IP Interconnection: trends and emerging issues

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20 June 2012

Agenda

- Overview of Internet connectivity
- The consumer context and trends in internet consumption
- IP Interconnection – the historic perspective and current trends
- Emerging commercial tensions and their potential impact
- The information gap?

Overview of recent work on internet connectivity

We have identified three major trends in the internet core

- Stabilisation of international connectivity traffic and pricing;
  - Capacity upgrades on submarine cables are expected to keep pace with demand for international traffic.
  - The lifetime of submarine cables is limited, and the majority of Transatlantic cables likely will need to be replaced in +/- 10 years. While we don't see this replacement to be an issue, we expect that ownership structures and investment models for such cables may change.

- Growth of local content storage & interconnection; Growth of Content Delivery Networks and local Internet exchanges
  - ... has led to internet "interconnect" becoming more regionalised and relying less on international transit.
  - ... highlights the growing importance of data centres.

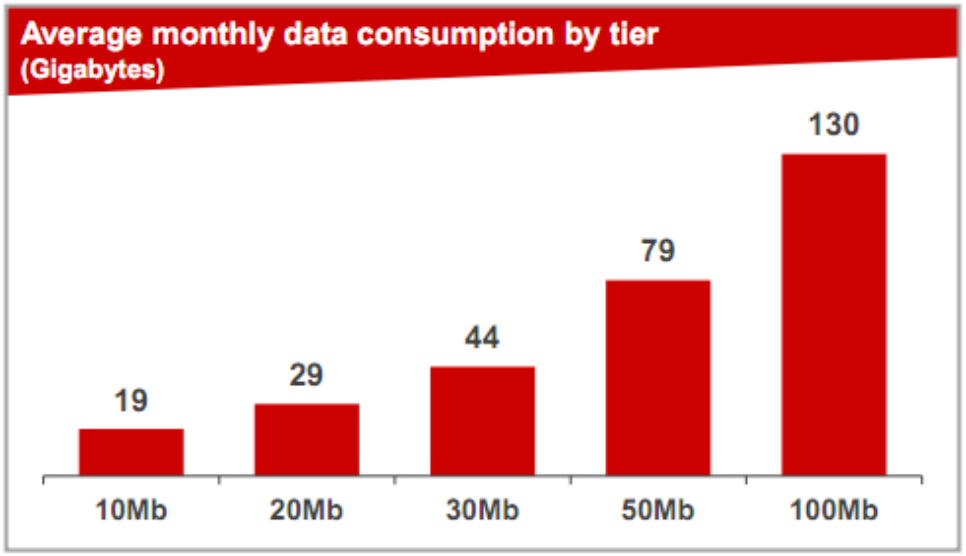
- Emerging interconnection disputes;
  - Tensions between the largest content providers (e.g. Google) and 'access networks' are bound to rise. Comcast vs. Level(3) in 2010 presents a typical example of such a dispute
  - As of yet, we haven't experienced any similar cases in the UK

Prior to the study our working hypothesis was that the market has and will continue to invest in the infrastructure associated with the core internet and the necessary commercial incentives would exist to ensure parties would work together. Our provisional findings support our hypothesis in that the risk of any issues developing within the Internet Core appears low at the moment. However if any issues do materialise, then the impact on the consumer's Internet experience would be significant.

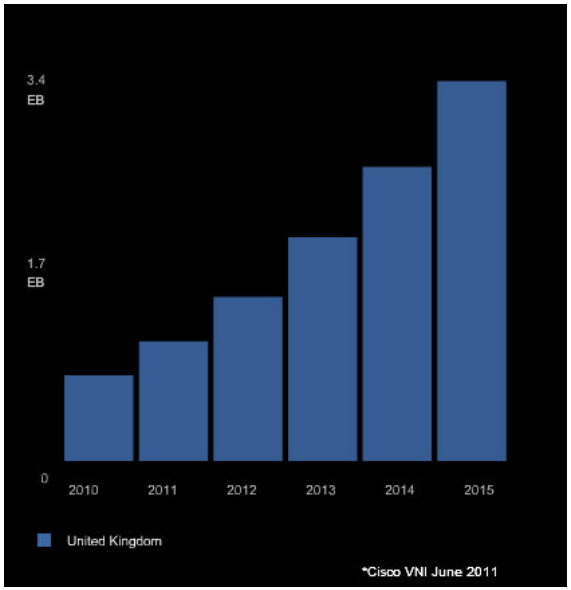
The Consumer Context

Whilst fixed broadband take-up has plateaued , consumers are transferring increasing amounts of data…

- Ofcom's 2011 Infrastructure Report revealed that, on average, UK fixed broadband customers uses 17GB of data a month
- Data consumption has increased 7 fold in last five years, CISCO predicts a further three fold increase between 2011 and 2015



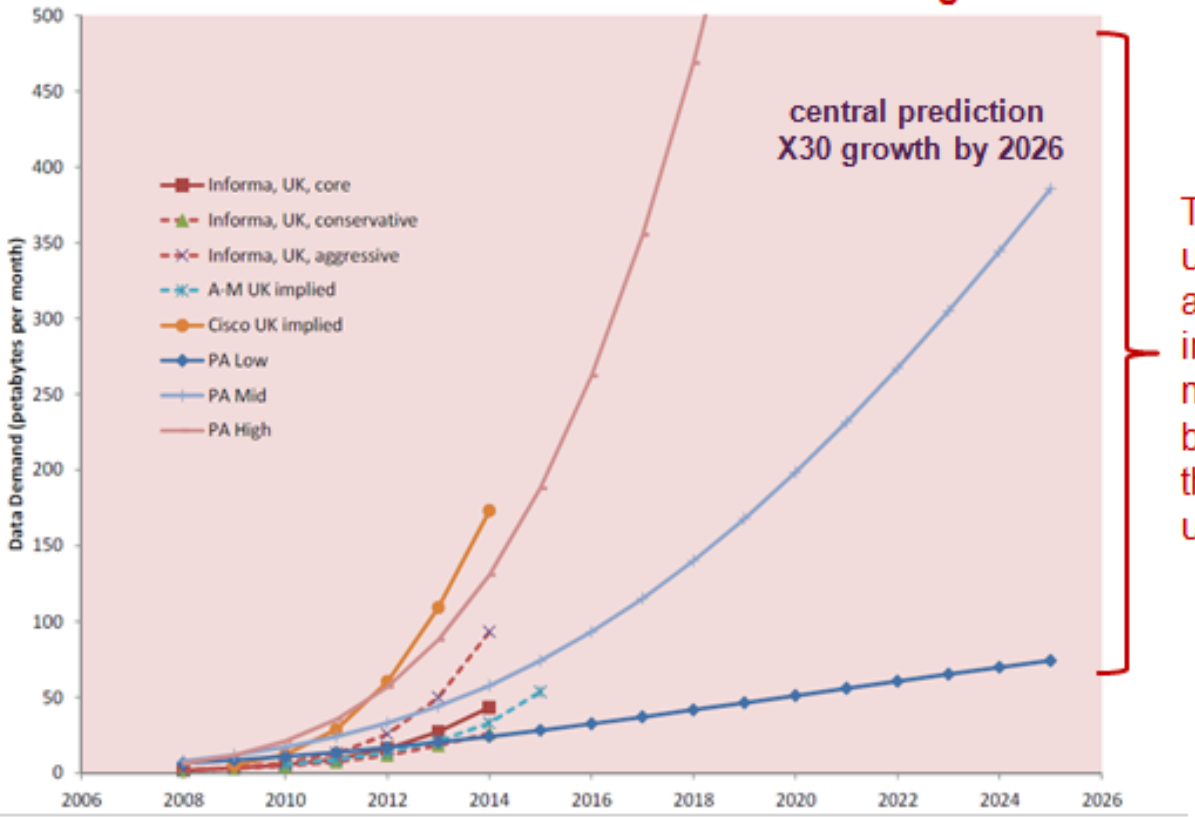
Source: Virgin Media October 2011



Source: CISCO

and the rate of increase in mobile data is expected to be even higher – primarily driven by greater take up and use of smart phones and tablets

