The Evolution of Carriage, Content and Interconnection

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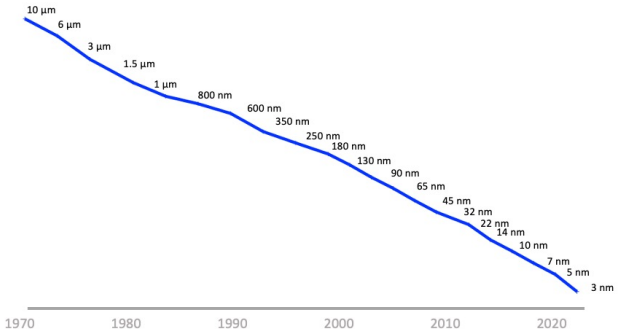
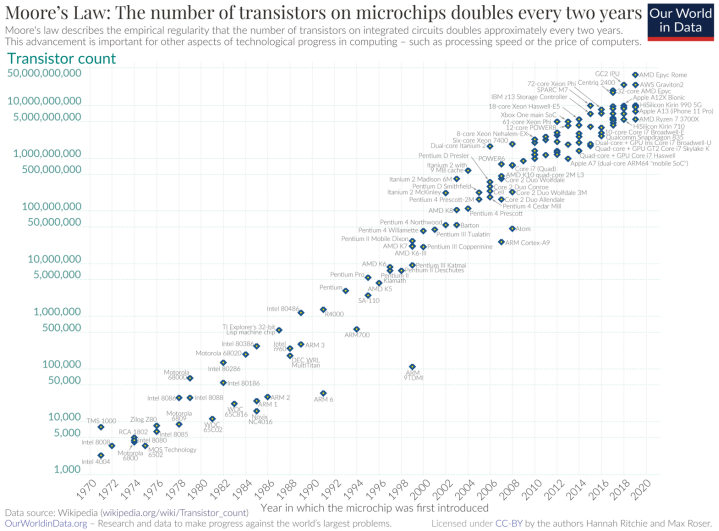
Conversations change

- We used to talk about “Tier 1” transit providers, peering, paid peering, and customers
- Then we talked about Exchange Points, Data Centres and peering
- Now we are talking about autonomous content distribution networks and embedding content in access networks
- Why is this such a rapidly changing environment?

The Driver of Change: Moore's Law



Silicon Chip Track Width over time



Silicon Chip transistor counts

Year	Mode	Baud	Capacity/Lambda	Cable Capacity	DSP
2010	PM-QPSK	32 GBd	100G	8T, C-Band	40nm
2015	PM-16QAM	32 GBd	200G	19.2T, Ext C	28nm
2017	PM-32QAM	56 GBd	400G	19.2T, Ext C	28nm
2019	PM-64QAM	68 GBd	600G	38T, Ext C	16nm
2020	PS-PM-64QAM	100 GBd	800G	42T, Ext C	7nm
2022	PCS-144QAM	190 GBd	2.2T	105T, Ext C	5nm

