Future Network Needs

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The Internet used to be simple…

1980's:

- The network was the transmission fabric for computers
- It was just a packet transmission facility
- Every other function was performed by attached mainframe computers

"dumb" network, "smart" devices

Then we went client/server

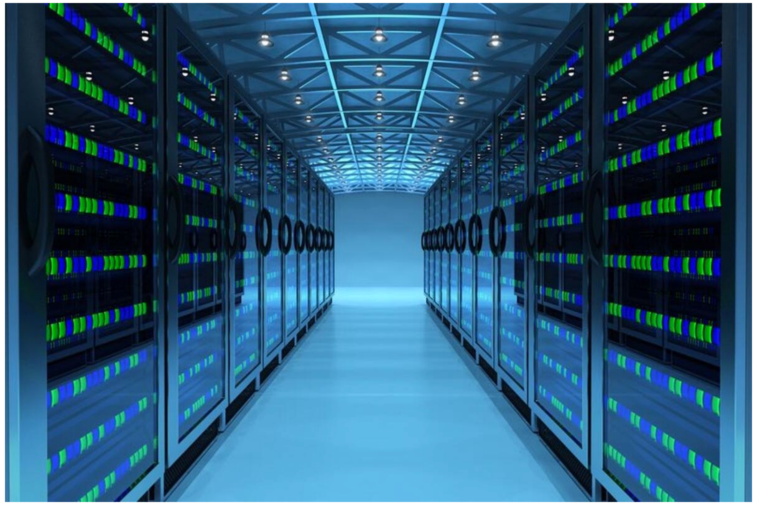
1990's:

- The rise of the Personal Computer as the "customer's computer"
- We started to make a distinction between "customers" and "network"
    - The naming system was pulled into the network
    - The routing system was pulled into the network
    - Messaging, content and services were pulled into the network
- We created the asymmetric client/server network architecture for the Internet

Internet Infrastructure of 2000

Rapid expansion of network infrastructure in many directions:

- Exchanges, Peering Points and Gateways
- Transit and Traffic Engineering
- Data Centres and Service “Farms”
- Quality of Service Engineering
- MPLS, VPNs and related network segmentation approaches
- Mobility Support – Mobile Networks
- Customer Access Networks
- Content Distribution Networks



Aren't these all "different" networks?

