Peering, QoS, and Price and Quality Differentiation

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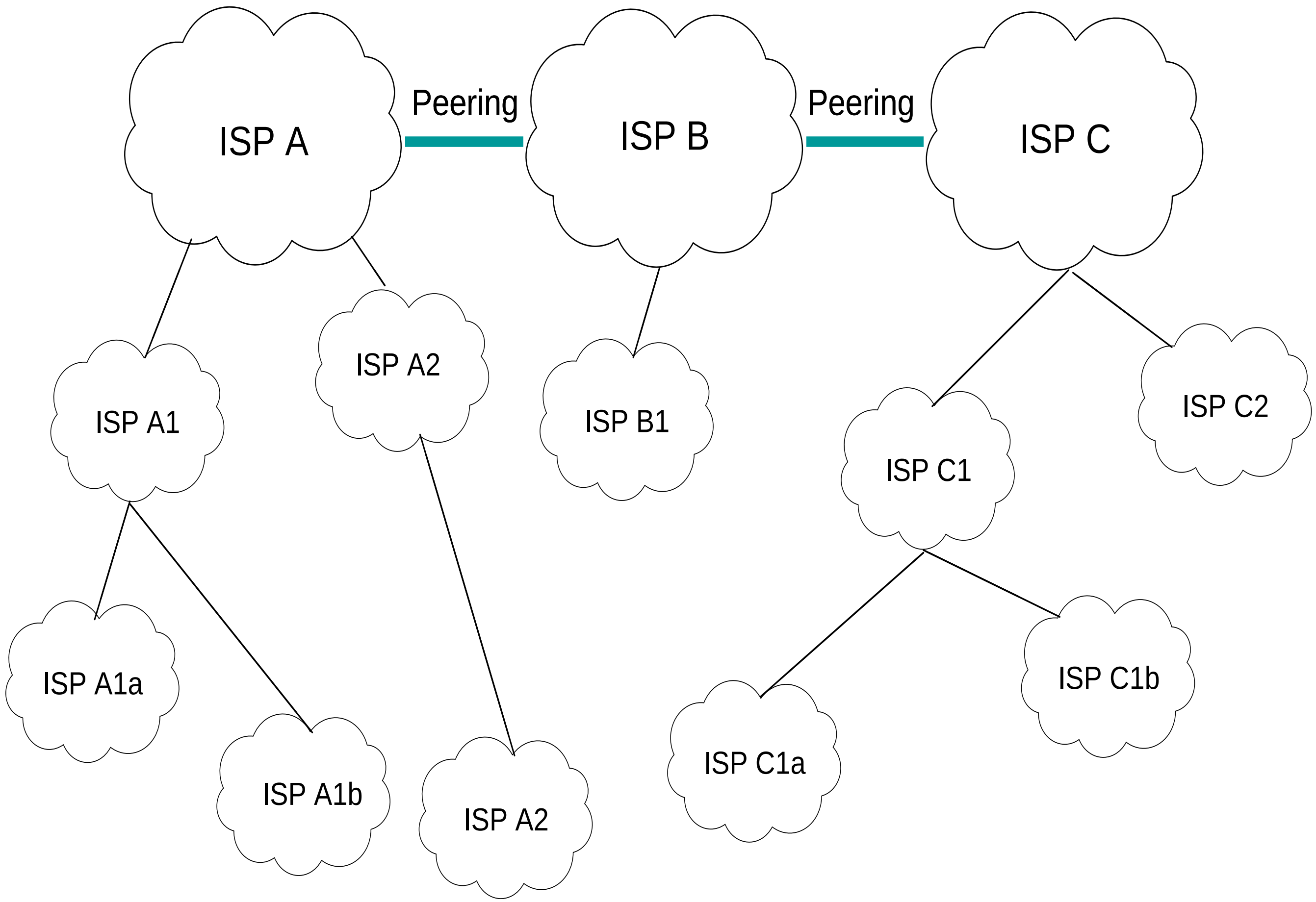
Network Operators, Content Providers, and the Open Internet

- Peering, transit, Internet access
- Quality of Service (QoS)
- A two-sided market view
- Traffic, costs, prices, and profitability
- Concluding observations

Peering, transit, and Internet access (1)

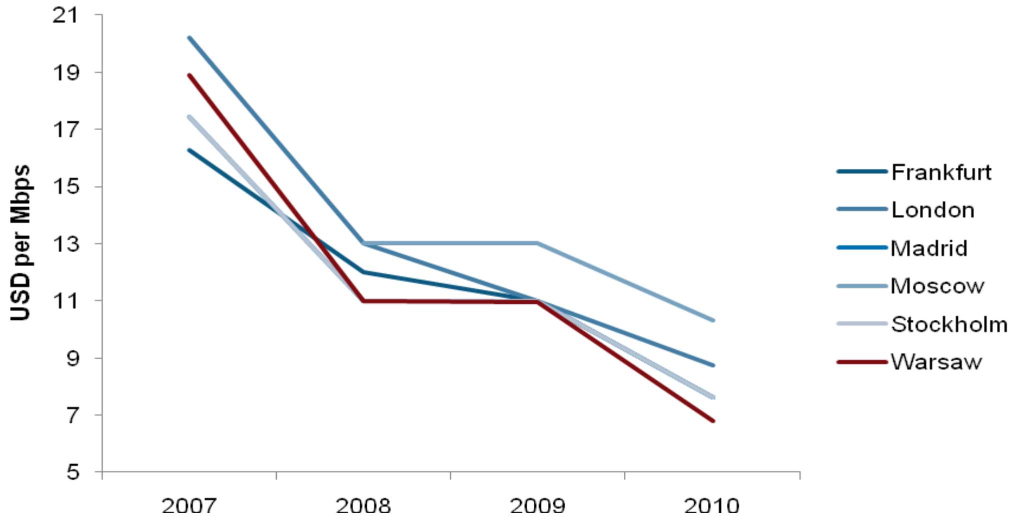
- Transit
  - The customer pays the transit provider to provide connectivity to substantially all of the Internet.
  - Essentially the same service is provided to consumers, enterprises, ISPs, content provider or application service providers.
- Peering
  - Two ISPs exchange traffic of their customers (and customers of their customers).
  - Often, but not always, done without charge.
- Variants of both exist.

