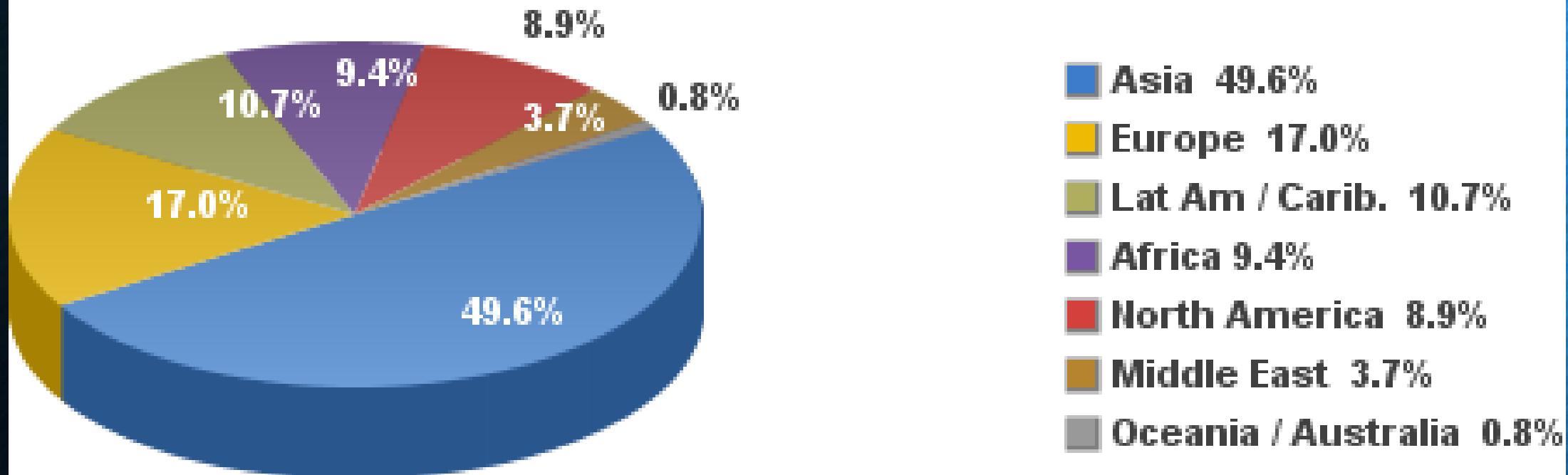


Internet: Architecture and The Internet Protocol Suite

Some Facts

Internet Users in the World by Regions June 2016



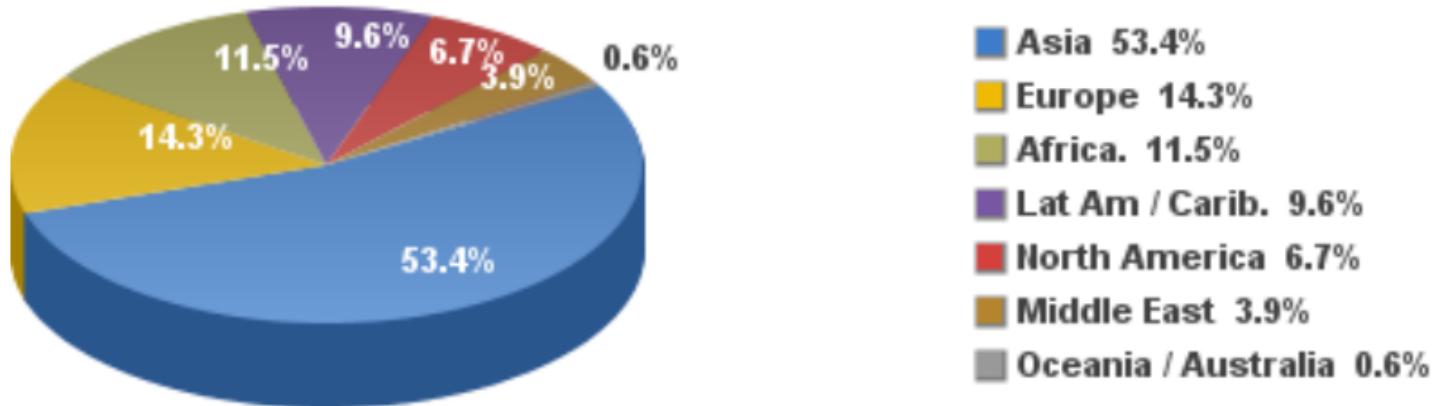
Source: Internet World Stats - www.internetworldstats.com/stats.htm

