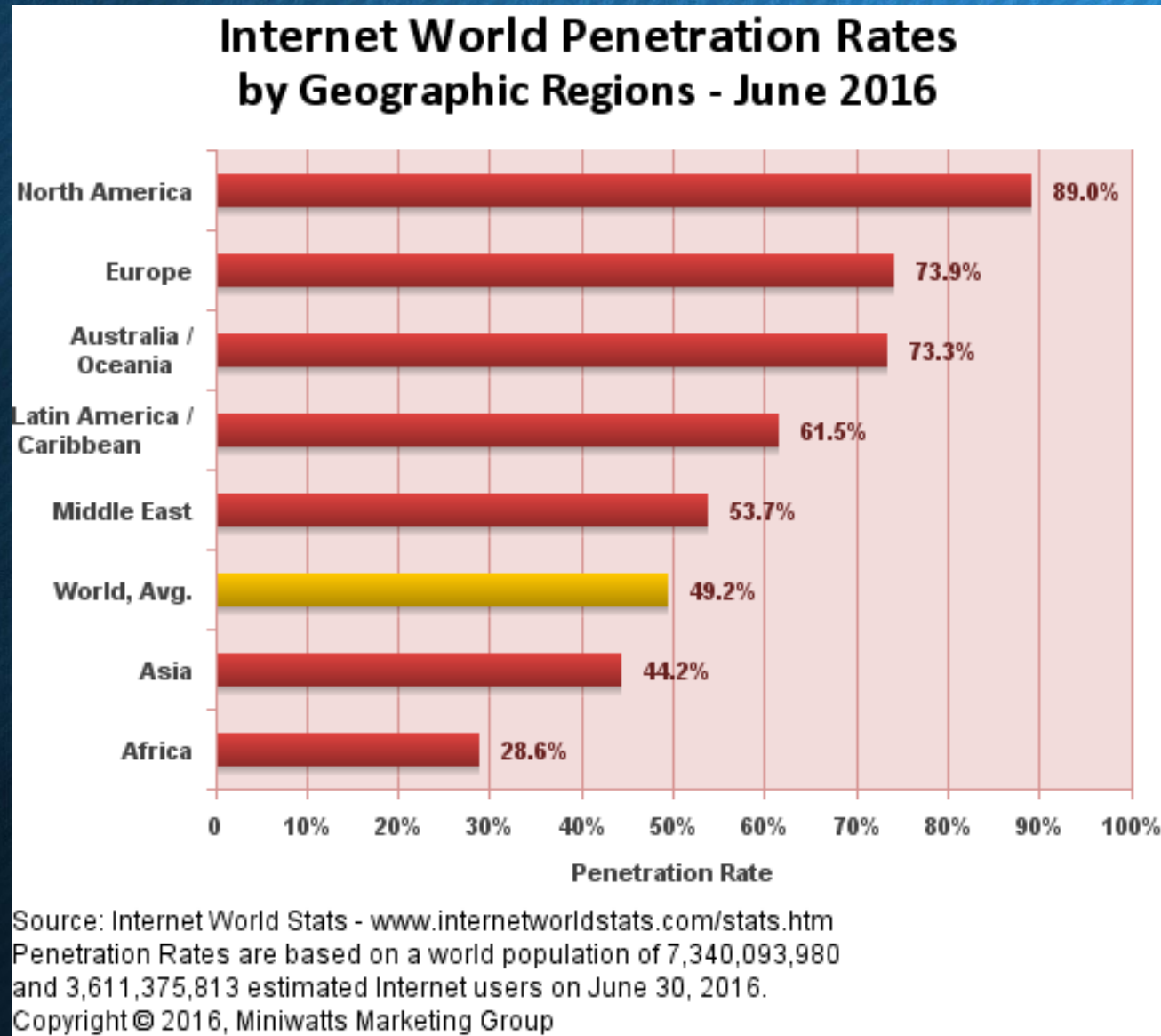
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## **INTERNET USAGE STATISTICS**

