Internet Centrality and its Impact on Routing

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Time is short

- And we are talking about some pretty fundamental topics about the nature and role of networking
- So I’m going to skate across a whole bunch of detail here as I try and head quickly through this space

Today's Centrality

- 2021 Outages by Fastly, Akamai and Facebook have global impact affecting all kinds of enterprises
- A DDOS attack on DYN managed to cause a meltdown of the Internet for the entire eastern seaboard of the US a few years ago
- Chrome completely dominates browser space
- Google has such a massively dominant position across advanced technologies that everyone else is left trying to just follow and fill in the gaps – HTTP/3, QUIC, BBR, to name just a few
- Mobile devices are either made by Apple and run iOS, or run Android
- The entire world now finds itself relying on just one chip manufacturer!
  - who is having trouble keeping up with orders

How did we get here?

- I thought that we were building a decentralised system with no critical orchestration components
  - No “Route Master 3000” in the middle controlling the routing space
  - No ”Name Czar” controlling all DNS resolution queries
  - No “Internet Service Controller” managing all Internet services
- All this was meant to be decentralised and adaptive
- We were meant to route around damage of any form
- Yet this is not exactly what we have today
- We’ve built something different

Why are we doing this?

Why are we building Internet infrastructure that has:

- Limited diversity of supply
- Points of critical vulnerability
- Increased reliance on a limited set of service orchestration elements

What's driving change today?

Scale

“The only real problem is scaling. All others inherit from this.”

Attributed to Mike O’Dell

Scale and Routing

"The most complicated computation ever attempted by mankind is the global distributed routing algorithm that runs the Internet.

In fact, if anybody thought about it very hard, before we started, they would've been too scared to try.

Ah, because it runs in near real-time, it's an online algorithm, it runs on a multimillion node multicomputer, of an arbitrary topology, built by lots of people who have never met each other. Right?

And, it's a very very complex computation because it's piecewise constructive, there is a lot of local consistency constraints, there is a bunch of global correctness criteria that are occasionally satisfied, and yet the thing mostly works.

Which is astounding, when you actually look at what's going on."

Also from Mike O'Dell, 2000 (http://www.dtc.umn.edu/~odlyzko/isources/odell-transcript.txt)

How have we responded?

- How has the Internet responded to these pressures of inexorable scaling in the Internet?

Bigger

Today's network architecture is based on abundance, not shared scarcity

- 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

Faster

- Reduce latency - stop pushing content and transactions across the network and instead **serve from the edge**
- The rise of CDNs that serve (almost) all Internet content and services from massively scaled distributed delivery systems.
- “Packet Miles” to deliver content to users has shrunk – fewer miles, faster service!
- 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 faster Internet

Better

- If “better” means “more trustworthy” and “more privacy” then we are making progress at last!
  - Encryption is close to ubiquitous in the world of web services
  - TLS 1.3 is moving to seal up the last open TLS porthole, the SNI field
  - Oblivious DNS and Oblivious HTTP is moving to isolate knowledge of the querier from the name being queried
  - The content, application, and platform sectors have all taken the privacy agenda up with enthusiasm, to the extent that whether networks are trustable or not doesn’t matter any more – all common shared network infrastructure is uniformly treated as untrustable!
  - And if you can’t trust it then avoid it (where possible)!

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 a small number of enterprises capitalising through advertising a collective asset that is infeasible to capitalise individually
- The result is that a former luxury service accessible to just a few has been transformed into an affordable, fast, mass-market commodity service available to all
  - but provided by a small clique of providers

So it's all good?

Right?

So it's all good?

