

Understanding Networks

IT4GIS
Keith T. Weber, GISP
GIS Director
ISU-GIS Training and Research Center

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

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

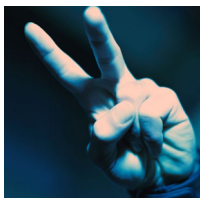


Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

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**



Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

How to Facilitate Sharing...

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



Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

In the beginning...

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

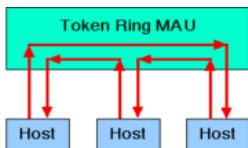


Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

Then along came...

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

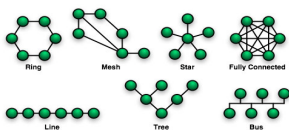


Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

Ethernet

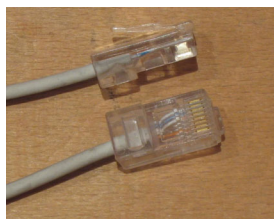
- Developed by Xerox
- Uses Star-topology
- And twisted pair cabling



Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

Cabling



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

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

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

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

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**



Pocatello | Idaho Falls | Meridian | Twin Falls



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

Pocatello | Idaho Falls | Meridian | Twin Falls



Comparing Ethernet

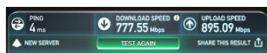
Category	Standard Bandwidth	Max Data Rate	Shielding
Cat5e	100MHz (up to 350)	1000Mbps	UTP or STP
Cat6	250MHz (up to 550)	1000Mbps	UTP or STP
Cat6A	500MHz (up to 550)	10Gbps	UTP or STP
Cat7	600MHz	10Gbps	Shielded only
Cat8	2000MHz	25Gbps or 40Gbps	Shielded only

Pocatello | Idaho Falls | Meridian | Twin Falls



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 **gigabit** / second = 125 **megabytes** / 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

Factor of 1000	1 KB	1024 B	B = byte
	1 MB	1024 KB	KB = Kilobyte
	1 GB	1024 MB	MB = Megabyte
	1 TB	1024 GB	GB = Gigabyte
	1 PB	1024 TB	TB = Terabyte
	1 EB	1024 PB	PB = Petabyte
	1 ZB	1024 EB	EB = Exabyte
	1 YB	1024 ZB	ZB = Zettabyte
			YB = Yottabyte

Pocatello | Idaho Falls | Meridian | Twin Falls




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).

Pocatello | Idaho Falls | Meridian | Twin Falls



What's Next...

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

Pocatello | Idaho Falls | Meridian | Twin Falls



A Look at 802.11

2019
802.11ax

The 6th Generation
of Wi-Fi

Designed to deliver faster speeds, support more devices simultaneously, decrease latency, improve security, and increase bandwidth. It operates in the 2.4 GHz band and supports speeds up to 11 Gbps.

2024
802.11be

The 7th Generation
of Wi-Fi

Will build on 802.11ax to achieve extremely high throughput for 30 Gbps and will use the 2.4, 5, and 6GHz bands to maximize data.

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

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

Idaho State UNIVERSITY

Pocatello | Idaho Falls | Meridian | Twin Falls

Advantages/Limitations of Wi-Fi for GIS

Brain-storm

- **Advantages**
 - No cabling
 - Fairly inexpensive

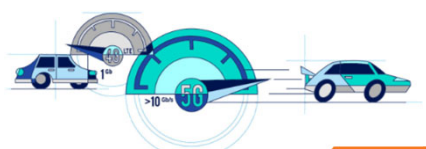
- **Disadvantages**
 - Security
 - Traffic can congest at the 2.4 Ghz frequency
 - Size of transmission (shared bandwidth)

Idaho State UNIVERSITY

Pocatello | Idaho Falls | Meridian | Twin Falls

What About Cellular?

- Wi-fi is NOT the same as Cellular
 - 4G LTE
 - 5G



<https://www.cnn.com/interactive/2020/03/business/what-is-5g/index.html>

Idaho State UNIVERSITY

Pocatello | Idaho Falls | Meridian | Twin Falls

Getting Data from Here to There

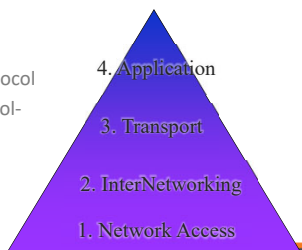
- Recap...
 - We know something about the history of networks
 - We know about current Ethernet, Fast Ethernet, and Gigabit Ethernet technologies
 - We know about Wi-Fi capabilities
- These are the *Data Link* and *Physical* Layers, referred to as the *Network Access Layer*.
- But, how does the GIS data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

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

Good Question!

- Packets and Protocols
 - TCP-IP is most common protocol
 - Transmission Control Protocol-Internet Protocol



Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

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



Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

Transport Layer






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

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

Application Layer



- You know these well...
 - HTTP
 - SMTP
 - FTP

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

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

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

The Internet Highway

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

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

Various Backbones

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



Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

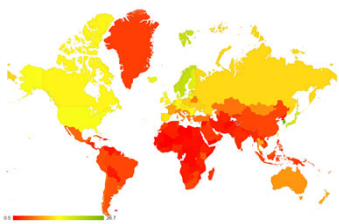
Undersea Fiber Optics



Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

Internet Bandwidth (Data Rates)



<https://www.fastmetrics.com/internet-connection-speed-by-country.php>

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

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

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

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"

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State
UNIVERSITY

Participatory Web

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



Pocatello | Idaho Falls | Meridian | Twin Falls



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>

Pocatello | Idaho Falls | Meridian | Twin Falls



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 browser is not about the delivery of data via the web
 - It is all about the value of data collection

Pocatello | Idaho Falls | Meridian | Twin Falls

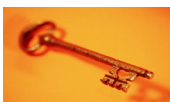


GIS and the Web



Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY



Key Concepts

- Understand how data moves over a network
- Understand the importance of **data rate** for GIS applications.
- Watch the potential of wireless for GIS
- Understand the roles of the various layers within the TCP-IP model
- Understand new terminology like PoP and GigaPoP
- The network is typically the **bottleneck** for GIS
- Contemplate the affect of Web2.0

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY

Questions...



Get ready for the 2-minute write

Pocatello | Idaho Falls | Meridian | Twin Falls

Idaho State UNIVERSITY