### **The Internet Big Picture**

**World Internet Users and 2021 Population Stats**

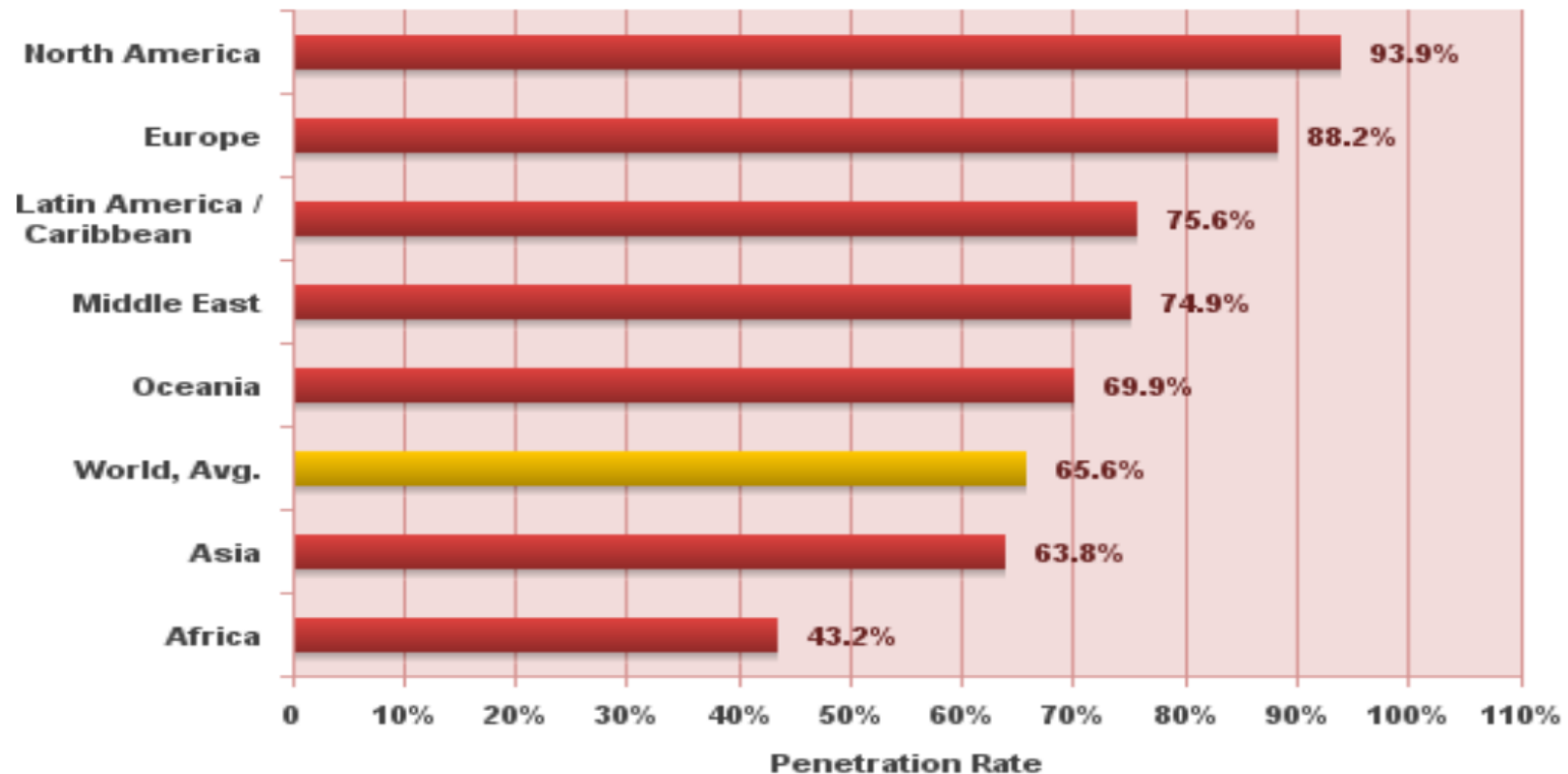
# Some Facts





# Some Facts

## Internet World Penetration Rates by Geographic Regions - 2021



Source: Internet World Stats - [www.internetworldstats.com/stats.htm](http://www.internetworldstats.com/stats.htm)  
Penetration Rates are based on a world population of 7,875,765,587  
and 5,168,780,607 estimated Internet users in March 31, 2021.  
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## Some Facts

**“In 2025, the key to learning and evolving with AI models will be hands-on experimentation, an open mind, and a sense of humor. Artificial intelligence will continue to evolve at a rapid pace, so learners and educators will need to adapt their approach and embrace trial and error to keep pace.”**



**Hampton Paulk**

Principal Author, GenAI, Pluralsight



# Web Concepts

## Internet

- Physical structure is very detailed- Transmission media includes fibre-optic, satellites, phone-lines etc.
- Internet grown to connect many devices: computers, cells, TVs etc.



# Web Concepts

## Networks

- Group of nodes throughout the world that are linked together by some media
- Most common structure is client/server-  
Server gives/offers something: service



# The Internet

- A global interconnection of networks and independent computers using a universal language/protocol (TCP/IP) to communicate
  - TCP/IP is the underlying difference between the Internet and other global networks(i.e. the telephone network)
  - If you want to connect to the net, you must speak/use TCP/IP
- Offers services: WWW, SMTP, FTP, Telnet\*, Gopher\*, NNTP\* (\*not greatly used today)



# The World Wide Web (WWW)

- A collaboration of computers that allow for the transmission of documents across the Internet
- Uses browser and server software to provide collection of documents in hypertext structure across the internet



# Internet

- The Internet is really a network of networks connecting millions of computing devices throughout the world.
- Each network is administered independently of all other networks
  - There is no central authority running the Internet.



