Technology Adoption and the Internet

Geoff Huston

Chief Scientist
APNIC Labs

Why?

Was IPv4 a runaway success, yet IPv6 is approaching its third decade of waiting in the wings?

Why?

Was IPv4 a runaway success, yet IPv6 is approaching its third decade of waiting in the wings?

Will this “transition” ever end?

Why?

Was IPv4 a runaway success, yet IPv6 is approaching its third decade of waiting in the wings?

Will this “transition” ever end?

When?

Why?

Was IPv4 a runaway success, yet IPv6 is approaching its third decade of waiting in the wings?

Will this “transition” ever end?

When?

Or has it already ended and the mess we have today is the mess we are going to have to live with for a few more decades until the Internet crumbles into chaos?

More Whys?

Are we still using BGP?

- It’s a 65 year old network routing protocol that creaks and groans! Haven’t we had better ideas since then?

And what about TCP, HTTP, DNS, SMTP?

- None of these protocols are recent inventions either
- We seem to spend most of our time tweaking around the edges and avoiding fundamental changes these days

What's happening?

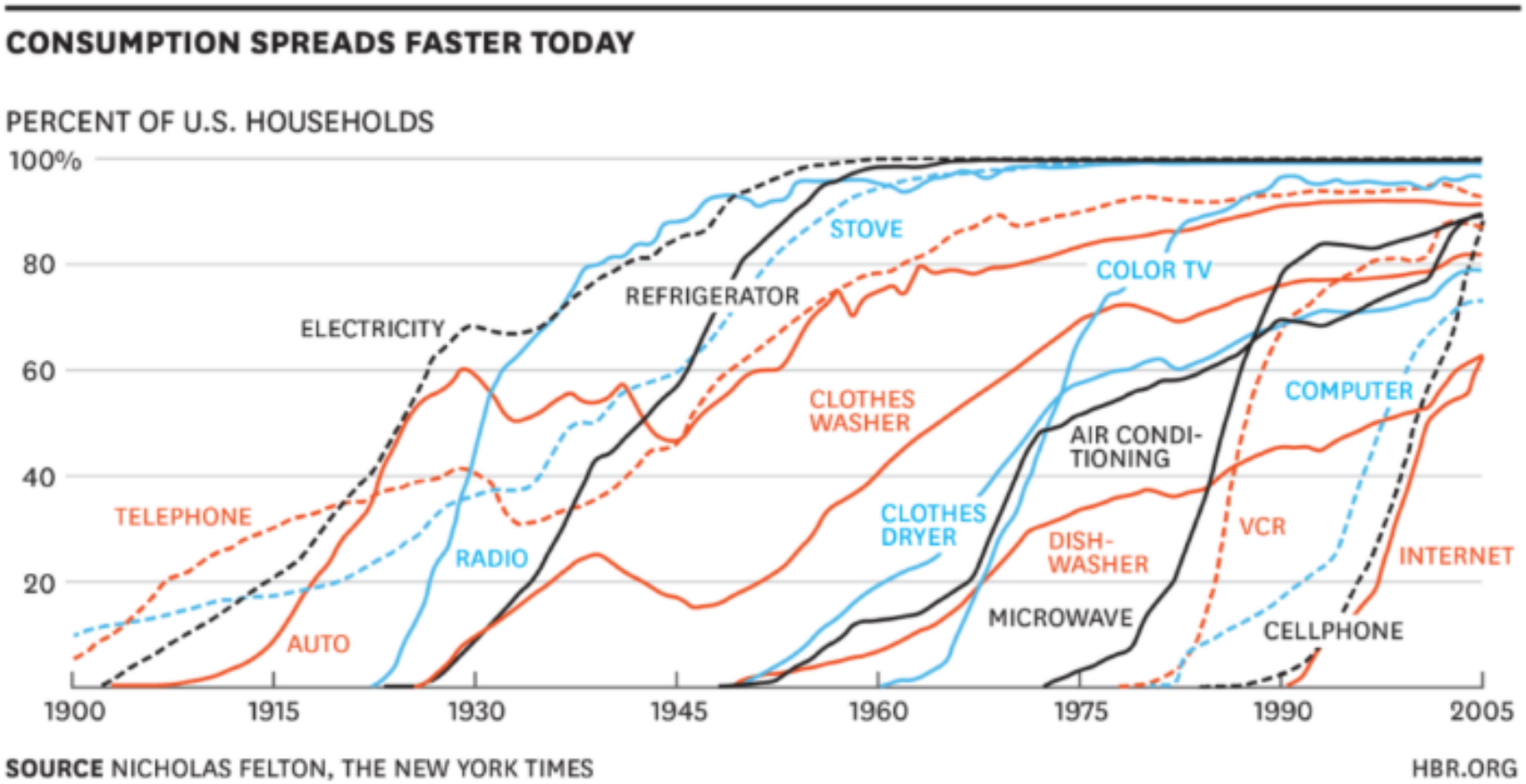
Is there any appetite left for technical innovation in the internet, or is the internet entering a terminal phase of sclerotic dotage?

We’re not making changes because what we have is perfect. Far from it.

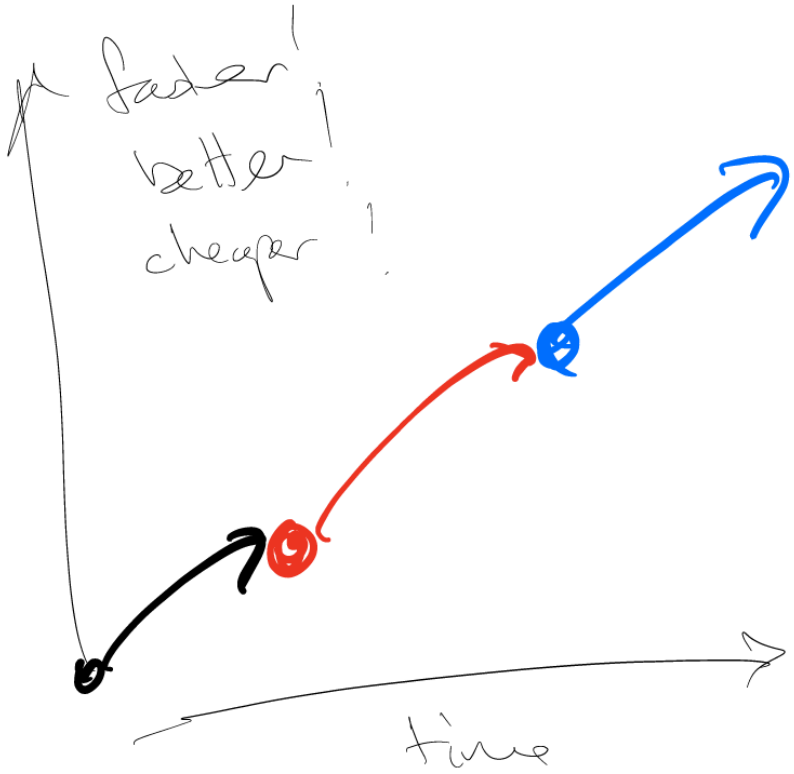
But despite many issues we are still slow to adopt changes

So why does today’s Internet actively resist change?

The Pace of Consumer Technology Adoption



A Conventional View of Progress



This view sees progress as progressive refinement

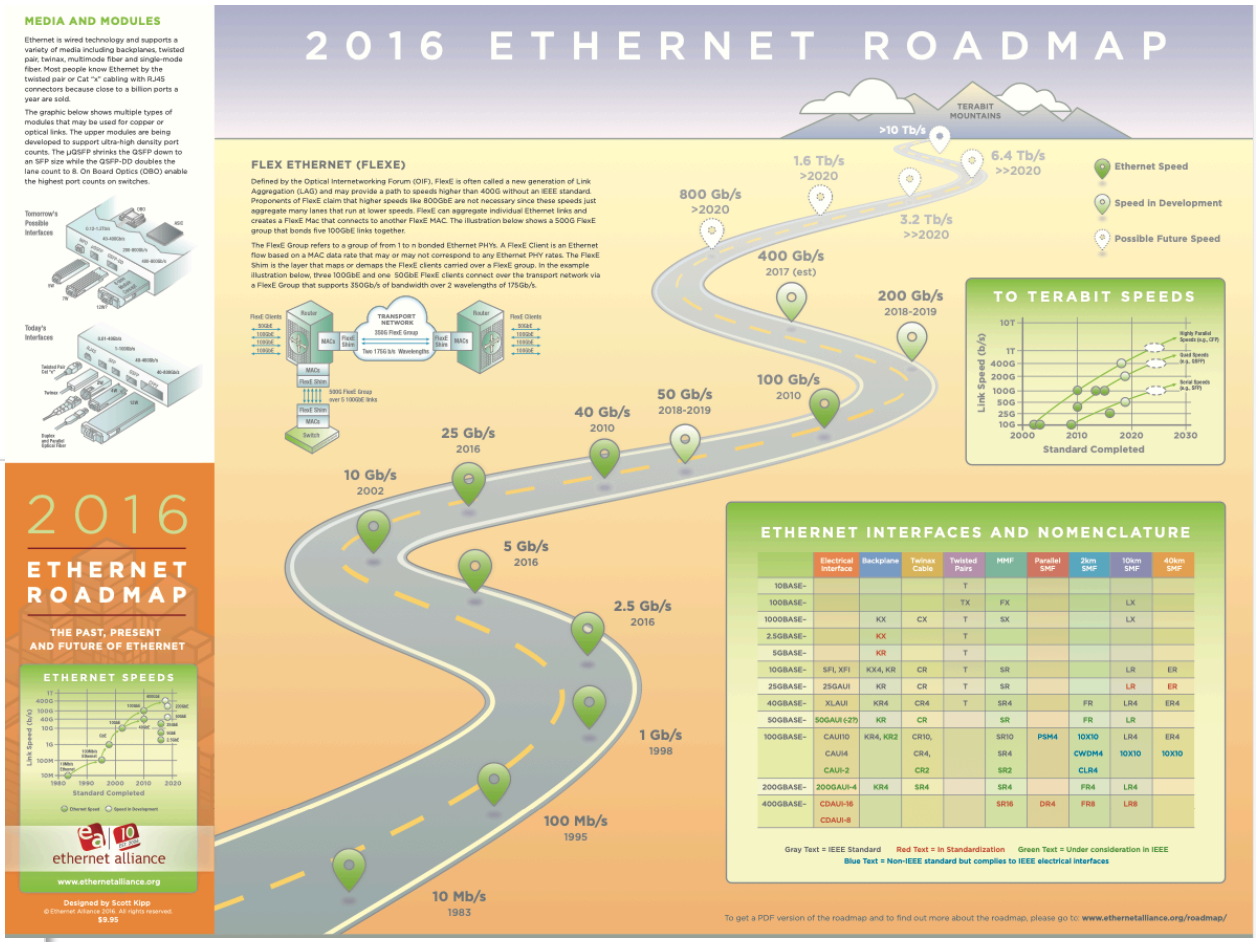
Adopted technologies build on existing capabilities