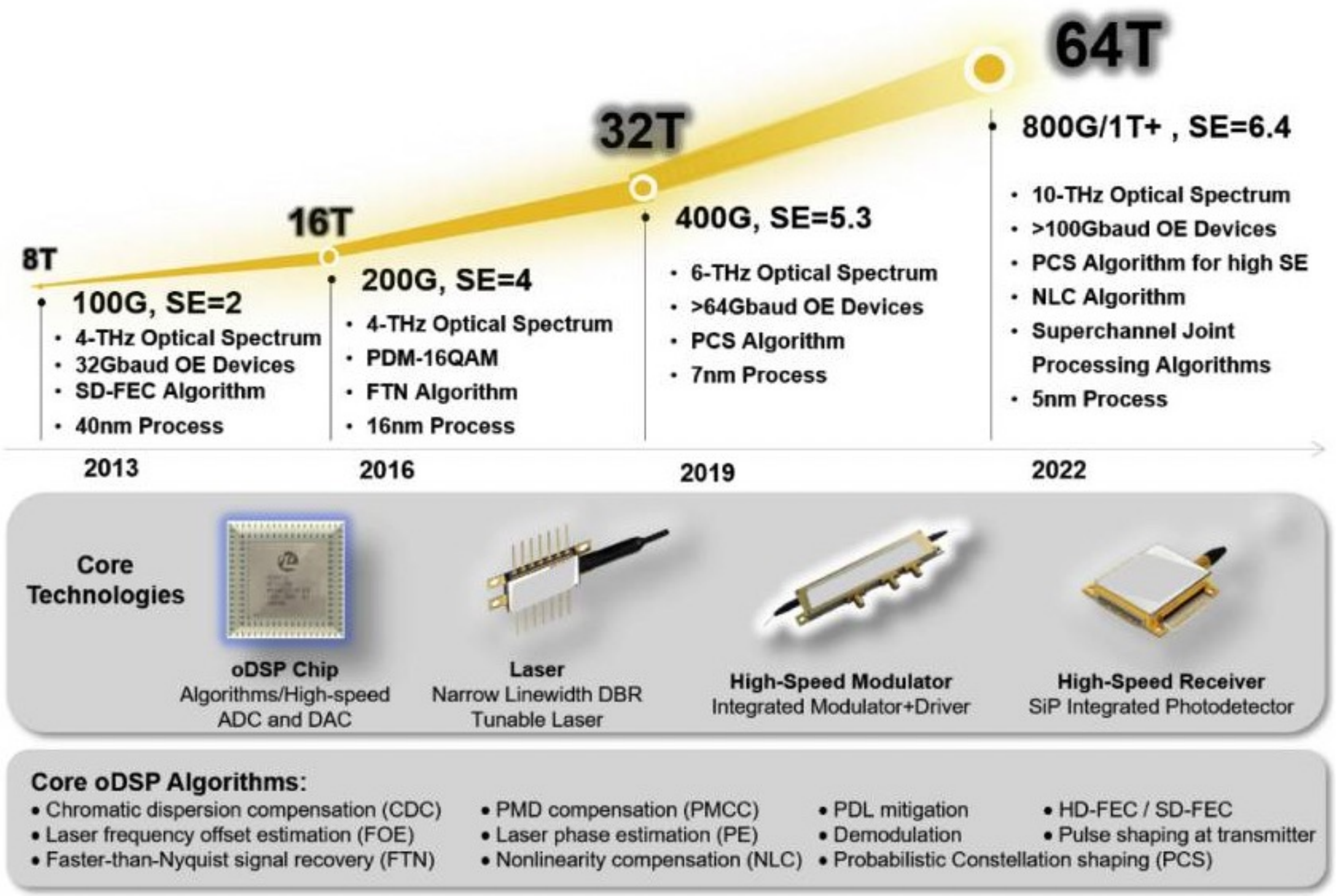
- Well, yes they are
- The true genius of the Internet was to separate the service environment from the link technology
    - Each time we invented a new comms technology we could just “map” the Internet onto it
    - This preserved the value of the investment in “the Internet” across successive generations of comms technologies

What about the coming decades?

- The seeds of the dominant factors of the future environment are probably with us today
- The problem is that a lot of other seeds are here as well, and sifting out the significant from the merely distracting is the challenge
- So with that in mind lets work out the big drivers in today’s environment…

Abundant Capacity

Fibre cables continue to deliver massive capacity increases within relatively constant unit cost of deployment



8T

100G, SE=2

- 4-THz Optical Spectrum
- 32Gbaud OE Devices
- SD-FEC Algorithm
- 40nm Process

2013

16T

200G, SE=4

- 4-THz Optical Spectrum
- PDM-16QAM
- FTN Algorithm
- 16nm Process

2016

32T

400G, SE=5.3

- 6-THz Optical Spectrum
- >64Gbaud OE Devices
- PCS Algorithm
- 7nm Process

2019

64T

800G/1T+ , SE=6.4

- 10-THz Optical Spectrum
- >100Gbaud OE Devices
- PCS Algorithm for high SE
- NLC Algorithm
- Superchannel Joint Processing Algorithms
- 5nm Process