# Outline

- The Internet: Structure & Service Views
- What is a Protocol?
- The Internet Protocol (IP)
- Protocol Layers & the OSI Model
- The Internet Protocol Stack
- TCP & UDP
- Application Protocols
- Summary



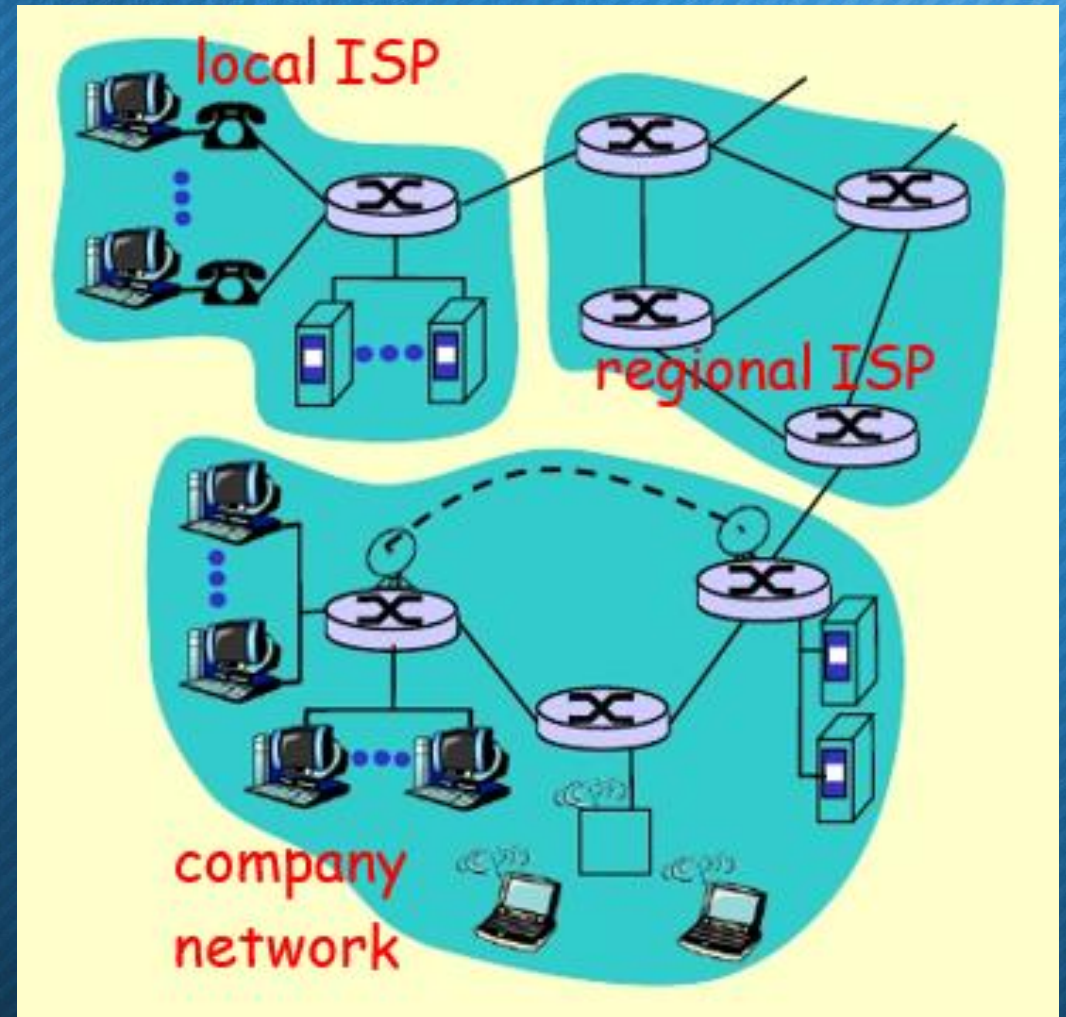
# Internet

- Wikipedia: <http://en.wikipedia.org/wiki/Internet>
- a connection of computer networks using the Internet Protocol (IP)
- layers of communication protocols: IP → TCP/UDP →  
HTTP/FTP/POP/SMTP/SSH...
- What's the difference between the Internet and the World Wide Web (WWW)?



