The Death of Transit and the Future Internet

Dave Crosby, https://www.flickr.com/photos/wikidave/4044498586/

Geoff Huston

Chief Scientist, APNIC

This presentation is not about any specific network details:

Or specific network plans

Or particular services

Or any particular technology

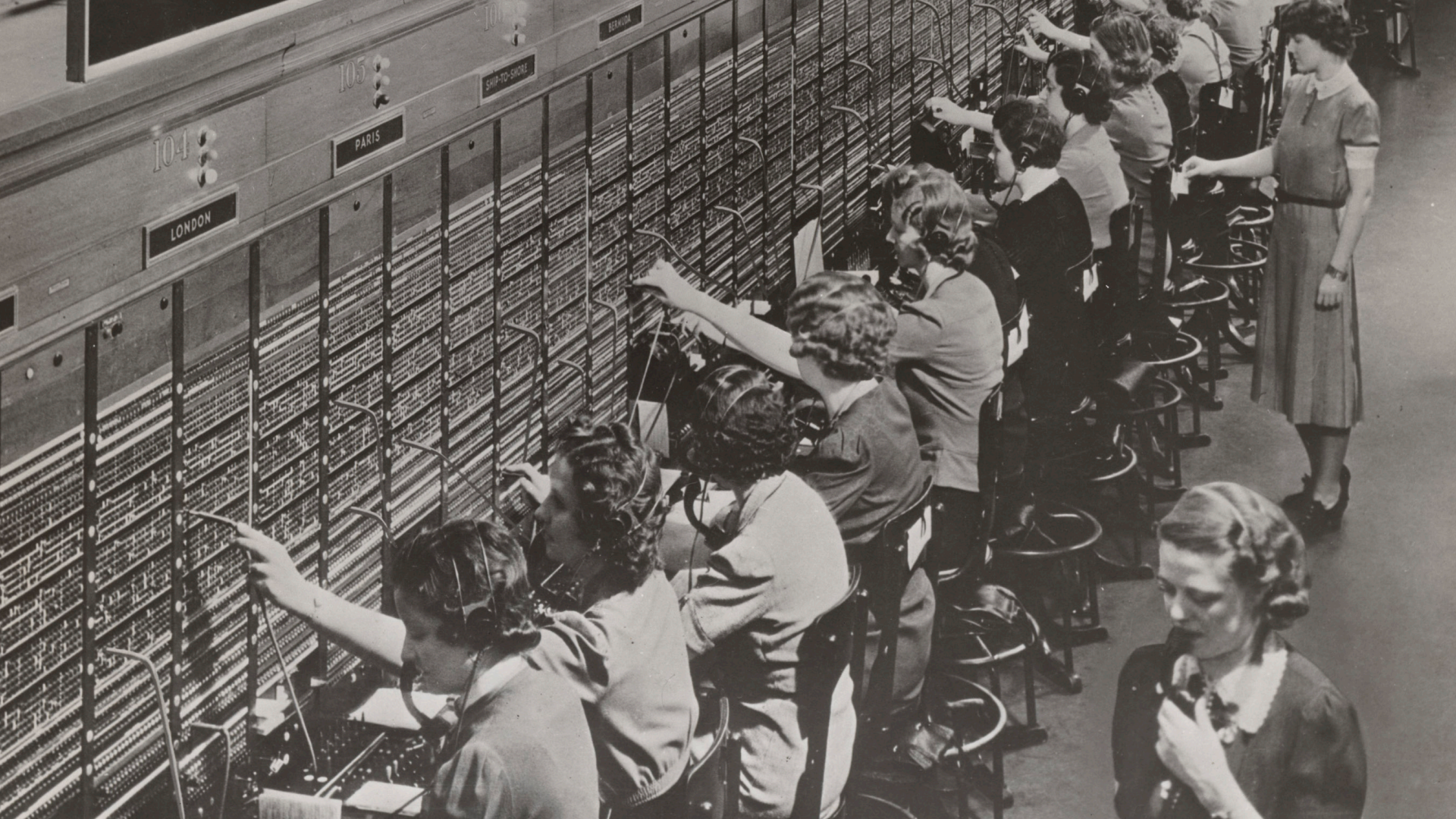
Or anything like that

It's about architecture

And, in particular, about the evolution of network architecture in the Internet

Our Heritage

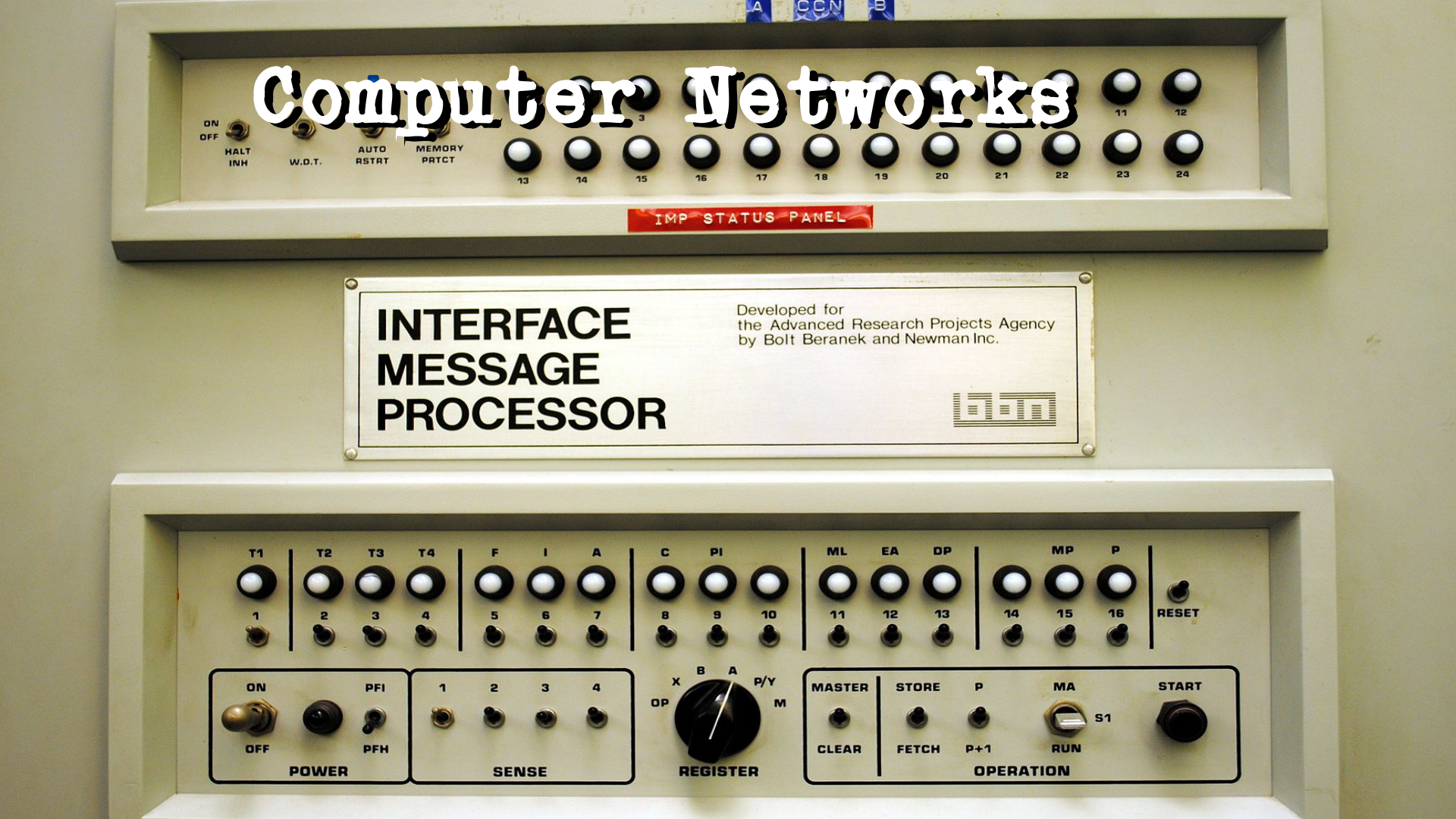
The Telephone Network


104
LONDON
105
PARIS
SHIP-TO-SHORE
BERMUDA

The Telephone Network

The major technology achievement of the twentieth century

- Connected handsets to handsets
- The network was intentionally transparent
- Real time virtual circuit support between connected edge devices
- Network-centric architecture with minimal functionality in the edge devices