Peering, transit, and Internet access (2)



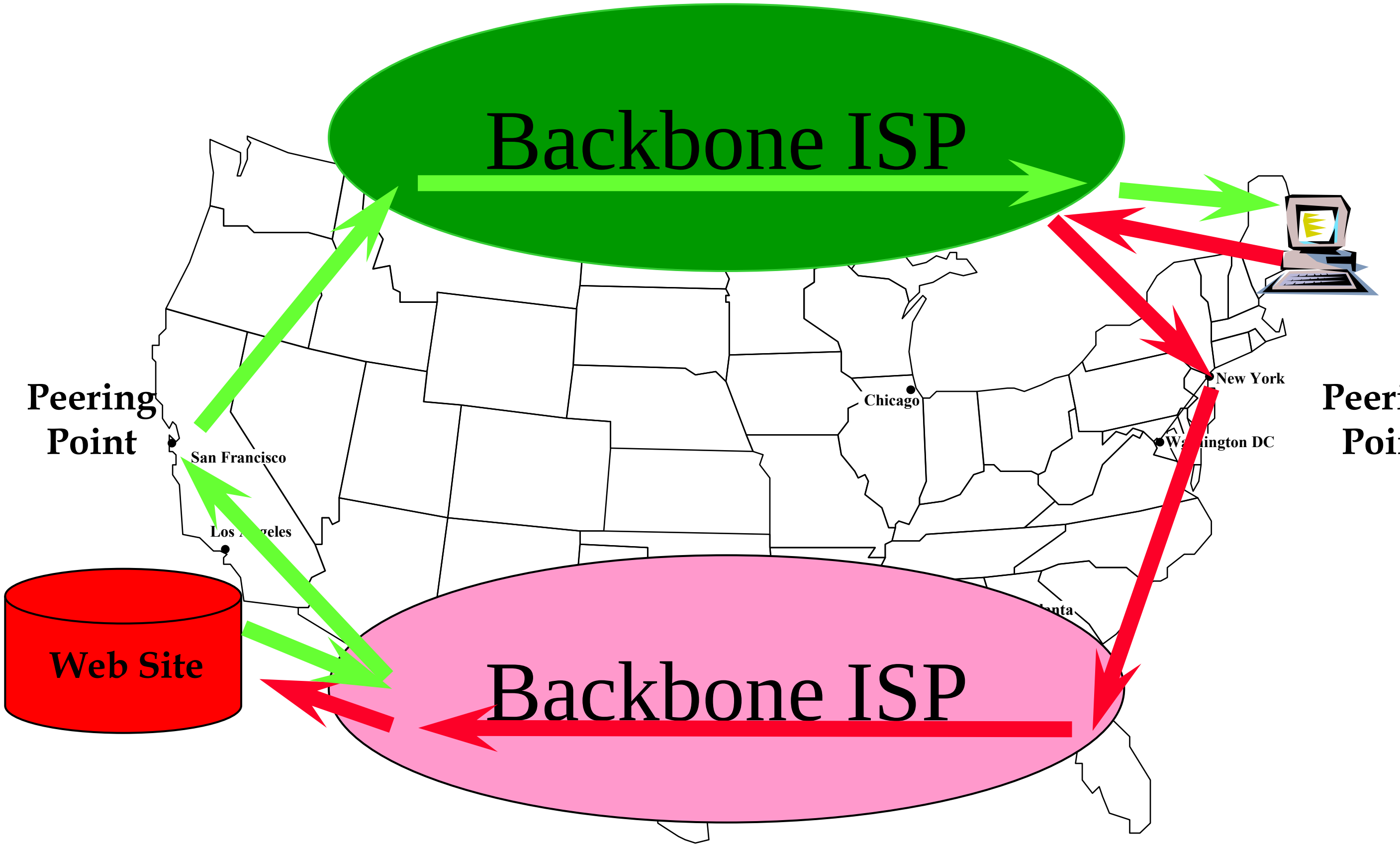
Peering, transit, and Internet access (3)

- Meanwhile, unit prices for global transit are declining rapidly.
- This decline reflects not only equipment costs but also circuits (over land and under water).
- Labour and other OPEX elements play only a small role, since they depend mostly on the number of subscribers.

