The Network is the Computer

Reprise

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Today’s Discussion

- **OPINION** — **What Drives Network Evolution**
- **LIKELY TRUTHS** — **Architecture & System Questions**
- **PREDICTION** — **The Network is the Computer*…reprise**

[*] John Gage, Chief Scientist, Sun Microsystems

How has **focus** shifted in **network evolution** ?

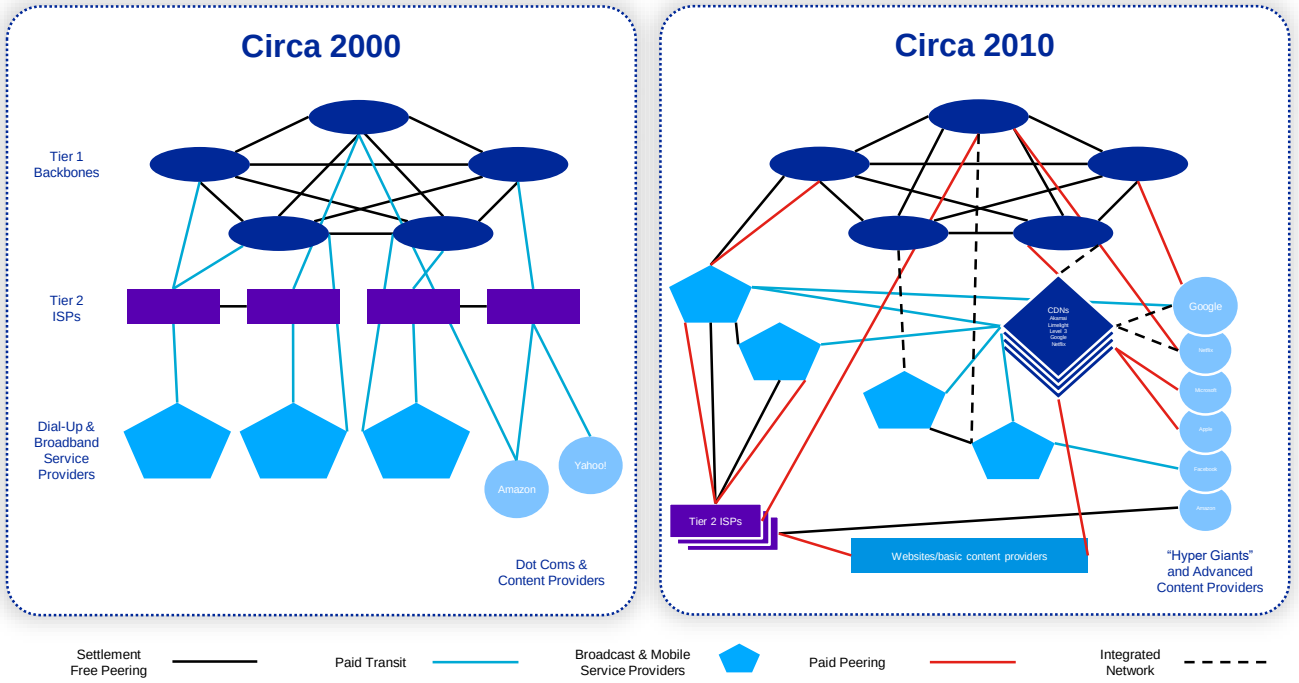
	2000 “Internet”	2010 “Data Center”	*2020 “Cloud Networking”*
			
Value Created	**Connect compute and networks**	**Connect VMs/Containers**	*Network-as-a-Service ?*
Value Delivered	**Switches & Routers**	**Overlay Networking**	*API ?*
Value Captured	**Access subscription, transit, backbone**	**Virtual Switching, Service Mesh and Centralized Control Plane**	*SD-WAN to SD-Network ?*
Competition	**Access speed**	**Scale**	**Data insights**

The shift from ***Internet*** to ***Data Center`***

In **2007**, **1000s of ASNs** made up **50%** of internet traffic[1]