Computer Networks
IMP STATUS PANEL
INTERFACE
MESSAGE
PROCESSOR
Developed for
the Advanced Research Projects Agency
by Bolt Beranek and Newman Inc.
POWER
SENSE
REGISTER
OPERATION

Computer Networks

The original concept for computer networks was based on the telephone network

- The network was there to enable connected computers to exchange data
  - All connected computers were able to initiate or receive “calls”
  - A connected computer could not call ”the network” – the network was an invisible common substrate
  - It made no difference if the network had active or passive internal elements

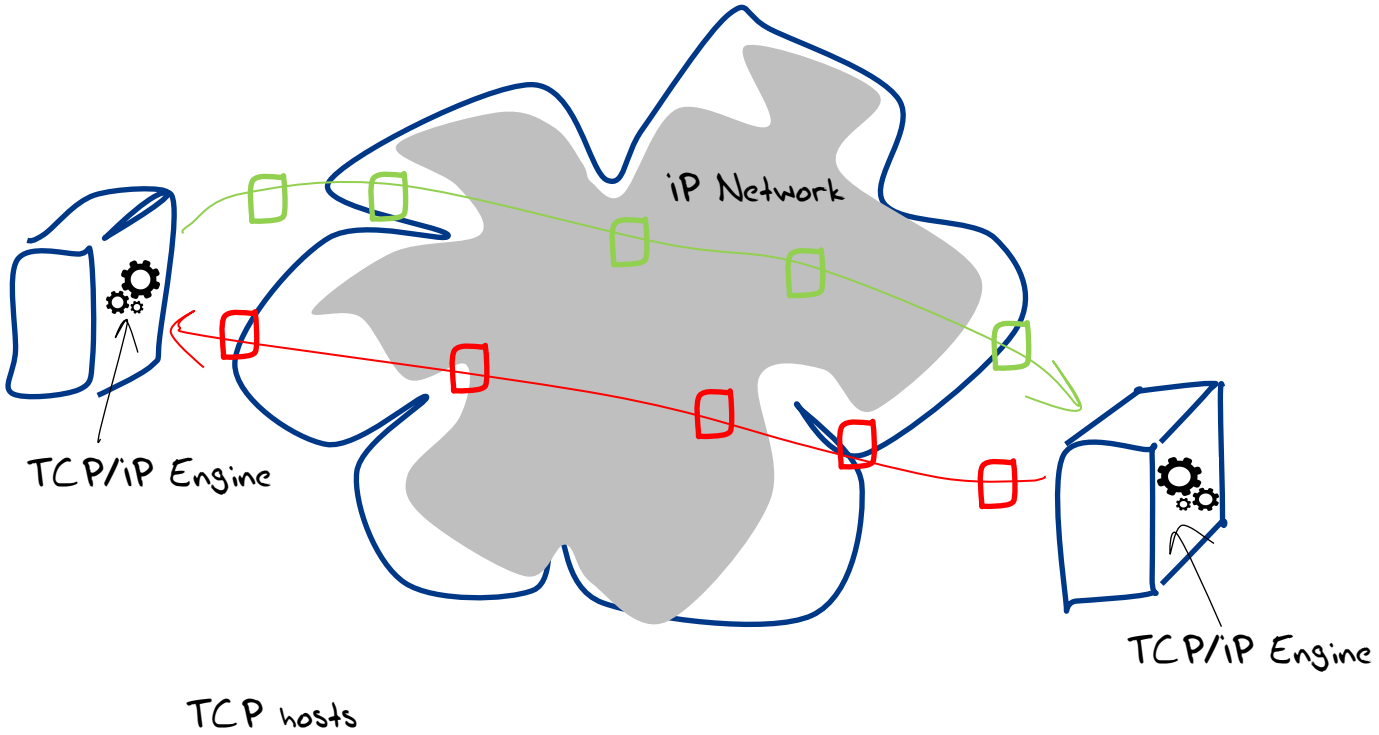
Internet Architecture (c1980's)

"End-to-End" packet design:

- Connected computer to computer
- All data is segmented into independent packets
- The network switching function was stateless

  No virtual circuits, no dynamic state for packets to follow
- Single network-wide addressing model
- Single network-wide routing model
- Simple datagram unreliable datagram delivery in each packet switching element
- hop-by-hop destination-address-based packet forwarding paradigm

Internet Architecture (c1980's)



The Result was Revolutionary!

By stripping out network-centric virtual circuit states and removing time synchronicity the resultant packet carriage network was minimal in design and cost and maximized flexibility and efficiency

More complex functions, such as flow control, jitter stability, loss mitigation and reliability, were pushed out to the attached devices on the edge

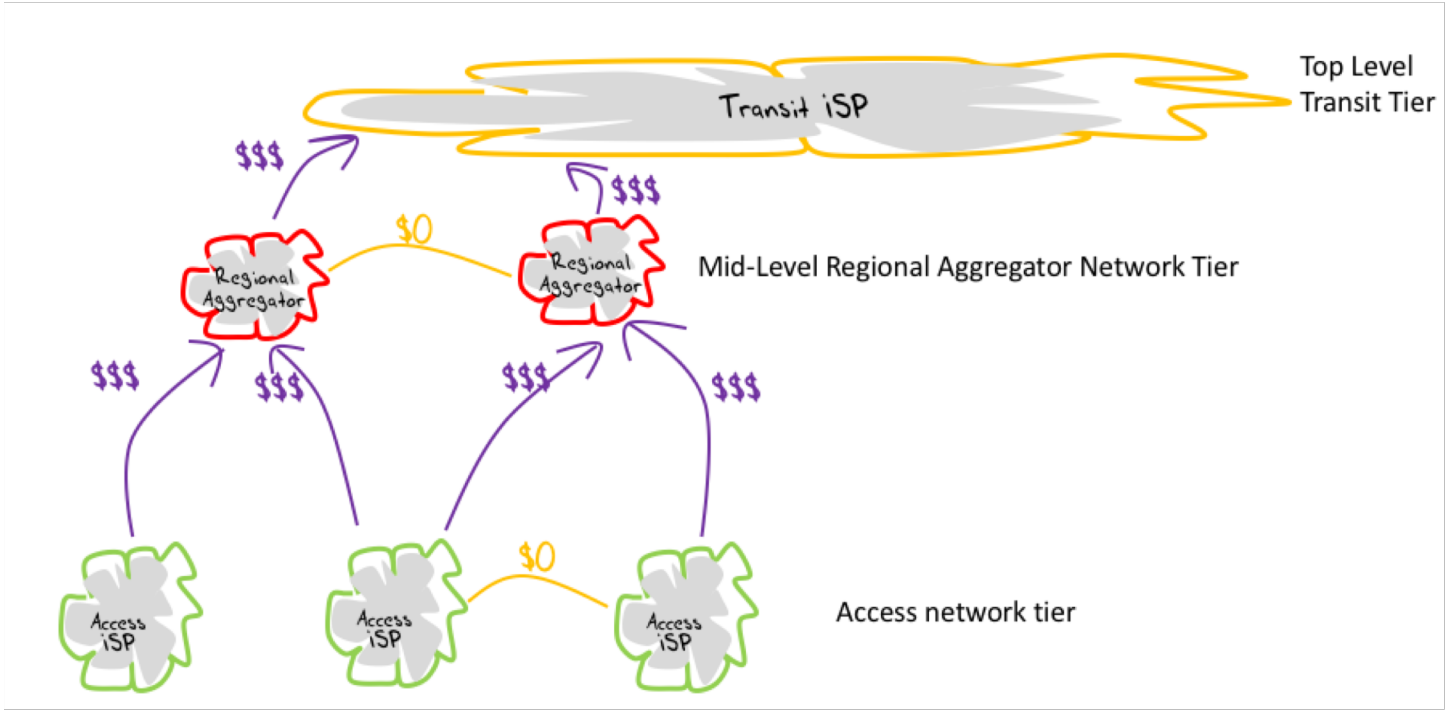
Role Specialization

In the regulated world of national telephone operators every telephone network was “equal”