Table 1 – Coherent Fibre Evolution

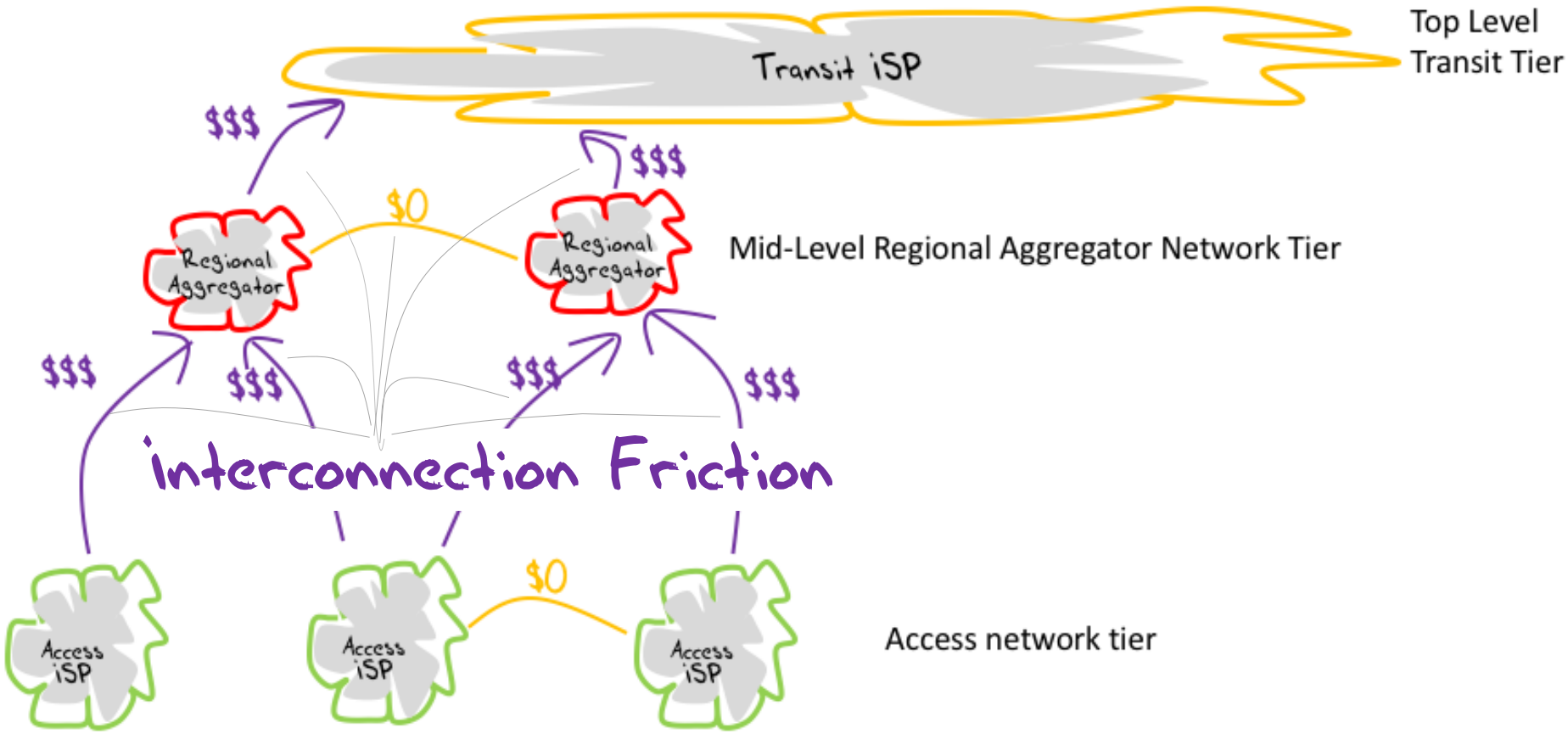
Year	Processor	Cores	Transistors	Clock	Cost	$/core
2019	Rome	64	40B	2.25GHz	$6,950	$109
2022	Milan	64	26B	2.20GHz	$8,800	$138
2022	Genoa	96	90B	2.40GHz	$10,625	$110
2023	Bergamo	128	82B	2.25GHz	$11,900	$92

Table 2 – CPU performance and unit price over time – AMD processors

What does this mean?

- The economics of silicon chip evolution have a profound impact on the computing space - no technology can survive more than 5 years in the computing sector!
- No business plan can survive more than 5 years in the computing area!
- And given that the carriage sector is now a digital carriage platform, the carriage sector is no exception here