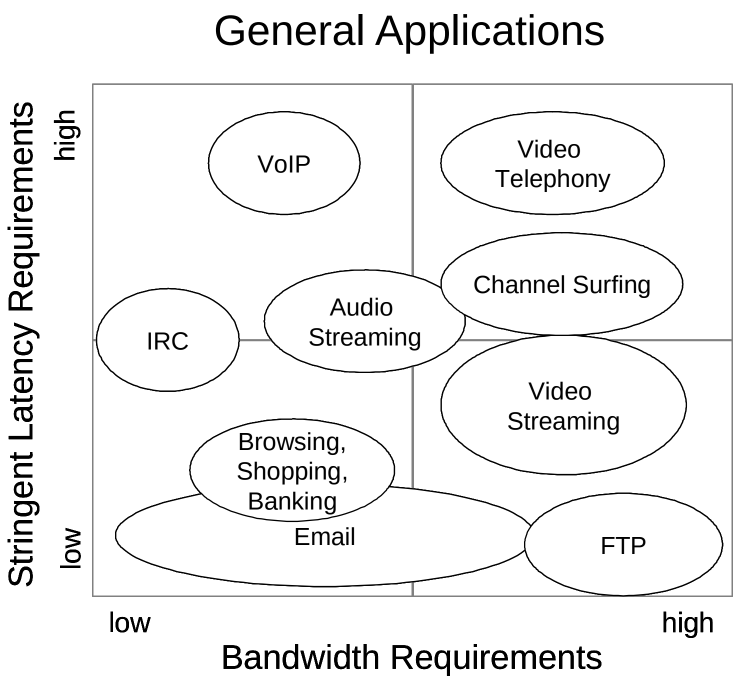


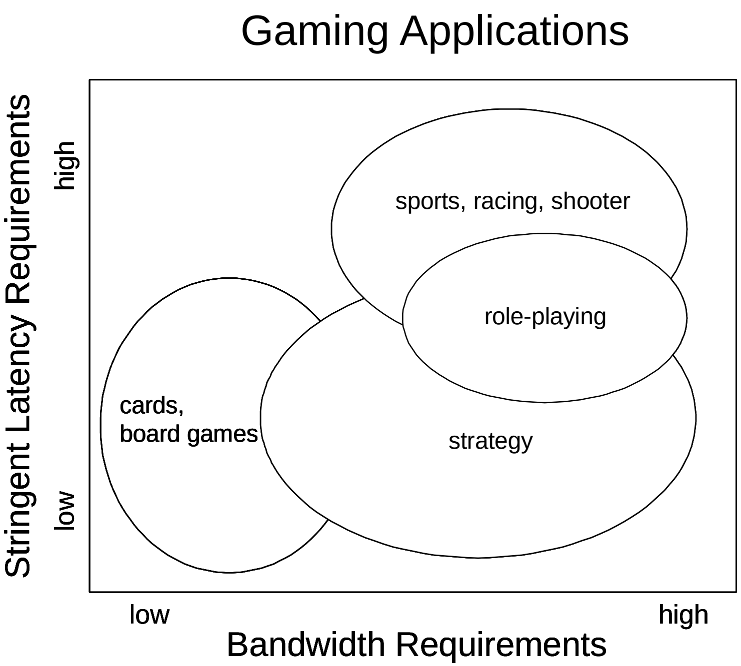
Source: Telegeography (2011), WIK calculations.

Peering, transit, and Internet access (4)
Shortest exit routing



Interconnection (QoS)