# What's the Internet: "nuts and bolts" view

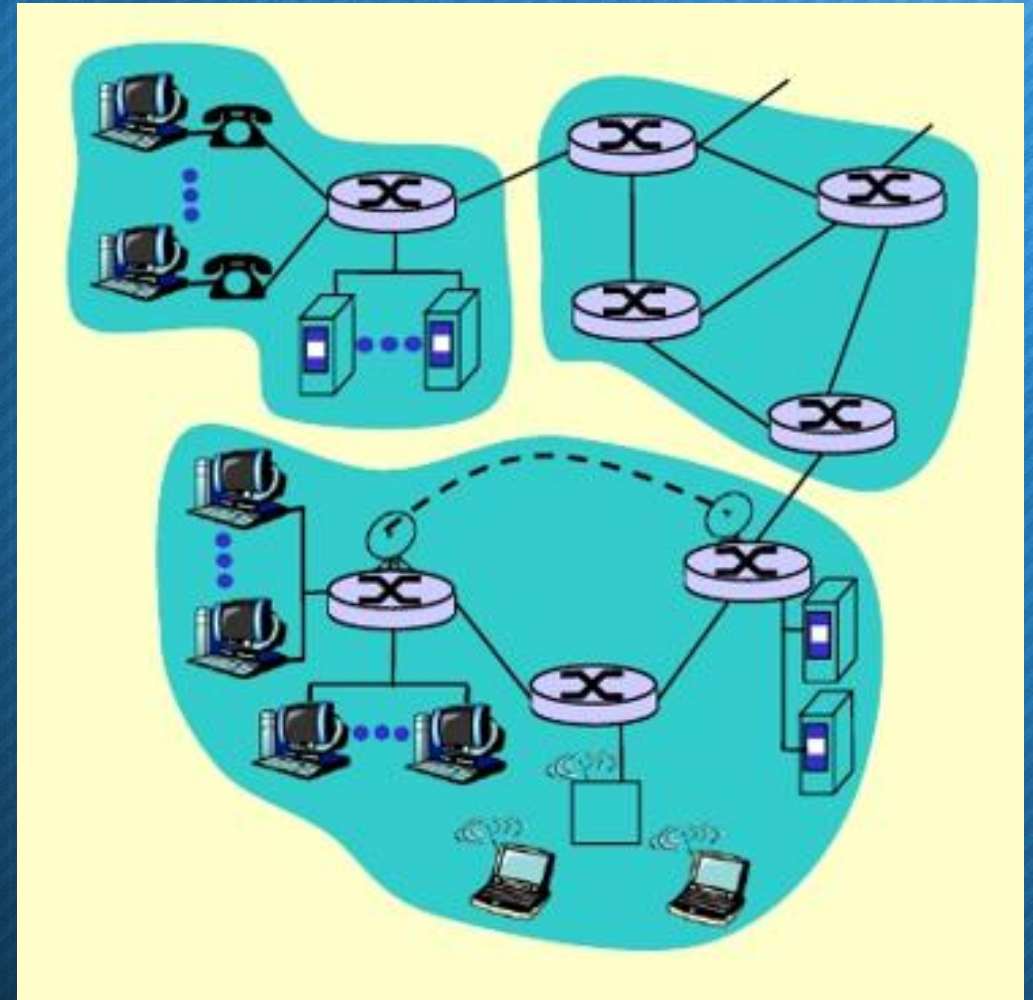
- protocols control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, FTP, PPP
- Internet: "network of networks"
  - loosely hierarchical
  - public Internet versus private intranet
- Internet standards
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force





# What's the Internet: a service view

- communication infrastructure enables distributed applications:
  - Web, email, games, e-commerce, file sharing
- communication services provided to apps:
  - Connectionless unreliable
  - connection-oriented reliable





# What's a protocol?

human protocols:

- "what's the time?"
- "I have a question"
- introductions

...specific msgs sent

...specific actions taken when  
msgs received, or other events

network protocols:

