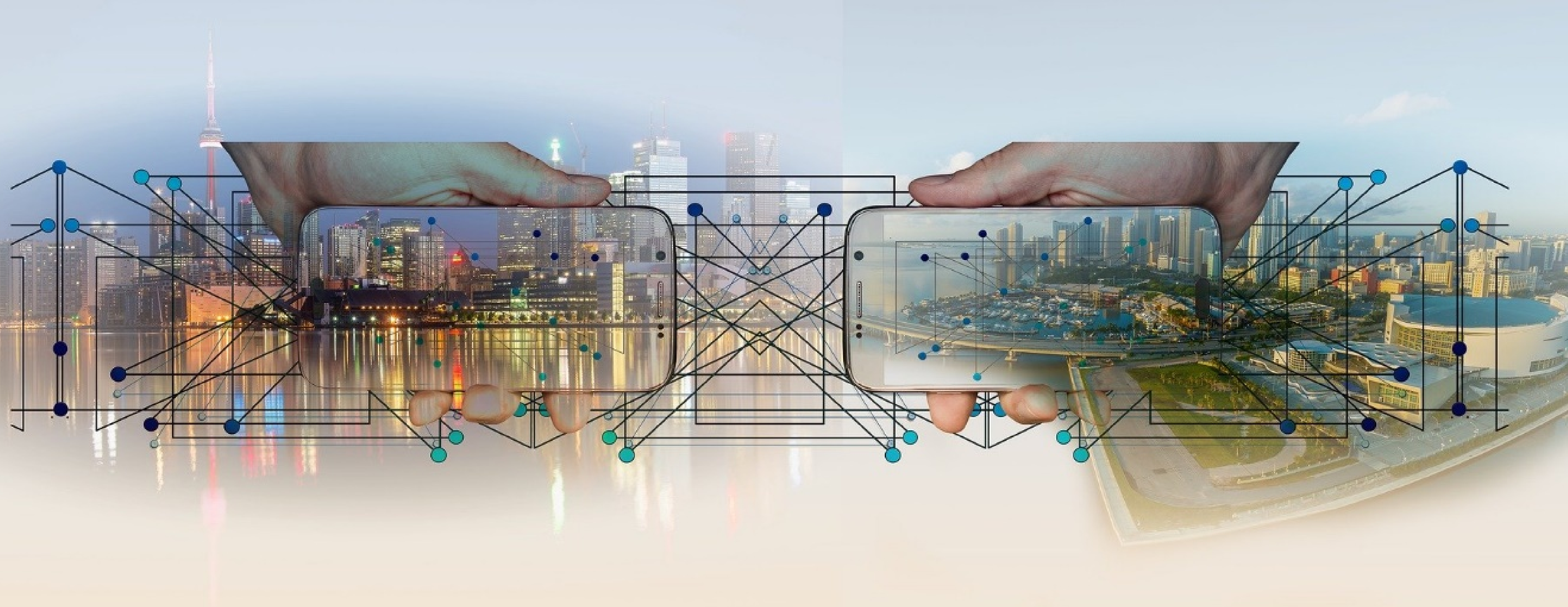
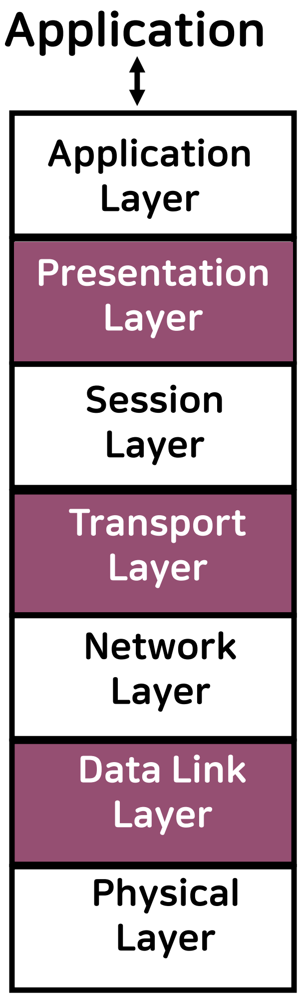
Lecture 1
Review of Computer Network Fundamentals



What is Computer Networks?