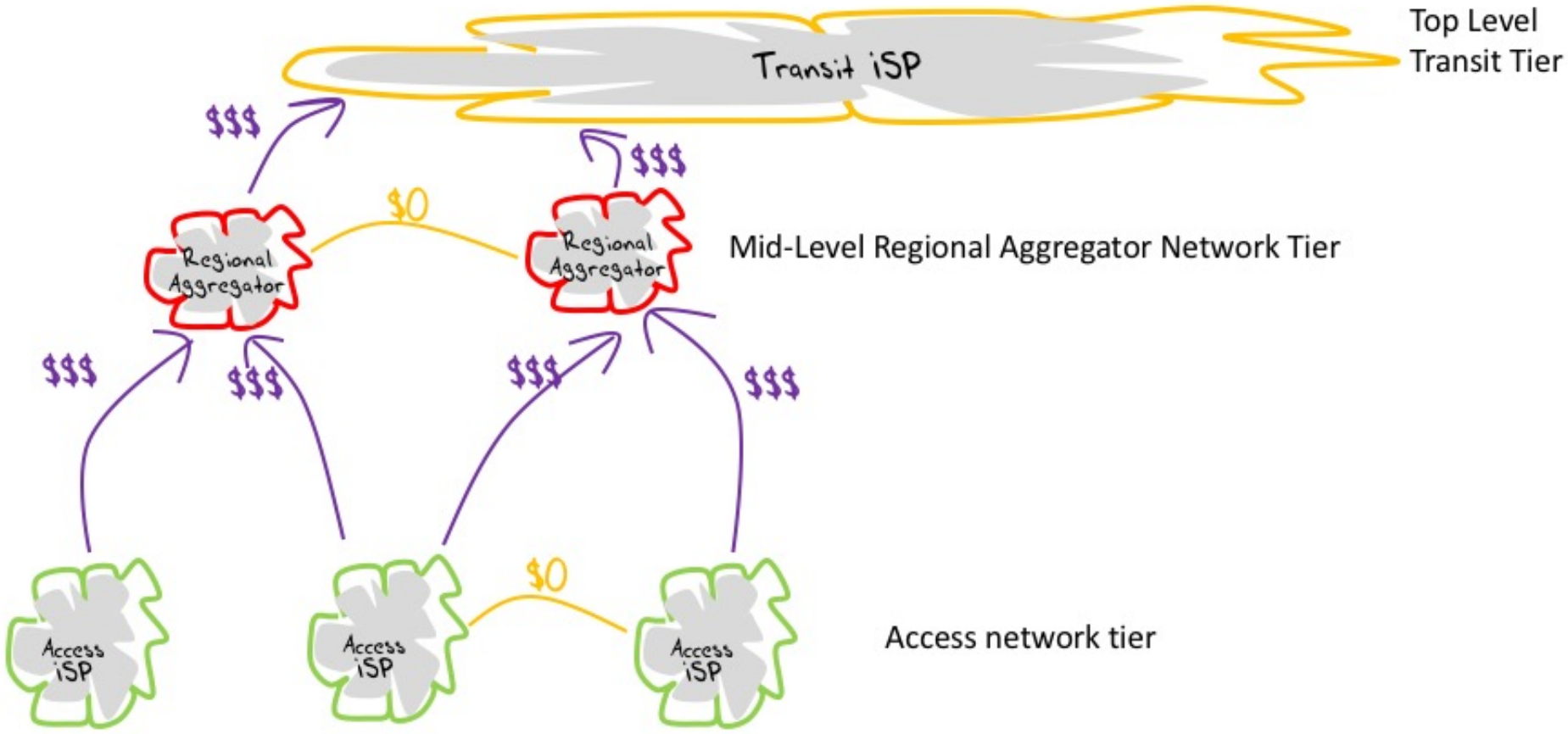
Or maybe not.