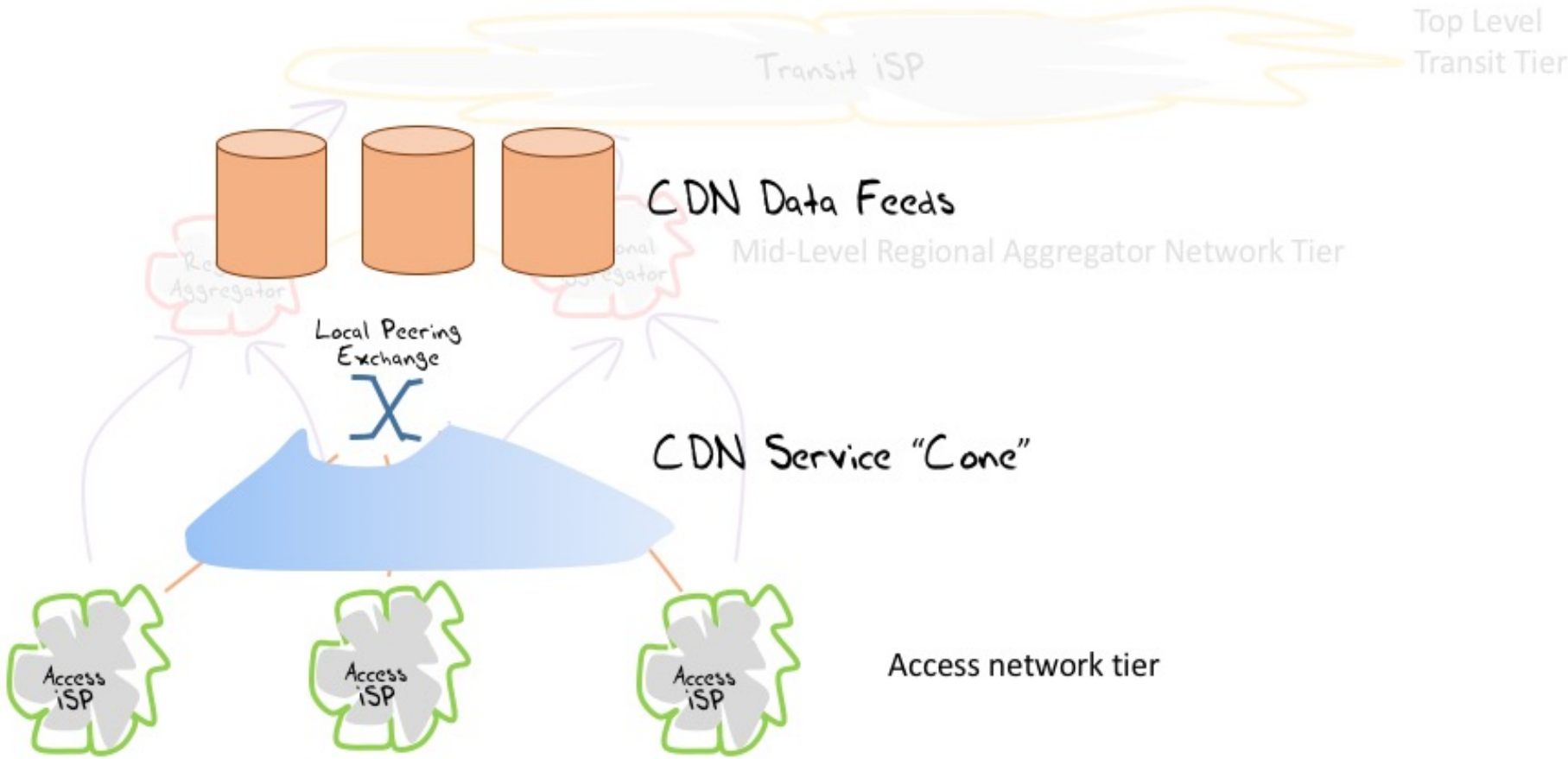
The 1990's Internet



Change

- Networks are no longer transit services that connect users to services
- Content distributors are using abundance of computing, storage and capacity to bring content to users