In **2016**, **10 ASNs** generated **70%** of consumer traffic[1]

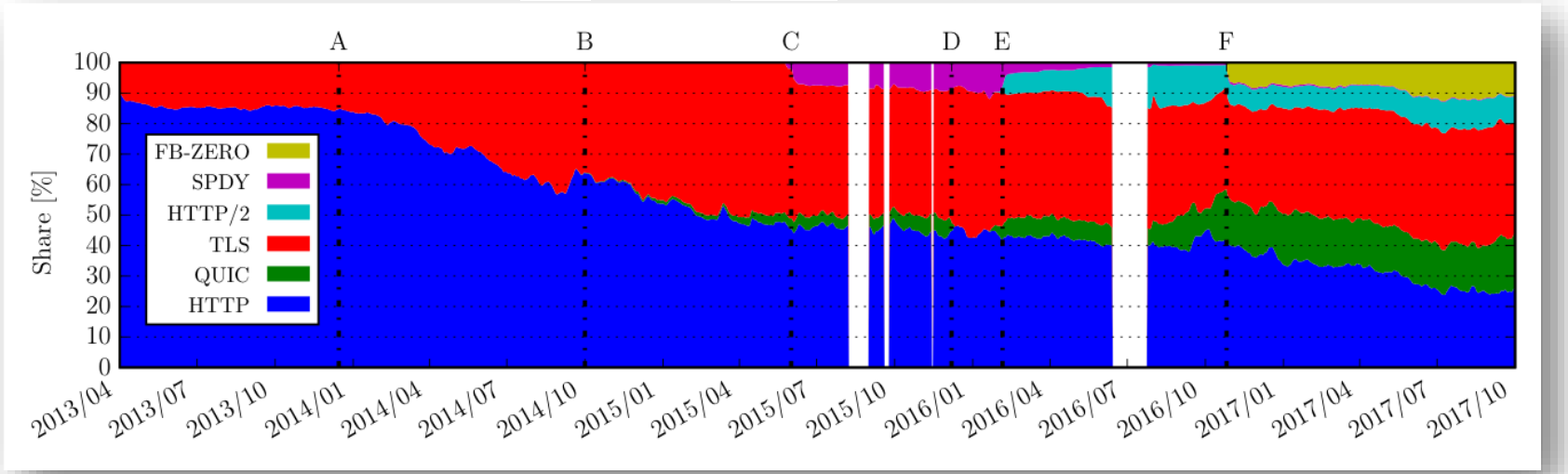
…and **30 ASNs** contribute more than **80%** of all traffic[1]



Source: [1] Craig Labovitz, ENOG presentation "The New Internet", Deepfield (now Nokia), published June 2016, retrieved on February 20th from "https://www.enog.org/presentations/enog-11/123-20160605_ENOG_The_New_Internet.pdf"

What were the consequences ?

Protocol agility increased for the 1%



Source: Giordano, Danilo, et al,"*Five Years at the Edge:Watching Internet from the ISP Network*." Published October 4rth, 2018, accessed on February 19th, 2019 from "https://smartdata.polito.it/five-years-at-the-edge-watching-internet-from-the-isp-network/"

…and decreased for the 99%

- **Almost as many middleboxes as routers**
- **Middleboxes kill the end-to-end principle**
  - Middleboxes make assumptions about headers, and/or modify network and transport protocol fields, this makes “new” protocols difficult to introduce
  - Many middleboxes restrict protocols they do not support

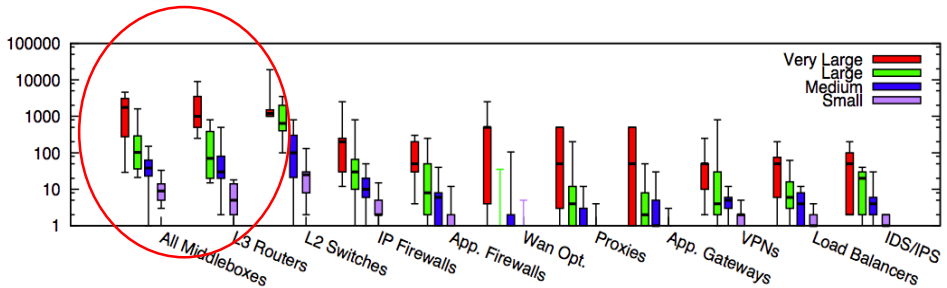


Figure 1: Box plot of middlebox deployments for small (fewer than 1k hosts), medium (1k-10k hosts), large (10k-100k hosts), and very large (more than 100k hosts) enterprise networks. Y-axis is in log scale.

