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CS 542

Assignment 1

1) The question asked in class was, "What is today's broadband lines per 100 people, per country?"

Data from *The World Bank* on 24 Jan 2019 shows (see full document attached):

Country Name	**Broadband Subscribers per 100 people in 2017**
Gibraltar	50.2531023
Monaco	49.768704
Switzerland	45.4223422
Andorra	44.544923
France	43.7506891
Denmark	43.1736284
Netherlands	42.3269913
Malta	42.0852531
Korea, Rep.	41.5751243
Germany	40.4521877

2) Access Network Technologies Available Today:
   a. Wired Broadband Technologies
      i. Copper Wires or Twisted Pair (used in xDSL-type connections)
      ii. Coaxial Cable (used for cable TV networks)
      iii. Broadband Over Power Line (BPL)
         1. Broadband delivered through low-medium power networks
         2. Speeds similar to xDSL and coaxial cables.
      iv. Fiberoptic Cables (FTTX or fiber-to-the-whatever)
         1. Glass fibers offering transmission rates up to 100Gbps within 10-60km but has high cost and is fragile.
   b. Wireless Broadband Technologies
      i. Antenna sites (Terrestrial broadband connectivity) with commercial applications below:
         1. WiMAX (Worldwide Interoperability for Microwave Access)
            a. up to 60km efficiency
         2. Wi-Fi (Wireless Fidelity)
            a. up to 300m efficiency
         3. 4G/LTE/LTE$^+$ (Long-Term Evolution)
            a. up to 3-6km efficiency
            b. There are various types of networks like 2G/H, 3G/H$^+$, etc. that use varying frequencies and have varying transmission rates.
         4. Satellite Broadband (internet via satellite for bi-directional comms.)
            a. End customer sends and receives data via a satellite dish
            b. Bandwidth depends on number of users, high signal latency, but costs less and does not require area networks
   c. Upcoming Broadband Technologies
      i. 5G Converged Networks (10Gbps)

ii. Low Earth Orbit Satellites delivering LTE, 3G, and Wi-Fi to areas
iii. Li-Fi (Light Fidelity, 224 Gbps) is very cheap and fast, but requires lots of conditions to ensure effectiveness like short distance

3) Internet Architecture
   a. Internet infrastructure

The internet is broken down into several levels. From the top-down, we start with NSPs (Network Service Providers) like IBM, SprintNet, etc. These connect to NAPs (Network Access Points) or MAEs (Metropolitan Area Exchanges) which interconnect NSPs. NAPs and MAEs are also called IXPs or Internet Exchange Points (where MAEs are privately owned). These NSPs all have Regional ISPs under them which connect to local ISPs or regional networks, and finally, access networks to the end customer.

   b. Information Routing

The internet creates pathways for data via routers or packet switches. Each router knows IP address under it. Routers receive information and checks the IP addresses before checking its Routing Table and forwarding the data. IP is used for routing packet data, while protocols like TCP are used to rout data to proper applications on a destination computer. IP headers are added to a segment after TCP establishes a connection (via a 3-way handshake or similar).

   c. Domain Names

When we search things on Google or send emails to a friend or skype call someone, odds are, we are not typing in their IP address. The reason why is because on the Domain Name Service (DNS). DNSs keep track of IP information. For instance, if you type **ping google.com** in Shell, shell may ping 172.217.9.78. The DNS is what resolves this IP address into a web address like google.com.

4) T-Mobile One Plan Information

I currently have an internet package with T-Mobile called the “T-Mobile One T” Plan. This plan lists 4G\LTE connection for what seems to be around 20 GB. This “4G\LTE” data rate is reliably around the 16.89 Mbps in an article mentioned in Mashable or around the 2 MB/s I get on my device. After I use around 20 GB of data, my speed seems to slow to a minimum of 256kbps (3G), or pretty much twice as fast as dial up. Data speeds also seem to be dependent on network congestion as I have used 4GB of data before and only got 500-ish kbps of a download rate. 4G has a theoretical maximum of 150 Mbps download and 50 Mbps upload speeds. LTE-Advanced is at an even higher theoretical. In real world use, LTE is around 20 and 10 Mbps download and upload speeds, respectively. So essentially, I’m being ripped off $25/month due to the almost 25% loss in network efficiency and the data bottlecap.