Different forecasts for increases in mobile data usage – to 2026



There is a high level of uncertainty over the amount of future growth in the demand for mobile data capacity – but there is consensus that there will be a significant upwards trend

Source: Ofcom commissioned research for UHF strategy programme

...and other market developments underpin these trends

- New OTT video services are proliferating – Netflix, Lovefilm, YouView, Sky Anytime+/NOW TV with high quality content, major consumer brand support and effective integration with consumer devices
- “Connected TV” capability is now becoming the norm for mainstream consumer brands and retailers are offering support in establishing in-home connectivity to broadband services
- Increasing use of personal devices (smartphones and tablets) for media consumption “in home” will drive increased fixed broadband data consumption through WiFi “off load” to avoid mobile network coverage and tariff problems
- Could result in crystallisation of SFBB latent demand to meet the aggregate needs of multi user/multi device households but this has yet to happen

Tablet take-up will accelerate the data growth trend for both fixed and mobile

- **In the UK, tablet ownership has risen rapidly in the last year to over 10% in early 2012.** This growth looks set to continue as around one in six of households say they intend to buy a tablet in the next year.

- **The most common motivation for purchase is entertainment. More than half of consumers buy a tablet for this reason.** Video streaming of one form or another is a key element of this usage.

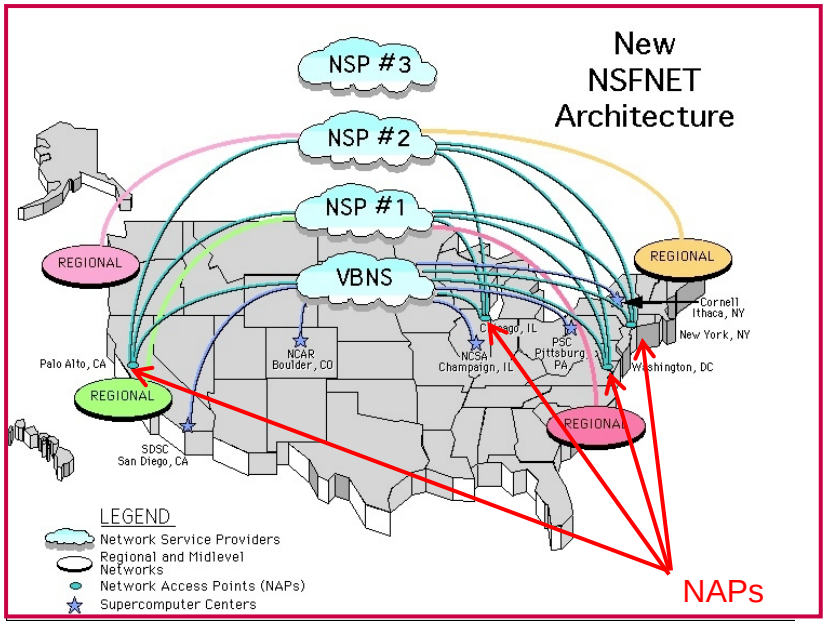
- **Even though a key reason for purchase is portability, most tablet owners say they mainly use it at home.**

- **Most claim to go online on their tablet everyday or most days, with many claiming that they browse the internet more than they did before owning a tablet**.

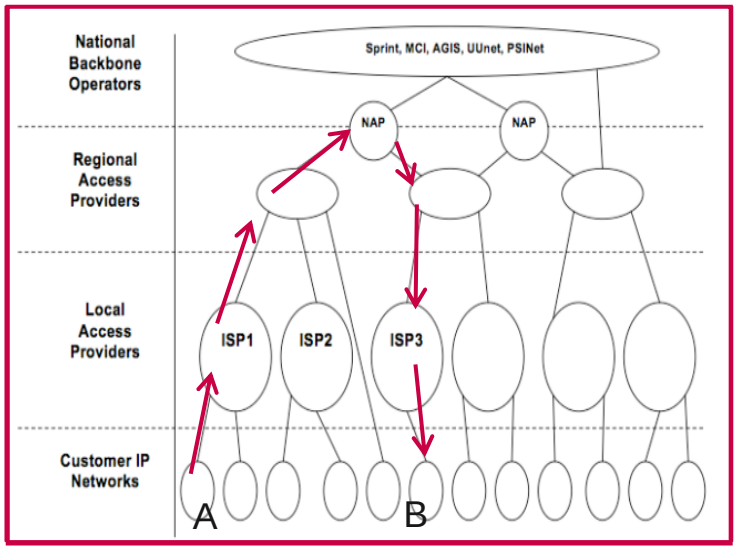
- **Tablet owners have a strong relationship with their new device – many say they couldn't live without their tablet.**

IP Interconnection

Start of the Commercial Internet (c.1995)



In the early beginning of the commercial Internet, NSFNet created 4 Network Access Points (NAPs) to exchange traffic between networks.



The Internet was organised in a hierarchical way. Customer traffic would often have to go all the way ‘up the hierarchy’ to reach the destination network.

This wasn’t always the most optimal routes, as Networks A and B could be geographically close, while the traffic between them could still have to go all the way via the hierarchical system.

The introduction of more IXPs (a term which replaced NAPs) made it possible to keep traffic flows more local, and contributed significantly to the rise of the Internet.

This hierarchical structure was valid till approx 2007-2008. After which the dramatic increase of video traffic altered the structure dramatically

IP Interconnection and the role of IXPs

- ***Internet Exchange Points may be key players in interconnection***

  – Internet eXchange Points (IXPs) provide the physical infrastructure that allows ISPs to **interconnect directly** (i.e. peering) to other ISPs, CDNs, etc. **rather than** having to pass **via third party networks** (i.e. transit) to reach each other.

  – Road networks provide a useful comparison – if roads represent different networks – an IXP is the roundabout to which all the roads connect. Via the roundabout one can directly travel from one road/network to another road/network.

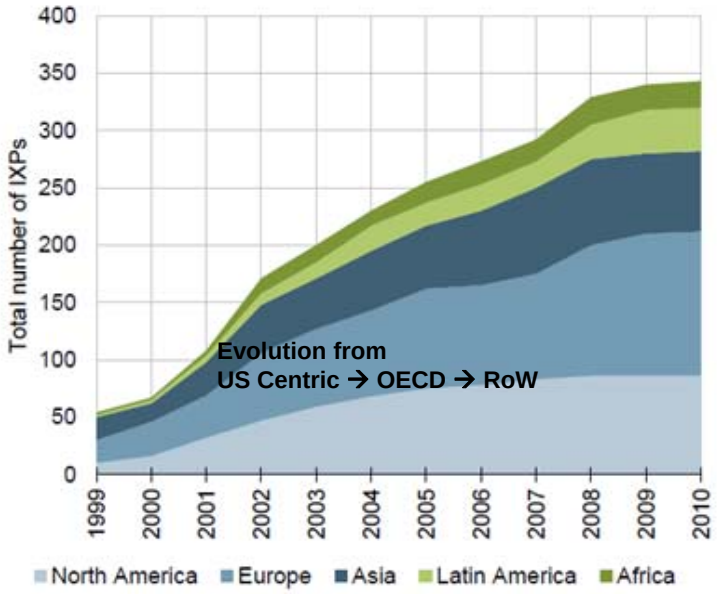
  – There are essentially two ways to have interconnection on the Internet. Which one to choose depends on the amount and type of traffic a network is generating/demanding
    – Via the IXP (directly interconnecting) – aka 'peering'
    – Via a third party network – aka 'transit'