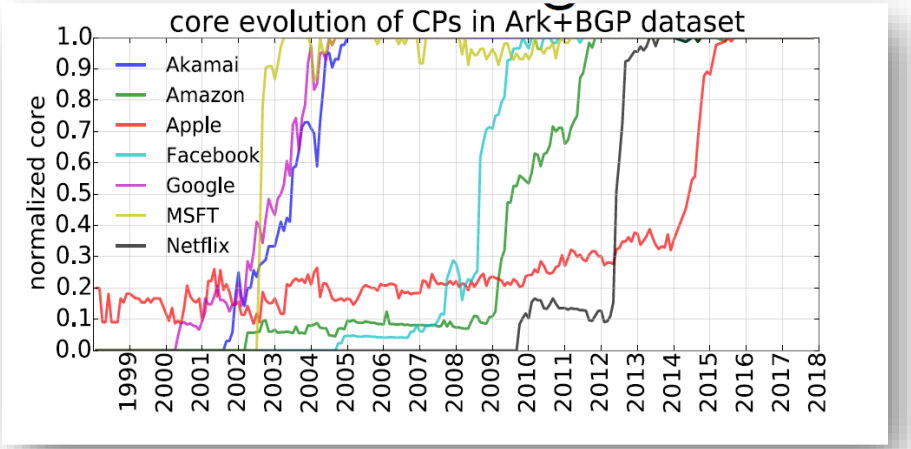
Source: Sherry, Justine, et al. "*Making middleboxes someone else's problem: Network processing as a cloud service*.“ Proceedings of the ACM SIGCOMM 2012 conference. ACM, 2012

*"Estimates vary of the device population of today's Internet, but they tend to fall within a range of **15—25 billion connected devices**. Yet only some **2.8 billion IPv4 addresses** are visible in the Internet's routing system. This implies that on average **each** announced public **IPv4 address serves between three to eight hidden internal devices**."*

Geoff Huston, "In Defence of NATs",
APNIC Blog, Published September 2017

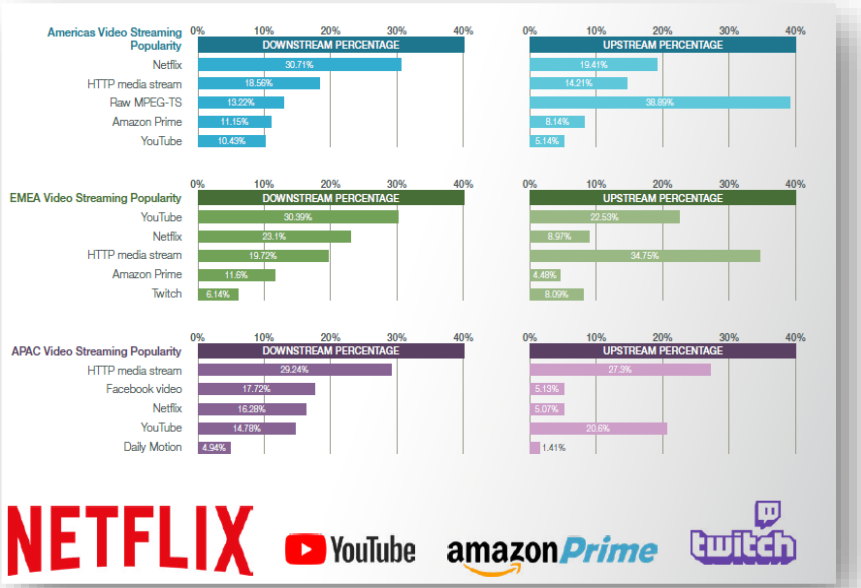
Content consolidation and middle-boxes manifests as the ***client-server internet***