Markets do not normally support such outcomes, and we see role specialization as a way of sustaining efficient distribution chains to support public services

We rapidly started differentiating between Internet networks differentiating on roles and services and differentiating on the flow of revenues between networks

The 1990's Internet



Transit Networks were "special"

- These were the so-called “Tier One” networks
- These networks collectively managed the “default-free zone” and arbitrated reachability on the network
- These networks were at the apex of the money flow within the Internet ecosystem
- They effectively formed a cartel that defined the Internet as we knew it at the time

Enter Content

Breaking the edge into **clients** and **servers**

- Access networks service the needs of “clients”
- Clients are not directly reachable by other clients
- Clients only connect to services

The role of the network here is to carry clients to the service access point

- The assumption here is that there are many more clients than service points

Content vs Carriage

Who pays whom?

- The only reason why access networks have clients is because there are content services that clients want to access
  - Carriage access providers should directly pay for content for their users

- There is no “end-to-end” financial settlement model in the Internet – both “ends” pay for access and network providers settle between themselves. To a carriage network, content is just another client
  - Content providers should pay for carriage, just like any other client

Content vs Carriage

Who pays whom?

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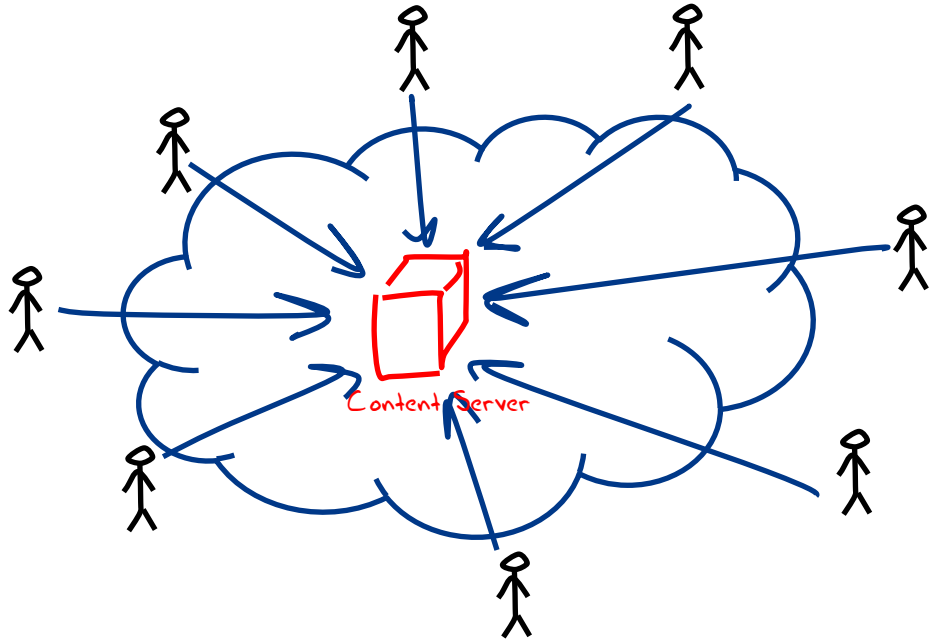
  - Carriage access providers [illegible] users

The content folk resolved this fight by going "over the top" and created relationships directly with end users

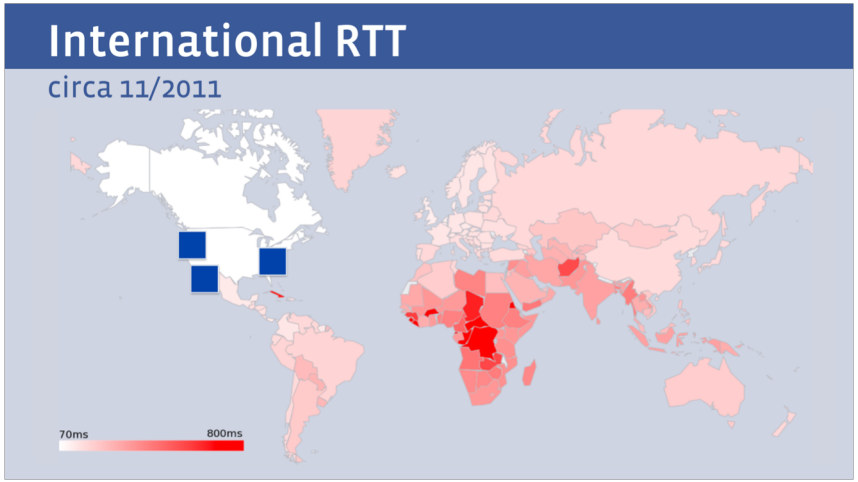
- Th[illegible]cial settlement model in the Internet – both [illegible] for access and network providers settle between themselves. To a carriage network, content is just another client
  - Content providers should pay for carriage, just like any other client