Longer Term Trends

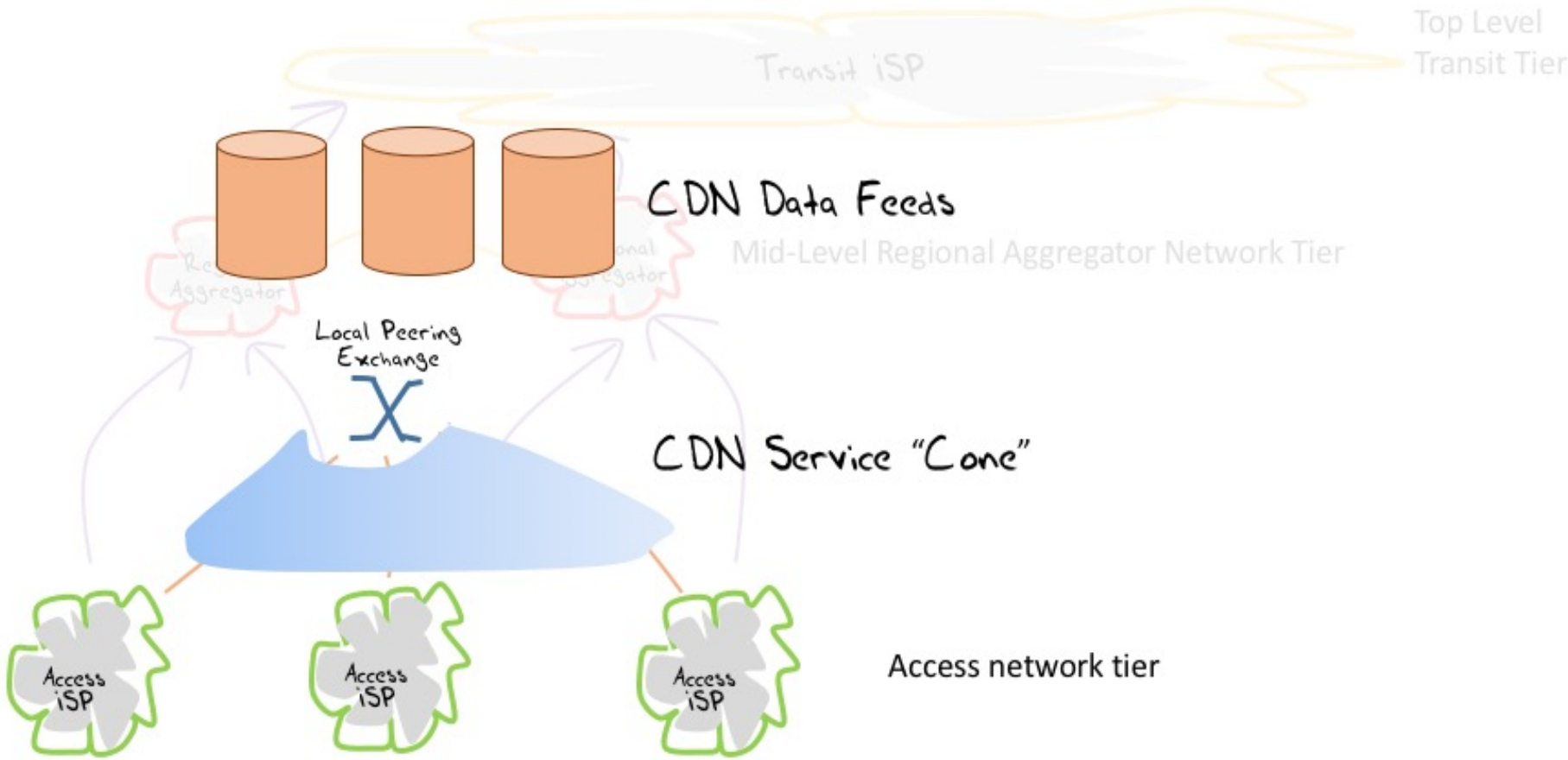
Pushing EVERYTHING out of the network and over to the edge!

- Transmission infrastructure is becoming an abundant commodity
  - Sharing technology (packet multiplexing) is decreasingly relevant is every large service platform migrates its own dedicated distribution system
- We have so much network and computing that we no longer have to bring consumers to service delivery points - instead, we are shifting services towards consumers and using private network slices to replicate service delivery from densely deployed data centres
- With so much computing and storage available the application is becoming the service, rather than just a window to a remotely operated service operated on expensive computing and storage platforms

