Understanding Networks

IT4GIS

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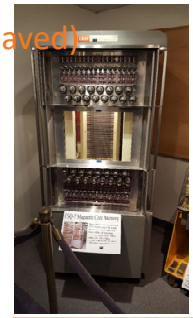
Once Data is Created (saved)

- Someone will want a copy (sharing)
  - BTW, this entire refrigerator-sized memory bank stored 4KB of data
  - That's 0.000004 GB



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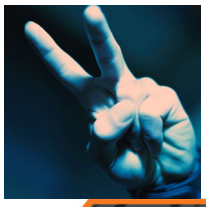
Why is Networking Important?

- GIS has always been *cursed* with the need to use large files
- GIS'ers have always acted as a community
- **Sharing is normal**



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How to Facilitate Sharing…

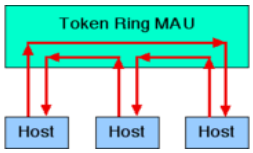
- Floppy disks
- Bernoulli disks
- Zip disks
- Jazz disks

In the beginning…

- There were floppy disks
- And the "Sneaker Net"

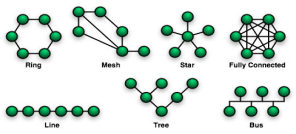
Then along came…

- Networks
  - Cabling that allowed computers to connect to one another
  - Token ring
    - Developed by IBM
    - Using coaxial cable
  - And then…

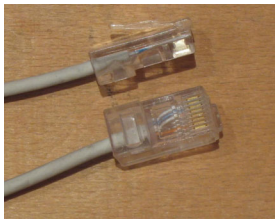


Ethernet

- Developed by Xerox
- Uses Star-topology
- And twisted pair cabling



Cabling



- Twisted pair cabling can be either unshielded (UTP) or,
- Shielded
- IT4GIS will focus on UTP

Capabilities

- Ethernet is described by its **data rate** and **range**
- For instance:
  - 10Base-2
    - 10 (data rate, 10Mb/s)
    - Base (base band)
    - 2 (range, 200 meter runs)
  - 10GBase-T

Ethernet and GIS

- Data rates are 10, 100, 1000, and 10000
  - 10 = 10 Mb/s: Cat 3 cabling
  - 100 = 100 Mb/s, called Fast Ethernet: Uses Cat 5
  - **1000 = 1 Gb/s: Uses Cat 5E**
  - **10000 = 10 Gb/s: Uses Cat 6 and Cat 6a**

Gigabit Ethernet

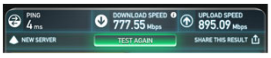
- Data rates of 1, 10, 40, or 100 Gbps
- **1 Gbps is supported by Cat5E cabling**
  - **A good GIS workstation option**
  - **Gigabit to the desktop**
- 10 Gbps supported by Cat 6a cabling
- Cat7 runs at 10 Gbps (shielded only (STP))
- Cat8 is capable of 40 Gbps (STP)
- 100 Gbps requires fiber optic cabling

Comparing Ethernet

Category	Standard Bandwidth	Max Data Rate	Shielding
Cat5e	100MHz (up to 350)	1000Mbps	UTP or STP
Cat6	250MHz (up to 550)	1000Mbps	UTP or STP
Cat6A	500MHz (up to 550)	10Gbps	UTP or STP
Cat7	600MHz	10Gbps	Shielded only
Cat8	2000MHz	25Gbps or 40Gbps	Shielded only

Quantifying Data Rate

- Think of Data Rate (Gbps or Mbps) as describing the highway speed limit
- To measure the actual speed messages are travelling is best described by **PING** (measured in milliseconds (*ms*))
- Think of Ping as describing *your* car's speed on the highway
- Download and Upload (data rate) may be very different



- Try it out at home using http://www.speedtest.net/

Understanding Data Rate

- Your data (packet) will travel only as fast as the slowest **component** between the source and destination!

Do Some Math!

- 1 giga**bit** / second = 125 mega**bytes** / second
  - 100 GB file = 100,000 MB
  - 800 seconds (100,000 / 125)~ 13 minutes
- This is under **ideal** conditions
  - No other traffic on your network
  - You are **allowed** to saturate the network
  - One file with a single open and close operation
  - 100, 1 GB files will transfer much slower due to I/O traffic (open and close for each file)

Orders of Magnitude

Ethernet and GIS

- Ranges are 2, 5, T
  - 2 = ~ 200 m
  - 5 = ~ 500 m
  - T = well… (for Cat 6/6a, T is about 100 m)
    - It stands for twisted pair. Cable testing tools will determine how long a run can be and still pass "characteristics" test (based on standards)
    - Runs as long as 150 m can be used (Cat 5e).

What's Next…

- Wi-Fi (wireless-fidelity)
- Developed by Cisco, 3Com, Lucent, Nokia, and others
- Specs are described under the IEEE 802.11 group.

A Look at 802.11

https://www.signalboosters.com/blog/ieee-802.11-standards-explained-802.11abgnacax/

- *Achievable throughput*
- How do these compare for GIS???

Advantages/Limitations of Wi-Fi for GIS

Brain-storm

- **Advantages**
  - No cabling
  - Fairly inexpensive
- **Disadvantages**
  - Security
  - Traffic can congest at the 2.4 Ghz frequency
  - Size of transmission (shared bandwidth)

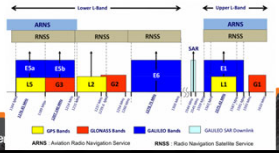
What About Cellular?