The Evolution of Content Service



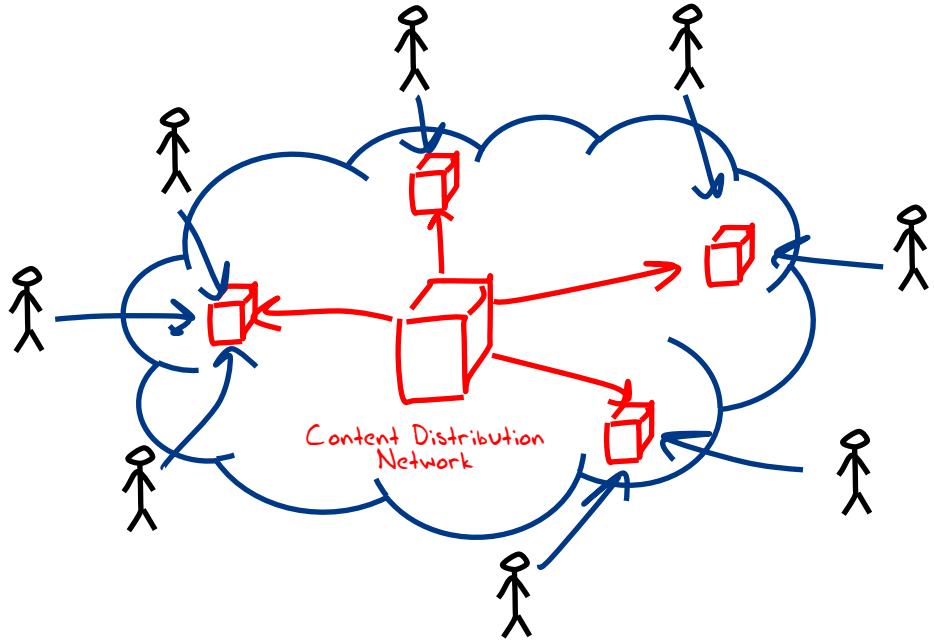
The Tyranny of Distance

But not all clients enjoy the same experience from a single service



Facebook presentation at NANOG 68

Enter Content Distribution

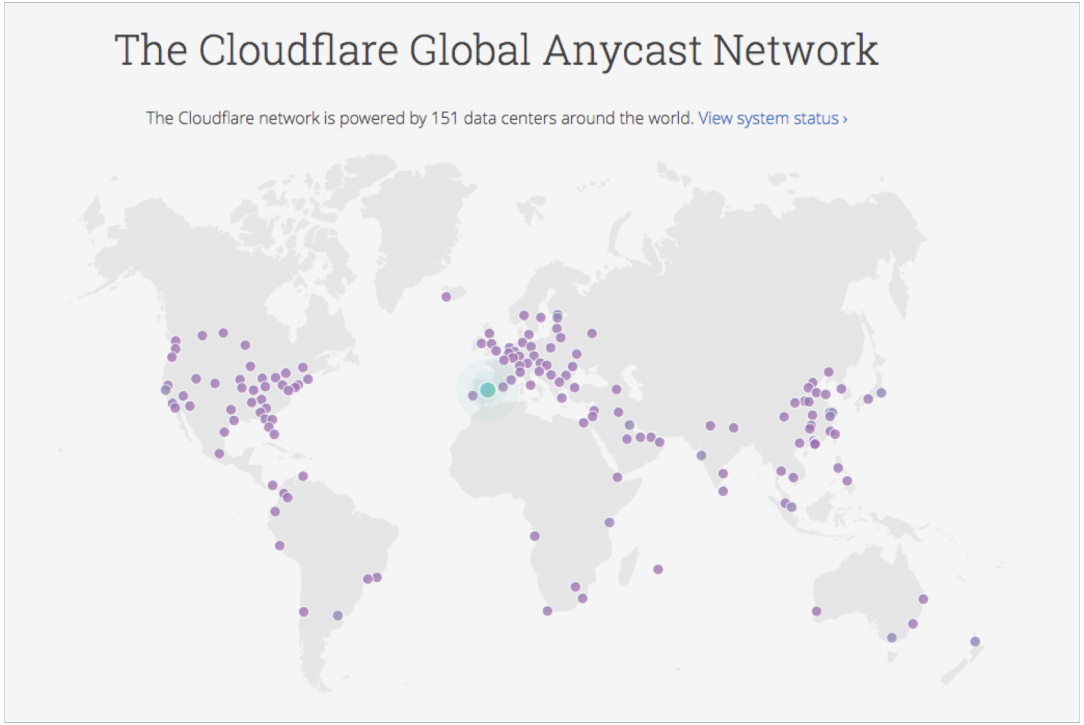


Let them eat data!

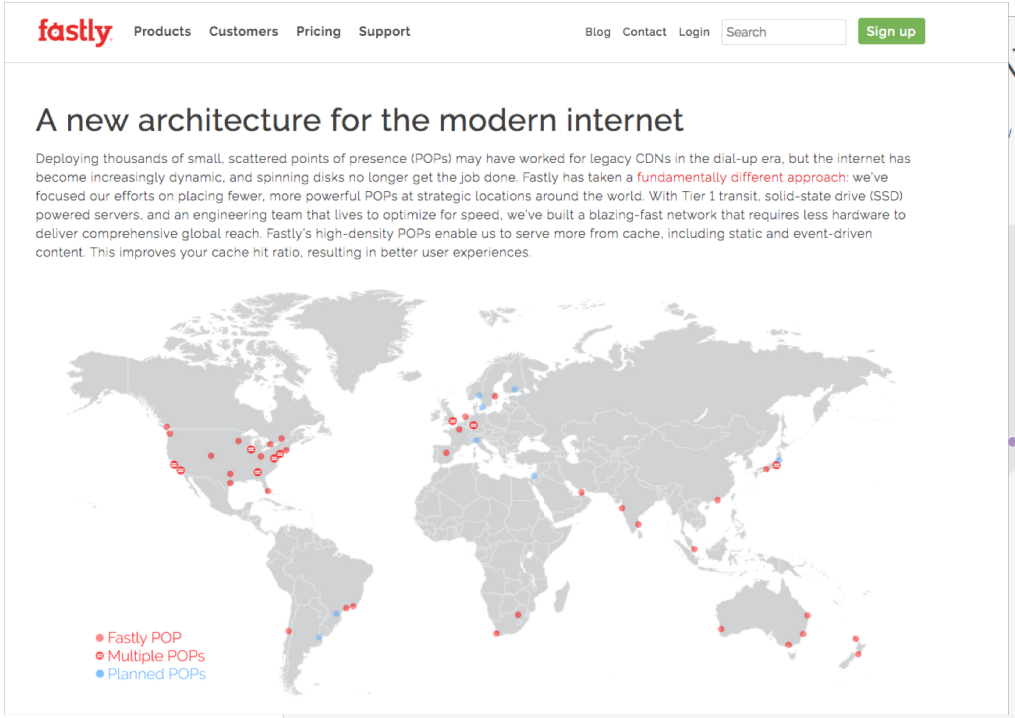
The rise of the Content Distribution Network

- Replicate content caches close to large user populations
- The challenge of delivering many replicant service requests over high delay network paths is replaced by the task of updating a set of local caches by the content distribution system and then serving user service requests over the access network
- Reduced service latency, increased service resilience, happy customers!

CDN Reach - some examples



CDN Reach - some examples



CDN Reach - some examples

CDN Reach - some examples

Google Data Centers

Search this site

Data centers › Inside look › Locations

Data center locations

We own and operate data centers around the world to keep our products running 24 hours a day, 7 days a week. Find out more about our data center locations, community involvement, and job opportunities in our locations around the world.

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Mayes County, Oklahoma
Montgomery County, Tennessee
Quilicura, Chile
The Dalles, Oregon