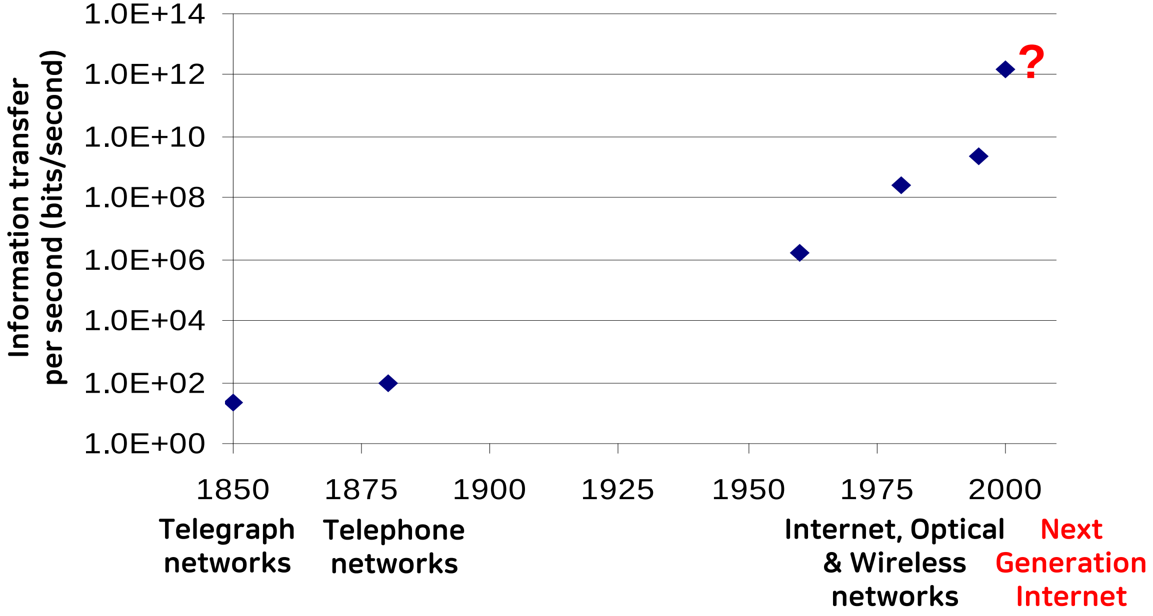
- A collection of autonomous computers interconnected by a single or multiple technologies
  - Interconnected via:
    - Copper wire
    - Fiber optics
    - Microwaves
    - Infrared
    - Communication satellites, etc.