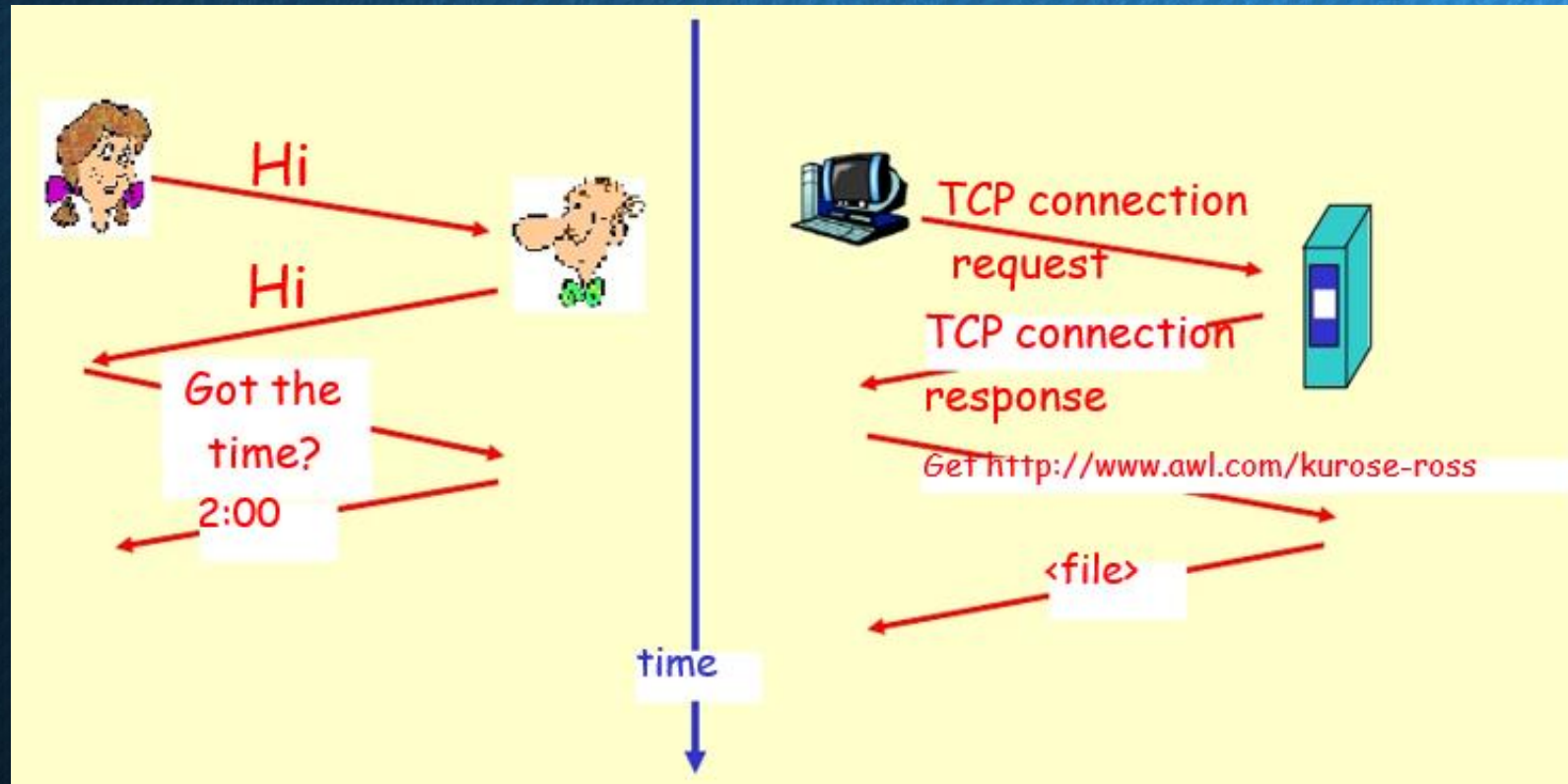
- machines rather than humans
- all communication activity in  
Internet governed by protocols

protocols define format, order of  
msgs sent and received among  
network entities, and actions taken  
on msg transmission, receipt



# What's a protocol?

a human protocol and a computer network protocol: "what's the time?"



Q: Other human protocols?



# Internet Protocol (IP)

- IP is the network layer
- packet delivery service (host-to-host).
- translation between different data-link protocols.
- IP addresses are logical addresses (not physical)
- 32 bits.
- Includes a network ID and a host ID.
- Every host must have a unique IP address.
- IP addresses are assigned by a central authority (the NIC at SRI International).



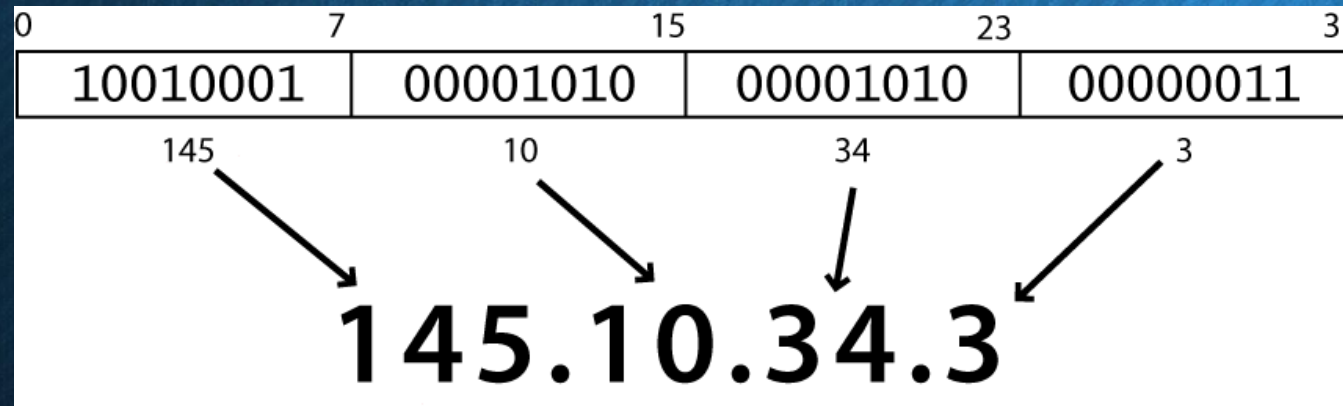
# Network and Host IDs

- A Network ID is assigned to an organization by a global authority.
- Host IDs are assigned locally by a system administrator.
- Both the Network ID and the Host ID are used for routing



# Internet Protocol (IP)

- a simple protocol for attempting to send data between two computers
- each device has a 32-bit IP address written as four 8-bit numbers (0-255)



- find out your internet IP address: [whatismyip.com](http://whatismyip.com)
- find out your local IP address:
- in a terminal, type: ipconfig (Windows) or ifconfig (Mac/Linux)



# Transmission Control Protocol

- TCP is a transport-layer protocol layered on top of IP. TCP provides
  - a connection-oriented,
  - two-way,
  - ordered,
  - reliable,
  - byte-stream
  - model of communication.
- IP provides none of the above services, so all of this functionality is found in the TCP protocol.