Progress is largely deterministic

Example: IEEE 802.3 GigE

Ethernet Speed Evolution Summary

- 2.5 GE and 5 GE is coming soon for higher speed Cat 5e/6 applications
- 10 GE is being widely deployed in every part of the network
- 25 GE is coming soon for server and ToR applications
- 40 GE is increasingly deployed in data center networks
  - Popular for 40 GE and 4 x 10 GE breakout
- 100 GE has transitioned to 2nd generation technology with CFP2, CFP4 and QSFP28
  - Still at least a generation away from 100 Gb/s serial signaling
- 400 GE development is well under way and will leverage 100 GE technology
- Ethernet at Terabit speeds is still unfeasible in the near future, but we'll get there eventually (2020+)



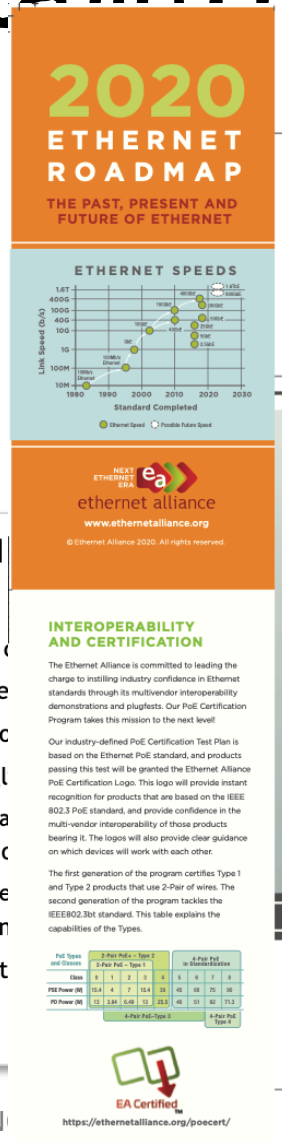
2016 Ethernet Alliance Road Map
http://ethernetalliance.org/roadmap

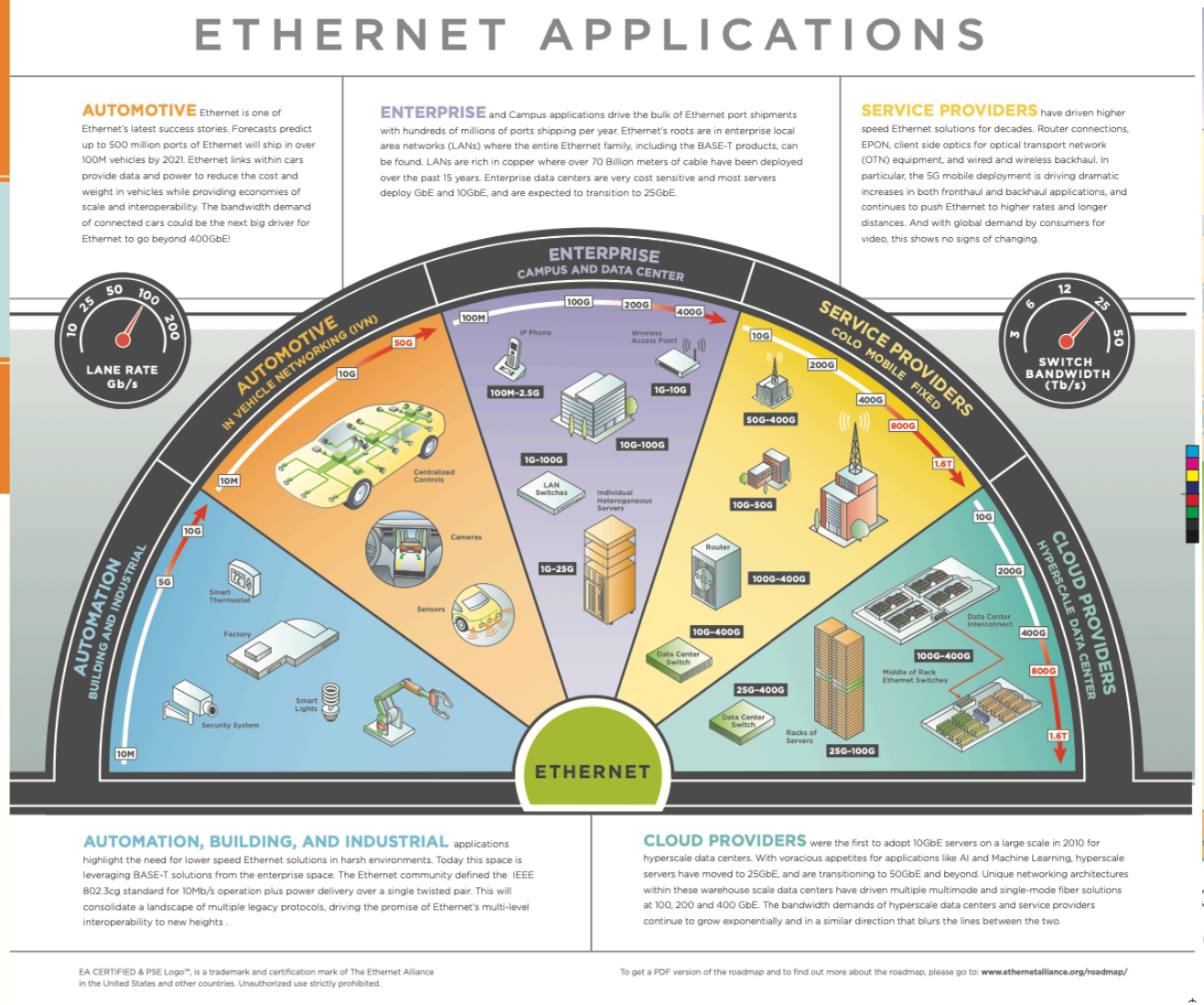
Greg Hankins, NANOG 64, Evolution of Ethernet Speeds: What's New and What's Next
June 2015

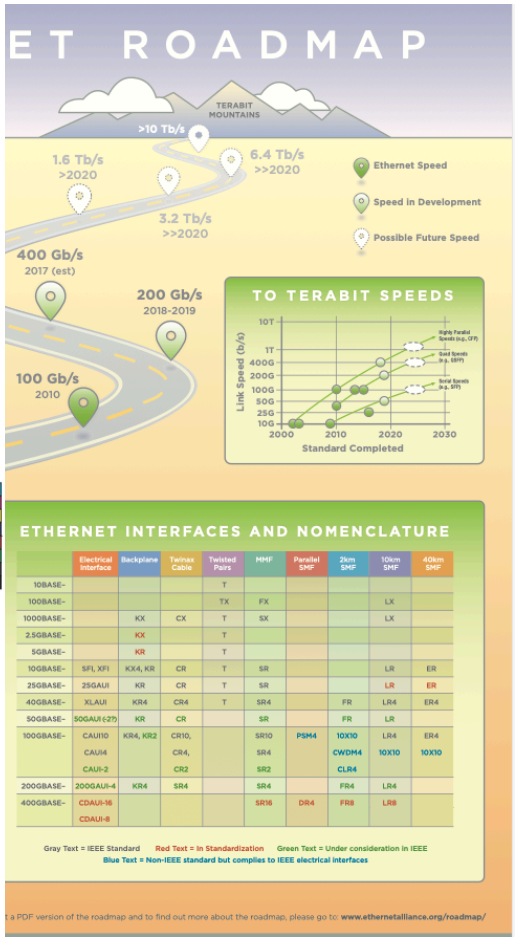
Example: The 802.3 CSD

Ethernet Speed

- 2.5 GE and 5 GE is
- 10 GE is being wide
- 25 GE is coming soo
- 40 GE is increasingl
  - Popular for 40 GE a
- 100 GE has transitio
  - Still at least a gene
- 400 GE developmen
- Ethernet at Terabit (2020+)