- ***Location of Internet Exchange Points***

  – In Europe IXPs are typically located in data centres (e.g. Telehouse in Docklands) that provides it with a reliable power supply, industrial cooling and network connectivity. Because of the presence of an IXP those data centres will find it more easy to attract ISPs, CDNs, etc. that now easily can connect - via the IXP – to a series of other networks. Sometimes if two networks exchange lots of traffic, they will bypass the IXP and have a direct one-to-one connection ('private peering')

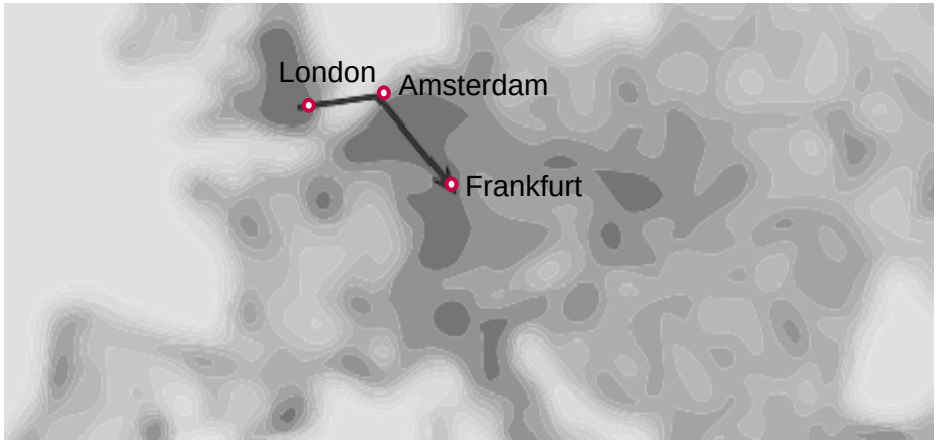
  – LINX (the London Internet Exchange) is one of the biggest IXPs in the world (others include Amsterdam, Frankfurt and New York). Next to LINX, the UK has several other IXPs, located mostly in London but also in Manchester and Leeds.

The importance of the regional IXP has risen



Source: Packet Clearing House – Analysys Mason

Number of operated IXPs in the world



Progression of largest EU IXPs towards centre of population density

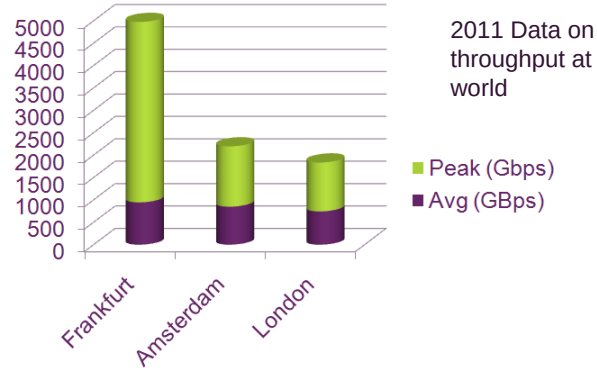
Source: OECD report on Internet Traffic Exchange

The picture above shows how the biggest IXP shifted from being located in London to Frankfurt. This is in line with population density

Since the commercialisation of the Internet in the 1990s, more IXPs have been established in Europe. Thereby keeping more traffic regional and avoiding tromboning via the US

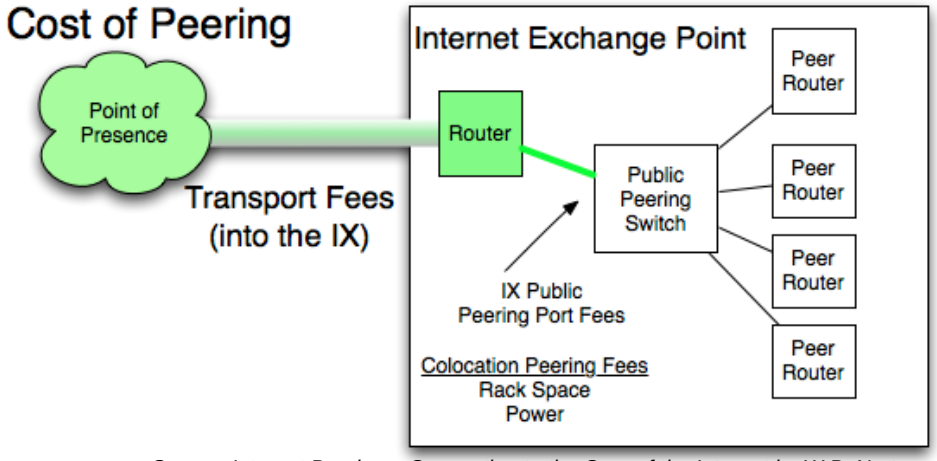
This is part of a general trend whereby IXPs are established wherever it is more efficient to exchange traffic locally .

European IXP's tend to be bigger than their US counterparts

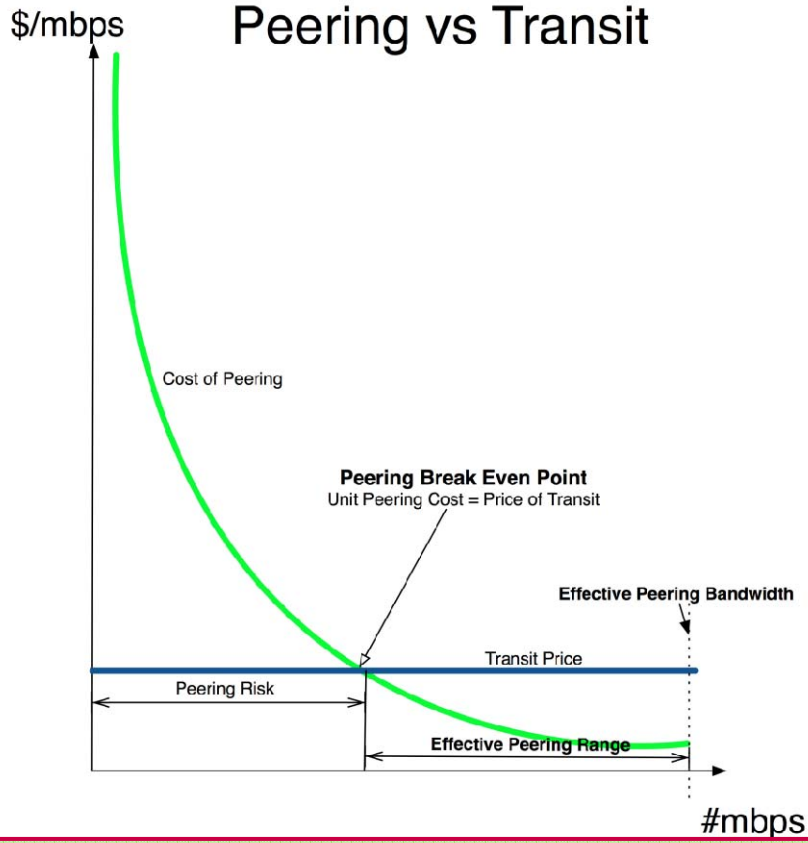


2011 Data on peak & average throughput at biggest IXP's in the world

Peering economics – when it makes sense to Peer



Source: Internet Peering – Connecting to the Core of the Internet by W.B. Norton



While peering between networks may be generally free, there are still costs associated with setting up the peering infrastructure:

- Data centre costs (rack space, power, equipment)
- IXP costs (switch ports)

Therefore, the decision to peer will depend on how much traffic can be directly exchanged between 2 peering partners