# Transmission Control Protocol

- TCP is connection-oriented. A logical connection must be established before communication begins.
- TCP is ordered - data is delivered to a receiving application in the order it was transmitted by the sender.
- TCP is reliable - Retransmissions and acknowledgements are used to ensure that all data arrives at the destination. Checksums are used to ensure that data is not corrupted in transit.
- TCP presents a byte-stream model - data may be delivered in different-sized chunks than it was transmitted.



# Transmission Control Protocol

- Every host has an IP address which identifies that host.
- We would like to support more than one simultaneous transport connection per host. TCP uses a 16-bit Port Number to distinguish different connections.
- Certain port numbers are reserved for specific applications:
  - 21 ftp (file transfer protocol)
  - 23 telnet (remote login service)
  - 25 SMTP (electronic mail)
  - 80 http (World Wide Web)
- We use the pair (IP Address, port number) to identify a particular endpoint for communication.



# Transmission Control Protocol

- IP + TCP = TCP/IP
- some programs (games, streaming media programs) use simpler UDP(User Datagram Protocol) protocol instead of TCP



# Protocol “Layers”

Networks are complex!

➤ many “pieces”:

- hosts
- routers
- links of various
- media
- applications
- protocols
- hardware,
- software

Question:

Is there any hope of  
organizing structure of network?

Or at least our discussion of  
networks?



# Organization of air travel

ticket (purchase)

baggage (check)

gates (load)

runway takeoff

airplane routing

ticket (complete)

baggage (claim)

gates (unload)

runway landing

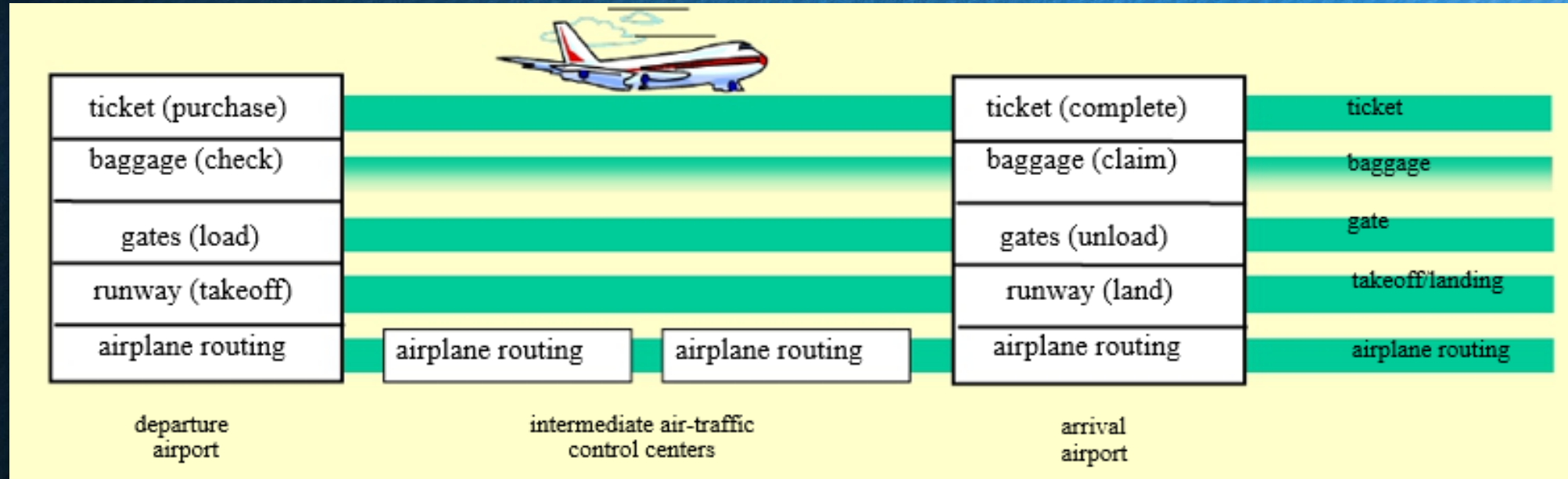
airplane routing

airplane routing

➤ a series of steps



# Layering of airline functionality



- Layers: each layer implements a service
  - via its own internal-layer actions
  - relying on services provided by layer below