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

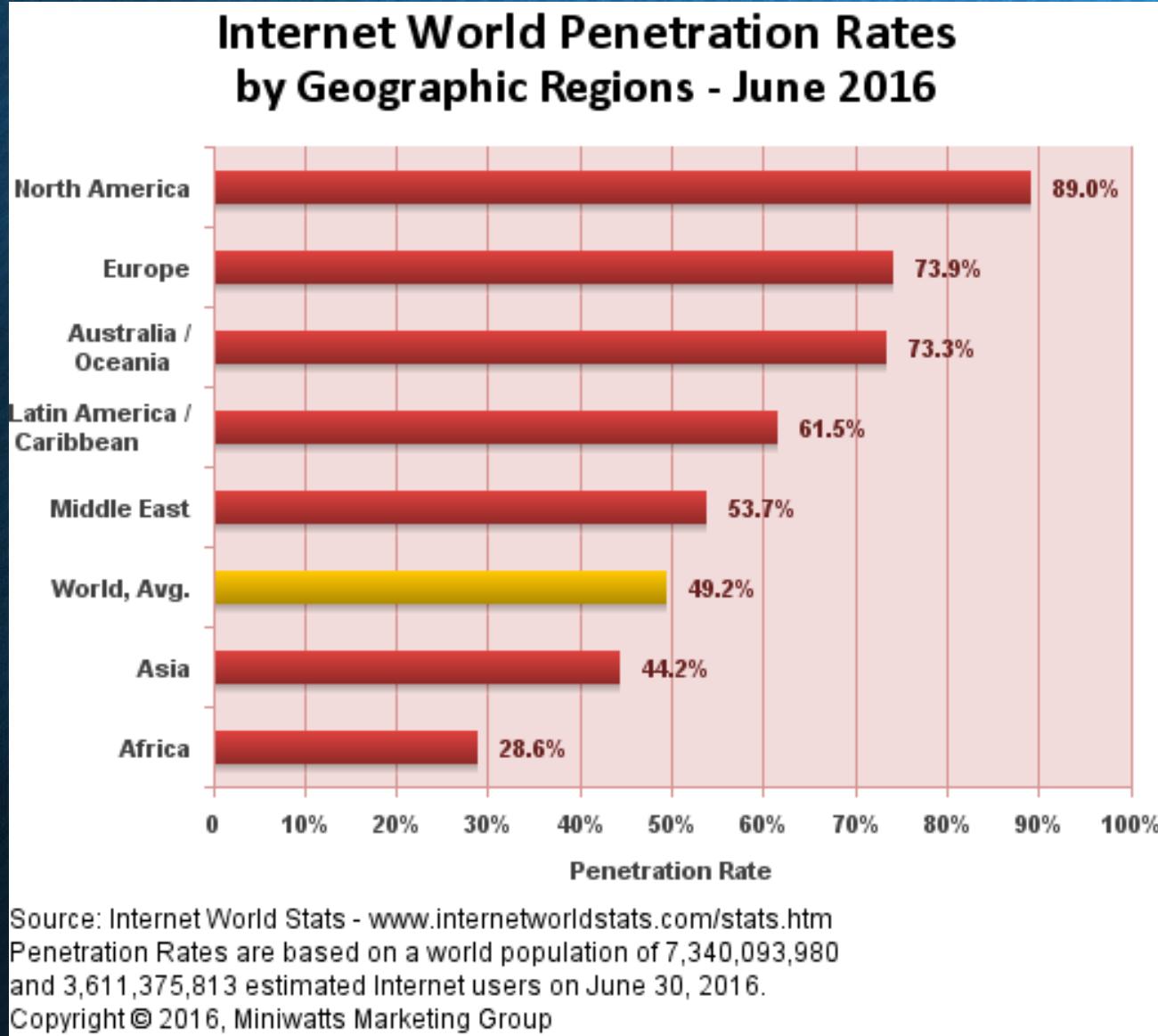
Basis: 5,168,780,607 Internet users in March 31, 2021