Asia

Changhua County, Taiwan
Singapore

Europe

Dublin, Ireland
Eemshaven, Netherlands
Hamina, Finland
St Ghislain, Belgium

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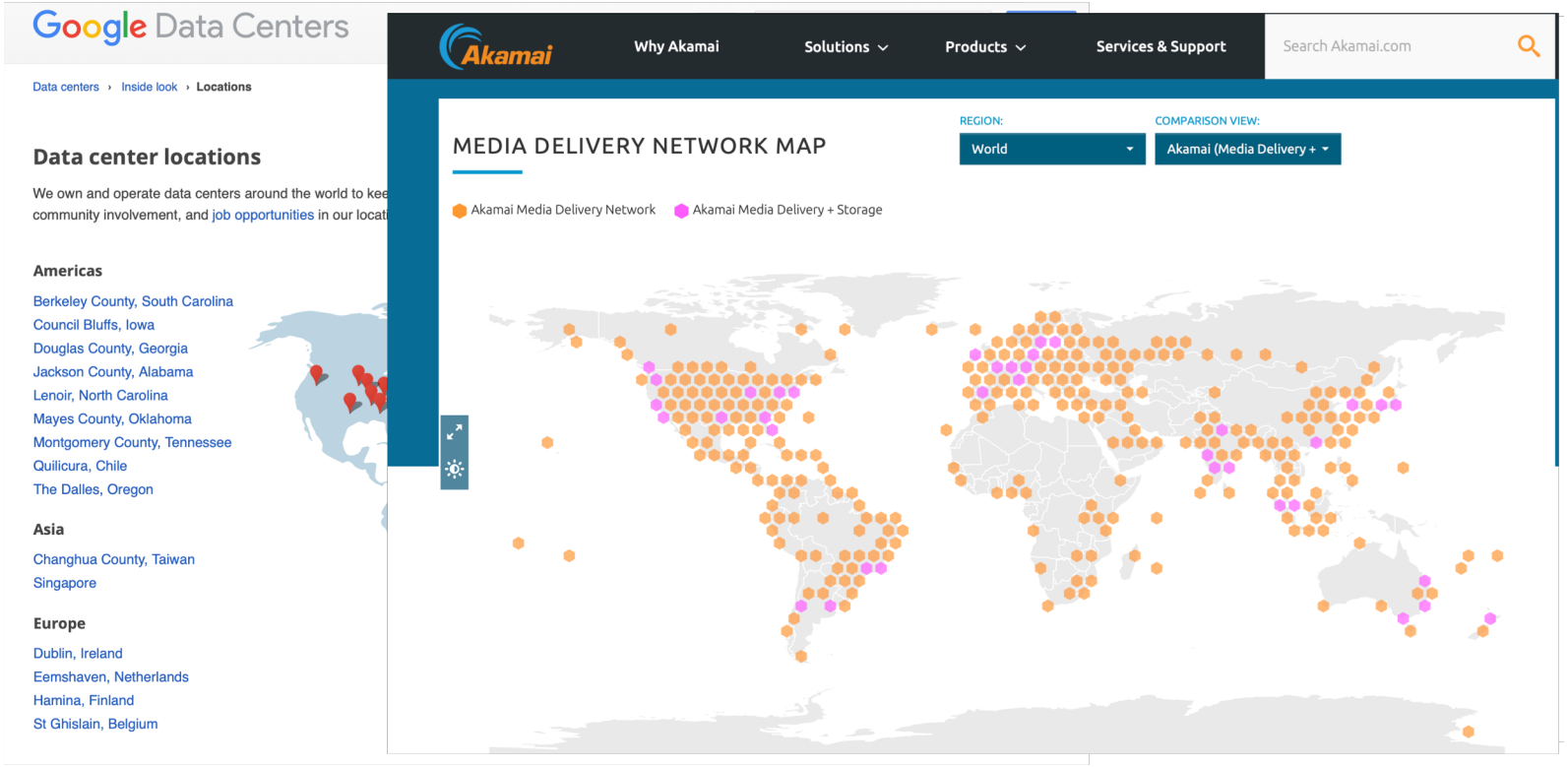

Today's Internet Architecture

We've split the network into **clients** and **servers**

- Web servers
- Streaming servers
- Mail servers
- DNS servers

Servers and services now sit in CDN bunkers with global replication and DDOS hardening

Users don't reach out to content any more - the CDNs bring content to users

Role Reversal

Service portals are increasingly located adjacent to users

And that means changes to the network:

- Public Networks no longer carry users' traffic to/from service portals via ISP carriage services
- Instead, Private Networks carry content to service portals via CDN services

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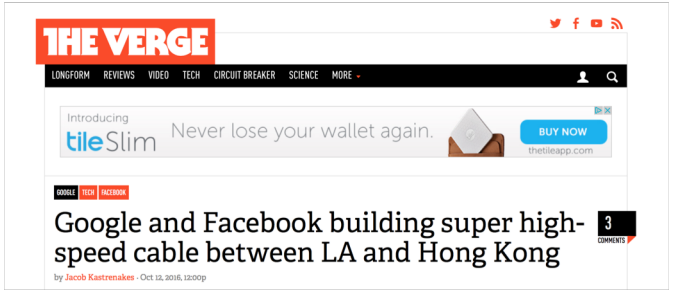
This shift has some profound implications for the 'internet

Who's building now?

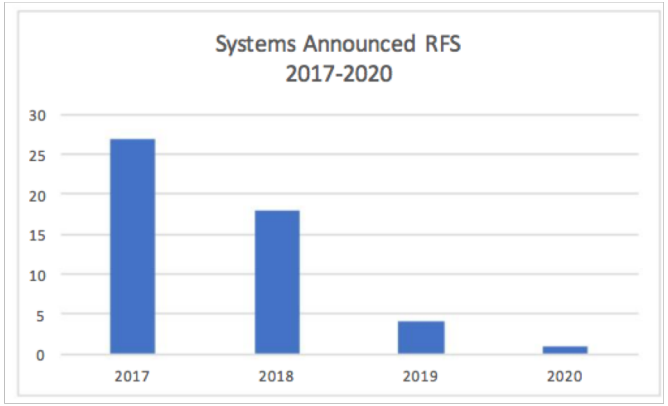
Almost all new submarine international cable projects are heavily underwritten by content providers, not carriers

Large content providers have huge and often unpredictable traffic requirements, especially among their own data centers. Their capacity needs are at such a scale that it makes sense for them, on their biggest routes, to build rather than to buy. Owning subsea fibre pairs also gives them the flexibility to upgrade when they see fit, rather than being beholden to a third-party submarine cable operator."

Tim Stronge of Telegeography, January 2017

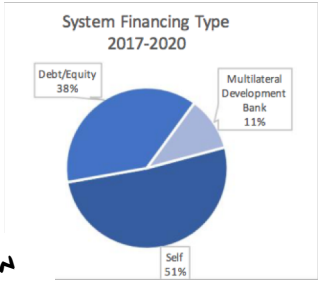


Submarine Cables



Fewer cables being built

And those that are being built are now single owner cables



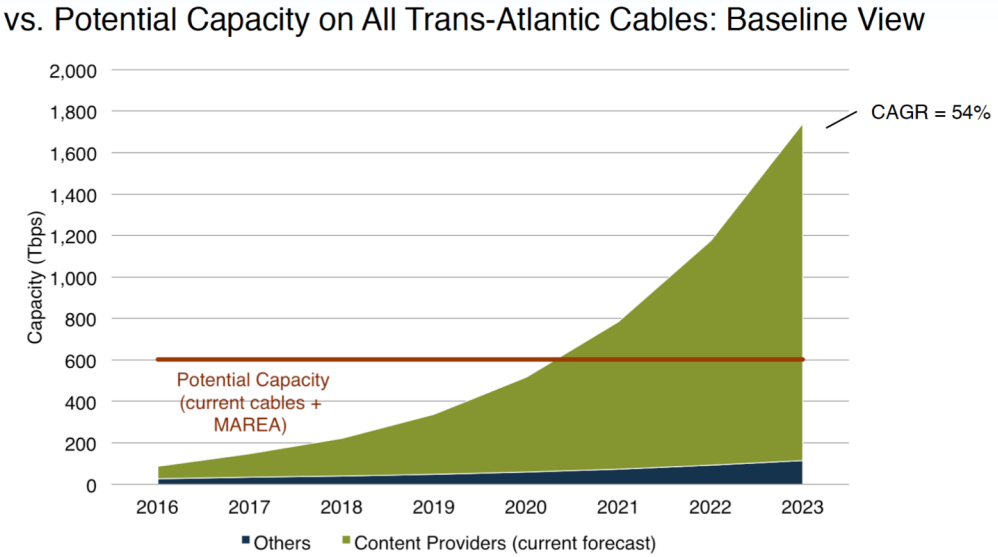
And the majority are now self-funded

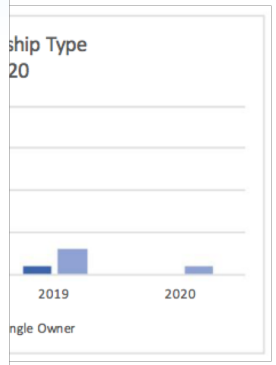
Tim Stronge, Telegeography, Jan 2017

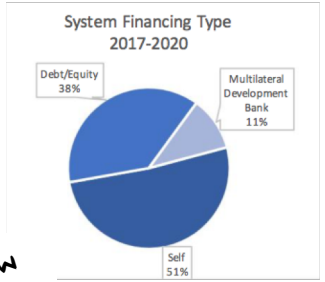
Submarine Cables

being built are now

Growth depends on content







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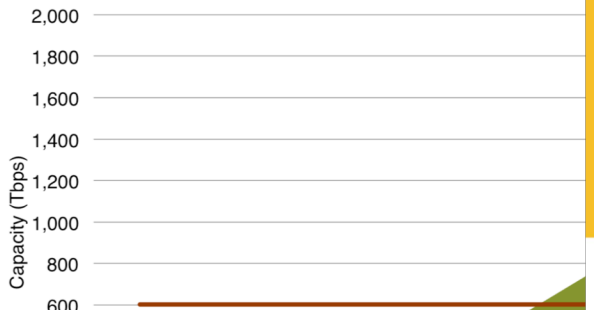
Tim Stronge, Telegeography, Sept 2017