5) CSW PSTN vs Packet-Switched Network

a. Circuit Switched Network (as a Public Switched Telephone Network (PSTN))

PSTNs have three phases: circuit connection, data transfer, and circuit disconnection. They can be multiplexed via frequency division (FDM) or time division (TDM). FDM lets each circuit for up to 24 connections in a DS-0 network use 1/24 of the bandwidth. TDM lets each circuit use 100% of the bandwidth for extremely short periods of time.

PSTNs are advantageous since they have dedicated, non-congestible connections that cannot be interrupted. PSTNs are disadvantageous today because of their high maintenance costs and international calling costs, are inefficient in use of the connection's capacity like when the line is silent, require higher network complexity, as all nodes must be connected in some way, physically, and have a slight initial delay when making calls. PSTNs also do not let you know when someone else has tried to call you if you are currently taking a call.

b. Packet Switched Network (for Internet use)

Packet switching occurs at the Network layer rather than the physical layer. Application data is segmented and then put into packets for IP transport, and then frames (if using the data link layer). Packets are sent through various networks and may arrive out of order or could be lost in data transmission.

Packet switched networks tend to be done for high-capacity links and have a scheme of advantages and disadvantages. Some advantages are that they have high efficiency as packets can be multiplexed and sent variably, the data rates between sender and receiver are not important as nodes in the network convert data rates, and for packet loss, data can be tracked and resent based on protocols used. Some disadvantages are that there are delays in packet processing at the node buffer as full packets must be processed before being sent to each node, there are large overhead amounts as packets are generally transmitted via a Datagram approach (where packets are independent and can arrive out of order), or a Virtual Circuit Approach, where packet order is preserved and follow the same (possibly congested) route. Packet-switched networks are also susceptible to a variety of cyber-attacks like DDoS and DNS flooding or ping-of-death for older networks.

6) Terminology

ISP – Internet service provider
    Tier 1 – Commercial ISP (like AT&T, IBM, etc.)
    Tier 2 – Regional ISP
    Tier 3 – "last hop" or local ISP
ISO – International Standard Organization
CDMA – Code-Division Multiple Access
LTE – Long-Term Evolution
WiFi – Wireless Fidelity
TCP – Transmission Control Protocol
IP – Internet Protocol
HTTP – Hypertext Transfer Protocol
RFC – Remote Function Call (req. for comments)
IETF – Internet Engineering Task Force
IEEE – Institute of Electrical and Electronics Engineers
VoIP – Voice-Over IP
CSW – Circuit-Switched (Network)

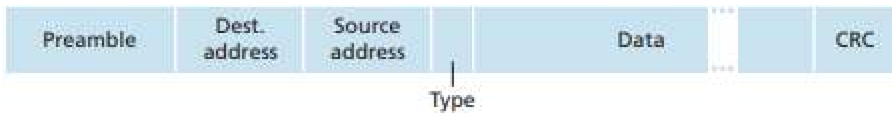
PSTN – Public-Switched Telephone Network
DS-0 – Digital Signal Zero (64kbps)
T-1 Channel – Terrestrial Carrier Channel 1 (24DS-0 or 1.544Mbps link)
FTTX – Fiber-to-the-wherever.
PON – Passive Optical Network (filters optical traffic)
AON – Active Optical Network (splits optical traffic)
LAN – Local Area Network
WAN – Wide Area Network
WLAN – Wireless Local Area Network
Packet Transmission Delay = $\frac{L\ (bits\ in\ packet)}{R\ (link\ bandwdth)}$
Pipelining – each link works in parallel
FDM – Frequency Division Multiplexing
TDM – Time Division Multiplexing
DSL – Digital Subscriber Line
IXP – Internet Exchange Points
NAP – Network Access Points
MAE – Metropolitan Area Exchanges (Privately owned NAPs)
REQ – Request Packet
ACK – Acknowledgement Packet
ALOHA – Additive Links On-Line Hawaii Area
MAC – Media Access Control
MTU – Maximum Transmission Unit
CRC – Cyclic Redundancy Check
HFC – Hybrid Fiber Coaxial (Network)

7) Ethernet and ALOHA Protocol

a. Ethernet Data Link Layer

Ethernet is commonly referred to in the sense of high-speed wired LANs. Ethernet at the data link layer provides a collision-less, store-and-forward packet switch operating through the network layer. This is analyzed through the *ethernet frame* in the reading.