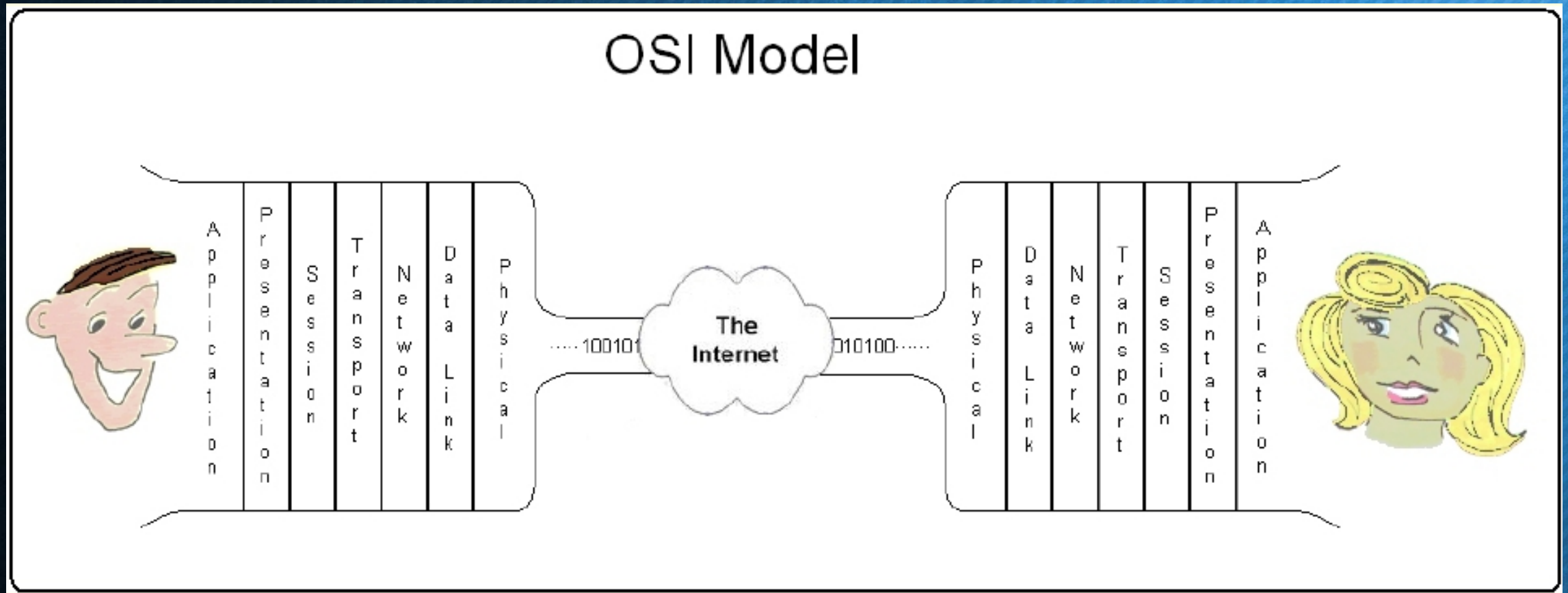
# Why layering?

Dealing with complex systems:

- explicit structure allows identification, relationship of complex system's pieces
  - layered reference model for discussion
- modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., change in gate procedure doesn't affect rest of system
- layering considered harmful?



# OSI Model for Networking Protocols





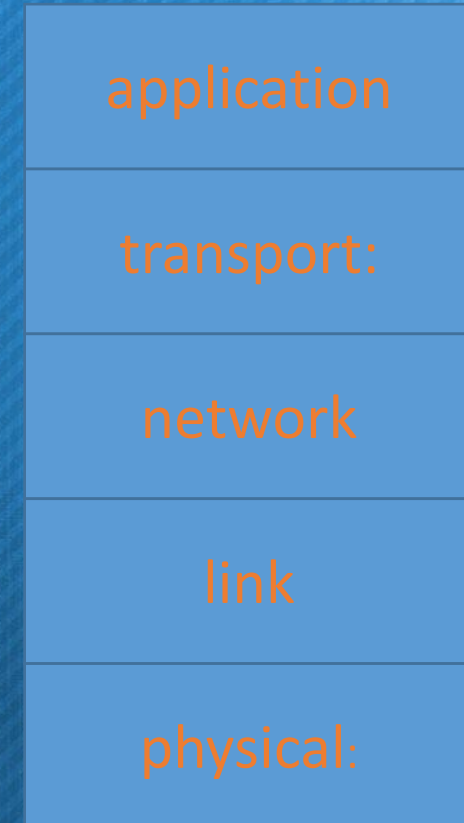
# Internet Protocol Stack

- Designed to be independent of the underlying physical medium,
- Any communications network, wired or wireless, that can carry two-way digital data can carry Internet traffic.
- Internet packets flow through wired networks like copper wire, coaxial cable, and fibre optic, and through wireless networks like Wi-Fi.
- Networks, sharing the same protocols,



# Internet Protocol Stack

- **application:** supporting network applications
  - FTP, SMTP, HTTP
- **transport:** host-host data transfer
  - TCP, UDP
- **network:** routing of datagrams from source to destination
  - IP, routing protocols
- **link:** data transfer between neighboring network elements
  - PPP, Ethernet
- **physical:** bits "on the wire"





# Internet Protocol Stack – 3 Layers

Reduced to 3 layers:

- Layer 1 – network protocols:

- IP (Internet Protocol)

- Layer 2 – transport protocols:

- TCP (Transmission Control Protocol), and

- UDP (User Datagram Protocol)

- Layer 3 - Application protocols

- DNS, POP3, IMAP, SMTP, HTTP, HTTPS and FTP.