So when traffic volumes between networks are low, it may be more cost effective to buy transit

[Note that in cases where a better latency is required there might still be a reason to peer even if the amount of traffic exchanged is low]

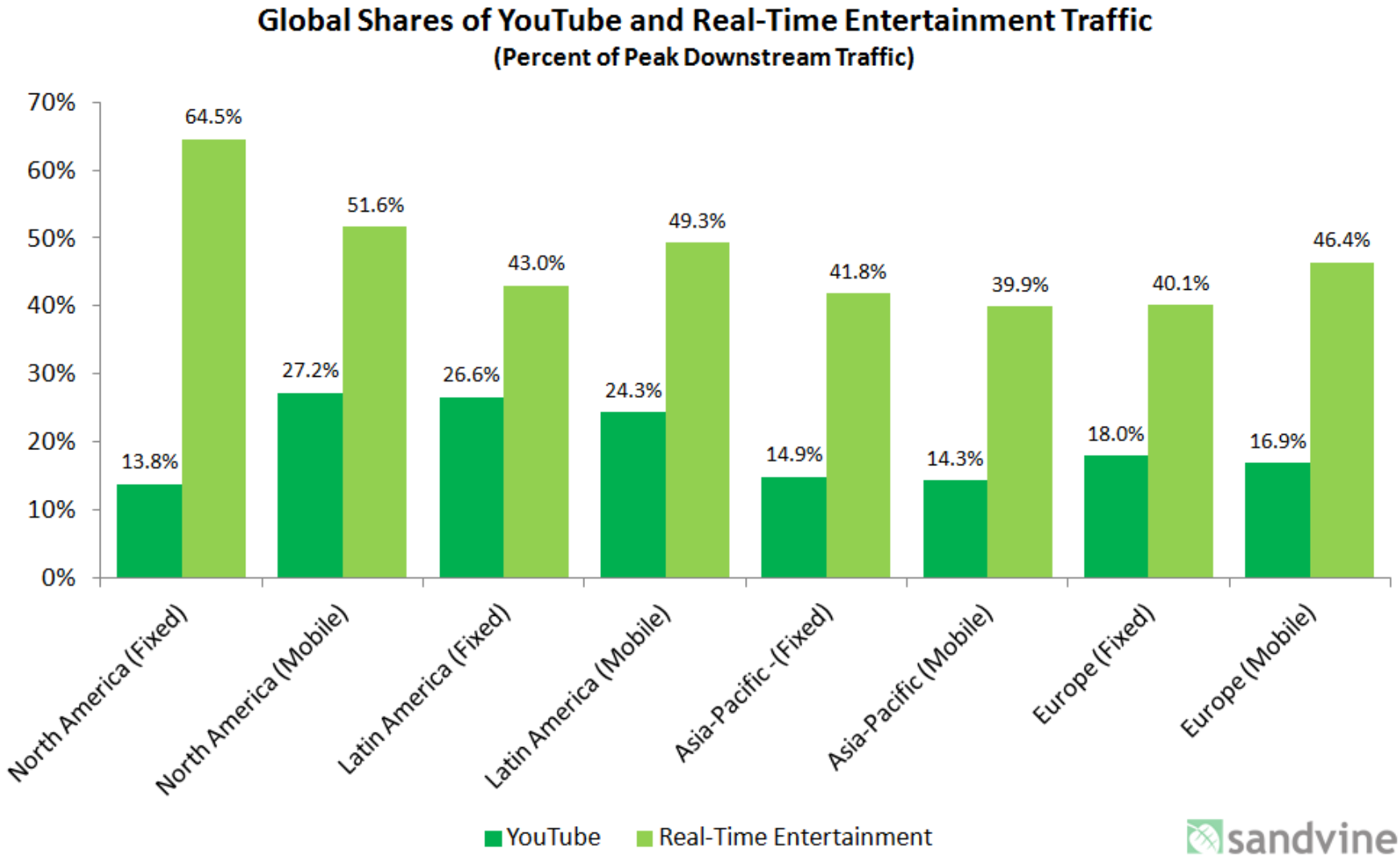
The introduction of IXP's allows network owners to choose whether to deliver traffic via either peering or transit. The possibility of having different routes to reach a network has led to an open market with cost and performance efficiencies.

Note that delivery of HQ video traffic (eg via a CDN) will generally favour (private) peering to ensure good quality.

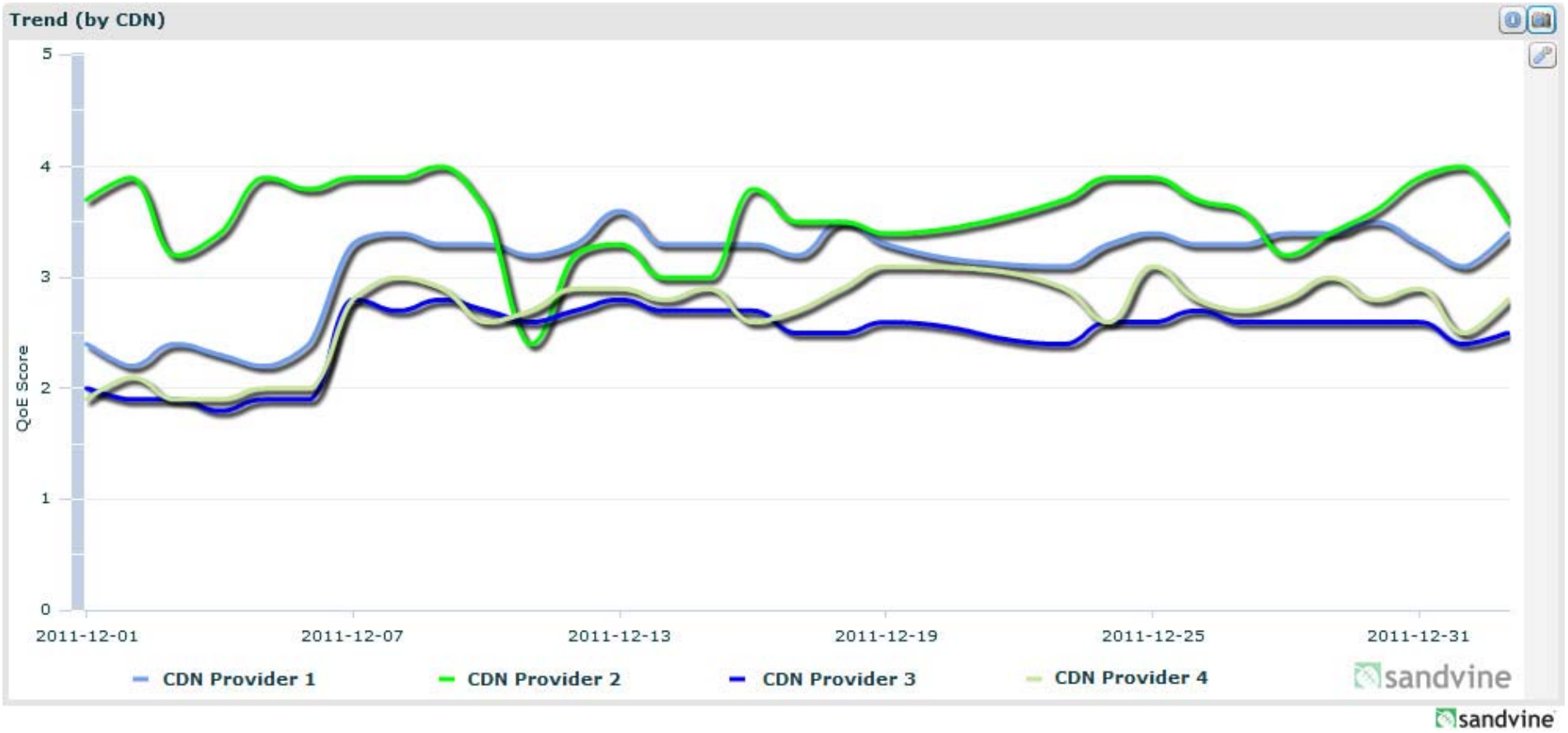
The growth of direct CDN “peering”

- ***Rise of the Hyper giants***
  - Historically, content on the Internet came from a myriad of users, companies, etc ... Nowadays fewer than 200 companies contribute to more than 50% of all Internet traffic. This evolution lead to the creation of so-called ‘hyper giants’ (i.e. Google, CDNs,....) that are fast becoming the main content providers on the Internet.
  - This evolution has had a significant impact on interconnection arrangements. Typically those content rich ‘hyper giants’ prefer to connect directly (peering) to access networks to ensure good quality video delivery, rather than relying on transit. An added consideration for them is that while transit is generally paid-for, the majority of peering is settlement free and in the interests of both parties.