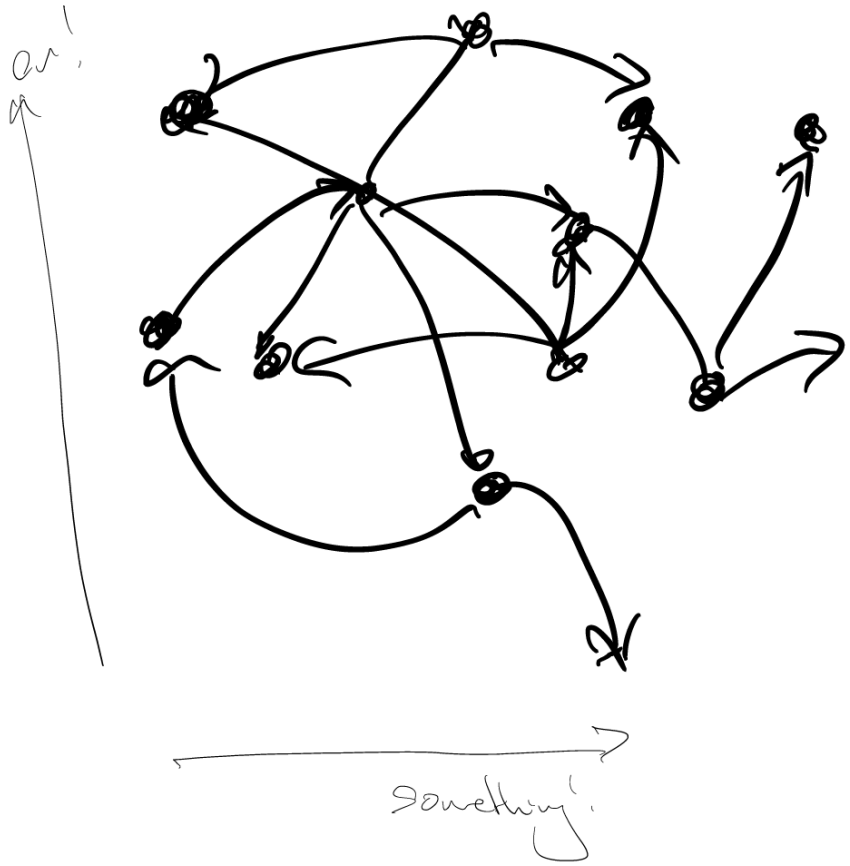




ce Road Map
ce.org/roadmap

Greg Hankins, NAN
Next
June 2015

Reality is often messier!



This view sees progress as a random outcome of an underlying chaotic set of circumstances

We have no real concept of any long term objective, and just shift from state to state in random directions

What is this telling us?

It appears that technology evolutionary process is like a biological process – pretty much random!

But the filter of natural selection has no clear analogue in technology

- Sometimes completely broken technologies gain market ascendency
- Sometimes we accidently make good choices for all the wrong reasons at the time!

We can't all decide on the same thing at the same time

Sometimes we just can’t choose, and then we pick both

- Household power: 110v vs 240v, 50Hz vs 60Hz?
- Driving vehicles: on the left or on the right?

Closer to home - Telephony:

- μ-Law or A-Law voice encoding?
- T vs E multiplexing?

Computing technology is not immune

- what’s a ‘word’ – 6 bits, 8 bits, 16 bits, 32 bits, 36 bits, 60 bits?
- big endian vs little endian?

Success!

Some technology platforms have been completely revolutionary in their impacts through widespread adoption:

- The IP packet switched model
- The browser application
- Mobile devices
- Social Media

Examples of Transformational Technologies

Circuits to Packets

- 100x unit cost reduction in network service
- The change was large enough to destroy the incumbent telco market

Hardware to Cloudware

- 2x – 4x unit cost reduction
- Moderate pace of change that has allowed some incumbents to ride the change while others have had a harder time

Failure!

Other technologies appear to fall far short of their intended adoption trajectory:

- OSI
- ATM
- SMS
- IPv6
- “New IP”

Failure Examples

IPv6

- No marginal unit cost improvement
- Incumbents feel no major pressure to adopt
- 25 year transition with no end in sight

DNSSEC

- Increased unit cost without clear incremental benefits
- Another protracted transition with no end in sight

Circuits to Packets

- True stateless packet switched networks exist only in textbooks these days
- With MPLS and its variants we've back to virtual circuits again!

What's going on?

- Why was IPv4 fast-paced success while IPv6 has been a slow motion train wreck of prevarication and delay?
- Why is security a market failure?
- Is Google now so entrenched that it is beyond all but the most disruptive of competitive technology pressures?

What drives change?

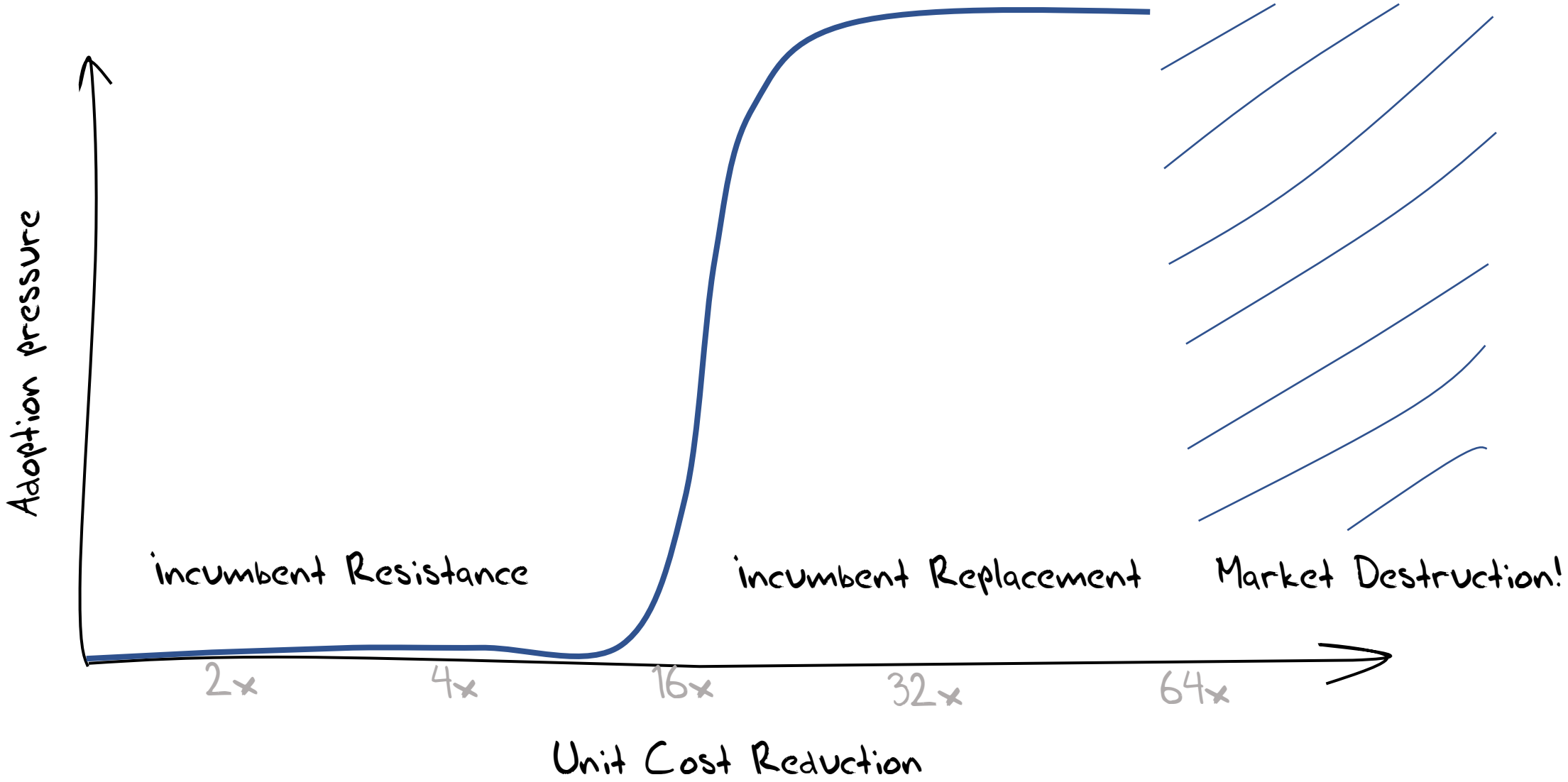
Market motivations:

- Incumbency breeds risk aversion and increasing inertia
- Breeds erection of increasing barriers to market entry by competitive actors
- The cost of risk rises
  - Venture capital funds increasingly uninterested in small cap ventures – its either billions or nothing, because underfunded exercises in disruptive competition are increasingly likely to fail