- Wi-fi is NOT the same as Cellular
  - 4G LTE
  - 5G (0.5 Gbps)
  - 6G (100 Gbps???)

Interference

- Broadband cellular networks (5G and 6G) use the same parts of the electromagnetic spectrum as GNSS

	Lower End (GHz)	Upper End (GHz)
GNSS	1.16	1.61
5G (low-band)	0.60	1.00
5G (mid-band)	1.00	6.00



Which Takes Precedence?

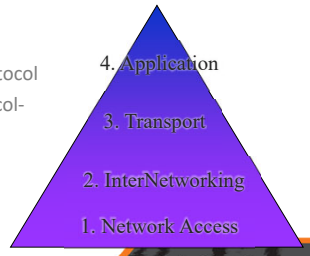
- GNSS
- Broadband cellular
- **What do you think?**

Getting Data from Here to There

- Recap…
  - We know something about the history of networks
  - We know about current Ethernet, Fast Ethernet, and Gigabit Ethernet technologies
  - We know about Wi-Fi capabilities
  - We know something about broadband cellular
- These are the *Data Link* and *Physical* Layers, referred to as the *Network Access* Layer.
- But, how does the GIS data get from *here to there* on the network?…regardless of the type of network

Good Question!

- Packets and Protocols
  - TCP-IP is most common protocol
  - **T**ransmission **C**ontrol **P**rotocol-**I**nternet **P**rotocol



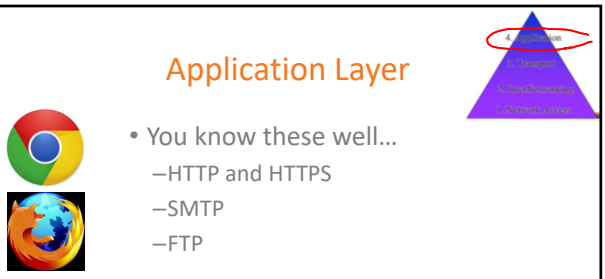
InterNetworking Layer

- Internet Protocol addressing
  - Currently IP v4 is common. This is a 32bit system allowing 4.2B addresses.
    - Example: 134.50.74.10
  - IP v 6 is newer, 128-bit addressing. Allowing 2^{128} addresses.
    - Example: 00-B0-D0-86-BB-F7

Transport Layer

- **TCP**
  - Transmission Control Protocol
  - Phases of operation
    - Establish connection
    - Transfer data
    - Terminate connection

Application Layer



- You know these well…
  - –HTTP and HTTPS
  - –SMTP
  - –FTP

Is HTTPS Really Secure?

- HTTPS enables an encrypted connection between your PC and the website server
- It does not mean the website you are visiting is free of malware, viruses, or vulnerabilites

Where's the Network

- Recap
  - We have now learned how the data moves in packets from our computer through the layers of the TCP-IP model onto the Internet
- But, where's The Internet

The Internet *Highway*

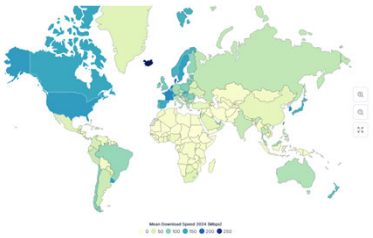
- From your workstation
- To the LAN
- To the Backbone at the Point of Presence
  - AKA…ISP
  - AKA…PoP

Various Backbones

- Redundancy through
  - ARPANet
  - NSFNet
  - Abilene (I2)
  - National LambdaRail
- What is IRON?

Undersea Fiber Optics

Internet Bandwidth (Data Rates)



https://worldpopulationreview.com/country-rankings/internet-speeds-by-country

We could go on forever…

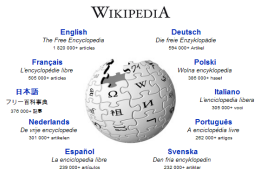
- For **IT4GIS**, we have gone far enough…
- But today's discussion of networks would not be complete without mention of the second-generation Internet, Web2.0

Web2.0

- Is not :
  - Internet2
  - Is not hardware
  - Is not software
- It is…a whole new way that the Internet is used.
  - Participatory
  - Users are now "prosumers" instead of "consumers"

Participatory Web

- Examples:
  - Wikipedia
  - Others?
- What will this mean for GIS?



Web 3.0

- We will cover this in greater detail later in the semester
- For now, what was it and what is it today?

  https://www.forbes.com/sites/forbestechcouncil/2020/01/06/what-is-web-3-0/?sh=68a3700e58df
- Emerging transaction tracking with Blockchain

The Web and AI

- Is it the same thing?
  - Not really, the emergence of Artificial Intelligence (especially AI browsers) reflects a change in how we analyze data
  - AI is not about the delivery of data via webbrowsers (ChatGPT, etc.)
  - AI will be covered in more detail later this semester

Key Concepts

- Understand how data moves over a network
- Understand the importance of **data rate** for GIS applications.
- Watch the potential of wireless and cellular technologies for GIS
- Understand new terminology like PoP and GigaPoP
- The network is typically the **bottleneck** for GIS
- Contemplate the affect of Web2.0

Questions…

Get ready for the 2-minute write

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