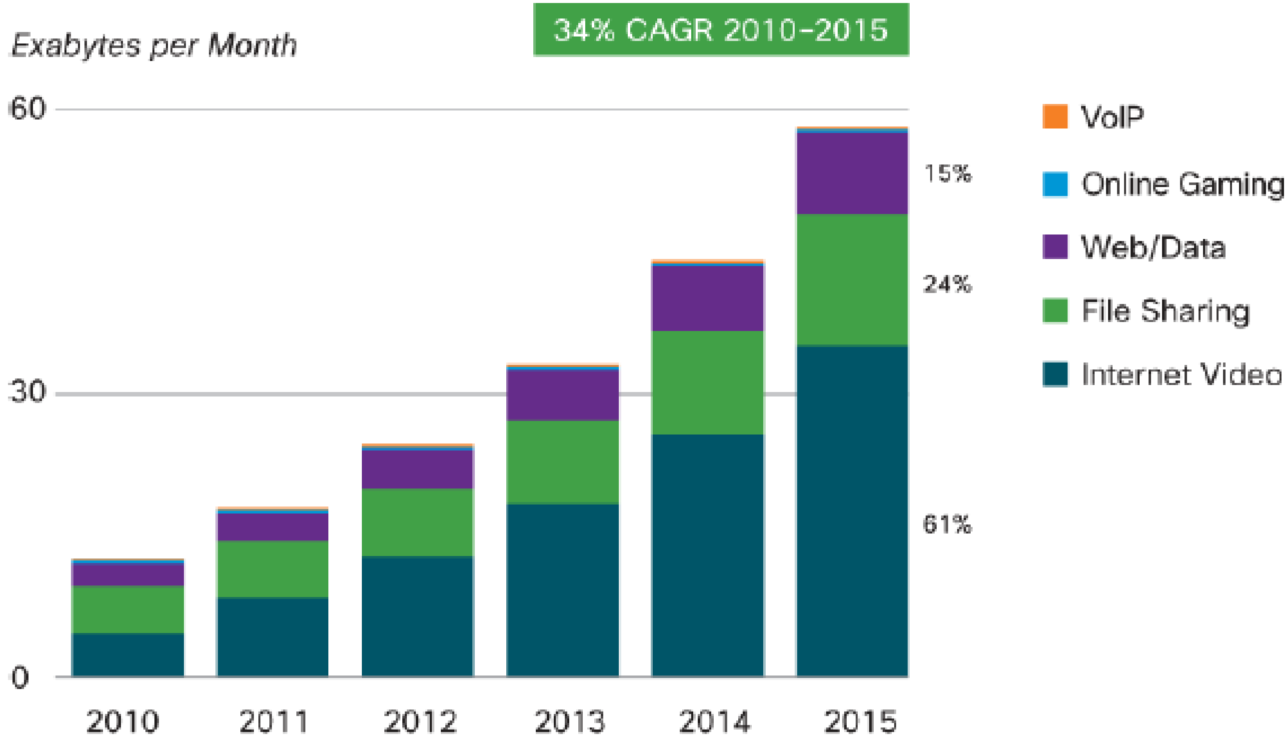




- Real time bidirectional audio: stringent requirements
- Email: liberal requirements
- Streamed audio and video: fairly liberal requirements. (Channel surfing?)

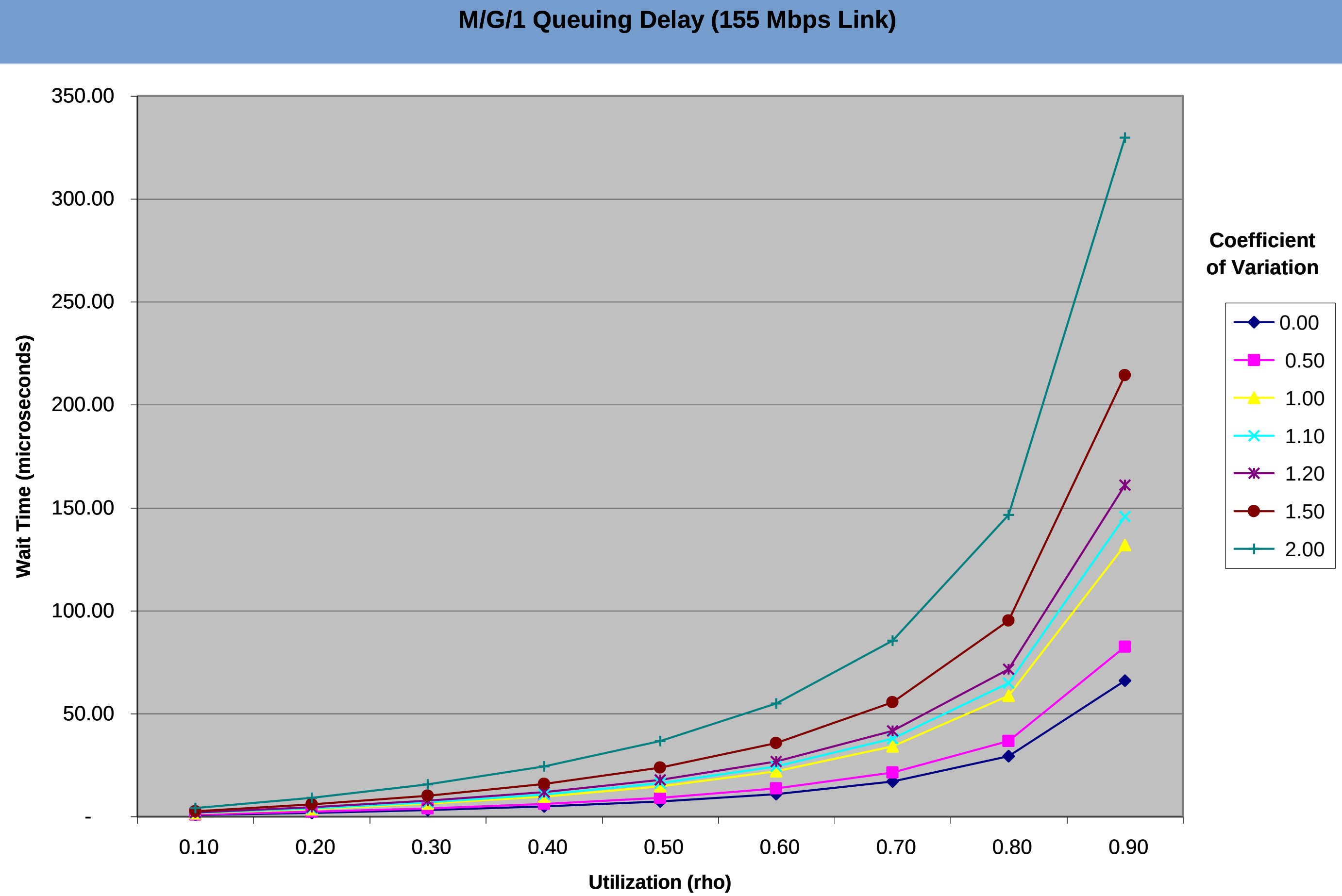
Shifts in Internet traffic

- Voice drives revenue, but is a declining fraction of traffic.
- Concerns have been voiced in recent years over the explosion of video traffic over the Internet, and its implications for network cost.