The New Tier 1s:
CDNs form a new Densely Connected Internet Core



Source: Esteban Carisimo, “Studying the Evolution of Content Providers in the Internet Core” June 28th, 2018. TMA 2018 → based on Sandvine and PeeringDB

Video is 58% of the Downstream Traffic Volume

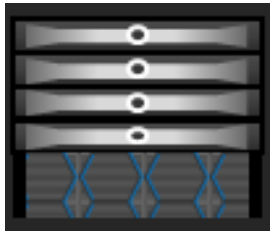


Source: Sandvine, “The Global Internet Phenomena Report”, October 2018

These trends form a ***North Star*** of ***Network Evolution***…

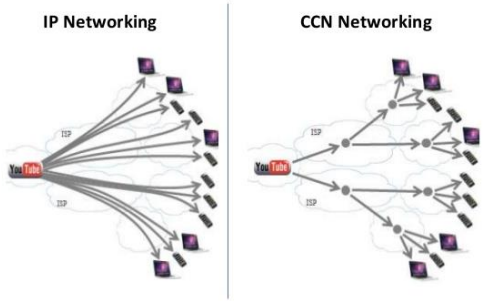
1

Edge Computing



2

Storage-Centric



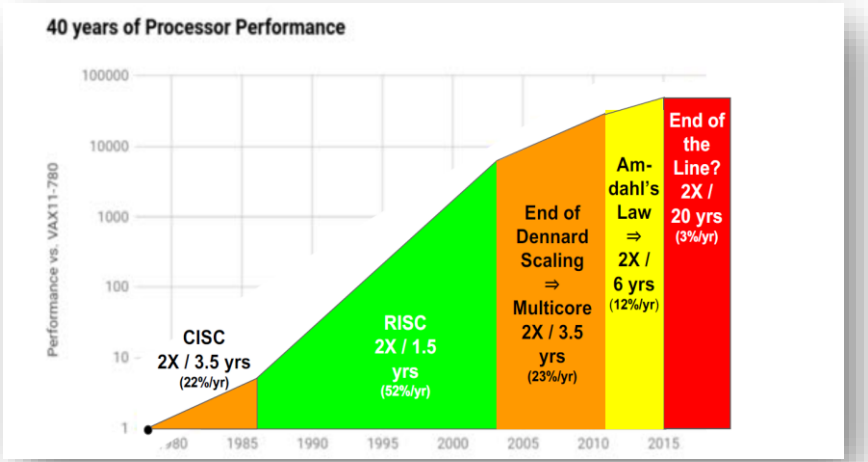
3

Overlay & Centralized Networking

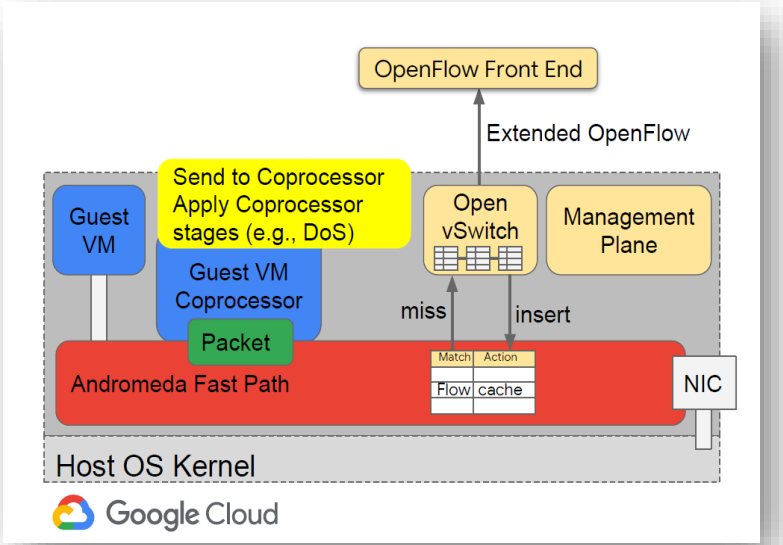
Source: V. Jacobson et al, “Networking Named Content”