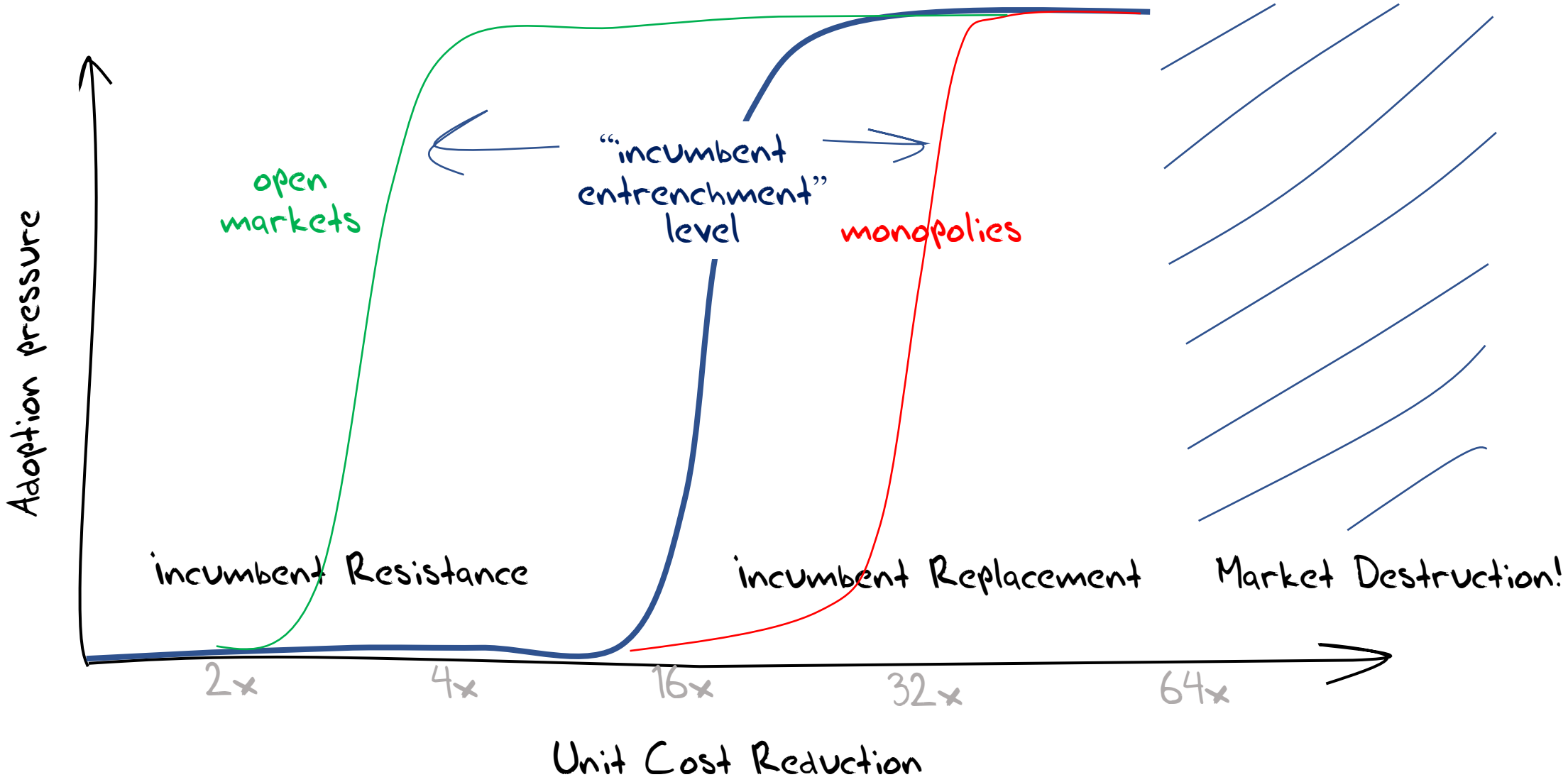
which

which means

Economics of Innovation

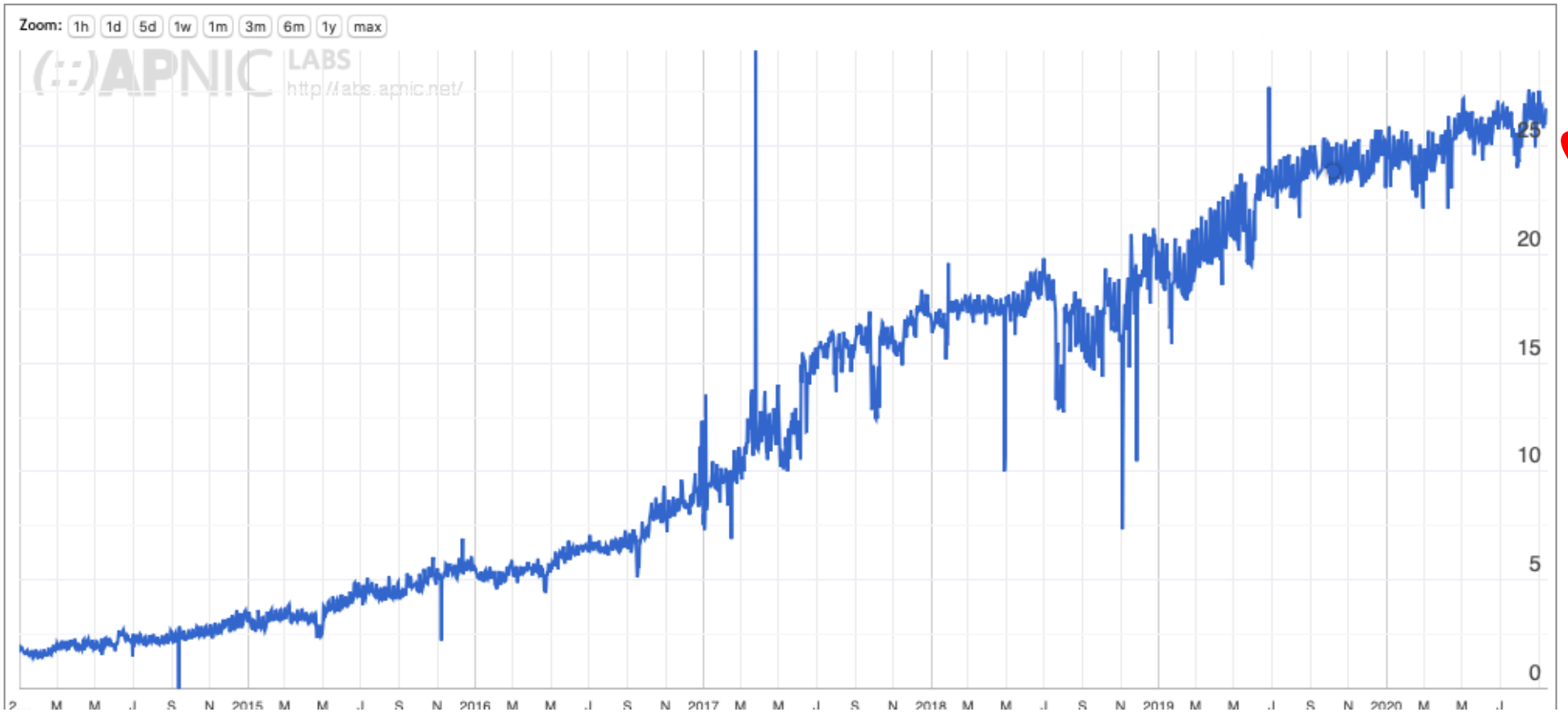


Economics of Innovation



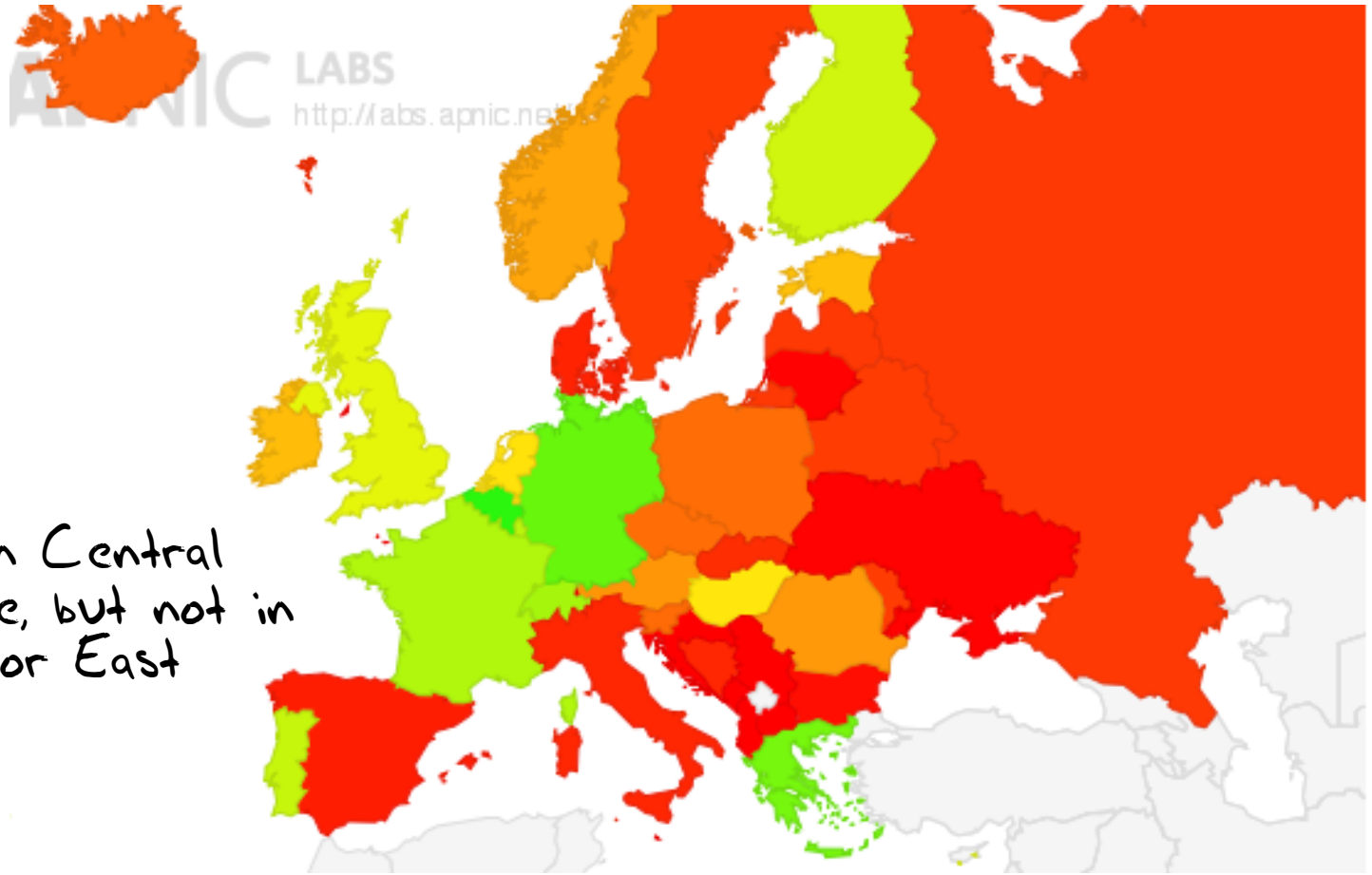
Some Examples

IPv6 adoption - 2012 to Today