What's fuelling CDN demand?



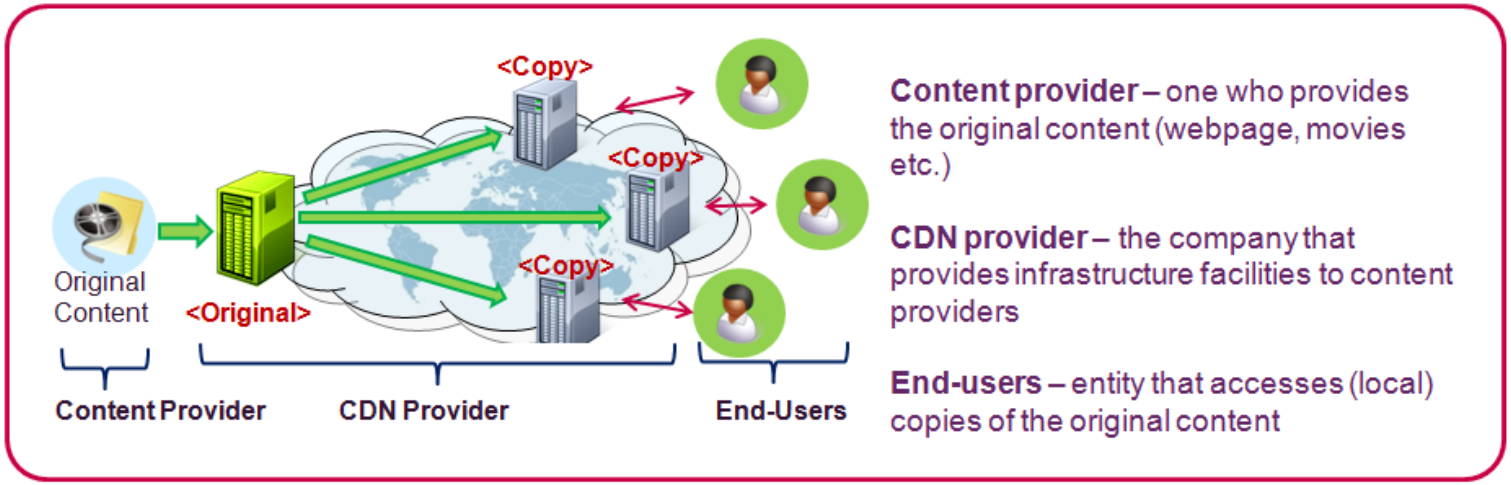
Quality as well as volume



Content delivery networks – the rationale

- Beefing up international backbone infrastructure is but one way of improving content delivery. ***Storing popular content locally*** is an important and efficient alternative to international transit and has led to the 'regionalisation' of the internet. It has the advantage of reducing both network requirements and improving end-user experience.

- Local storage needs to be managed. Local copies of popular content need to be kept up-to-date; new content needs to be distributed and stored locally (for example in data centres or even large exchanges or other 'points of presence'), etc.... **Content Delivery Networks (CDNs)** perform these functions and **integrate this form of local storage into the wider internet**.



Example: Should an end-user in the UK want to download software from Symantec (the Content provider), Akamai (the CDN provider) will provide a copy of that software (stored locally in the UK) to the end-user.

- ***A CDN is a network of servers containing copies of the original content***. These are typically placed within regional/ local data centres so that the content can be delivered from a point closer to the consumer. This underlines the crucial role of data centres.

Content delivery networks - trends

- Using content delivery networks allows content providers to make a trade-off between investing in bandwidth and investing in (local) storage capacity. Content owners can either develop local storage solutions themselves (usually only practical for the largest players e.g. Google/Microsoft) or buy CDN services from third party providers such as Akamai. These new and important but little-known players play an increasingly important part in the content delivery value chain.

- ***Key trends in the CDN market***
  - Prices are falling rapidly as CDNs become commoditised
  - New entrants are entering the market place (e.g. Telcos trying to diversify their offerings or companies like Google and Netflix building their own)
  - Traffic volumes continue to rise

Who is Akamai?

- 15-30 % of all the content users access worldwide, passes via the servers of Akamai
- Akamai has 95.000 servers in 1900 different networks across the world
- First commercial service started in April 1999
- Currently has 2300 employees
- 2010 Revenue 1.02 Billion USD

Some other CDN providers are:

- ***Case Study: BBC iPlayer***
  - Demand for BBC web/iPlayer content can be very high – and includes live content.
  - E.g. peak demand of 800k streams for the 2010 England vs. Slovenia Football World Cup match – almost 3x previous record – and the London Olympics will present a new challenge with a predicted 1 Tbps incremental load.
  - Currently uses 4 CDNs – Akamai, Limelight, Level 3, Siemens.
  - This allows for redundancy and content type differentiation (e.g. Level 3 for HD content; Limelight for streaming).

Rise of the Hyper Giants

Tier-1 providers (2007)

Rank	Provider	Percentage
1	Level (3)	5.77
2	Global Crossing	4.55
3	AT&T	3.35
4	Sprint	3.20
5	NTT	2.60
6	Cogent	2.77
7	Verizon	2.24
8	TeliaSonera	1.82
9	Savvis	1.35
10	AboveNet	1.23

2010

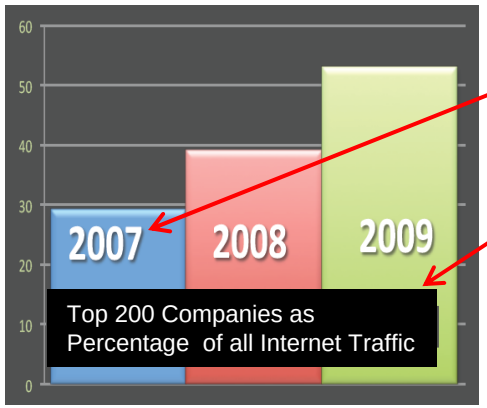
Rank	Name	%	
1	ISP A	9.09	
2	Google	7.00	← Google
3	ISP B	4.70	
4	ISP F	3.00	
5	ISP H	2.96	
6	ISP K	2.89	
7	ISP L	2.82	← CDNs
8	ISP M	2.60	
9	ISP E	2.30	
10	Comcast	2.07	

Source: Labovitz

By 2007, the hierarchical structure of the Internet still prevailed. And the top contributors in term of volume of traffic shifted where all traditional Telco's.