Let’s take a closer look at scale limits of compute

Domain Specific Architectures Drive Performance

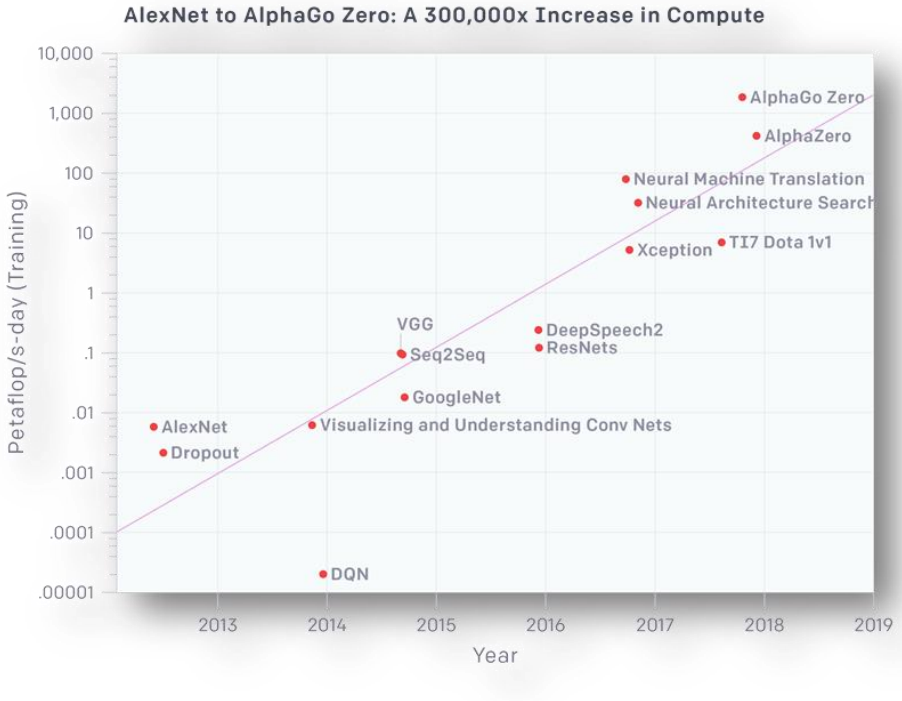


Source: John Hennessy and David Patterson, "Computer Architecture: A Quantitative Approach", 6/e. 2018

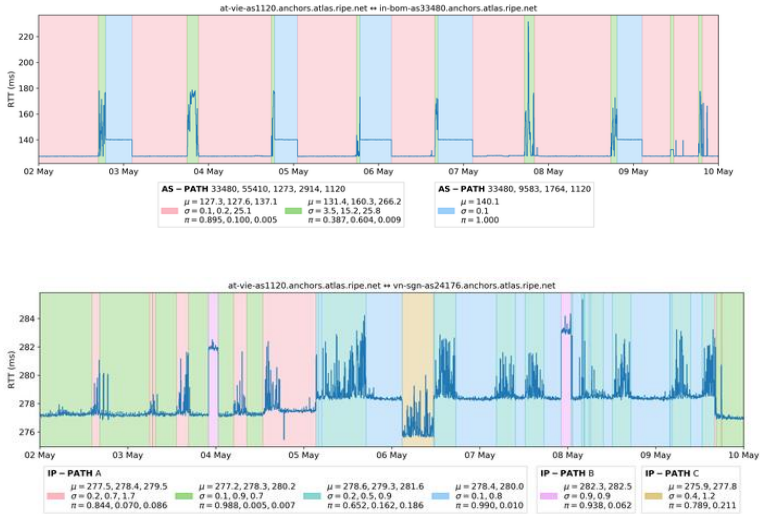


Source: Michael Dalton, David Schultz, "Andromeda: Performance Isolation and Velocity at Scale in Cloud Network Virtualization", NSDI, April 10, 2018

ML Improvements Lead to Management of Networks At Scale
Should Networks Provide Labelled Data in the Future ?