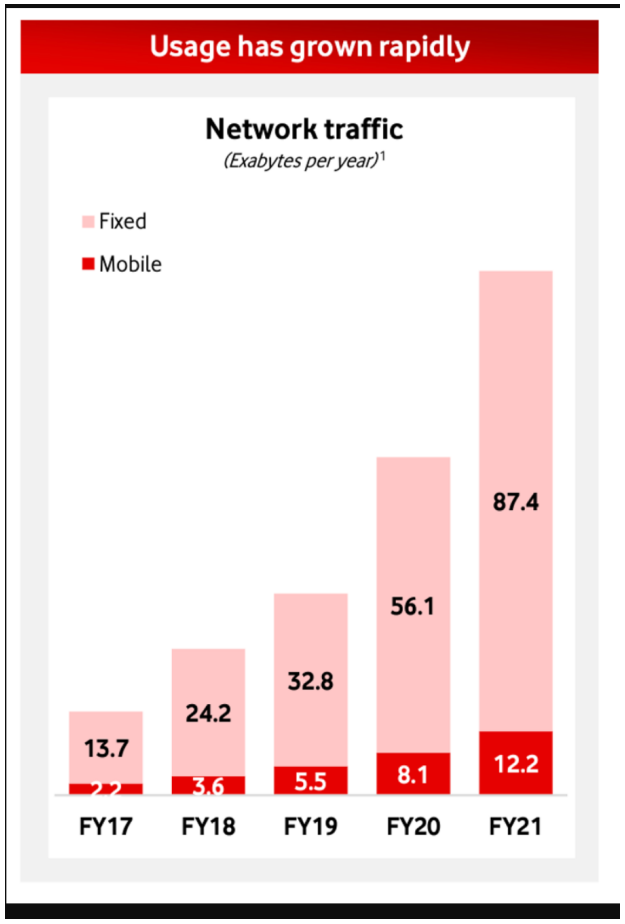
Today's Internet Architecture

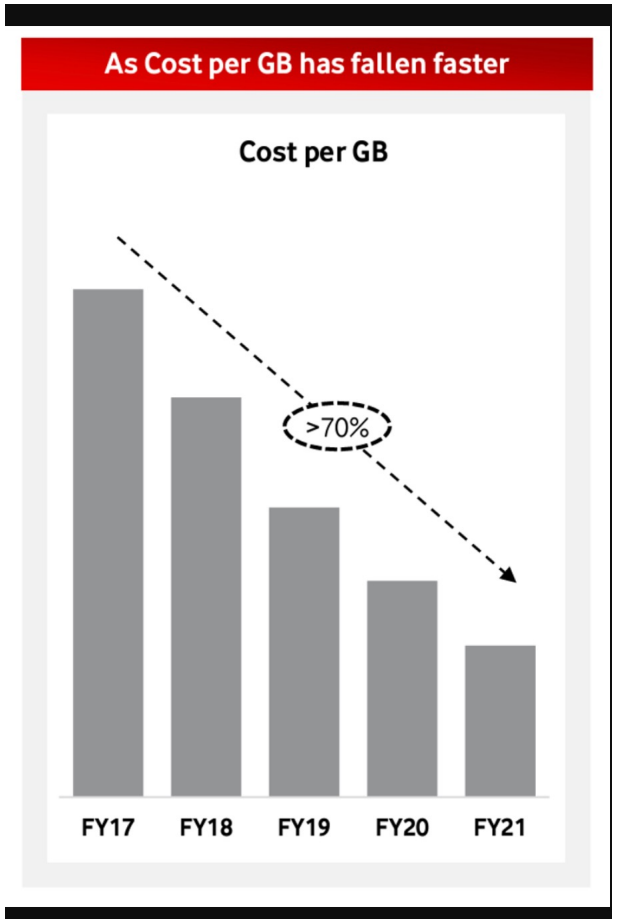


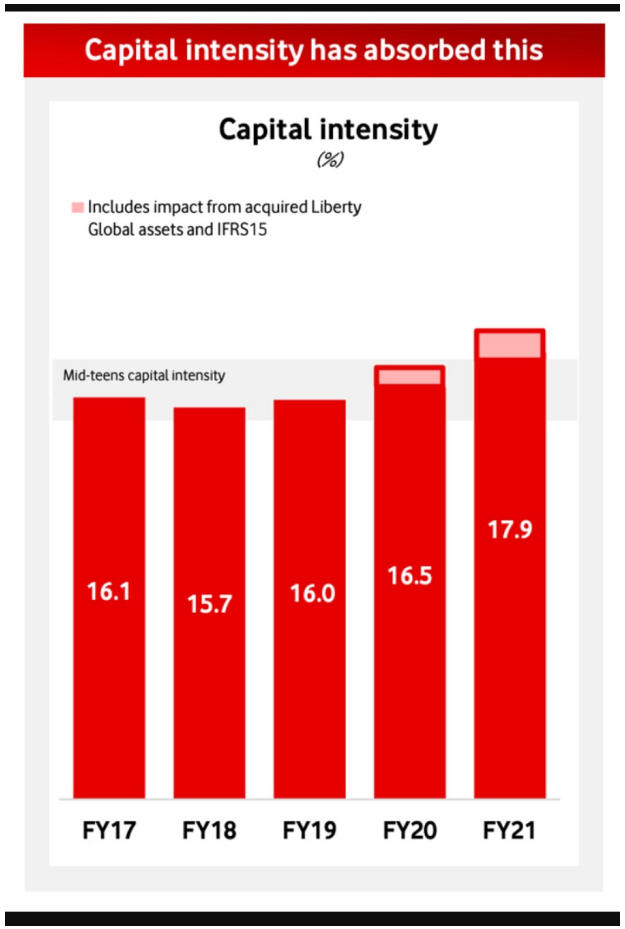
Change

- Greater capacity in edge networks has enabled
- Greater use of high-volume streaming content
- Leading to adoption of higher capacity technologies in edge network
- Which also enables reductions in the unit cost of carriage in edge networks

Change







Source: [Vodaphone 2021 Investor Briefing]

Change

- Refreshing edge network technologies allows for significant capacity increases
  - 3G -> 4G -> 5G mobile access
  - DSL -> VDSL -> Fibre in wired access
- Failure to reinvest in edge access places the operator in a disadvantaged competitive position

Conclusion

- The carriers' case that increases in carried traffic volumes should be funded by content streamers is based on a desire by the carriage sector to cling to outdated technology and financial models for carriage that are well and truly over their Use By dates!

Regulatory Responses?

- Regulate the interconnection regime?
  - Poor outcomes that distort the interconnection market whern regulators have attempted this
- Regulate inter-provider pricing?
  - Allows the less efficient operators to be cross-subsidised by more efficient operators
  - Inhibits technology refresh in carriage networks

How to deal with termination monopolies?

- Neutralise the capital investment infrastructure as a competitive level and facilitate competition at the retail level
  - Australian NBN-style of common access network, or New Zealand's Crown Infrastructure Partners program
  - Allow seamless consumer switching between retail providers
  - Encourage MVNO operators in the mobile space

What are we learning?

- “Sender Pays” in Internet access networks does not improve the efficiency of the carriage infrastructure, nor does it benefit consumers
- Carriage is no longer an inescapable monopoly - massively replicated content can be used as a substitute for many public carriage service elements
- Structural cross-subsidies and poor regulatory responses weaken the longer-term incentives for efficient infrastructure investment

Thanks!