By 2010, Content heavy networks (Google, CDNs) have entered the top-10

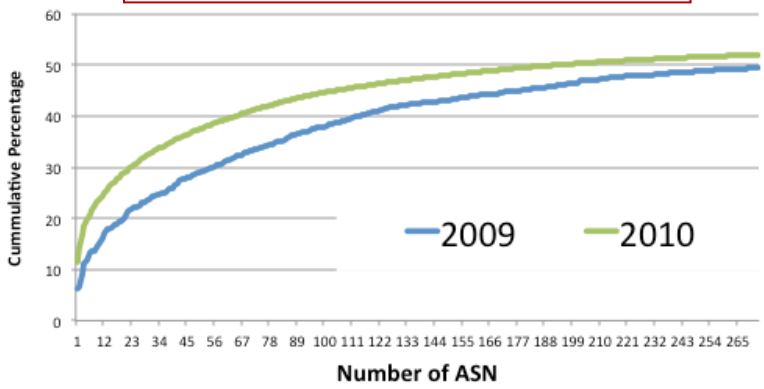
Also a smaller number of providers is responsible for a bigger chunk of all Internet traffic



Rise of the Hyper Giants

- In 2007, top 200 grouped ASN generate **30% of** all Internet traffic
- In 2009, top 200 grouped ASN generate **53%**

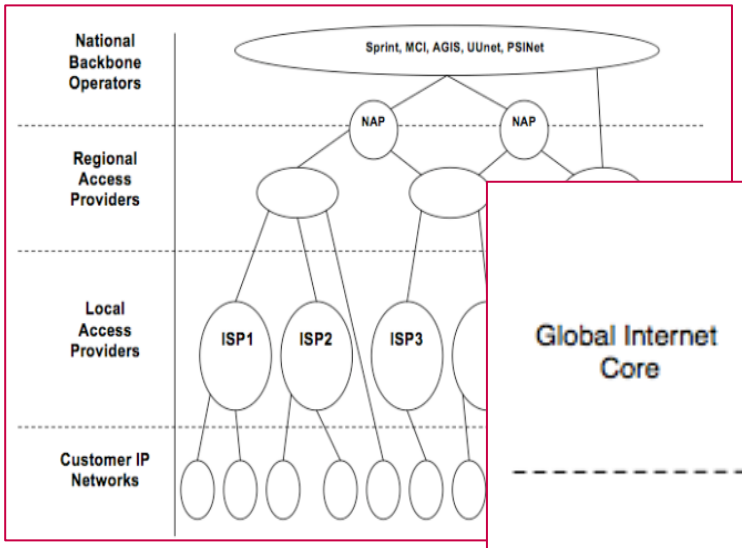
Amount of traffic generated / network



An autonomous system (**AS**) is one network or sets of networks under a single administrative control.
For example, an AS might be the set of all computer networks owned by a company. An Autonomous System Number (**ASN**) is a unique number identifying those group of networks to the outside world

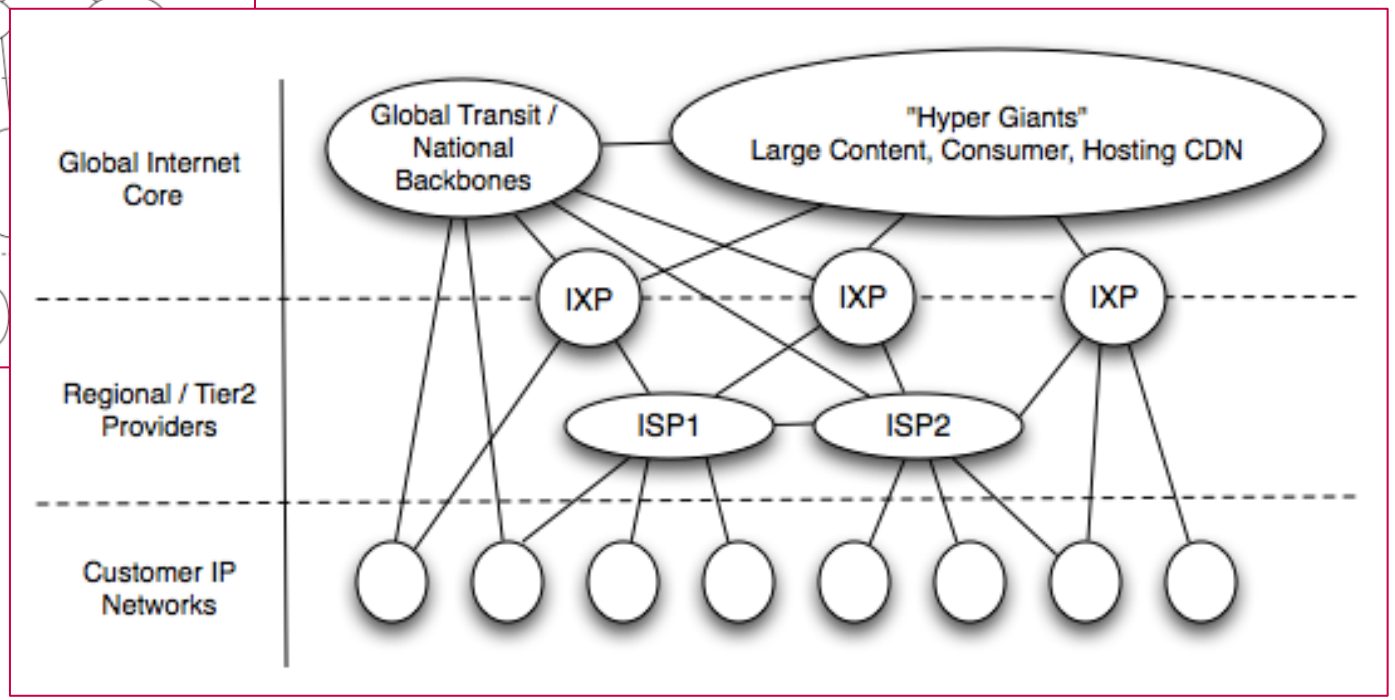
Rise of the IXP & Peering

Rise of the Hyper Giants leads to ...



Hierarchical Internet structure

... a new structure of the Internet



Today's Internet structure

Commercial tensions?

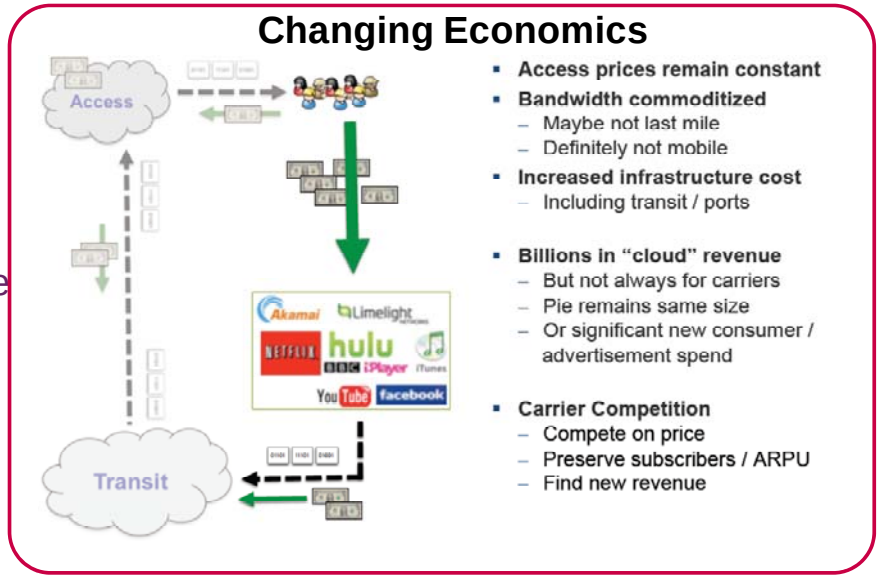
Commercial interconnection disputes are emerging

- Efficient, easy and harmonious interconnection between networks is fundamental to the smooth running of the internet.

