Lessons from Two Decades of Networking

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NC State Class of 2001

Who is Andy Gospodarek?

- NC State class of 2001 (Computer Engineering)
- Open Source Expert/Enthusiast/Advocate/True Believer
- Spent entire career in computer networking:
  - Two Co-op terms at Cisco and one summer internship at SAS
  - Worked at 2 startups (LVL7 Systems and Cumulus Networks), one high-growth company (Red Hat), and one large company (Broadcom)
- Enjoy running, biking, wakeboarding, and Oxford commas
- Married to a NC State graduate (Class of 2001 in EE and Applied Math) and have 3 young kids

What was happening in 2001?

2001:
Linux Kernel contained ~4M LoC

2018:
Linux Kernel contains ~26M LoC

2001:
Google was just starting to take off (Search was the only product)

2018:
It’s hard to imagine life without Google’s products

2001:
Smartphones were nowhere to be found

2018:
Everyone has a smartphone including [sadly] many kids in elementary school

2001:
Wi-Fi hardware was extremely expensive

2018:
Hardware is so cheap that free Wi-Fi is everywhere

2001:
Systrom, Spiegel, and Zuckerberg were all still living with their parents

2018:
Systrom, Spiegel, and Zuckerberg are all billionaires

2001:
Felt like the Internet was mostly used for [illegally] passing around copyrighted material

2018:
Feels like the Internet is mostly used for sharing memes and selfies

2000:
NC State beat UNC-CH in football
38-20 in Chapel Hill

2018:
NC State beat UNC-CH in football
34-28 in Chapel Hill

I thought this was a talk about networking?

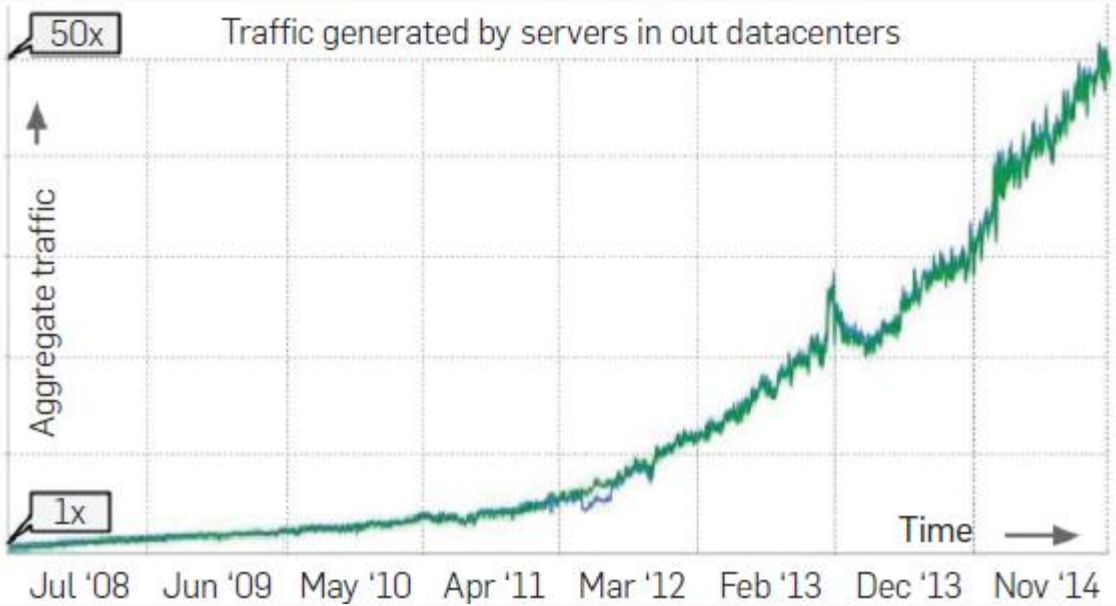
2001: My Job (LVL7 Systems)

- Startup with ~100 people in RTP
- First task was to write MIPS assembly network processor and driver code in C for a network operating system
- Goal was to use as few instructions as possible so we could achieve 100Mbps throughput between two ports

2018: My Job (Broadcom)

- Finished project writing firmware for a 200Gbps NIC (2 x 100Gbps ports)
- NIC is so fast that current servers cannot even send or receive traffic fast enough to maximize the NIC's capabilities
- Also work on a project where we have a NIC with 8 ARMv8 cores capable of processing 25Gbps of traffic before the server ever sees the traffic

Datacenter Traffic Growth



So 200x faster server connectivity, what else is different?