2022

Core Technologies

oDSP Chip
Algorithms/High-speed ADC and DAC

Laser
Narrow Linewidth DBR Tunable Laser

High-Speed Modulator
Integrated Modulator+Driver

High-Speed Receiver
SiP Integrated Photodetector

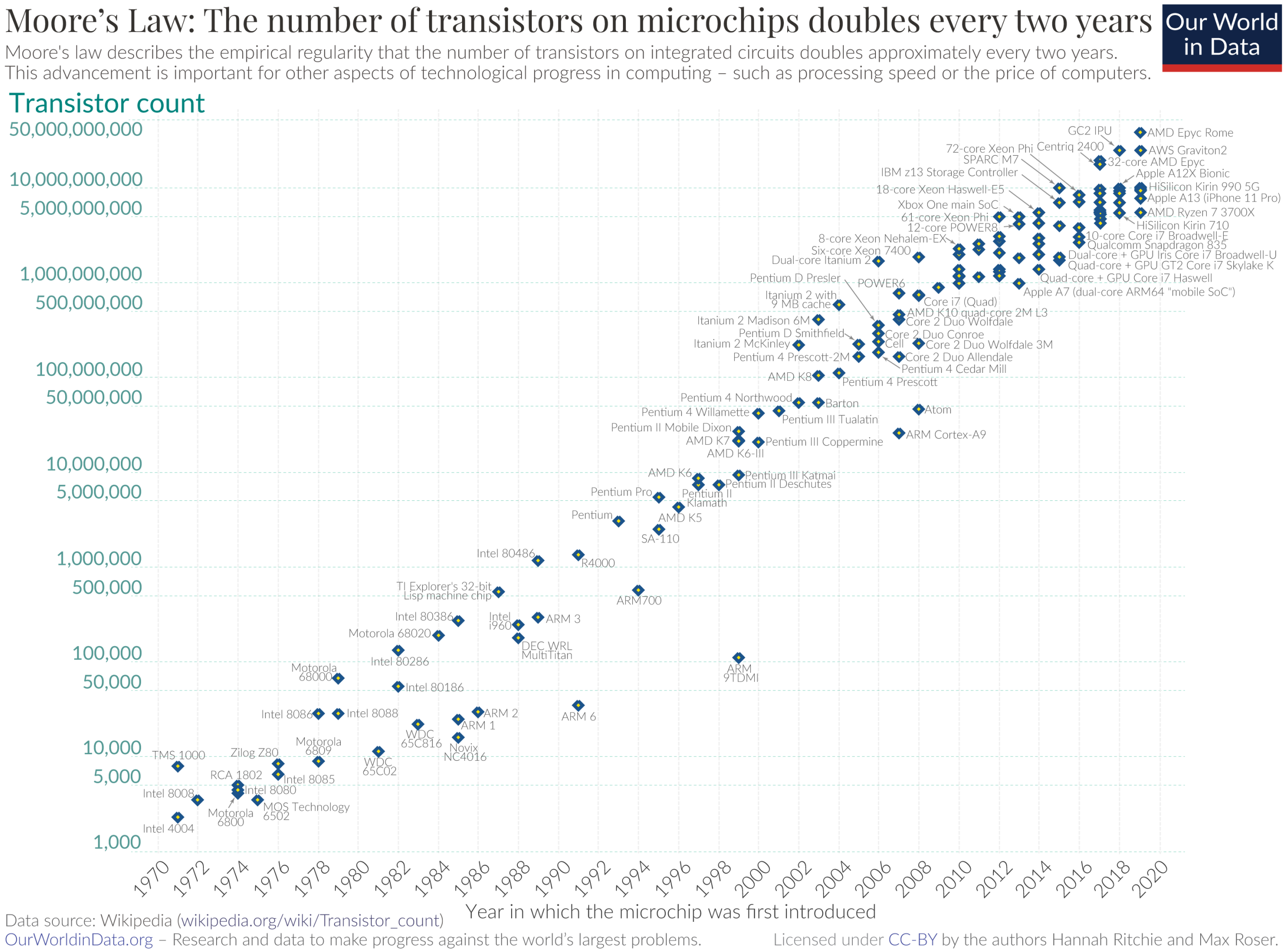
Core oDSP Algorithms:

- Chromatic dispersion compensation (CDC)
- Laser frequency offset estimation (FOE)
- Faster-than-Nyquist signal recovery (FTN)
- PMD compensation (PMCC)
- Laser phase estimation (PE)
- Nonlinearity compensation (NLC)
- PDL mitigation
- Demodulation
- Probabilistic Constellation shaping (PCS)
- HD-FEC / SD-FEC
- Pulse shaping at transmitter

https://www.ncbi.nlm.nih.gov/

(That 2022 number is probably low – at the end of 2022 we can pull 2.2T per lambda with a 190Gbd signal rate, giving a fibre capacity of 105T)