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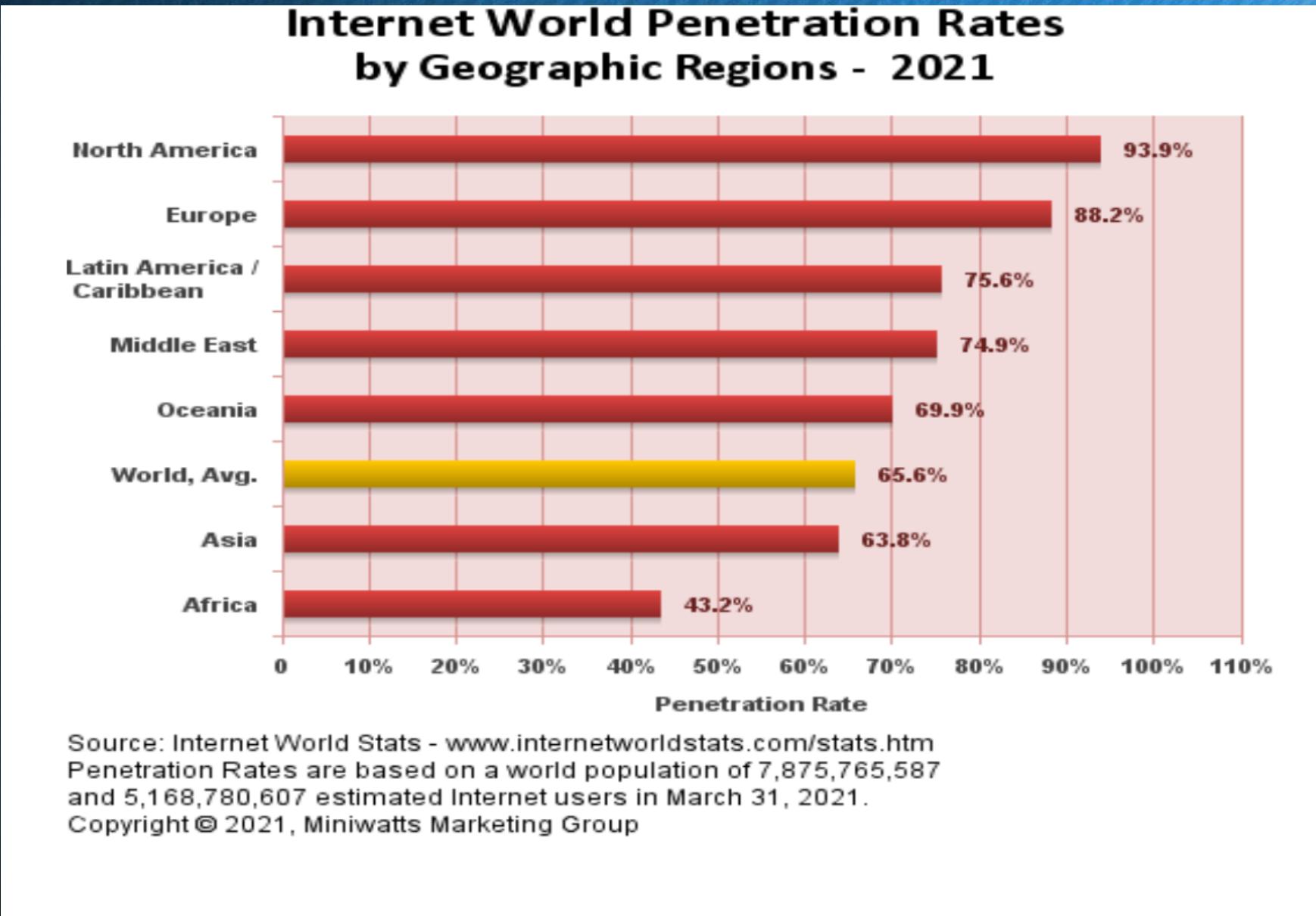
INTERNET USAGE STATISTICS The Internet Big Picture