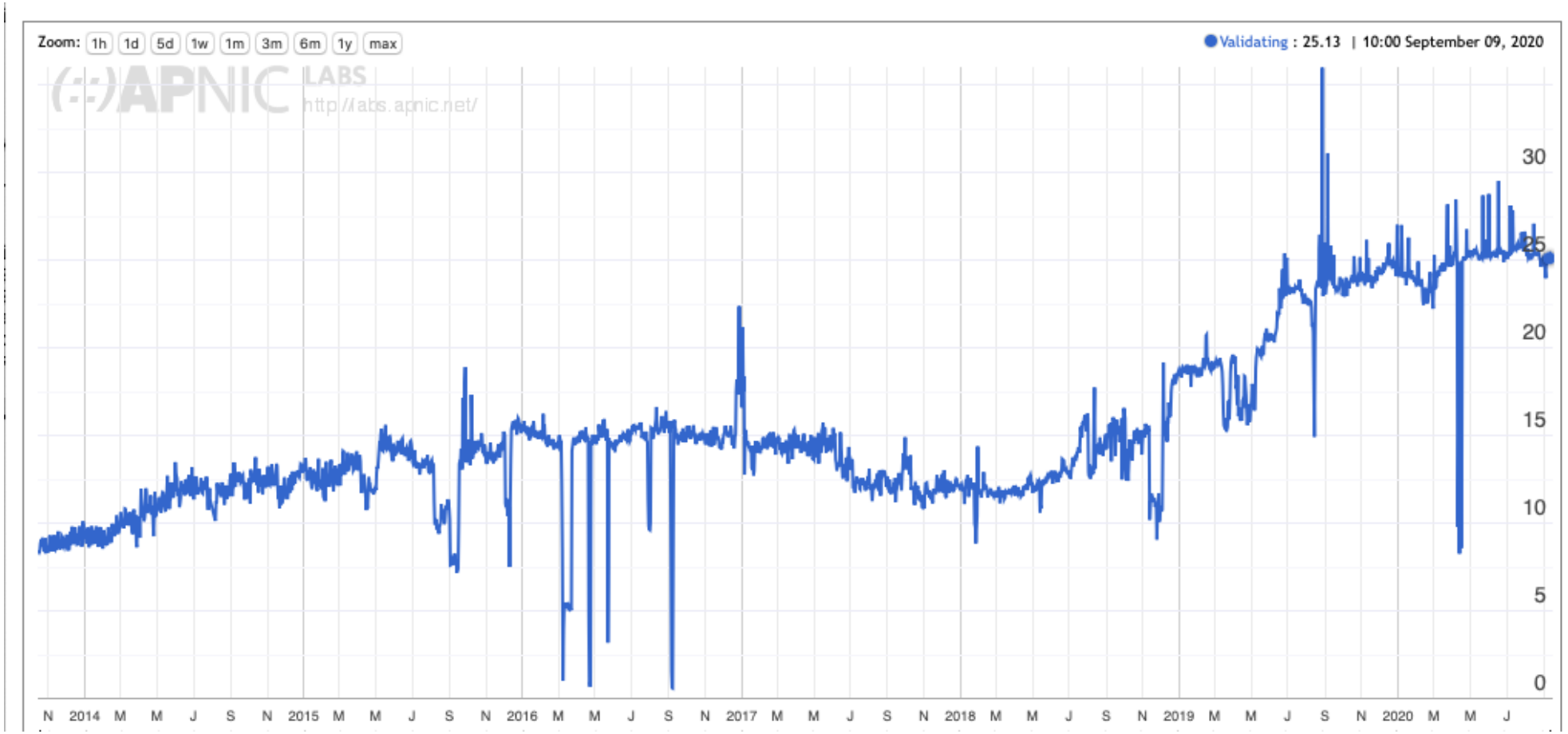
26% of the Internet's user base have IPv6 today

And is very diverse in Europe

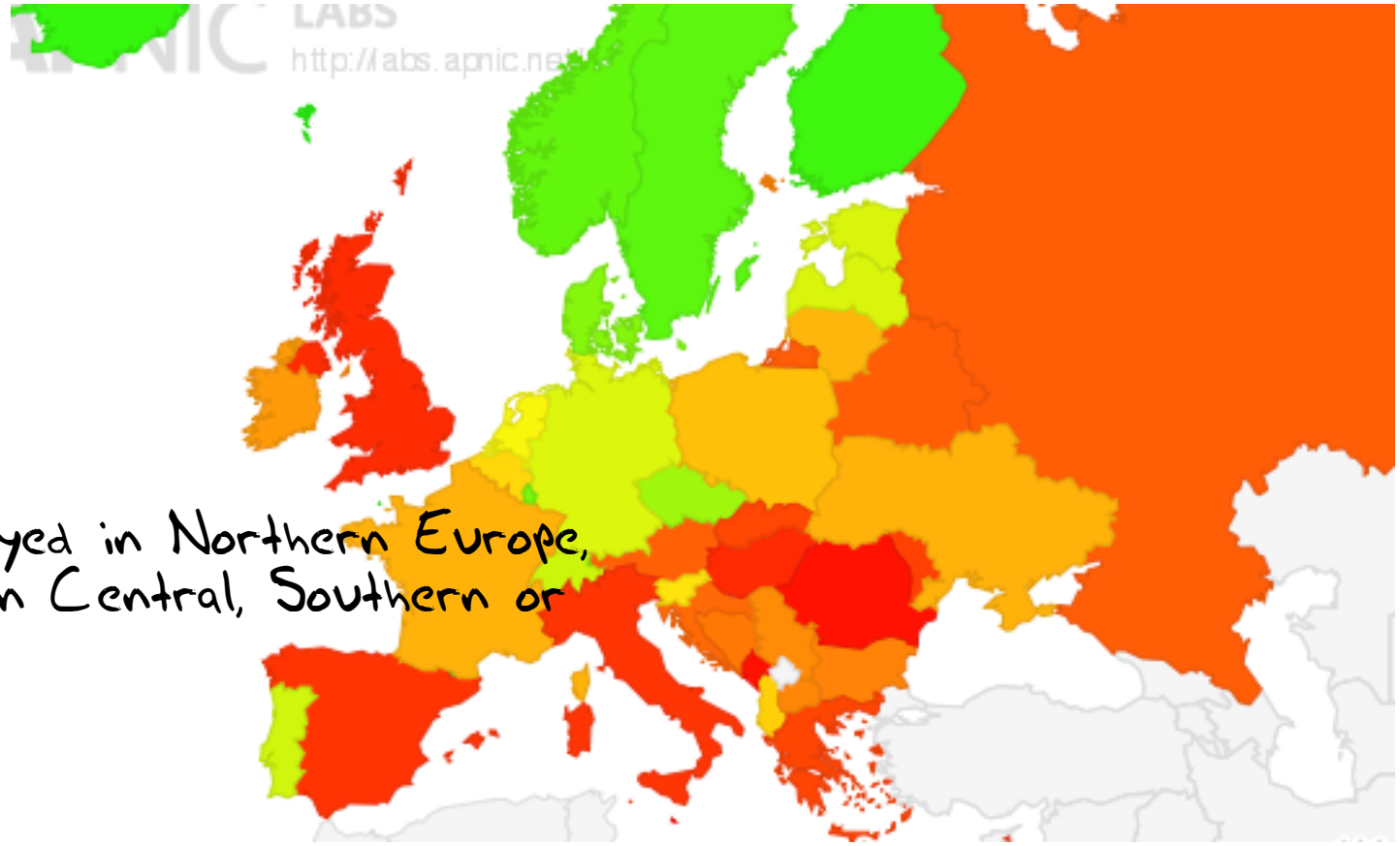


IPv6 is deployed in Central Europe and Greece, but not in the North, South or East