Submarine

Growth depends on con

Lit vs. Potential Capacity on All Trans-Atlantic



Submarine cables now interconnect content data centers

ANALYTICS BY KIERAN CLARK

SUBMARINE TELECOMS MARKET SECTOR REPORT

Data Center & OTT Edition

To address the growing reporting and analysis needs of the submarine fiber industry, STF Analytics continues its Market Sector Report series – designed to provide the industry with the information it needs to make informed business decisions. The Submarine Telecoms Market Sector Report is a bi-monthly product covering a specific sector of the submarine fiber industry, coinciding with the theme of each issue of the SubTel Forum Magazine. The second edition of this report addresses the data center and Over-The-Top (OTT) provider aspect of the submarine fiber industry.

STF Analytics collected and analyzed data derived from a variety of public, commercial and scientific sources to best analyze and project market conditions. While every care is taken in preparing this report, these are our best estimates based on information provided and discussed in this industry.

The following Executive Summary provides an overview of the topics addressed in this month's report.

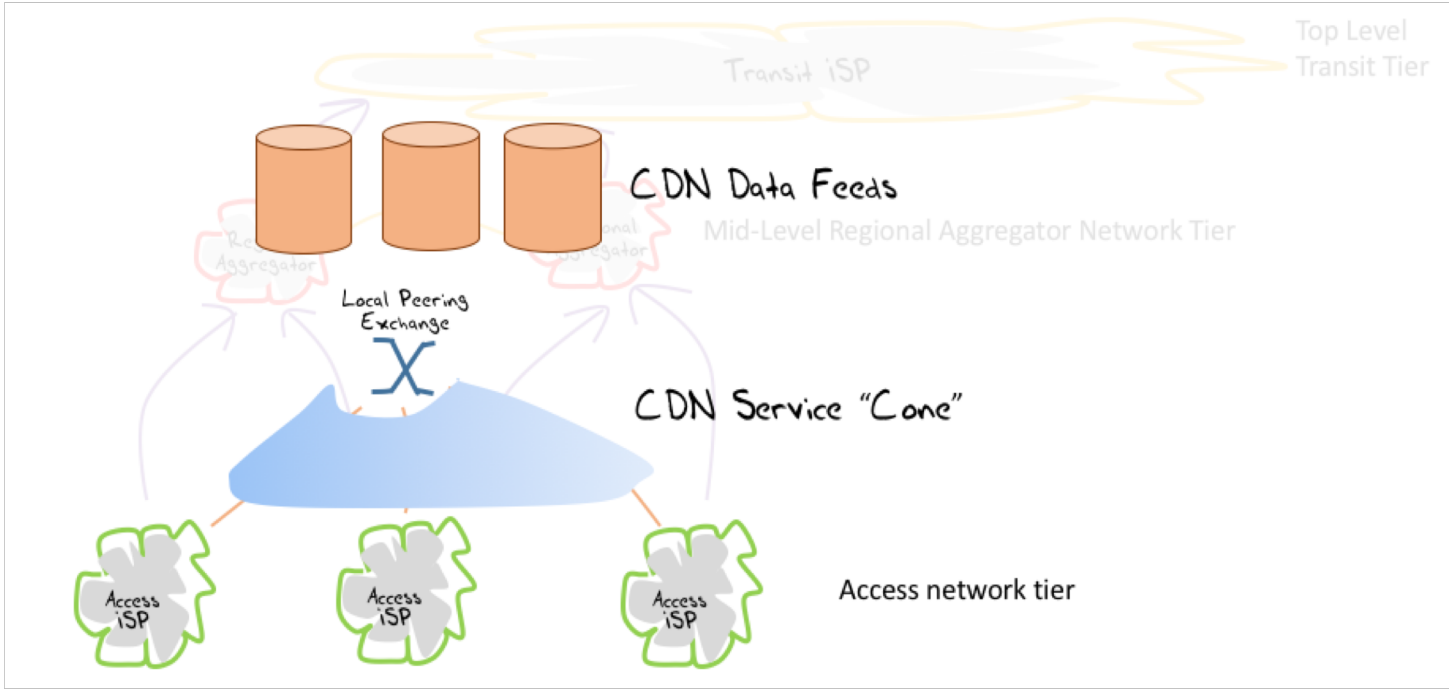
EXECUTIVE SUMMARY

The world continues to consume more and more bandwidth as digital activity for both enterprise and consumer applications move to "the cloud". The companies behind these services – including the likes of Facebook, Google and Microsoft – continue to grow at nearly astronomical rates in an effort to keep up with demand – presenting numerous opportunities for the submarine fiber industry to provide new infrastructure for the growing digital economy.Data Center and OTT providers are an increasingly integral part of the submarine cable system development process. OTT providers like Facebook, Google, Microsoft – and Amazon in the near future – are moving from capacity purchasers to cable owners. Meanwhile, data center providers work to bridge the gap between the cable landing station and backhaul or interconnection services in an attempt to maximize network efficiency and throughput for their customers by attempting to bring once disparate infrastructure into a single facility. More closely integrating data centers and

6 SUBMARINE TELECOMS MAGAZINE

Submarine Telecoms Magazine, November 2018

Today's Internet Architecture



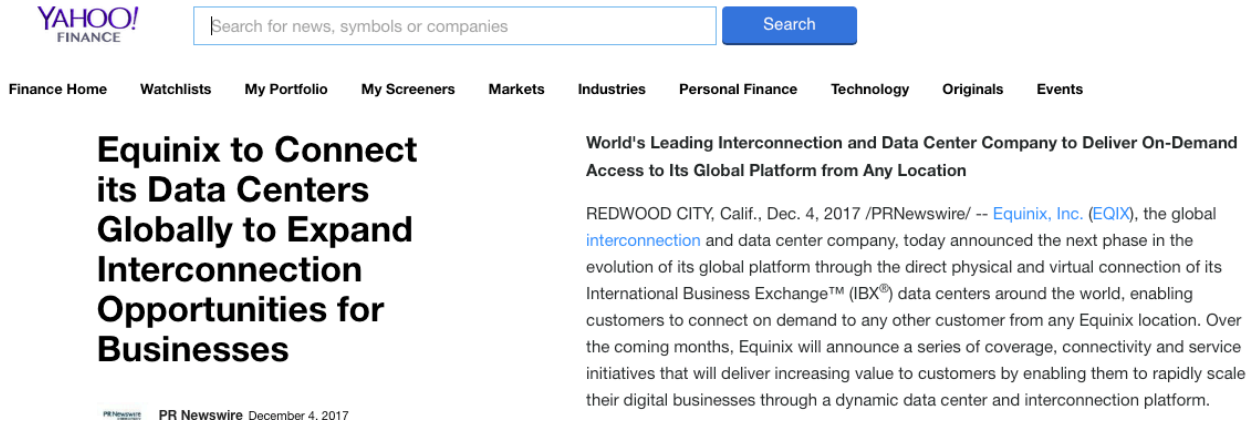
Who needs Transit?