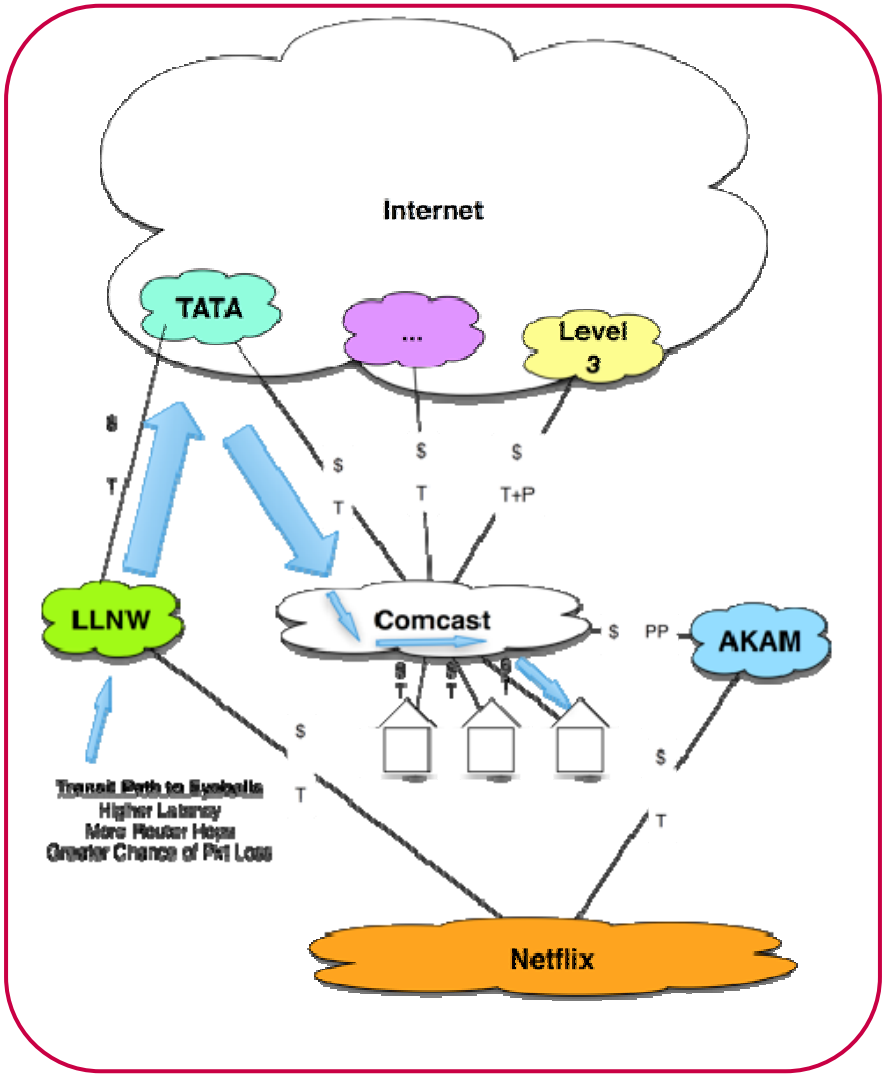
- But **interconnection disputes have come to the fore** as the underlying economics of internet connectivity have changed. Traffic asymmetries (where there is an imbalance in traffic flow between two networks) have further undermined relationships previously based upon settlement-free peering.

- This has led to tensions between 'hyper giants' that control popular content and ISPs that control access to significant numbers of eyeballs. **The negotiation-power of access networks is bound to rise**.
  - this was most clearly illustrated in the **peering dispute** last year between **Comcast and Level3;**
  - a similar dispute between Cogent and France Telecom has drawn **attention from regulators**; and
  - several European incumbents [Telefonica, FT, DT, Telecom Italia] made proposals to the Commission to introduce a **'data termination'** charge for IP Interconnection to help fund NGA.

- Despite this, interconnection **tensions do not obviously appear to be a problem for the UK**.
  - We understand from stakeholders that the competitive nature of our access market means the attractiveness of content delivered through CDNs gives their operators effective countervailing buyer power during negotiation.



Video delivery & Importance of paid peering



Source: Internet Peering – Connecting to the Core of the Internet by W.B. Norton

Case Study - 1

Akamai (AKAM) has paid peering to Comcast and thus enjoys higher quality (lower latency, lower packet drops) connections to Comcast's customers

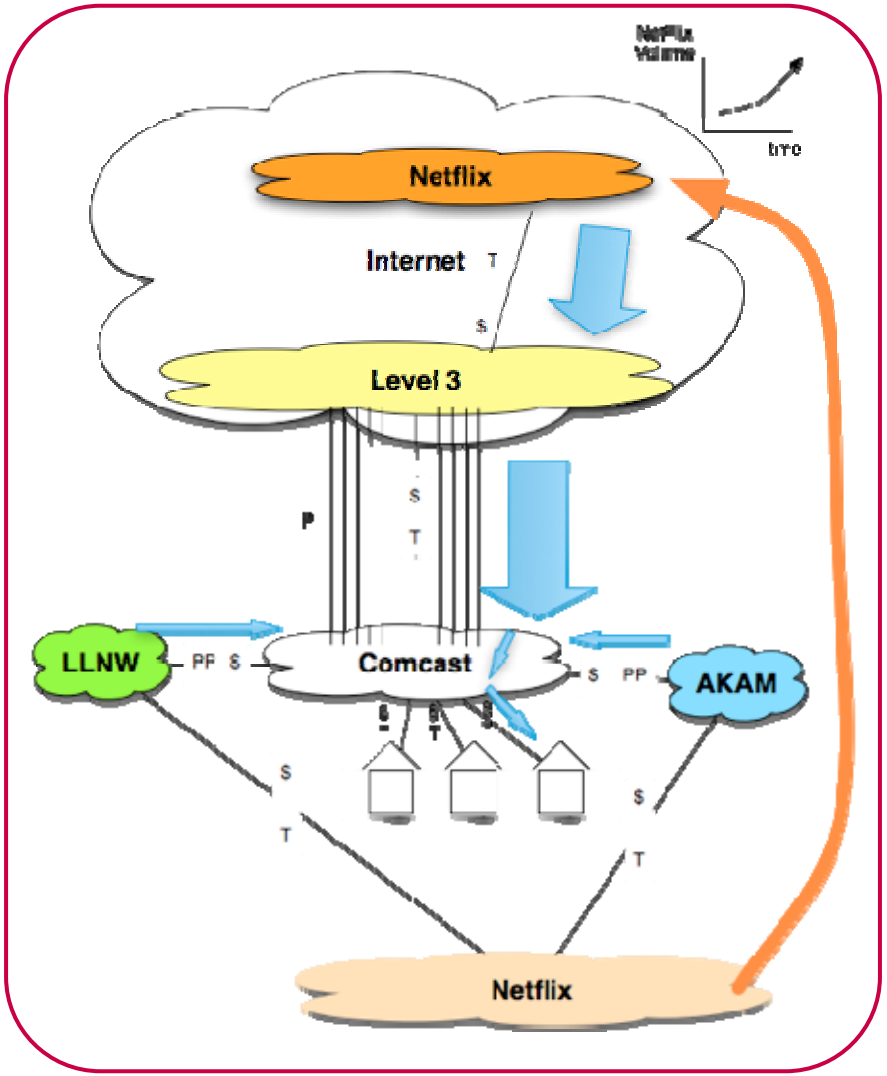
Limelight (LLNW) another CDN used transit to deliver video traffic to Comcast's network. Because of a congestion problem with Comcast's transit provider, Limelight was forced to enter into a paid peering arrangement with Comcast

Although theoretically one can deliver video either via Transit or Peering, if one wants to guarantee a certain traffic (which most content owners paying the likes of Akamai and Limelight want) a paid peering with Comcast has to be established.