DNSSEC adoption

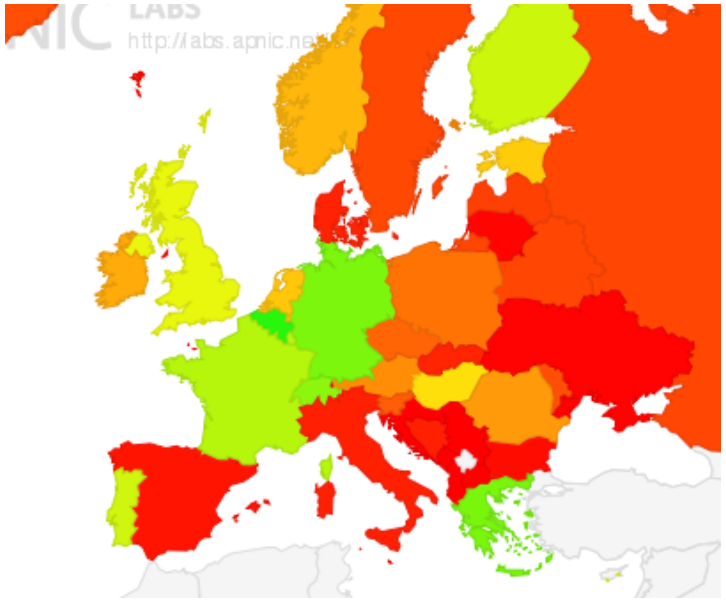


Same (but different) diversity



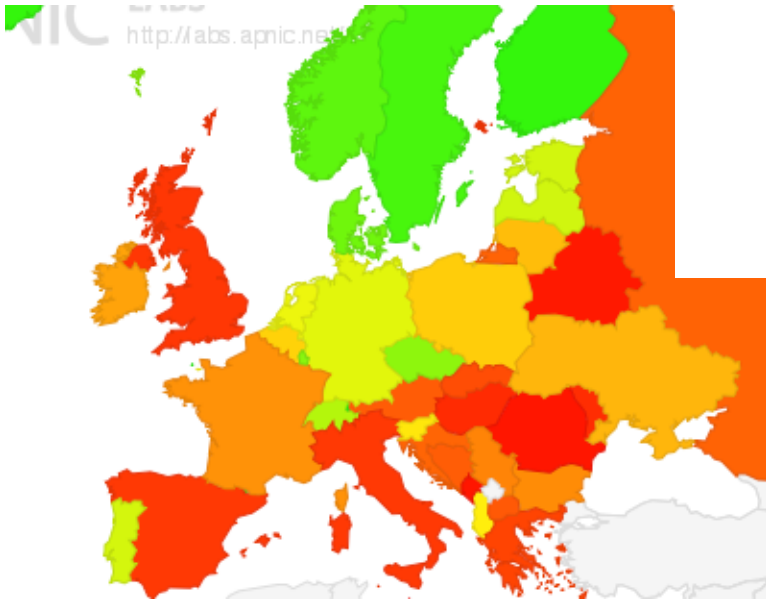
DNSSEC is deployed in Northern Europe, but not as much in Central, Southern or Eastern Europe

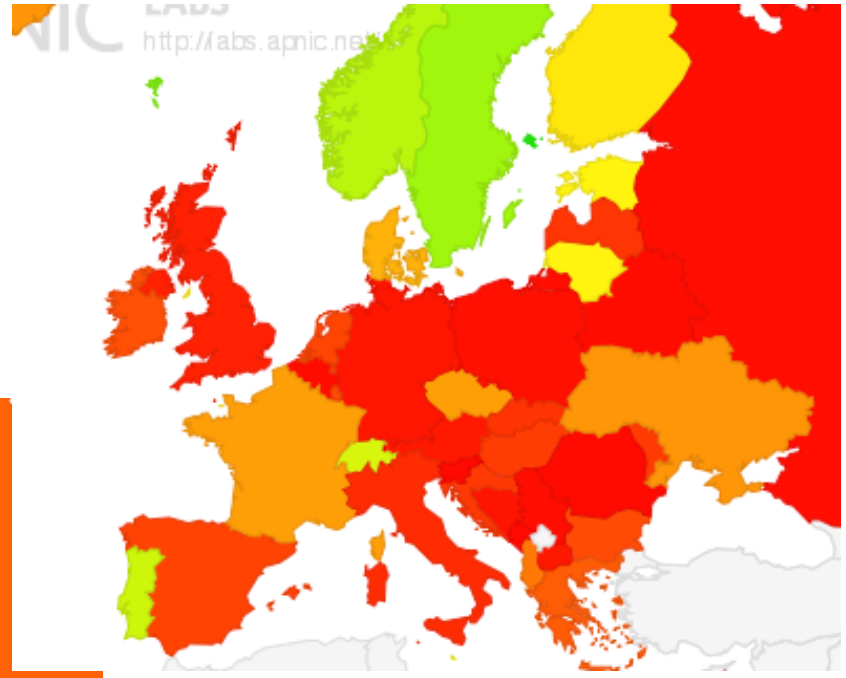
Why is there such diversity in deployment?



IPv6

DNSSEC





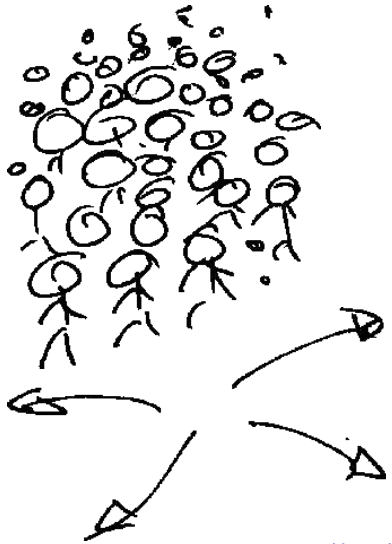
RPKI ROV

Challenges for adoption:

1. This is a deregulated and highly competitive environment

There are many different players

Each with their own perspective



And all potential approaches will be explored!

Challenges for adoption:

2. The myth of long-term planning

"IPv6 Transition will take many years...

5 years, maybe 10 years, maybe longer"

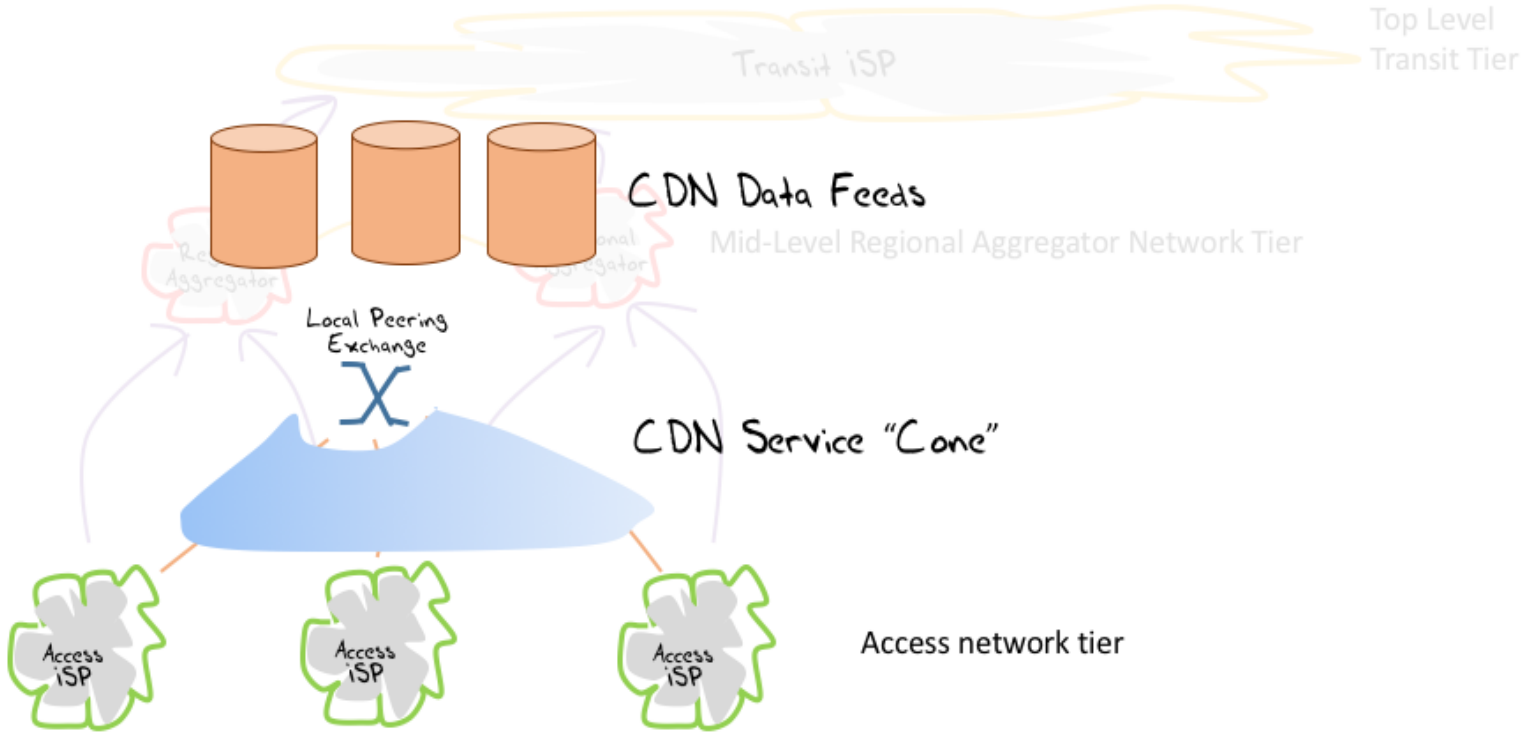
Are we still firmly committed to the plans we had 5 years ago? How about our 10-year-old plans?