- If users don’t send packets to users any more…
- If content is now delivered via CDNs to users via discrete service cones…
- If there is no universal service obligation…

Then why do we still need Transit Service providers?

Closed Transit?

We see the CDN systems reserve a carriage resource through dedicated bandwidth / wavelength / cable purchase and effectively bypass the open IP carriage infrastructure



Transit?

Once the CDN caches sit “inside” the Edge NAT of the Access ISP then the entire wide area network becomes a marginal activity compared to the value of the content feeds!

Internet Names and Addresses?

If the Internet is (or maybe soon will be) a collection of discrete CDN service ‘cones’ then why do we expect end users to pay for the maintenance of:

- A global address plan?
- A global name system?
- A single global network?

It's not just Death of Transit

It’s the re-purposing of the entire network

- Service provisioning sits within cloud providers and distributed data centres
- Edge computers are now acting as televisions into the clouded world of data
- The distinction between personal and public data realms is disappearing into the realm of corporately owned private data empires

Exactly where are we?

- We started this journey building a telephone network for computers to communicate between each other
- But now one-way content distribution lies at the core of today's Internet
- This content distribution role is an enterprise service framework rather than a public carriage service
- The internal parts of the carriage network are now being privatized and removed from public regulatory oversight

Policy?

If CDN feeder networks are private networks, and there is little residual public carriage other than last mile access networks, then what do we really mean by “public communications policy”?

In the regulatory world ‘content’ is ***commerce***, not ***carriage***!

Policy?

In today's Internet what do we mean in a policy sense by concepts such as:

"***universal service obligation***"

"***network neutrality***"

"***rights of access***" or even

"***market dominance***"

when we are talking about diverse CDNs as the dominant actors in the Internet?

The Large and the Largest

Company	Market Cap (B)
Apple	1,091
Amazon	976
Microsoft	877
Alphabet	839
Berkshire Hathaway	523
Facebook	473
Alibaba	423
Tencent	388
JPMorgan Chase	379
Johnson & Johnson	370

The world's 10 largest publicly traded companies, as ranked by their market capitalization, Q3, 2018

Content Really is King!

- None of these seven technology companies are a telephone company, or even a transit ISP, or even an ISP at all!
- All of them have pushed aside carriage networks in order to maintain direct relationships with billions of consumers
- These valuable consumer relationships are based on content services, not carriage

Content Consolidation

- There are not thousands of content service platforms any more
  - There are just a few left
- And the space is dominated by a small number of dominant actors who set the rules of engagement for all others

Content Consolidation

"The size and scale of the attacks that can now easily be launched online make it such that if you don't have a network like Cloudflare in front of your content, and you upset anyone, you will be knocked offline.

…

In a not-so-distant future, if we're not there already, it may be that if you're going to put content on the Internet you'll need to use a company with a giant network like Cloudflare, Google, Microsoft, Facebook, Amazon, or Alibaba.

…

Without a clear framework as a guide for content regulation, a small number of companies will largely determine what can and cannot be online.

https://blog.cloudflare.com/why-we-terminated-daily-stormer/ August 2017

Consolidation?

Alphabet is primarily an advertising company that dabbles in blue-sky technology projects.

Never in the history of the world has a single company had so much control over what people know and think. Yet Washington has been slow to recognize that Google's power is a problem, much less embrace the obvious solution: breaking the company up.

Google accounts for about 90 percent of all Internet searches; by any honest assessment, it holds a monopoly at the very gateway to information in the modern world. From there, the company's power radiates outward, dominating everything from maps to smartphone operating systems to video distribution — vacuuming up huge quantities of highly specific data about users along the way.

Boston Globe , June 14 2018

Competition or Cartel?

With a small number of truly massive enterprises at the heart of the area of digital content and service is this still a space that is shaped by competitive pressures?

Or do these dominant incumbents get to set their own terms of engagement with each other, with users, and even with the public sector?

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With a small number of truly massive enterprises at the heart of the area of digital content and servi[illegible]ace that is shaped by compet[illegible]

Or d[illegible] get to set their own terms of e[illegible] each other, with users, and even with the public sector?

As concerning as this might sound, it's not a novel situation!

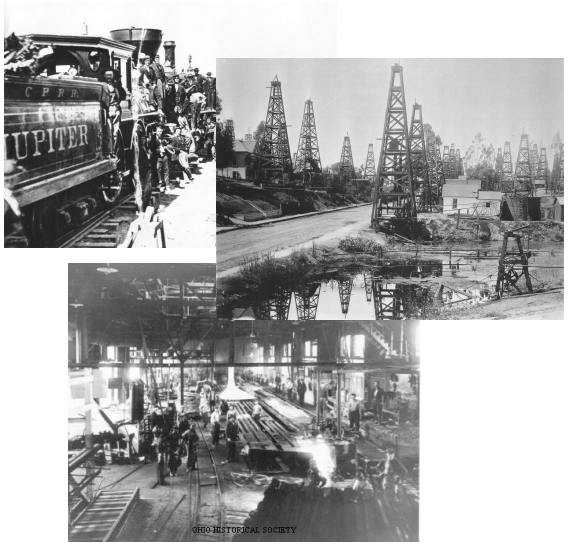
We've been here before…

High Museum of Art, Atlanta

The Gilded Age

A term applied to America in the 1870 – 1890's about the building of industrial and commercial corporate giants on platforms that were a mix of industrial innovation and enterprise with elements of greed, corruption and labor exploitation

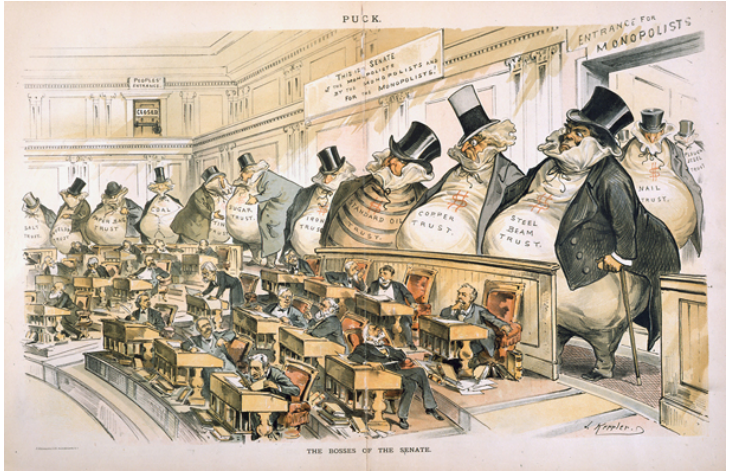
Andrew Carnegie - US Steel
John Rockfeller - Standard Oil
Theodore Vail - AT&T
George Westinghouse – Rail Brakes
Thomas Edison – General Electric
J P Morgan - Banking



The Gilded Age

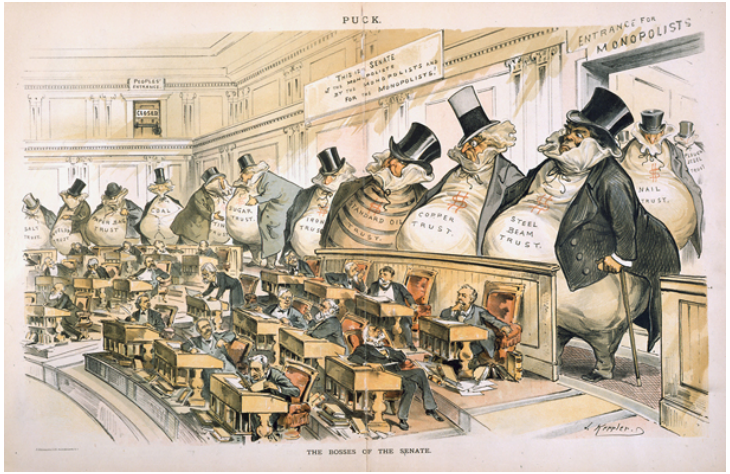
During this period in the United States the dominant position within industry and commerce was occupied by a very small number of players who were moving far faster than the regulatory measures of the day.