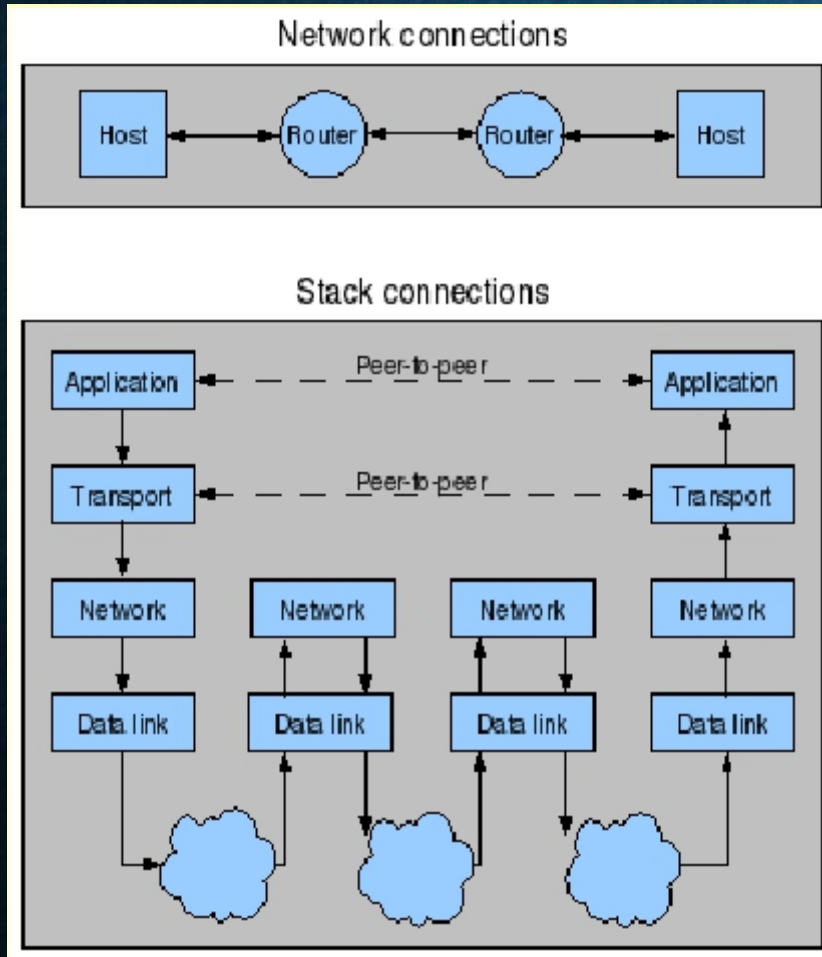


# Internet Protocol Stack - TCP and UDP

- The protocols by which one host sends data to another;
- TCP makes a virtual 'connection', which gives some level of guarantee of reliability; and
- UDP is a best-effort, connectionless transport, in which data packets that are lost in transit will not be re-sent.



# Internet Protocol Stack - Structure



- Layer 4 - Application - DNS, TFTP, TLS/SSL, FTP, HTTP, IMAP, IRC, NNTP, POP3, SIP, SMTP, SNMP, SSH, TELNET, ECHO, BitTorrent, RTP, PNRP, rlogin, ENRP, ...
- Layer 3 - Transport - TCP, UDP, DCCP, SCTP, IL, RUDP, ...
- Layer 2 - Network - IP (IPv4, IPv6)
- Layer 1 – Data Link - Ethernet, Wi-Fi, Token ring, PPP, SLIP, FDDI, ATM, Frame Relay, SMDS, ...



# Application Protocols

- This defines the specific messages and data formats sent and understood by the applications running at each end of the communication.
- Internet protocol suite:
  - most-used application protocols are: DNS, POP3, IMAP, SMTP, HTTP, HTTPS and FTP.



# Common Internet Protocols: HTTP

➤ Most widely used internet protocols:

➤ DNS,

➤ POP3,

➤ IMAP,

➤ SMTP,

➤ HTTP,

➤ HTTPS and

➤ FTP.



# Summary

## ➤ Internet Protocols:

- IP – internet protocol
- Application Protocols
- TCP and UDP
- Internet Protocol Suite/Stack
- The OSI Model

## ➤ Widely Used Internet Protocols:

- HTTP, FTP, POP, SMTP, IMAP, SSH, VoIP