Source: Cisco (2011).

Interconnection (QoS)



M/G/1 queueing analysis of the performance ***of a single link***

(with clocking delay of 50 µsecs (284 byte packets) and a 155 Mbps link)

(with clocking delay of 50 µsecs (284 byte packets) and a 155 Mbps link)

Interconnection (QoS)

- As we have seen, per-hop delay, even in a network with 90% load, is about 1,000 times less than the 150 millisecond delay “budget” for real-time bidirectional voice.
- IMPLICATION: Most of the time, and under normal conditions, variable delay in the core of the network is unlikely to be perceptible to the users of VoIP or other delay-sensitive applications.
- FURTHER IMPLICATION: Consumers will not willingly pay a large premium for a performance difference that they cannot perceive.
- Packet delay is more likely to be an issue:
  - For slower circuits at the edge of the network
  - For shared circuits (e.g. cable modem services)
  - When one or more circuits are ***saturated***
  - When one or more components have failed
  - When a *force majeure* incident has occurred

Implementing inter-provider QoS

- Although the technology is reasonably straightforward, little practical experience in enforcing QoS across IP-based networks.

- It is not due to a lack of standards – there are too many standards, not too few.

- Classic problem of introducing change into a technological environment:
  - Network effects – no value until enough of the market has switched.
  - Long, complex value chains.
  - Costs and complexity of transition.

- Analogous problems have slowed IPv6 and DNSSEC

Implementing inter-provider QoS

- Efforts to extend Quality of Service (QoS) across network operators have failed to catch fire for many reasons:
  - **Scale:** Bilateral peering arrangements will tend to be acceptable to both network operators only when the networks are of similar scale, or more precisely when both networks can be expected to be subject to similar cost drivers for carrying their respective traffic.
  - **Traffic balance:** Where traffic is significantly asymmetric, cost drivers are likely to also be asymmetric.
  - **Monitoring and management:** There are many practical challenges in determining whether each network operator has in fact delivered the QoS that it committed to deliver.
  - **Financial arrangements:** There has been no agreement as to how financial arrangements should work. In particular, there has been enormous reluctance on the part of network operators to accept financial penalties for failing to meet quality standards.

Implementing inter-provider QoS

- Many efforts over the years to define inter-provider QoS standards.
- One of the best and most practical was organised by MIT, with substantial industry participation.
- The following values from the MIT white paper would appear to be resonable for IP interconnection suitable for real time bidirectional voice:

Delay:	100 msec
Delay Variance:	50 msec
IPPM Loss Ratio:	1 x 10-3 (One Way Packet Loss)

- The MIT WG white paper also explains how to measure these, and how to allocate end-to-end requirements to multiple networks. IPPM probes could be suitable.
- A challenge: No network operator will want another to operate

Implementing inter-provider QoS

- As part of the functional/operational separation of Telecom New Zealand, there were commitments
  - To interconnect with competitors using IP
  - To support a suitable QoS for VoIP in those interconnections
- The first of these is in place.
- For the second, Telecom New Zealand made a quite interesting proposal, based on their methodology for the first of these.

Quality differentiation and network neutrality

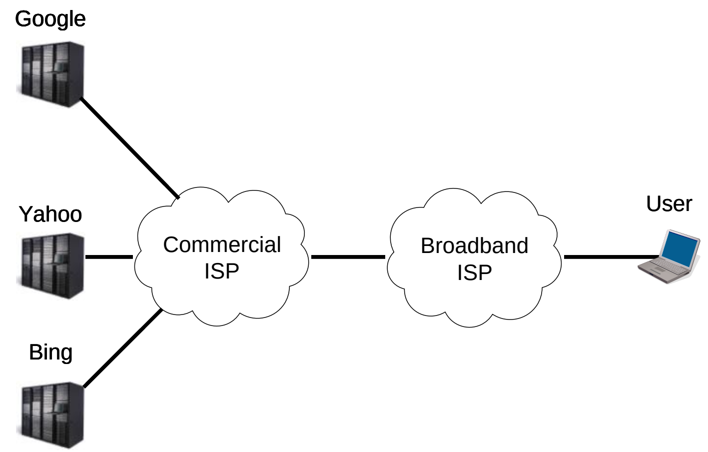
- Quality differentiation
- Economic foreclosure
- Two-sided (or multi-sided) markets

Quality differentiation

- Quality differentiation and price differentiation are well understood practices.
- In the absence of anticompetitive discrimination, differentiation generally benefits both producers and consumers.
- We typically do not consider it problematic if an airline or rail service offers us a choice between first class and second class seats.