The resulting monopolies took the US decades to dismember, and even today many of these gilded age companies remain dominant in their field



The Internet's Gilded Age

At some point in the past decade or so the dominant position across the entire Internet has been occupied by a very small number of players who are moving far faster than the regulatory measures that were intended to curb the worst excesses of market dominance by a small clique of actors.



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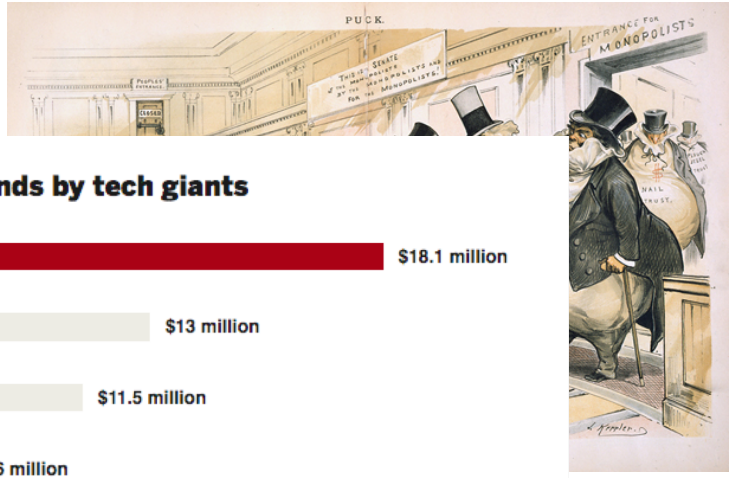

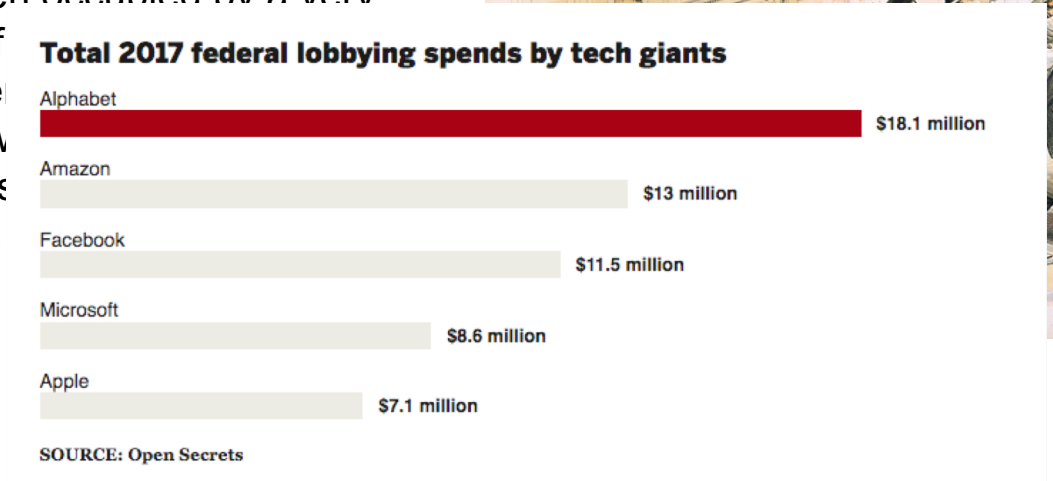

The Internet's Gilded Age

These actors have enough market influence to set their own rules of engagement with:

- Users,
- Each other,
- Third party suppliers,
- Regulators and Governments

By taking a leading position with these emergent technologies, these players are able to amass vast fortunes, with little in the way of accountability to a broader common public good

The Internet's Gilded Age

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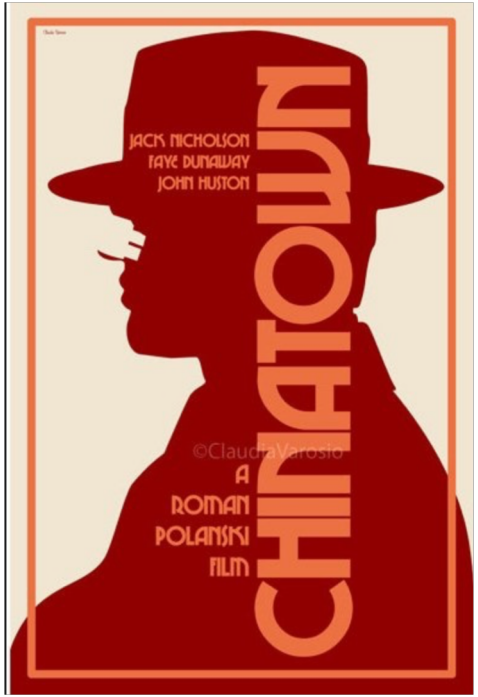
- Users,
- Each other,
- Third party
-

By ta ing position with these emergent technologies, these players are able to amass vast fortunes, with little in the way of accountability to a broader common public good

The Internet's Future

Gittes: How much are you worth?
Cross: I've no idea. How much do you want?
Gittes: I just want to know what you're worth. Over ten million?
Cross: Oh my, yes!
Gittes: Why are you doing it? How much better can you eat? What can you buy that you can't already afford?
Cross: The future, Mr. Gittes - the future!

Chinatown (1974)



What is this all about?

This is no longer just a conversation about incremental changes in carriage and communications within the Internet.

For me, the essential topic of this conversation is how we can strike a sustainable balance between an energetic private sector that has rapidly amassed overarching control of the digital service and content space, and the needs of the larger society in which we all would like some equity of opportunity to thrive and benefit from the outcomes of this new digital age.

The Economist
The next space race
Immigration's poisonous politics
Something's coming: Bernstein at 100
Our Big Mac index
JANUARY 20TH–26TH 2018
The new titans
And how to tame them

What's the problem?

Is it that these enterprises are:

- so big?
- exploitative of their workers?
- distorting markets?
- extracting monopoly rentals from consumers?
- not providing consumers what they want?

What's the problem?

- In the quest for ever-faster service delivery we are seeing the return of proprietary solutions in applications and service delivery platforms that expose as little as possible to the underlying network platform

What's the problem?

- Perhaps the problem is the looming demise of open technologies and open technology standards
  - Akamai uses Fast to improve content delivery
  - Google uses QUIC and BBR
  - Facebook and WhatsApp use strong encryption to hide the application from the network and the platform

  - Applications are no longer constructed on a platform of common libraries provided by the platform
  - Applications are now paranoid and avoid exposing their behaviour wherever and whenever possible
  - Applications are increasingly reluctant to use standard open technologies in standard and open ways

What's the problem?

- In its place we are seeing a resurgence of various closed technologies that create a set of datacentre-to-application bindings that are impervious to all third parties
- These closed architectures make minimal assumptions about a common network protocol, a common name space or even a common name space
- What happens to the efforts that support open technologies, open standards and open networking in such a world?

Where does all this head?

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i just don't know!

But i'm not sure that it's all good!

Thanks!