Source: Dario Amodei and Danny Hernandez, “AI and Compute”, Published May 16, 2018, Retrieved on February 21, 2019 from “https://blog.openai.com/ai-and-compute/”

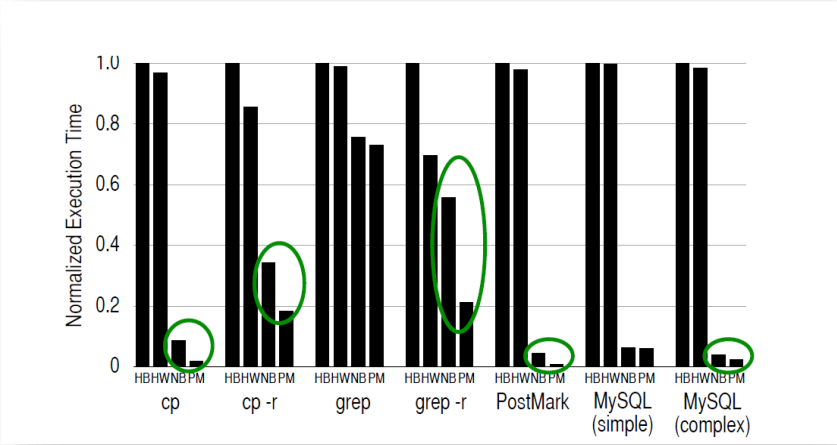


Source: Maxime Mouchet, “More meaningful RTT metrics through statistical characterization”, Published on APNIC blog on February 7, 2019, Retrieved February 22, 2019 from “https://blog.apnic.net/2019/02/07/more-meaningful-rtt-metrics-through-statistical-characterization/”

Likely Truth 1: *Compute scale will drive a new heterogeneous edge compute substrate & ML driven network management*

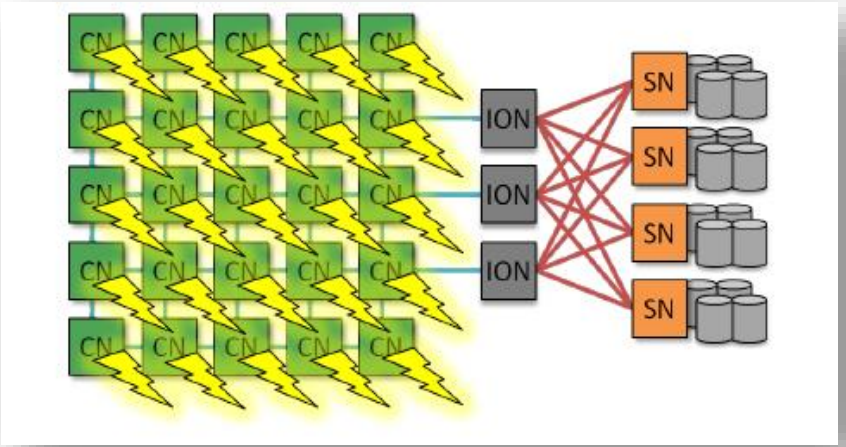
…where is storage going ?

PMEM 10x Improvement over NVMe



Source: Justin Meza et al, “A case for Efficient Hardware/Software Cooperative Management of Storage and Memory”, Workshop on Energy-Efficient Design, 2013

Eliminating IOP Bottleneck Drives New Storage Architectures



Source: Jakob Luttgau et al “Survey of Storage Systems for High Performance Computing”, Published 2018 at SuperFri.org

Likely Truth 2: *Emerging Memory Technologies Will Drive Wide-Scale Distributed Storage Architectures*

Connect the dots to predict the future

…The Network is the Computer, *again*.

Questions ?

Divider blue

Divider gray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