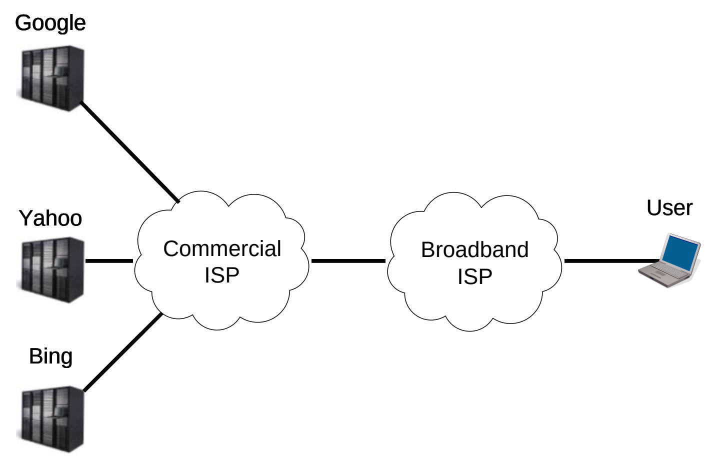
Economic foreclosure

- When a producer with market power in one market segment attempts to project that market power into upstream or downstream segments that would otherwise be competitive, that constitutes economic foreclosure.
- Foreclosure harms consumers, and imposes an overall socio-economic deadweight loss on society.



Two-sided markets

- The Internet can be thought of as a two-sided market, with network operators serving as a platform connecting providers of content (e.g. web sites) with consumers.
- Under this view, some disputes are simply about how costs and profits should be divided between the network operators and the two (or more) sides of the market.



Traffic, costs, prices, and profitability (1)

- A.T. Kearney (2010):

  "Internet traffic is exploding in an unprecedented way due to increasing use of video. Costs for network operators are sky-rocketing, even under existing technology and even without considering the huge investments needed for fibre-based Next Generation Access. Due to market defects, there is no way to make consumers shoulder the cost of the increased bandwidth; thus, it will soon become necessary for firms that provide content to pay for the network for the first time, much as content and advertising typically pay for over-the-air broadcast television."

- Intuitive? Satisfying? Plausible?

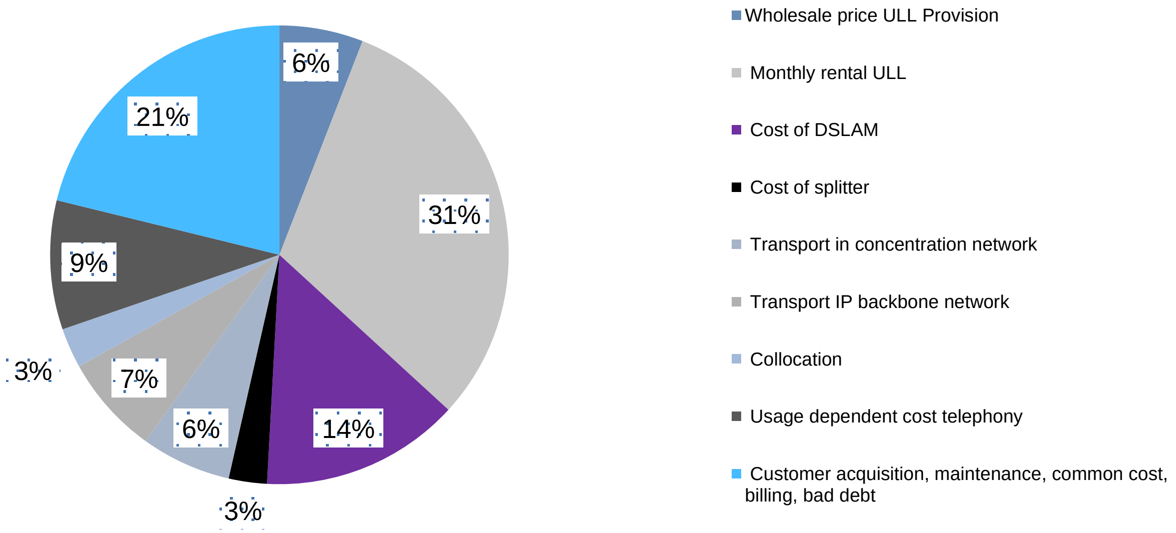
Traffic, costs, prices, and profitability (2)

- Traffic growth is largely a function of:
  - an increase in the number of subscribers, and
  - an increase in traffic per subscriber.
- Some costs are largely driven by the number of subscribers, and are largely independent of usage per subscriber.
- Unit costs for network equipment in the core and concentration networks (including routers and optoelectronics), where costs are usage-dependent, are declining at a rate comparable to that of Internet traffic increase per user in the fixed network. This can be viewed as an example of Moore's Law.
- Cost per customer and revenue per customer in the fixed network remain in balance, despite the increase in traffic.

Traffic, costs, prices, and profitability (3)

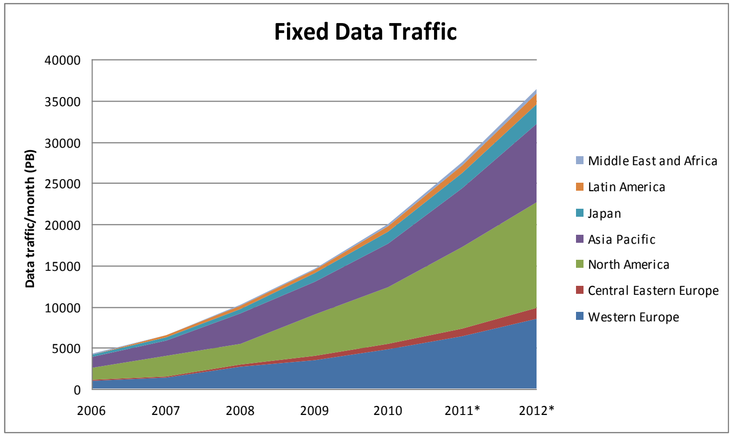
- The core network is about 7% of total cost, the concentration network about 6%.
- Both benefit from these technological enhancements.