World Internet Users and 2021 Population Stats

Some Facts



Some Facts



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

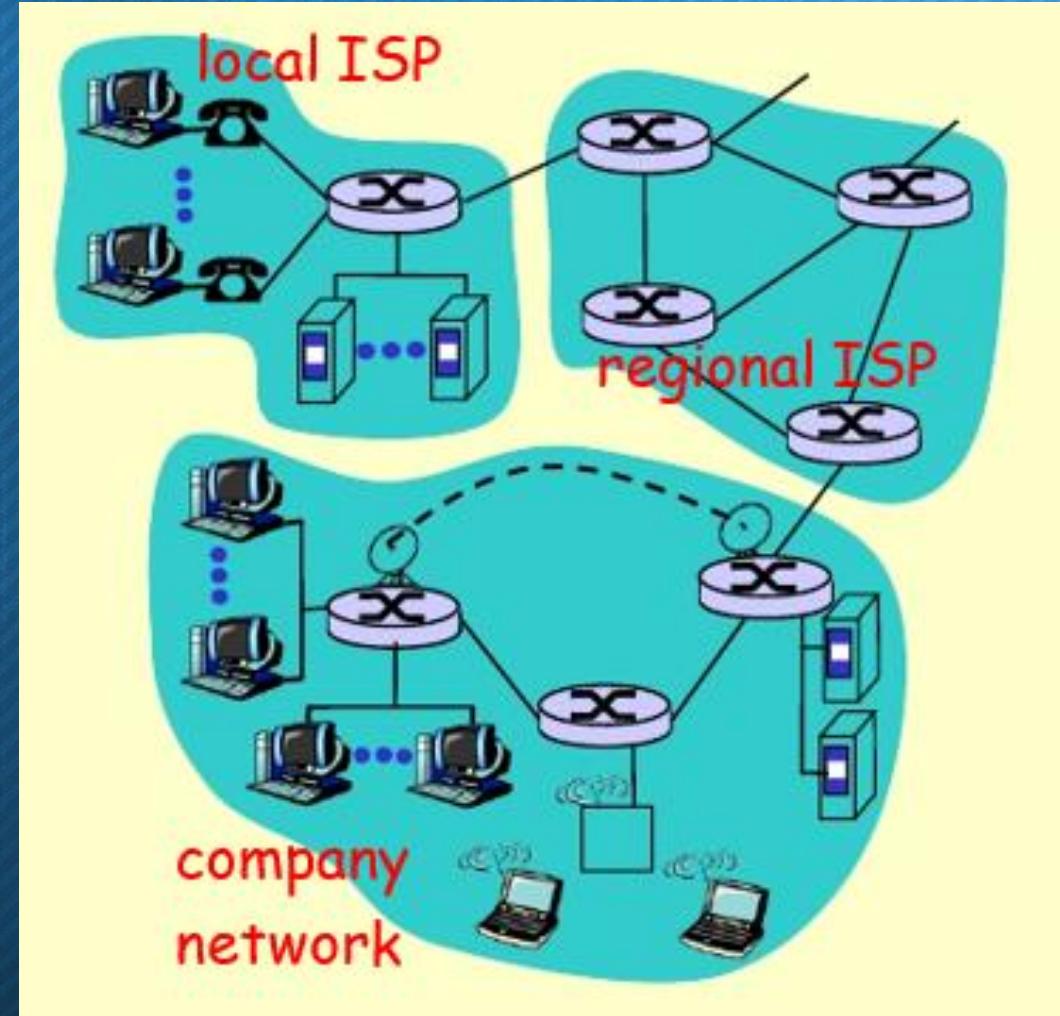
- The Internet: Structure & Service Views
- What is a Protocol?
- The Internet Protocol (IP)
- Protocol Layers & the OSI Model
- The Internet Protocol Stack
- TCP & UDP
- Application Protocols
- Summary

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)?

