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 mountain biking, running, 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:
Google was just starting to take off (Search was the only service)

2020:
It’s hard to imagine life without Google’s services...

2020:
...but many people wonder if that’s a good thing?

2001:
Smartphones were *rare*

2020:
Everyone has a smartphone including [sadly] many kids in elementary school...

2020:
...but more and more adults are taking a break from their phones

2001:
Wireless networking hardware was extremely expensive

2020:
Wireless networking hardware is cheap...

2020:
...and service is so cheap that it is either free or practically free

2001:
Kevin Systrom, Zhang Yiming, and Mark Zuckerberg were all still living with their parents

2020:
Systrom, Yiming, and Zuckerberg are all billionaires

2001:
Internet was used for [illegally] sharing copyrighted images and music

2020:
Internet is used for sharing videos that may contain copyrighted material

I thought this was a talk about networking?

What enabled these changes to occur?

2001:
Networking was hard

2001:
Proprietary software dominated networking infrastructure

2001:
Networking vendors were extremely powerful and valuable

2020:
Networking infrastructure has been commoditized

2020:
Open-source or standards-based software now dominates the networking industry

2020:
Data centers operators now extremely powerful and valuable

What software enabled this shift in power?

2001:
Linux Kernel contains ~4M LoC

2020:
Linux Kernel contains ~28M LoC

Linux is more featureful and runs on more hardware than ever

Packet processing frameworks like DPDK (userspace) or XDP (kernel) enable high-speed application development

What about protocol changes over the years?

When was TCP first proposed as a standard?

1974: TCP described by Vint Cerf and Bob Khan

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

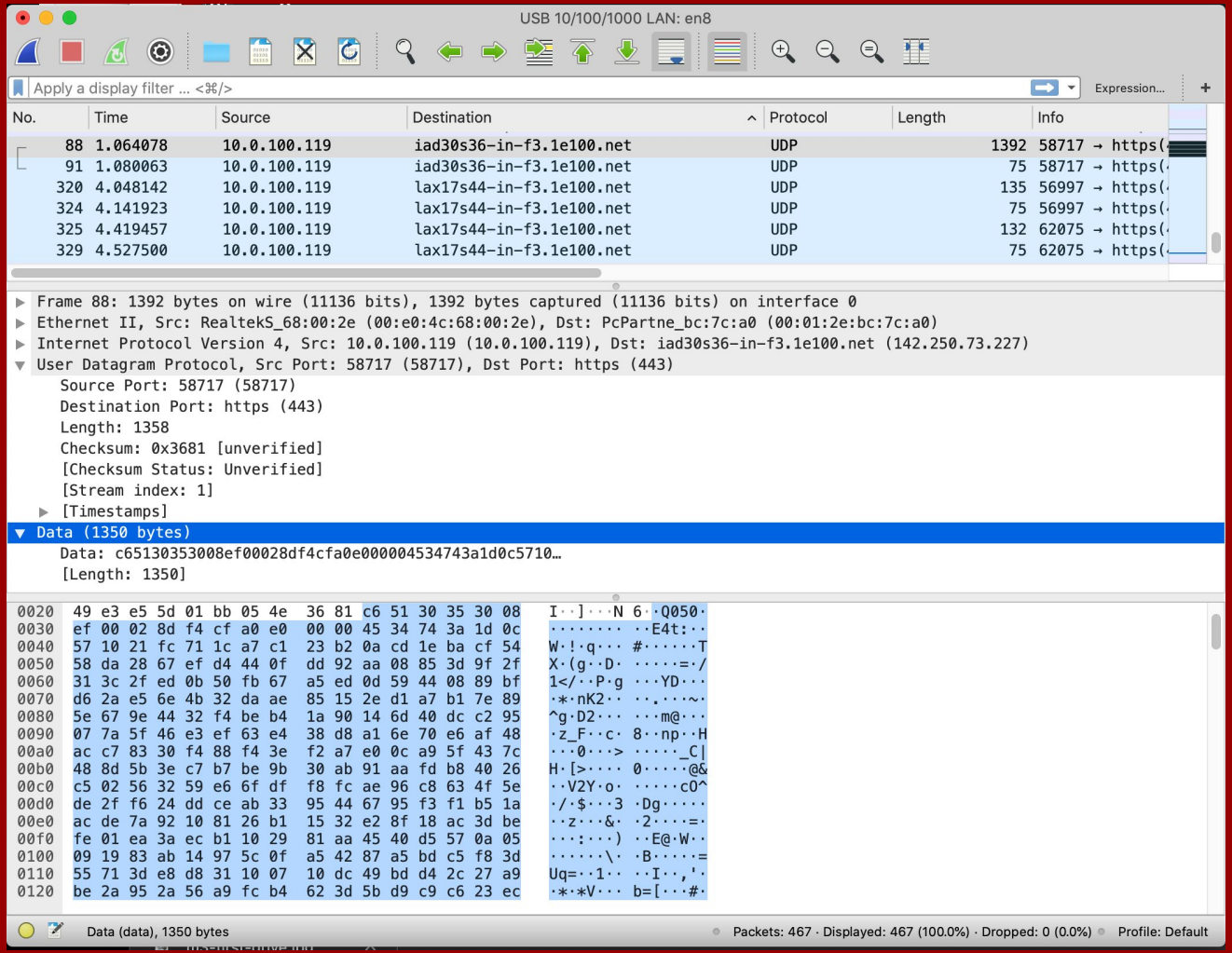
2010: Data Center TCP (DCTCP) research begins and continues today to boost network utilization