2001: Networking Industry was an Oligarchy

- Large vendors like Cisco, Juniper, Nortel, and others controlled networking infrastructure
- Proprietary hardware and software locked users into their solutions
- Bigger and more complicated systems ruled the wiring closet and the datacenter

The ‘God Box’

Networking was hard

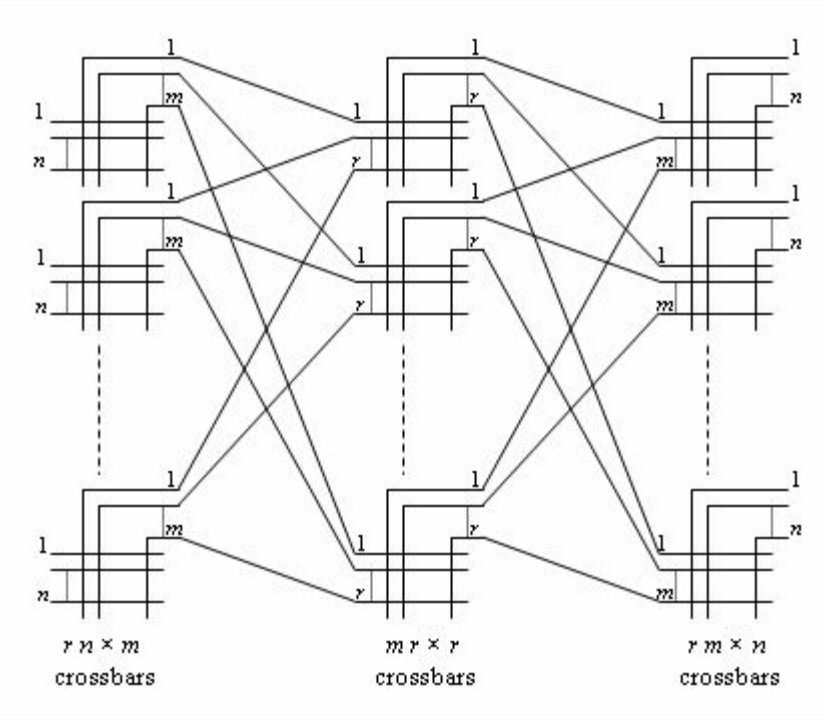
Proprietary software and hardware dominated the networking industry

Networking vendors were extremely powerful and valuable

2018: Networking Industry is democratized

- Large datacenters do not buy equipment from traditional vendors like Cisco, Juniper, or Arista
- Open Source software allow operators more flexibility
- Commodity hardware cabled together using a 1950s-era design from Charles Clos replaces unnecessarily complicated hardware
- “Software [Defined Networking] is eating the world”

Clos Topology



Turn of the Century networking has been commoditized

Open-source or standards-based software now dominate the networking industry

Data centers are now extremely powerful and valuable

Protocols must be the same, right?

When was TCP first proposed?

2001: New TCP congestion algorithms begin to be developed to deal with growing scale of the internet

2008: Cubic TCP released based on research done at NC State

2010: Data Center TCP (DCTCP) research begins and continues today to boost network utilization

2011: TCP Fast Open introduced by Google to cut down on number of RTTs per session

2012: Google develops SPDY that serves as the basis for HTTP/2

2013: Google develops QUIC that will serve as the basis for HTTP/3, but will now be over UDP

Open-source implementations exist to allow others to use them

Today’s technologies will become commoditized over time

What has not changed in the last two decades?

Playing well with others is critical for success

“First I learned to read and write and then I conquered the world”

1% inspiration
99% perspiration

Value is created by people

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exit(0);
```

References

- “Jupiter Rising: A Decade of Clos Topologies and Centralized Control in Google's Datacenter Network” https://cacm.acm.org/magazines/2016/9/206261-jupiter-rising/fulltext
- God Box https://www.dltec.com.br/blog/cisco/entenda-os-diferentes-tipos-de-switch-ethernet/
- Clos Topology https://upload.wikimedia.org/wikipedia/commons/9/9a/Closnetwork.png
- “BGP in the Data Center: Part Two” https://www.packetdesign.com/blog/clos-architecture-in-the-data-center/

Backup/Overflow

Commoditize?

To make the difference in quality between the most expensive and cheapest version of products in the same category virtually indistinguishable