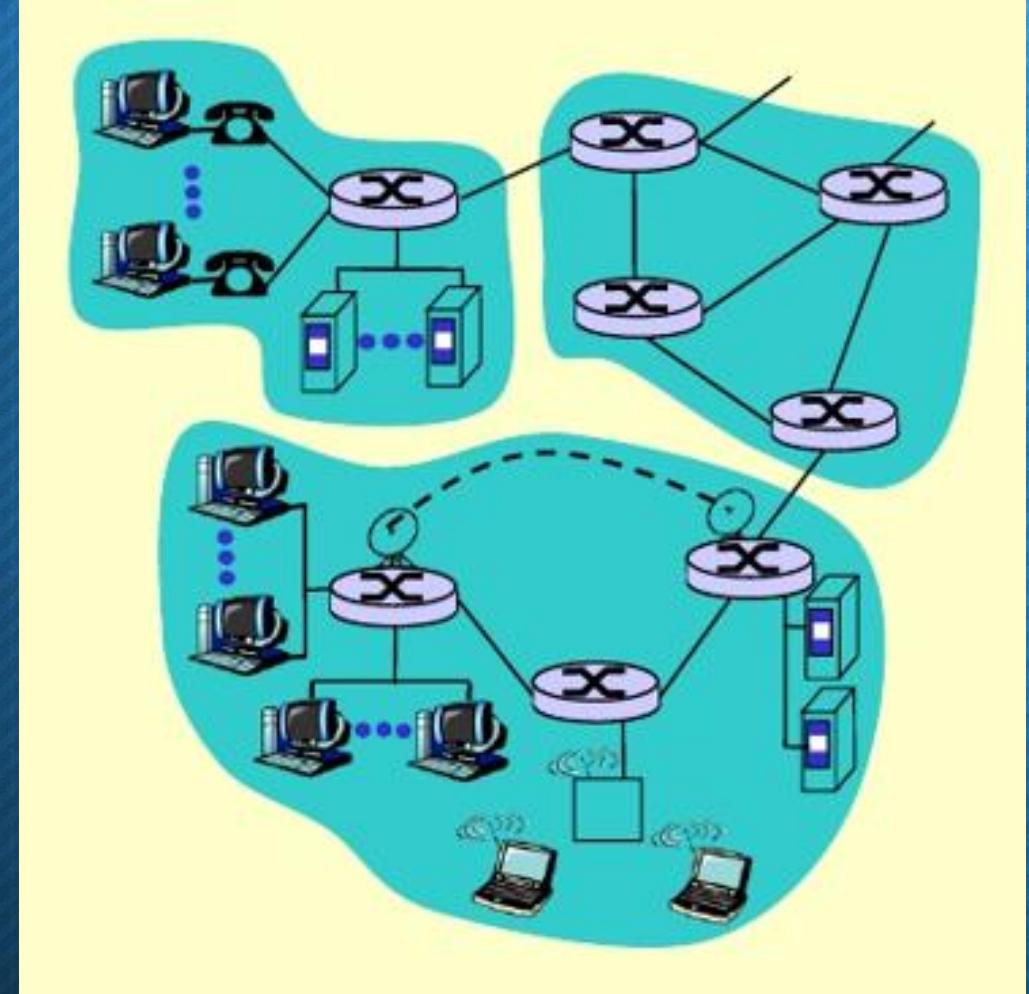
What's the Internet: "nuts and bolts" view