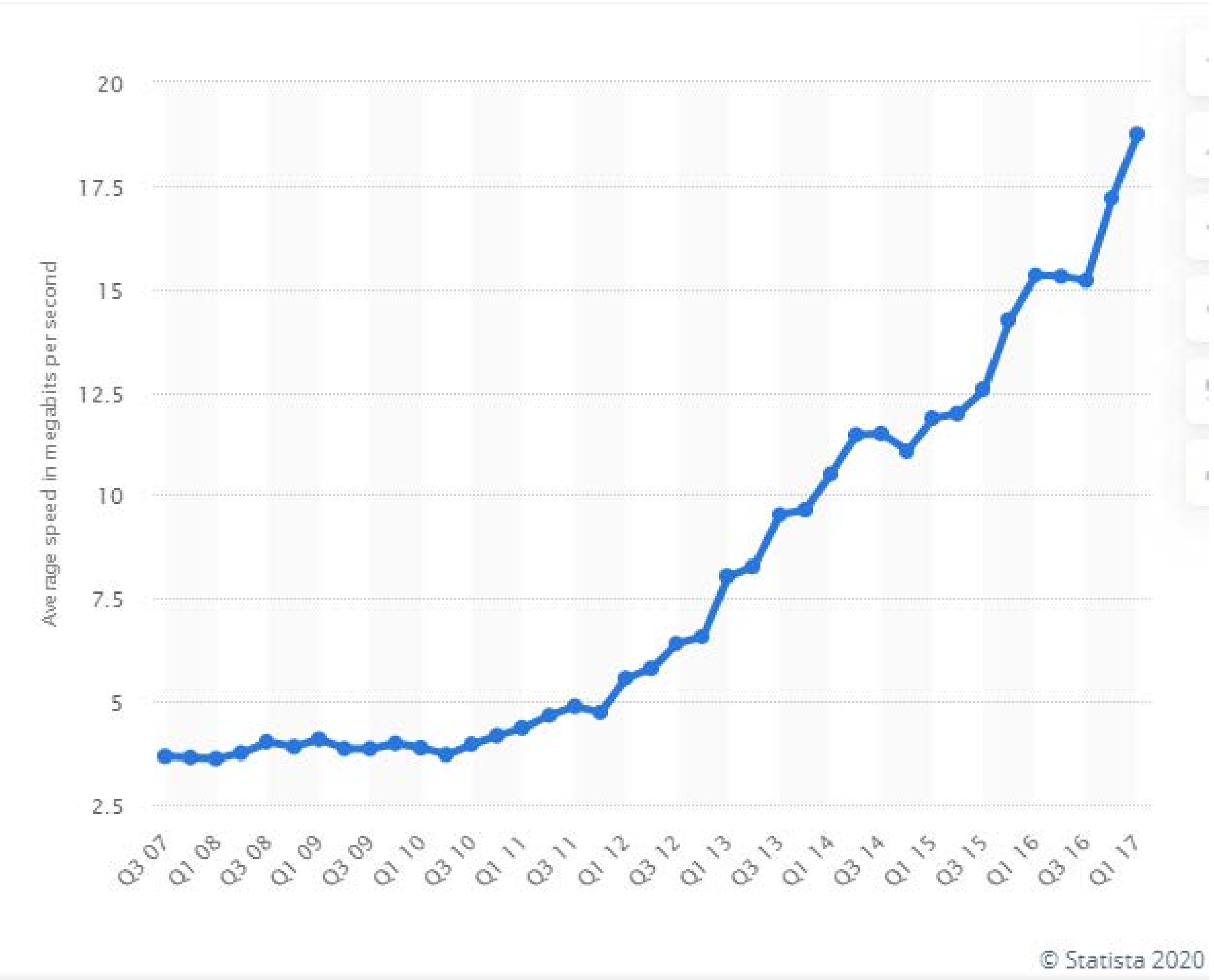
OSI Reference Model & TCP/IP Protocol Stack



OSI Reference Model & TCP/IP Protocol Stack

Network Architecture Evolution





[Source] https://www.statista.com/statistics/616210/average-internet-connection-speed-in-the-us/
https://ourworldindata.org/internet

Classification of interconnected processors by scale.

<table>
<tr><th>Interprocessor distance</th><th>Processors located in same</th><th>Example</th></tr>
<tr><td>1 m</td><td>Square meter</td><td>Personal area network</td></tr>
<tr><td>10 m</td><td>Room</td><td rowspan="3">Local area network</td></tr>
<tr><td>100 m</td><td>Building</td></tr>
<tr><td>1 km</td><td>Campus</td></tr>
<tr><td>10 km</td><td>City</td><td>Metropolitan area network</td></tr>
<tr><td>100 km</td><td>Country</td><td rowspan="2">Wide area network</td></tr>
<tr><td>1000 km</td><td>Continent</td></tr>
<tr><td>10,000 km</td><td>Planet</td><td>The Internet</td></tr>
</table>

Metric Units

Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	Kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	Mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	Giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	Tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	Peta
10^{-18}	0.0000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	Exa
10^{-21}	0.0000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	Zetta
10^{-24}	0.0000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	Yotta

The principal metric prefixes.