The 1990's Internet



Today's Internet Architecture



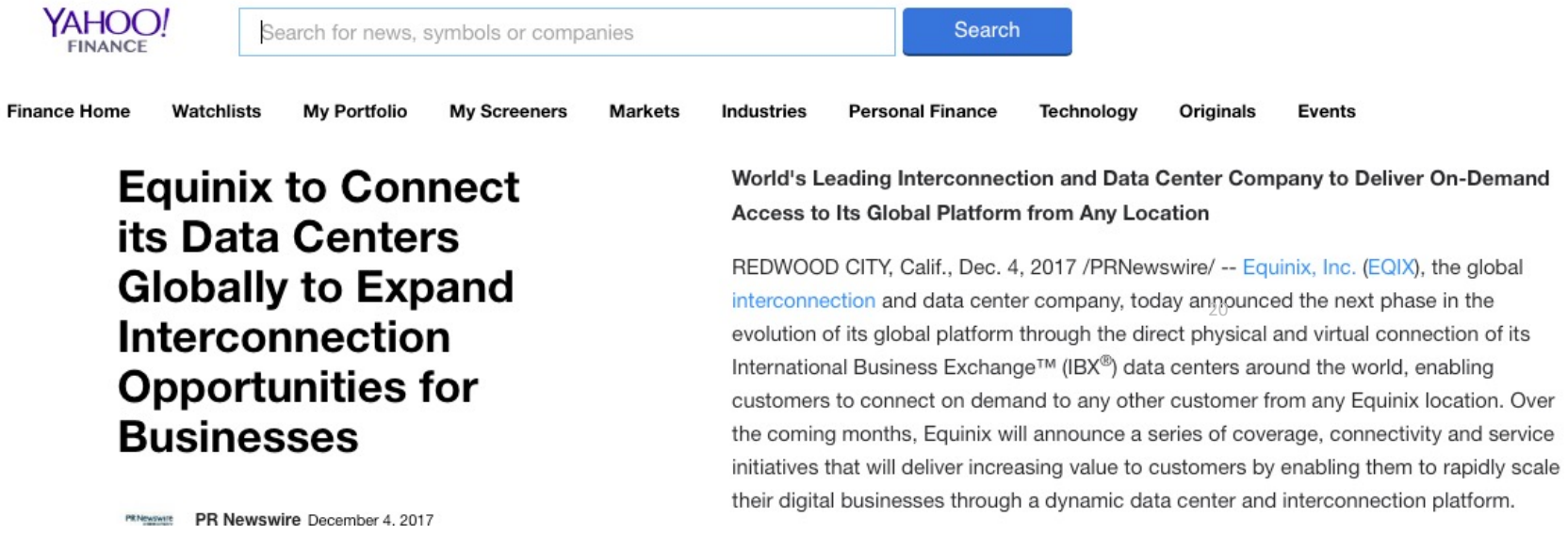
Who needs Transit?

- 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!

Transit Routing

- How much data is delivered from the local Data Centre through Access network to the end device?
- How much data is delivered across just 1 AS hop?
- Who *needs* to route with a full routing table?
  - From the perspective of the edge are we just making a routing decision within local datacentre to select services points hosted by Amazon, Google, Cloudflare, Akamai, Fastly, Microsoft and Apple?
- What's the cost and benefit of a transit and a full routing table any more?
  - Who is willing to spend 80% of their effort and cost providing a service for less than 1% of their traffic and less than 1% of their revenue?

Internet Names and Addresses?

If the Internet is just a collection of discrete CDN service ‘cones’ then why should we expect end users to pay for the maintenance of:

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

Exactly where are we now?

- 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

It's not just Centrality of Content and Service

It’s a shift in the role of the network itself

It's not just the Death of Transit

It's the rethinking of the entire network as a common shared glue

- 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
- And the barriers to entry for new players get increasingly larger as the platform incumbents bolster their role to replace a single common network with a small number of such platforms in a cartel-like arrangement

  (Today's version of "centrality")

Do shared networks matter any more?

- We have increasingly stripped out network-centric functionality in out search for lower cost, higher speed, and better agility
- We are pushing functions out to the edge and ultimately off “the network” altogether and what is left is just dumb pipes
- What defines “the Internet”?
  - A common protocol, common protocol address pool, and a common routing system?

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

How can we fix this?

- Such a level of global dependence of a small set of platform enterprises that completely dominate their market sector is never a comfortable place to be
- Monopolies always end up price gouging and entrenching their incumbency by supressing further innovation
- Is it too late to try and fix it?

Yes. It's just too late!