- 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

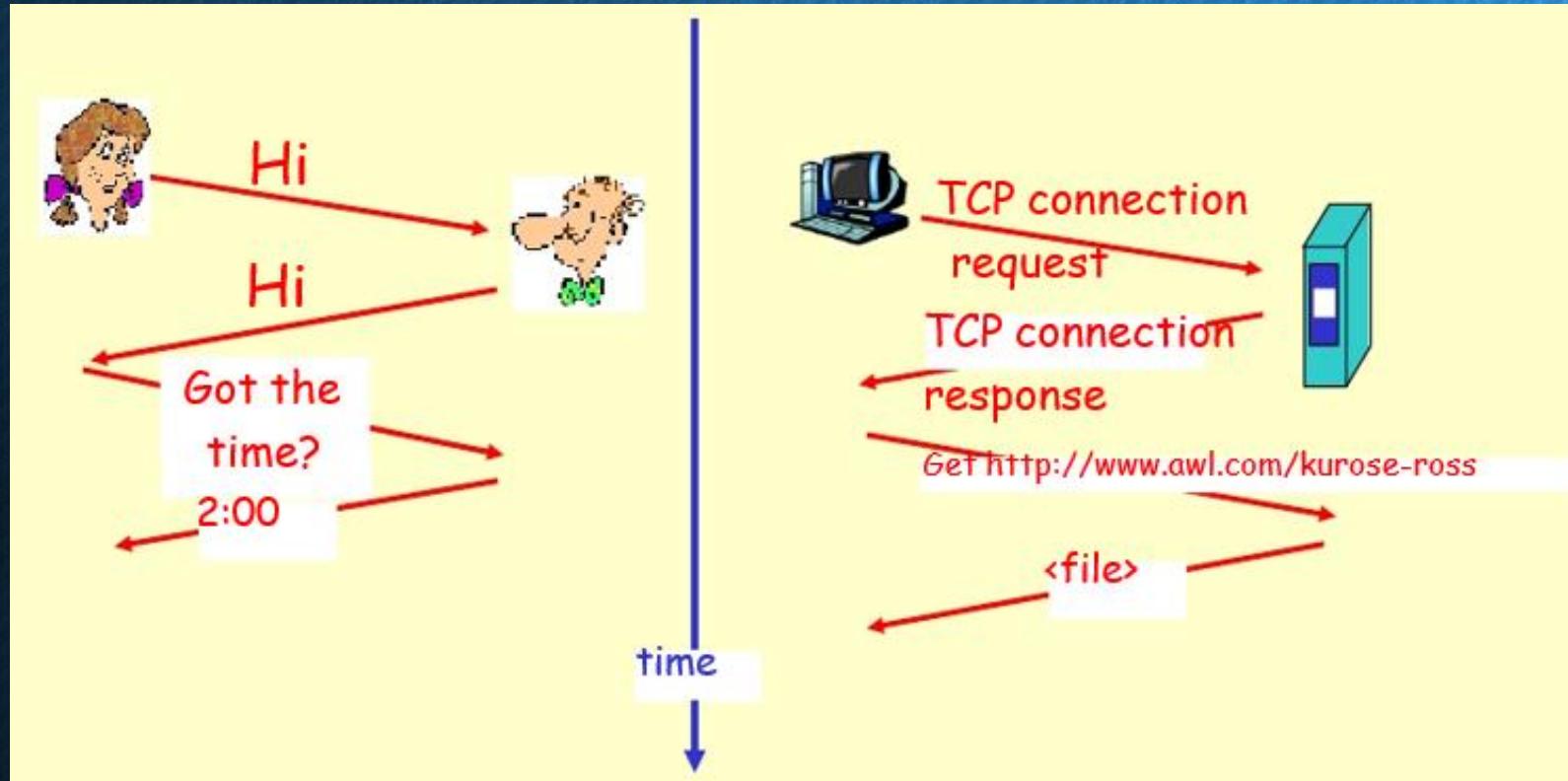
network protocols:

- 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)

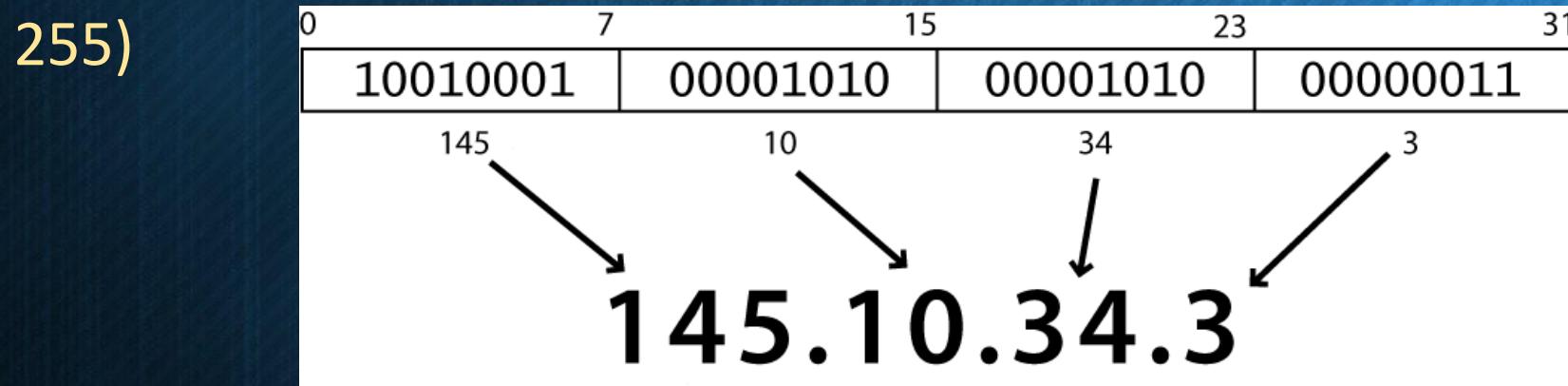
- IP is the network layer
- packet delivery service (host-to-host).
- translation between different data-link protocols.
- IP addresses are logical addresses (not physical)
- 32 bits.
- Includes a network ID and a host ID.
- Every host must have a unique IP address.
- IP addresses are assigned by a central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