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 instead of TCP

2020: Google, YouTube, Facebook, and more all use QUIC/UDP by default instead of HTTPS/TCP


USB 10/100/1000 LAN: en8
Apply a display filter ... <⌘/>
Expression...
No. Time Source Destination Protocol Length Info
88 1.064078 10.0.100.119 iad30s36-in-f3.1e100.net UDP 1392 58717 → https(
91 1.080063 10.0.100.119 iad30s36-in-f3.1e100.net UDP 75 58717 → https(
320 4.048142 10.0.100.119 lax17s44-in-f3.1e100.net UDP 135 56997 → https(
324 4.141923 10.0.100.119 lax17s44-in-f3.1e100.net UDP 75 56997 → https(
325 4.419457 10.0.100.119 lax17s44-in-f3.1e100.net UDP 132 62075 → https(
329 4.527500 10.0.100.119 lax17s44-in-f3.1e100.net UDP 75 62075 → https(
Frame 88: 1392 bytes on wire (11136 bits), 1392 bytes captured (11136 bits) on interface 0
Ethernet II, Src: RealtekS_68:00:2e (00:e0:4c:68:00:2e), Dst: PcPartne_bc:7c:a0 (00:01:2e:bc:7c:a0)
Internet Protocol Version 4, Src: 10.0.100.119 (10.0.100.119), Dst: iad30s36-in-f3.1e100.net (142.250.73.227)
User Datagram Protocol, Src Port: 58717 (58717), Dst Port: https (443)
Source Port: 58717 (58717)
Destination Port: https (443)
Length: 1358
Checksum: 0x3681 [unverified]
[Checksum Status: Unverified]
[Stream index: 1]
[Timestamps]
Data (1350 bytes)
Data: c65130353008ef00028df4cfa0e000004534743a1d0c5710…
[Length: 1350]
0020 49 e3 e5 5d 01 bb 05 4e 36 81 c6 51 30 35 30 08
0030 ef 00 02 8d f4 cf a0 e0 00 00 45 34 74 3a 1d 0c
0040 57 10 21 fc 71 1c a7 c1 23 b2 0a cd 1e ba cf 54
0050 58 da 28 67 ef d4 44 0f dd 92 aa 08 85 3d 9f 2f
0060 31 3c 2f ed 0b 50 fb 67 a5 ed 0d 59 44 08 89 bf
0070 d6 2a e5 6e 4b 32 da ae 85 15 2e d1 a7 b1 7e 89
0080 5e 67 9e 44 32 f4 be b4 1a 90 14 6d 40 dc c2 95
0090 07 7a 5f 46 e3 ef 63 e4 38 d8 a1 6e 70 e6 af 48
00a0 ac c7 83 30 f4 88 f4 3e f2 a7 e0 0c a9 5f 43 7c
00b0 48 8d 5b 3e c7 b7 be 9b 30 ab 91 aa fd b8 40 26
00c0 c5 02 56 32 59 e6 6f df f8 fc ae 96 c8 63 4f 5e
00d0 de 2f f6 24 dd ce ab 33 95 44 67 95 f3 f1 b5 1a
00e0 ac de 7a 92 10 81 26 b1 15 32 e2 8f 18 ac 3d be
00f0 fe 01 ea 3a ec b1 10 29 81 aa 45 40 d5 57 0a 05
0100 09 19 83 ab 14 97 5c 0f a5 42 87 a5 bd c5 f8 3d
0110 55 71 3d e8 d8 31 10 07 10 dc 49 bd d4 2c 27 a9
0120 be 2a 95 2a 56 a9 fc b4 62 3d 5b d9 c9 c6 23 ec
Data (data), 1350 bytes
Packets: 467 · Displayed: 467 (100.0%) · Dropped: 0 (0.0%)
Profile: Default

QUIC moves many features of TCP to userspace (client and server) rather than kernel

QUIC’s main goal is to reduce latency of connection setup and retransmission

QUIC’s secondary goal is to enable rapid protocol enhancement and development

Switch to UDP will have impacts on every firewall product that exists today

Adoption of QUIC by IETF as standard *should* prevent a return to proprietary networking

Impact of COVID-19

Everyone is online more than ever

Buy all the Chromebooks!

Virtual connectivity has increased at a higher rate than I expected during quarantine

Network effects are accelerated

Providers do not want us to put down our devices

Providers know what we like better than we know ourselves

What has not changed over the last 20 years?

Humans still have the power to impact change

Value is created by people

1% inspiration
99% perspiration

Playing well with others is critical for success

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

```
exit(0);
```

Commoditize?

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