The longer the period of transition, the higher the risk of completely losing the plot and heading into other directions!

Challenges for adoption:

3. The environment keeps changing

Today's Internet Architecture



Some Providers see advantage in early adoption

- Competitive positioning in a diverse market
- Early adoption of future mainstream technologies (first user advantage)
- Perception of enhanced utility, security and safety in these more recent technologies

Other Providers see compelling reasons to wait …

- **IPv6** is a 1990's technology solution to a 1980's networking architectural challenge – CDN feeder networks do not need globally unique address plans across every device all of the time
- **DNSSEC** is merely a pantomime of secure DNS. If we pushed DNSSEC validation to the edges of the network where it truly matters we're scared that the DNS will slow down to unacceptable levels. DANE's demise is a good example of this DNS paranoia!
- **RPKI Route Origin Validation** is also a thin veneer of supposed security. It makes routing attacks ever so slightly harder. More moving parts can introduce fragility, and not necessarily enhance operating stability

What drives change?

This is a market, like any other

And consumers of goods and services make choices

These user choices are what drives the market

What resists change?

- Volume tends to increase inertial resistance
  - And the digital world has massive volume
- Incumbency resists change
  - And the digital world is now dominated by a small set of incumbents
- The emergence of large scale digital incumbents creates its own challenges

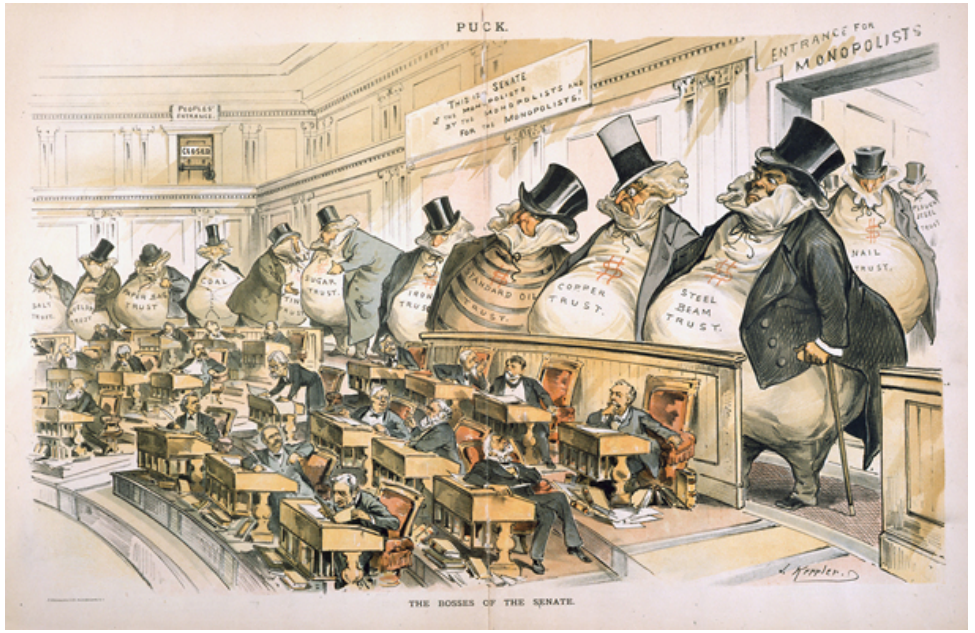
Change and Monopolies

- We are now communicating with a computer-mediated environment rather than with each other
- The network itself is largely incidental to this evolving story, and this is not really about the Internet any more
- It's about a set of revolutionary social changes on a par with the industrial revolution that have been triggered by abundant computing, storage and comms
- And its dominated by a very small cartel of monopolists

The Gilded Age in the United States

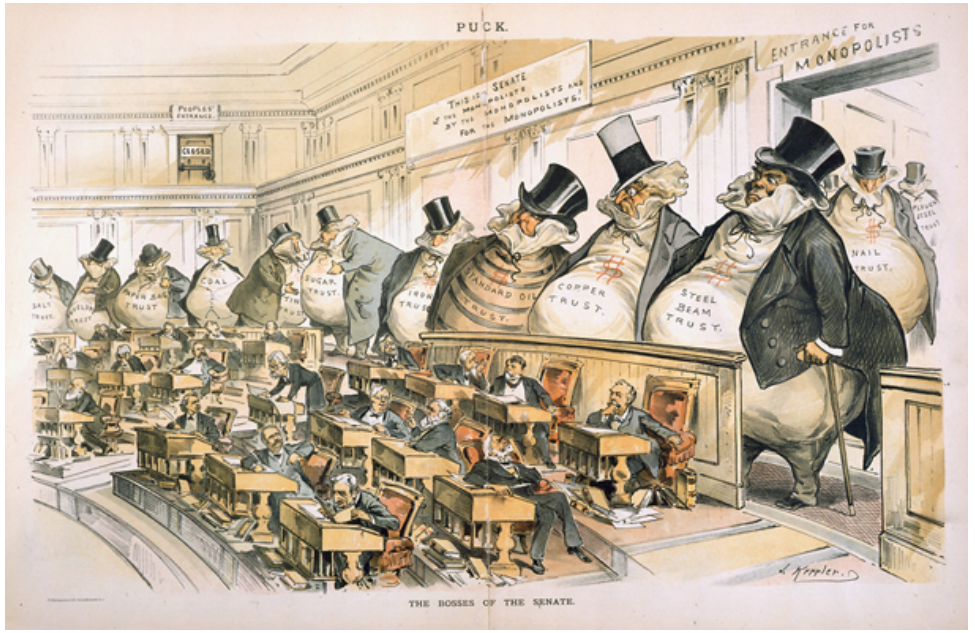
During latter part of the 19th century in the United States the dominant position within industry and commerce was occupied by a very small number of players who were moving far faster than the regulatory measures of the day.

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.



Gilded Age

The New York Times

Tech Giants Amass a Lobbying Army for an Epic Washington Battle

Catlin O'Neill, right, listening to Facebook's chief executive, Mark Zuckerberg, testify before a House committee on the protection of user data last year. Ms. O'Neill is now director of United States public policy for Facebook after serving as Speaker Nancy Pelosi's chief of staff.
Tom Williams/CQ Roll Call, via Getty Images

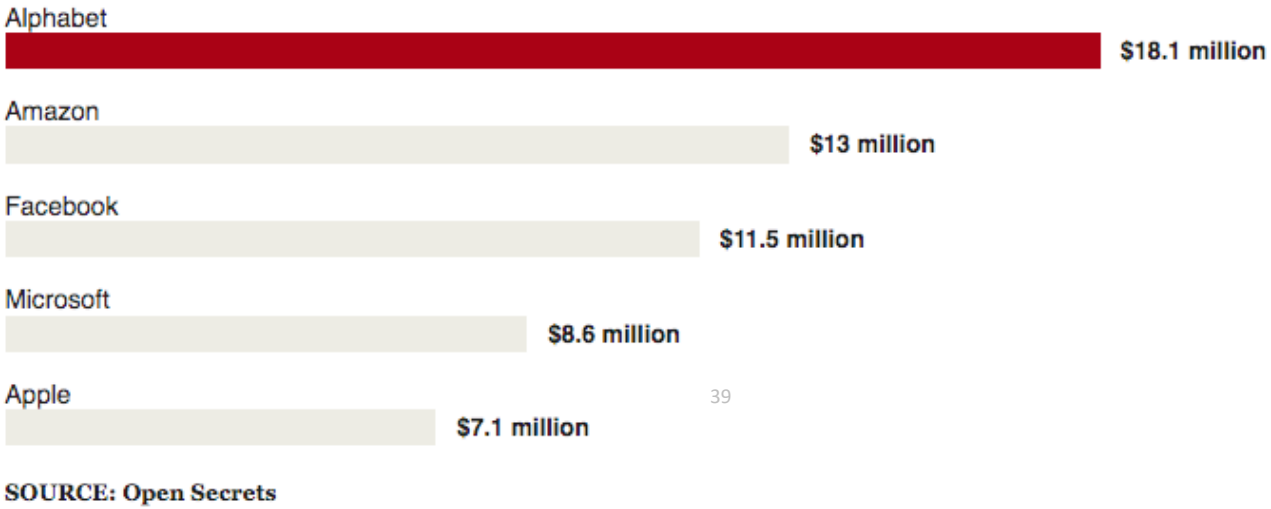
By Cecilia Kang and Kenneth P. Vogel

June 5, 2019

155

WASHINGTON — Faced with the growing possibility of antitrust actions and legislation to curb their power, four of the biggest technology companies are amassing an army of lobbyists as they prepare for what could be an epic fight over their futures.