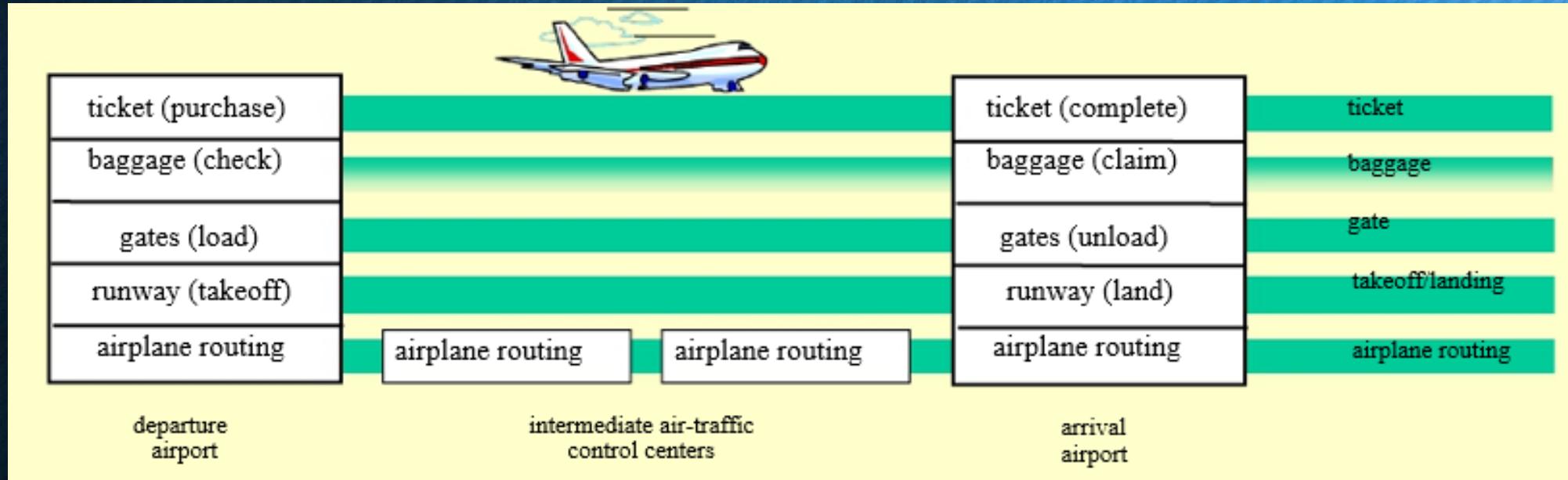
ticket (purchase)
baggage (check)
gates (load)
runway takeoff
airplane routing