Ethernet Frame:



The *ethernet frame* uses MAC addresses to filter out network data and pass it along the network layer. Mismatched addresses are discarded.

The *Data Field* is 46 to 1500 bytes and has the IP datagram. The *source* and *destination addresses* (6 bytes each) contain the MAC addresses of the adapters on the LAN.

The *type* field (2 bytes) allows frames to have multiplexed protocols like IP and TCP, UDP, ASV, etc. together.

The *CRC* field (4 bytes) allows adapters to check for errors in the frame.

The *Preamble* (8 bytes) syncs the clock of the receiver to the adapter by using standard values.

b. ALOHA Random Access

ALOHA (Additive Links On-Line Hawaii Area) Random Access Protocol allows all nodes in a network to be given the same priority and transmit frames over a shared channel as it receives it. *Pure ALOHA* considers frame collision by destroying overlapping frames. Each frame is transmitted on a shared channel and gets an ACK. If no ACK is received after a time-out period *J*, then the node receives a Dropped ACK and the node waits some random amount of time (that is not J) before retransmitting. If retransmission fails, then the node quits. *Slotted ALOHA* uses time division to transmit frames over a shared channel. Nodes transmit frames at the beginning of each standardized time slot. If a collision occurs in *Slotted ALOHA*, then the node waits for *k* slots until the next free slot to retransmit.

8) Physical Media

Bit – propagates between transmitter/receiver pairs (8 bits = 1 byte)
Physical link – the mediums between the transmitter/receiver pairs
Twisted Pair – pair(s) of insulated copper wires (category 5 = 0.1-1Gbps ethernet, category 6 = 10 Gbps)
Coaxial Cable – two concentric copper conductors that carry broadband content
Fiberoptic cables – Glass fibers offering transmission rates up to 100Gbps within 10-60km
Terrestrial Microwave – up to 45 Mbps channels
LAN – up to 1Gbps Wireless
WAN – 3G/4G/5G, up to 150 Mbps (theoretical) for 4G
Satellite – up to 45 Mbps channel and 0.27s latency (depends on congestion)

Works Cited

"Difference Between Circuit Switching and Packet Switching." *TechDifferences*, TechDifferences, 22 Aug. 2016, techdifferences.com/difference-between-circuit-switching-and-packet-switching.html .

"Fixed Broadband Subscriptions (per 100 People)." *The World Bank*, International Telecommunication Union, 24 Jan. 2019, data.worldbank.org/indicator/IT.NET.BBND.P2?year_high_desc=true.

Gupta, Jyoti. "What Is Aloha in Networking?" *Quora*, Quora, 11 Mar. 2017, www.quora.com/What-is-Aloha-in-networking.

Nvaliuda. "Broadband Technologies." *The European Commission*, European Union, 10 Jan. 2019, ec.europa.eu/digital-single-market/en/broadband-technologies#%22%20name=.

"Packet-Switched vs. Circuit-Switched Telephone Systems." *Expert Market*, Marketing VF, www.expertmarket.co.uk/telephones/what-is-circuit-switched-packet-telephone-system.

Shuler, Rus. "How Does the Internet Work?" *Pomeroy IT Solutions*, Stanford University, 2002, web.stanford.edu/class/msande91si/www-spr04/readings/week1/InternetWhitepaper.htm.

"Switched Local Area Networks." *Computer Networking: a Top-down Approach*, by James F. Kurose and Keith W. Ross, Pearson, 2017, pp. 469–476.

Wong, Raymond. "T-Mobile Finally Beats Verizon to Become Fastest 4G LTE Network in U.S." *Mashable*, Mashable, 22 Jan. 2018, mashable.com/2018/01/22/tmobile-rules-opensignal-report-2018/#.wLz.NRWhkqZ.