Abundant Compute Power



Moore's Law: The number of transistors on microchips doubles every two years

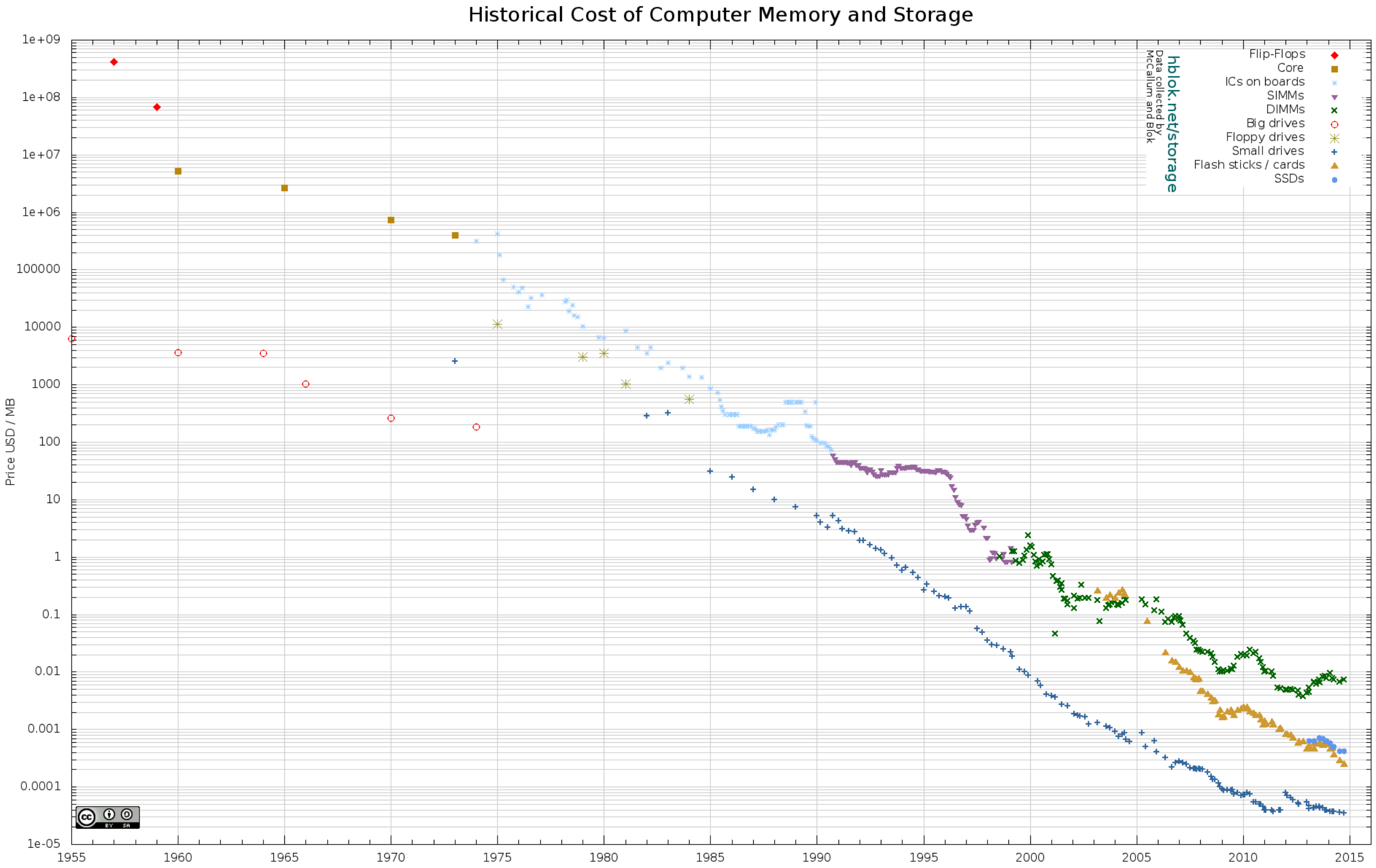
Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)

OurWorldinData.org – Research and data to make progress against the world's largest problems.

By Max Roser, Hannah Ritchie - https://ourworldindata.org/uploads/2020/11/Transistor-Count-over-time.png, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=98219918

Abundant Storage



http://aiimpacts.org/wp-content/uploads/2015/07/storage_memory_prices_large-_hblok.net_.png

What's driving change today?