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

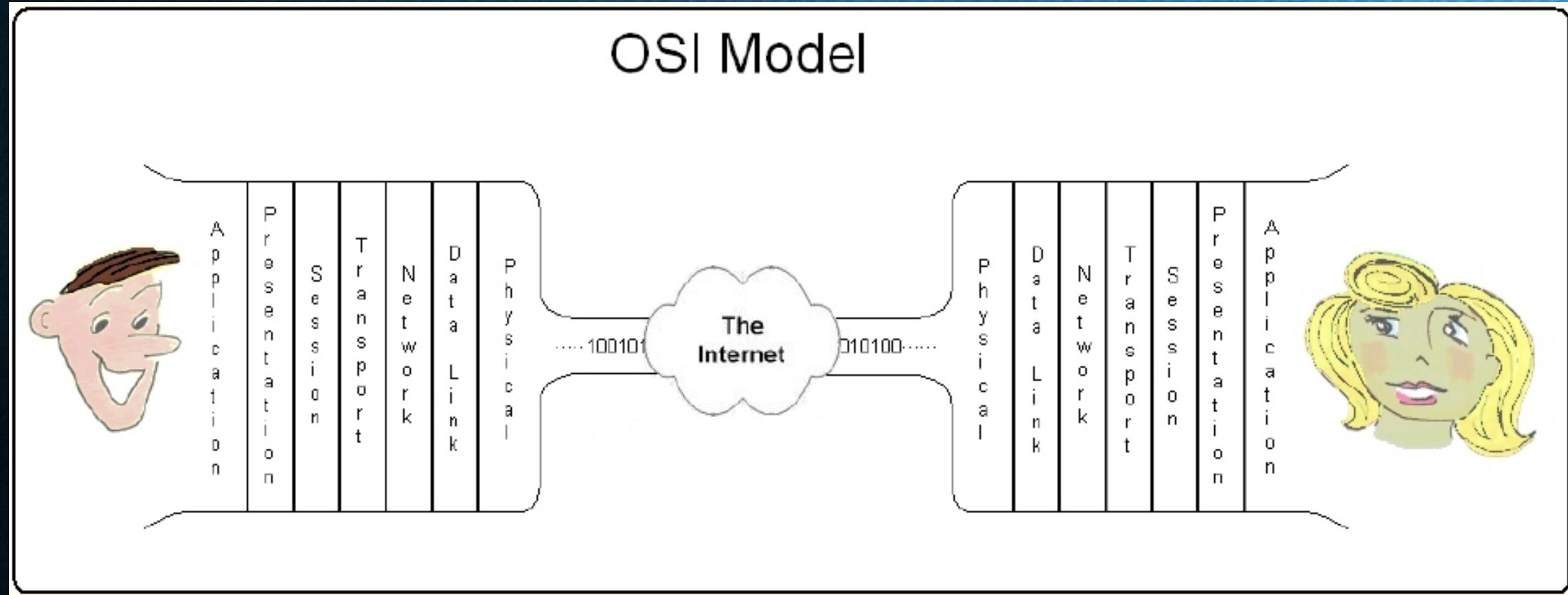
➤ relying on services provided by layer below

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

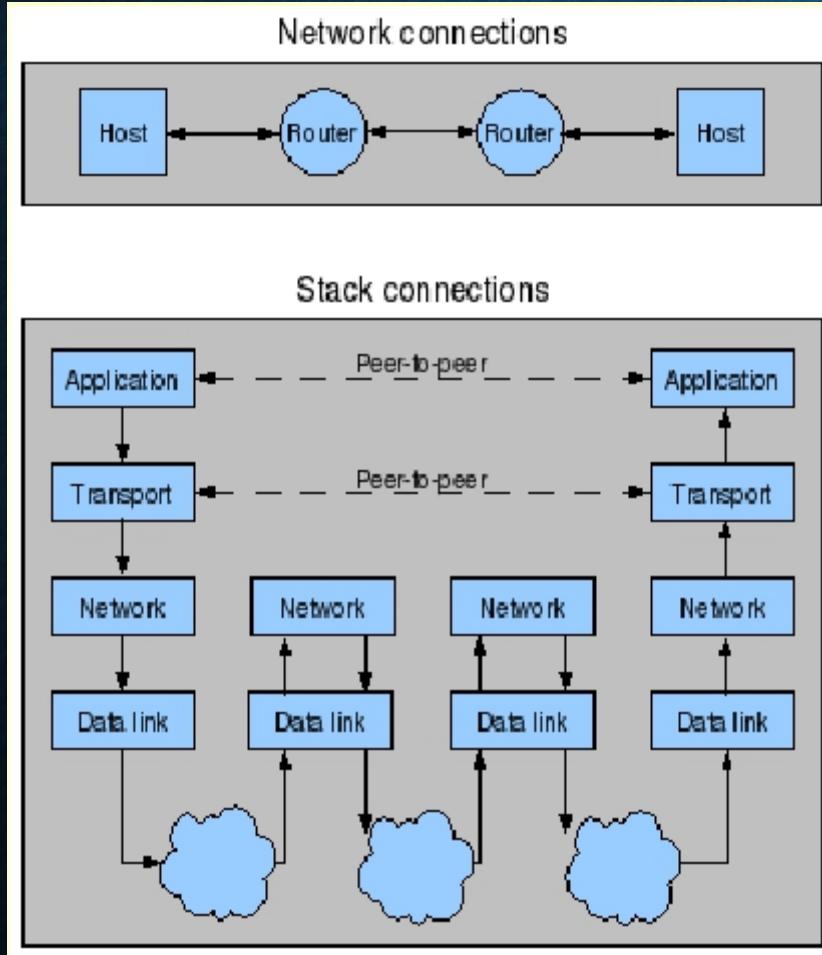
Reduced to 3 layers:

- 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