IP Addresses

- An IP Packet can be sent to
  - A single workstation (unicast)
    - Efficient for data between pairs of addresses
  - A specific list of workstations (multicast)
    - Efficient for specific groups, but must specify all individual workstations IP addresses
  - All stations on a network (broadcast)
    - Efficient for large (unknown) group – use special broadcast IP address.
- IP addresses have a special broadcast address
- Class .vs. Classless Addressing.
- Internet Assigned Numbers Authority (IANA)

IP Address Ranges, Or "Classes"

From:	To:	Description
1.x.x.x	126.x.x.x	Class A license
127.x.x.x	127.x.x.x	Loop back
128.x.x.x	191.x.x.x	Class B license (172.16 thru 31. 0. 0 reserved for private addresses)
192.x.x.x	223.x.x.x	Class C license (192. 168. x. 0 reserved for private addresses)
224.0.0.0	224.0.0.255	Multicast: Reserved Link Local Addresses
224.0.1.0	238.255.255.255	Multicast: Globally Scoped Addresses
239.0.0.0	239.255.255.255	Multicast: Limited Scope Addresses
240.x.x.x	255.255.255.254	Experimental
255.255.255.255		Broadcast

IP Addressing and Subnetting

"Anding" a Binary Subnet Mask

10001001001011010110100010101100

11111111111111111111111100000000

10001001001011010110100000000000

subnet ID = (137.45.104.0)

Recap: Network Classes

- IANA (Internet Assigned Numbers Authority)
- Class A
  - IP address := <8bits>.<24bits>
  - 16 Million hosts in a class A network domain
- Class B
  - IP address = <16bits>.<16bits>
  - 65534 hosts in a class B network domain
- Class C
  - IP address = <24bits>.<8bits>
  - 256 hosts in a class C network domain

→ Waste of Address Range~!

Note on Classful vs. Classless

- Note that, in classful subnetting, we lose quite a few blocks of addresses.
- RFC 1519 (Classless Inter-Domain Routing = CIDR) was introduced in 1993 to deal with rapid depletion of IP address space due to “Classful Fragmentation”
- Problem:
  - Given the entire internet was “classful” in 1993, how to transition to classless methods?
  - What exactly is the impact to internet protocols (in all the millions of devices and hosts) of such a change?

Routable and Nonroutable Addresses

- Nonroutable Address [RFC 1918]
  - Internet Router ignore the following addresses.
    - 10.0.0.0 – 10.255.255.255
    - 172.16.0.0 – 172.31.255.255
    - 192.168.0.0 – 192.168.255.255
  - Millions of networks can exist with the same nonroutable address.
  - "Intranet" : Internal Internet
  - NAT (Network Address Translation) router
  - Side benefit : "Security"

VLSM (Variable Length Subnet Masking)

- Can support variable length of subnet id in a single domain
- How?
  - Decide the necessary number of bits for a host id first
  - Then, get the number of bits for a subnet id

VLSM: Sample Question

- [Given] IP Addr 192.3.4.0/24
  - AtlantaHQ: 58 hosts
  - PerthHQ: 26 hosts
  - SydneyHQ: 10 hosts
  - CorpusHQ:10 hosts
  - WAN1: 2 IP addresses
  - WAN2: 2 IP addresses
  - WAN3: 2 IP addresses

➔Give a subnet address, an address range, a broadcast address, and a network prefix

Reference: Cisco Network Fundamental course

Standards

- New technologies very costly and risky
- Standards allow players to share risk and benefits of a new market
  - Reduced cost of entry
  - Interoperability and network effect
  - Compete on innovation
  - Completing the value chain
    - Chips, systems, equipment vendors, service providers
- Example
  - 802.11 wireless LAN products

Standards Bodies

- Internet Engineering Task Force
  - Internet standards development
  - Request for Comments (RFCs): www.ietf.org
- International Telecommunications Union
  - International telecom standards
- IEEE 802 Committee
  - Local area and metropolitan area network standards
  - https://en.wikipedia.org/wiki/IEEE_802
- Industry Organizations
  - MPLS Forum, WiFi Alliance, World Wide Web Consortium