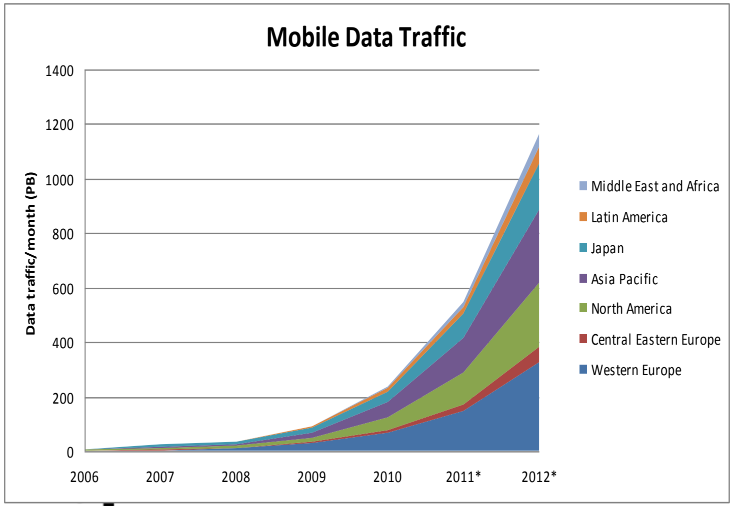
Monthly cost of a bundled DSL broadband/voice service (BNetzA 2009)



Source: German BNetzA (2009).

Traffic, costs, prices, and profitability (4)



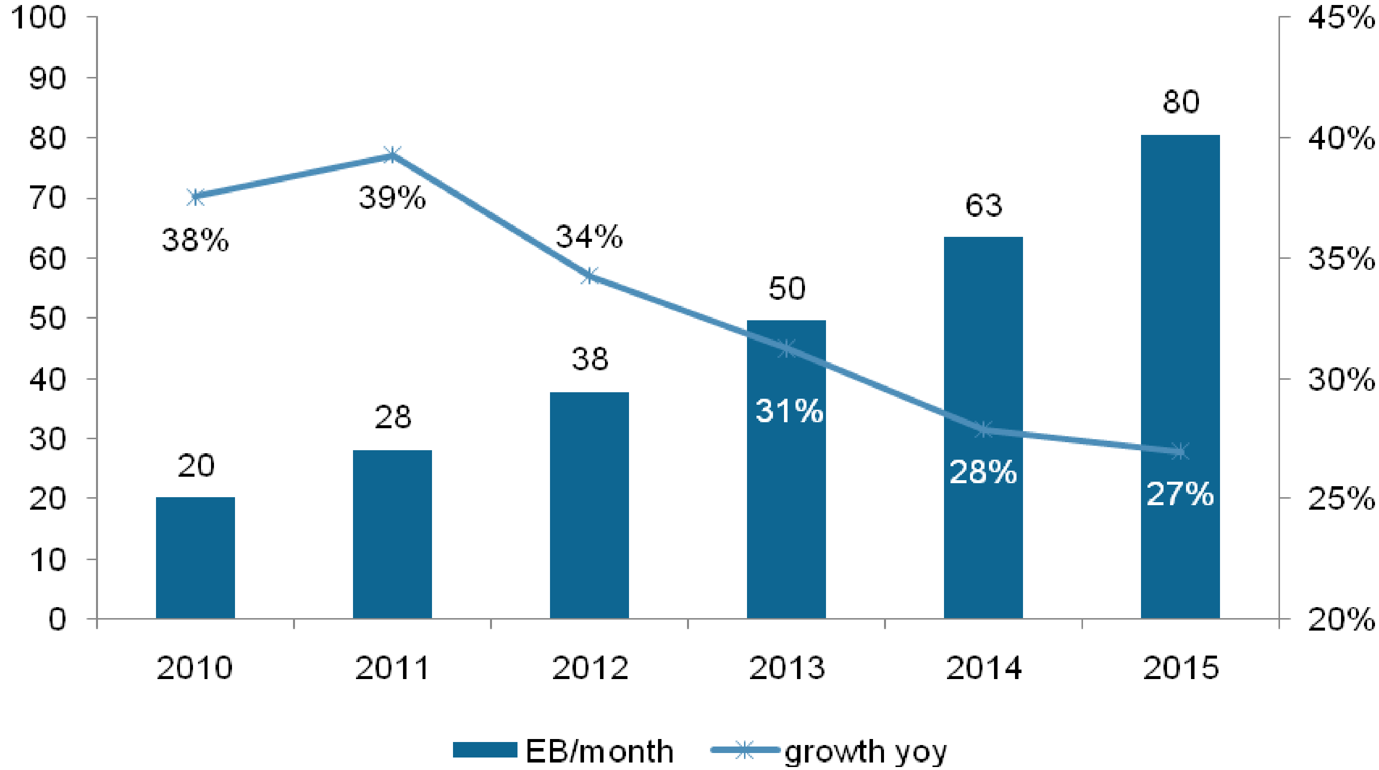


Traffic is indeed increasing in both the fixed and the mobile networks.