Total 2017 federal lobbying spends by tech giants

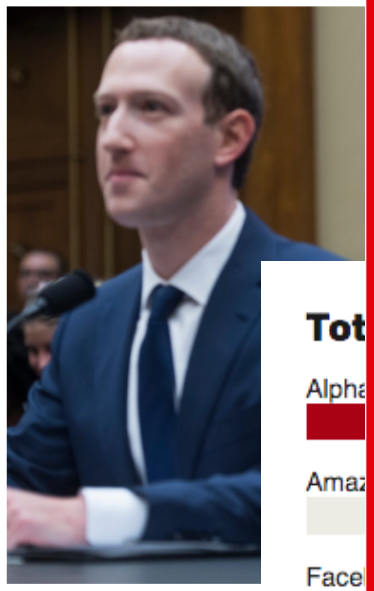


SOURCE: Open Secrets

T ge

The

Tech Giants Ar
Army for an Ep



Catlin O'Neill, right, listening to
committee on the protection of
policy for Facebook after servin
Tom Williams/CQ Roll Call, via Gett

Tot
Alpha
Amaz
Face
Micro
Apple

By Cecilia Kang and K

June 5, 2019

WASHINGTON - SOU
actions and legislation to
technology companies are
prepare for what could be

The Economist

JANUARY 20TH–26TH 2018

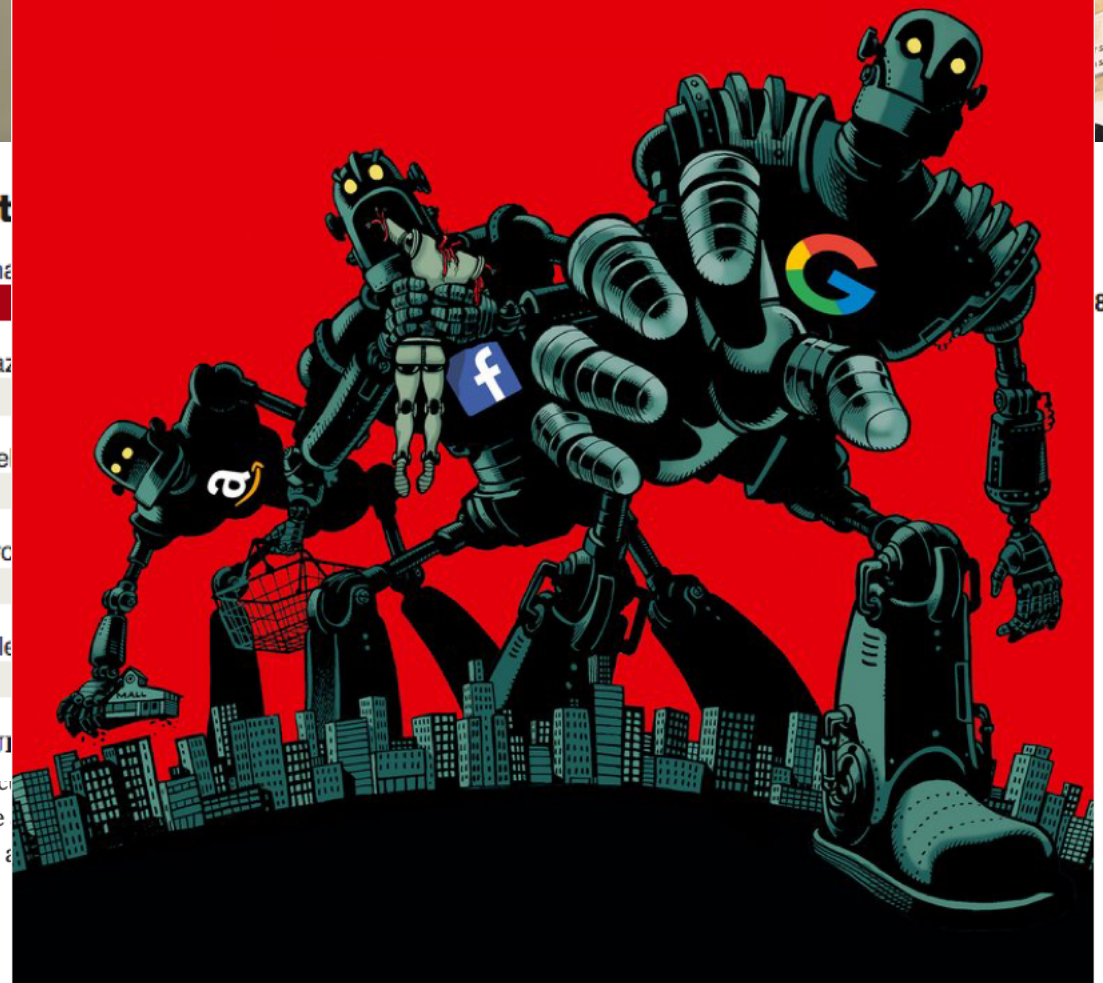
The next space race

Immigration's poisonous politics

Something's coming: Bernstein at 100

Our Big Mac index

The new titans



8.1 million

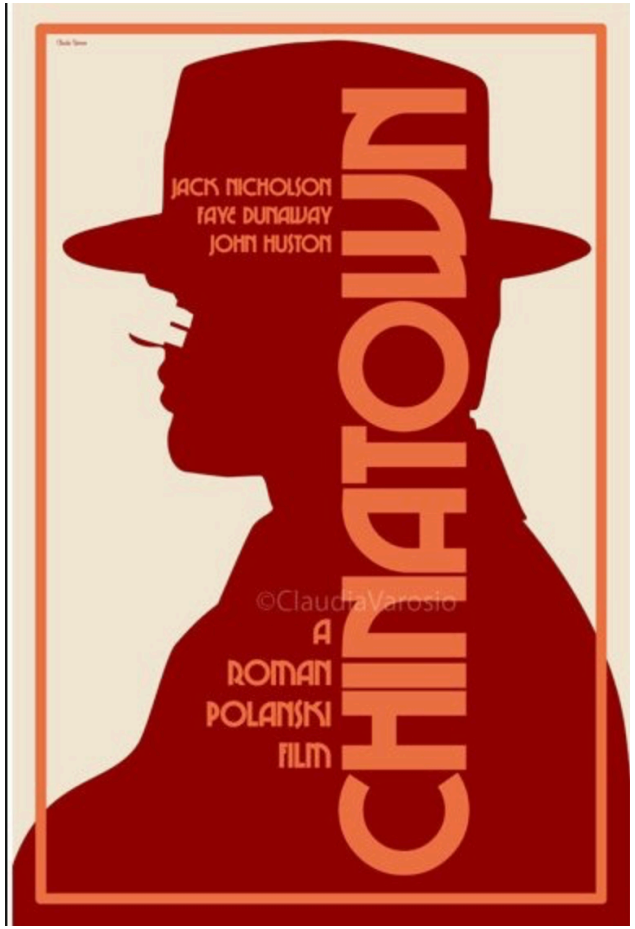
Change and Monopolies

- We are now communicating with a computer-mediated environment rather than with each other
- "Every monopoly and all exclusive privileges are granted only at the expense of the public interest" Andrew Jackson, 1830
- Industrial revolution that have[illegible] with the computing, storage and comm[illegible]dant
- And its dominated by a very sm[illegible] cartel of monopolists

Incumbency Rewards

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)



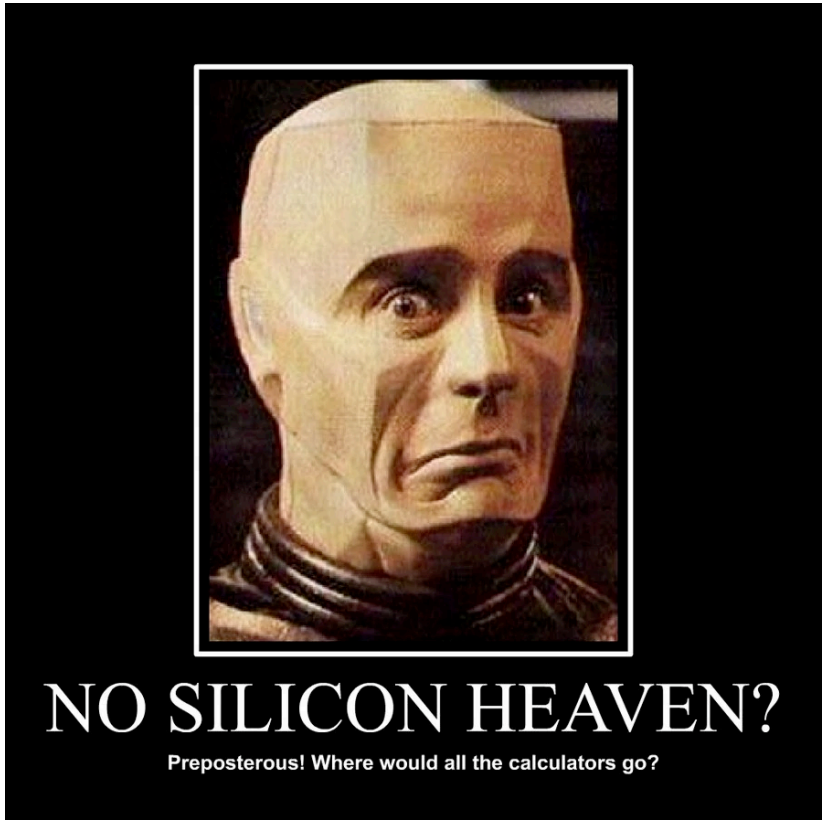
Where does all this head?

For our society, this rapid market-driven digitisation of our world has the potential to be incredibly empowering or incredibly threatening

Or both at the same time!

Wherever we're heading…

- It’s not the Internet any more
- That has already died and gone to silicon heaven!



Sic transit gloria mundi

In 1776 English historian Edward Gibbon published a mighty 6 volume work tracing the Roman Empire (and Western Civilisation) from the height of Empire to the fall of Byzantium

The seeds of of the empire's eventual decline and fall were sown early in its rise

The 100 best nonfiction books: No 83 – The History of the Decline and Fall of the Roman Empire by Edward Gibbon (1776-1788)

Perhaps the greatest and certainly one of the most influential history books in the English language retains its power today

Thanks!