- From scarcity to abundance!
- For many years the demand for communications services outstripped available capacity
- We used price as distribution function to moderate demand to match available capacity
- But this is no longer the case – available capacity in today’s communications domain far outpaces demand

How can we use this abundance?

- By changing the communications provisioning model from ***on demand*** to ***just in case***
- Instead of using the network to respond to users by delivering services *on demand* we’ve changed the service model to provision services close to the edge just in case the user requests the service
- With this change we’ve been able to eliminate the factors of *distance* from the network and most network transactions occur over shorter network spans
- What does a *shorter* network enable?

Bigger

- Increasing **transmission capacity** by using photonic amplifiers, wavelength multiplexing and phase/amplitude/polarisation modulation for fibre cables
- Serving content and service transactions by distributing the load across many individual platforms through **server and content aggregation**
- The rise of high capacity mobile edge networks and mobile platforms add massive volumes to content delivery
- To manage this massive load shift we've stopped pushing content and transactions across the network and instead **we serve from the edge**

Faster

- Reduce latency - stop pushing content and transactions across the network and instead **serve from the edge**
- The rise of CDNs serve (almost) all Internet content and services from massively scaled distributed delivery systems.

- The “Packet Miles” to deliver content to users has shrunk - that’s faster!
- The development of high frequency cellular data systems (4G/5G) has resulted in a highly capable last mile access network with Gigabit capacity
- Applications are being re-engineered to meet faster response criteria

- Compressed interactions across shorter distances using higher capacity circuitry results in a much faster Internet

Cheaper

- We are living in a world of abundant comms and computing capacity
- And working in an industry when there are significant economies of scale
- And being largely funded by capitalising a collective asset that is infeasible to capitalise individually – the advertisement market
- The result is that a former luxury service accessible to just a few has been transformed into an affordable mass-market commodity service available to all

So it's all good!

Right?

Longer Term Trends?

Pushing EVERYTHING out of the network and over to applications

- Transmission infrastructure is an abundant commodity
  - Network sharing technology (multiplexing) is decreasingly relevant
- We have so much network and computing that we no longer have to bring consumers to service delivery points - instead, we are bringing services towards consumers and using the content frameworks to replicate servers and services
- With so much computing and storage **the application is becoming the service**, rather than just a window to a remotely operated service

Do Networks matter any more?

- We have increasingly stripped out network-centric functionality in our search for lower cost, higher speed, and better agility
- As we push functions out to the edge and ultimately off “the network” altogether and all that’s left is just dumb pipes
- What defines “the Internet”?
  - A common shared transmission fabric, a common suite of protocols and a common protocol address pool?

  or

  - A disparate collection of services that share common referential mechanisms?

Some issues to think about

What matters today?

- **End Point Addressing** – IPv4 / IPv6 / IPv? Absolute? Relative?
    - Is universal unique end-point addressing a 1980's concept who's time has come and gone?
    - If network transactions are localised then what is the residual role of unique global end point addressing for clients or services?
    - And if we cannot find a role then why should we bother?
    - Who decides when to drop it?
        - Is this a market function, so that a network that uses local addressing can operate from an even lower cost base gains a competitive market edge?
        - Or are carriage services so cheap already that the relative benefit in discarding the last vestiges of unique global addresses are so small that its just not worth bothering about?

Some issues to think about

What matters today?

- **Naming and Name Spaces** – DNS evolution?
    - Are ”names” a common attribute of the network, or an attribute of a service environment or application realm?
    - Should names be persistent over time?
    - Is the resolution of a name absolute or relative to the content of the resolution query?
    - In a world of densely replicated service delivery points how does a client rendezvous with the “best” service point? Does the client work it out? Or the network? Or the service?
    - If names are an attribute of applications then why do we need a single name domain? Surely each application realm can define its own name space? How can we associate a referential name space with a given name?
    - If both names and addresses are ephemeral and unstable then what defines the Internet?

Some issues to think about

What matters today?

- **Referential Frameworks?**
  - Without a common referential space then how do we usefully communicate?
  - What do we mean by “common” when we think about referential frameworks?
  - How can we join the ‘fuzzy’ human language spaces with the tightly constrained deterministic computer-based symbol spaces?

Thanks!