Source: Cisco (2011), WIK calculations.

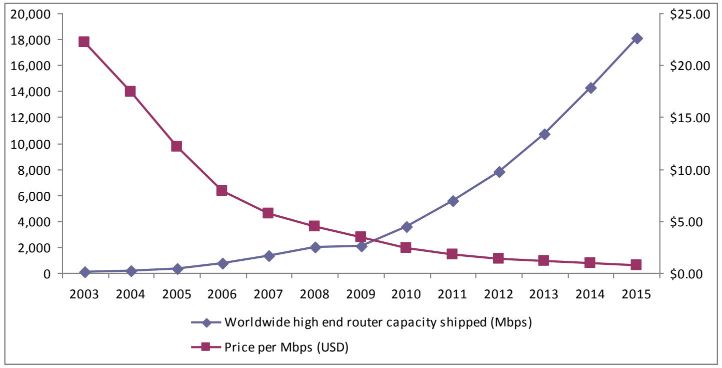
Traffic, costs, prices, and profitability (5)

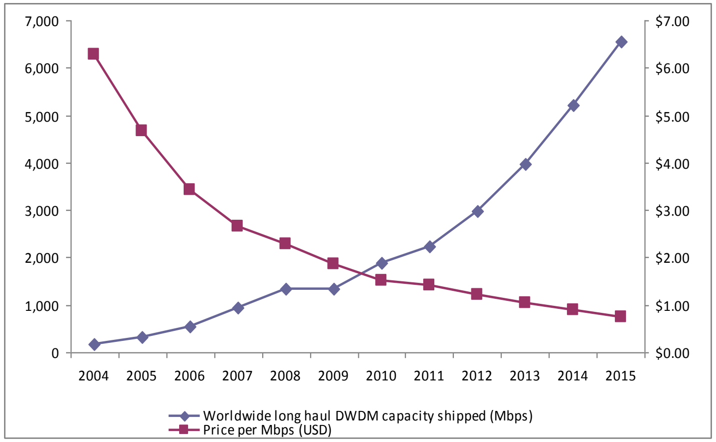
- However, the rate of growth in percentage terms is declining over time.



Source: Cisco (2011), WIK calculations.

Traffic, costs, prices, and profitability (6)





Here we have the shipment quantities in Mbps and the price per Mbps (USD) for high end routers and for long haul DWDM optoelectronic equipment.

These are among the key cost drivers for Internet core and aggregation networks.

The growth in shipments generally tracks the Cisco projections.

The growth in *shipment volume* does not equate to a growth in *costs*, because the decline in unit costs is nearly in balance with it.

Source: Dell’Oro (2011), WIK calculations.

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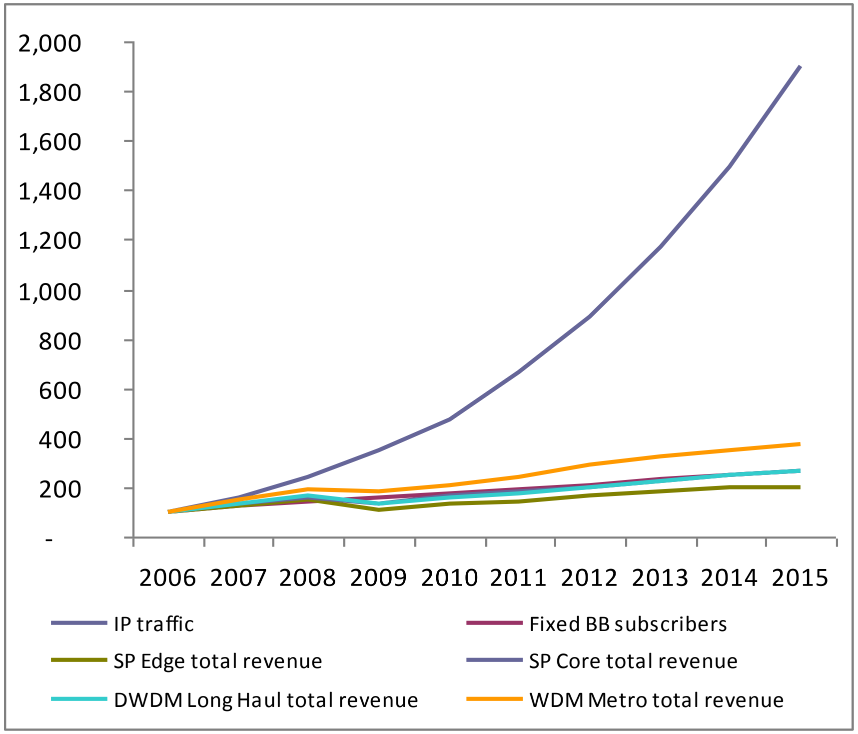
Traffic, costs, prices, and profitability (7)

- The trend in underlying equipment costs (and many other costs) tracks subscribership and revenue, not with the volume of traffic.



Source: Dell'Oro (2011), Cisco (2011), WIK calculations.

Concluding observations

- In competitive markets, quality differentiation typically benefits both suppliers and producers.
- Beware quick fixes! If a solution seems too good to be true, it probably is.
- Market mechanisms often reach better solutions than well intentioned policymakers.

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