A shift in the Internet Eco-system

Since over 80% of traffic is video-traffic, content owners will be applying pressure on CDN providers to ensure good quality delivery of their content.
This could lead to a shift in power to the owners of the Access Networks, and hence an increase in Paid Peering, but other competitive forces could balance this out

Video delivery & Importance of paid peering



Source: Internet Peering – Connecting to the Core of the Internet by W.B. Norton

Case Study - 2

In 2010, Netflix which till then has used Limelight and Akamai as its CDN providers, decides to use Level(3) as its primary CDN provider. Level(3) is also a 'Tier 1' provider and hence does not pay any money for its interconnection with any other ISP.

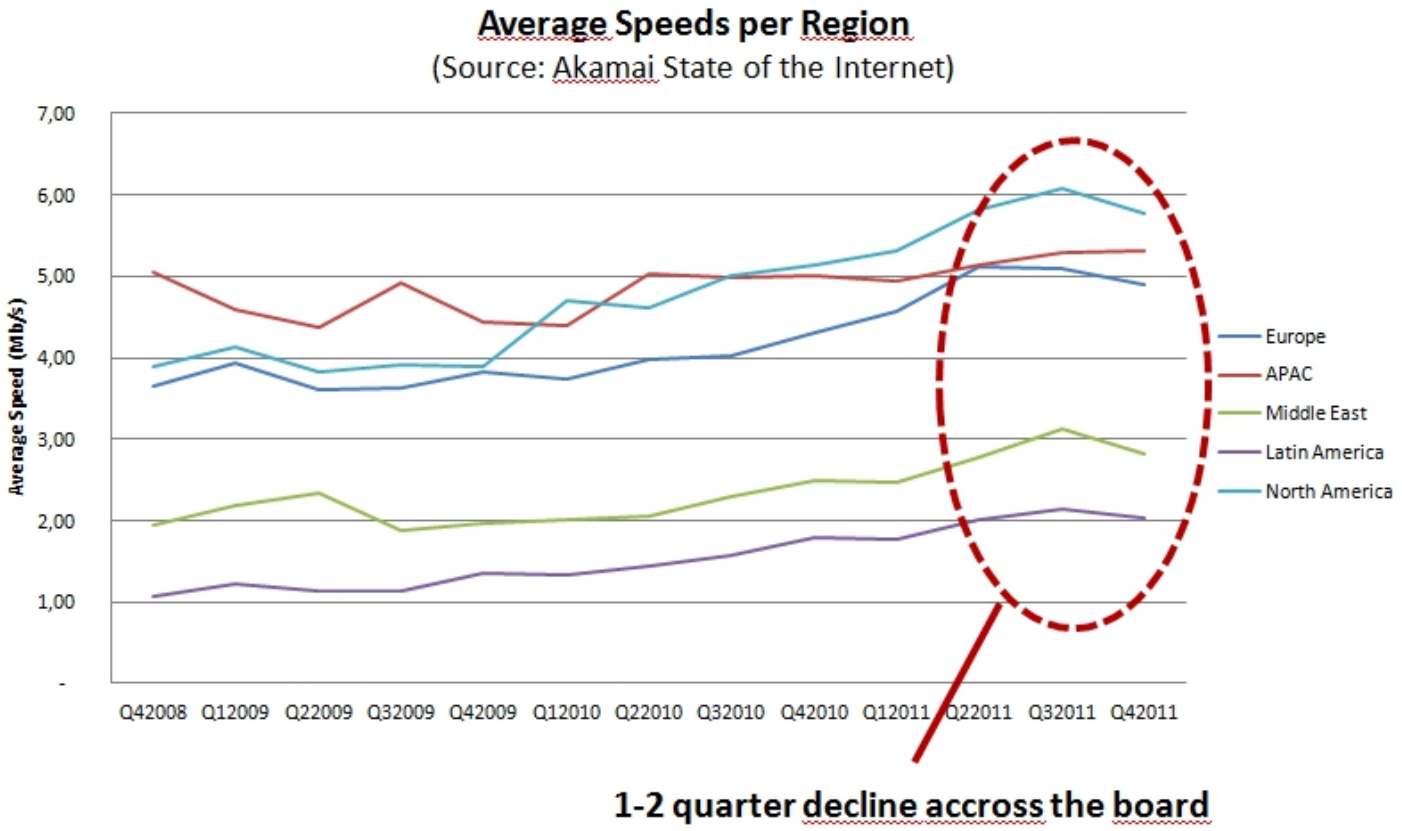
However because of the Netflix traffic, Level(3) and Comcast will need to boost the interconnection capacity between them .

Comcast refuses to do so, insisting that Level(3) should pay for its interconnection to its eyeballs.

Like in the previous case, if Level(3) wants to ensure good quality delivery of its content, it has no choice. Level(3) has to purchase paid interconnection with Comcast.

This is a 'first' in Internet history: a provider with Tier-1 status which pays an access ISP.

...and what's this?



Possible explanations?

- **Lowering of Speed Package Subscriptions:** in a context of international recession, it could be argued that consumers may be downgrading their broadband packages to save money, trading comfort for extra disposable income **– no evidence that this is actually happening**.

- **Actual degradation of the quality of experience in wireline broadband:** could be explained by both an increase in devices connecting on the same line in the home and the increase in size and usage of online content, not compensated by a commensurate increase in broadband speeds offered, leading to less bandwidth being available for each applications/session pending a migration to NGA **– possibly, but seems a little earlier/more universal than would be expected given differing adoption rates**.

- **The commercial/operational connectivity they have in place with access networks has not been expanded sufficiently to deal with the actual demand:** this poses the biggest concern in that it might signal a fundamental breakdown in the "virtuous circle" that has led to escalating consumer service demands being met without increasing service charges as access providers are unable or unwilling to make the step change investments in connectivity capacity needed to meet continuing growth **– if so, is there a consumer impact that justifies regulatory intervention?**

The Information Gap

Who's doing what and how has it changed?

- While overall technical and topology interconnection arrangements are well understood, and general trends are clear, there are few details of how access networks connect to the "Internet" in practice and how these arrangements might be changing with the evolution in customer service use and of the overall "ecology"

- Despite the rise of regional IXPs and the opportunity they present to allow "horizontal" peering between local access networks, usage trends suggest that, increasingly, internet connectivity is dominated by "paid for" transit and highly asymmetric "peering" with CDNs, particularly the "hyper giants".

- Consequently, access network economics and, hence, consumer pricing and QoS are increasingly influenced by relationships between telco/ISPs and a small number of global players. Regulators currently have little visibility and understanding of how this operates in practice which may lead to problems if disputes arise.

- ARCEP survey attempts to address this gap and Ofcom are capturing some equivalent data through a planned "Infrastructure Report Update" that will be published in Autumn.

Other factors related to interconnection may influence the customer experience

- How do you measure the customer experience and approach the issue of potentially setting a QoS threshold?

- Is a simple “speed” measure, headline or actual, an effective surrogate for customer satisfaction and do available measurement methodologies provide relevant metrics? (eg SamKnows approach only captures data when access line is idle – is this truly representative of the customer experience, particularly in the light of the application of traffic management practices that vary by time of day or network load?)

- What are the roles of variations in latency and loss in delivering “acceptable” QoS? There seems to be emerging evidence that, despite improving headline speeds, customer satisfaction is not rising as some applications become less consistently reliable.

- Do current interconnection arrangements suit emerging patterns of use, in terms of multiple concurrent sessions, often involving high bandwidth streaming? Should “application” optimisation be an explicit part of interconnection “standards” and contracts and what is the role of regulatory authorities in their development or enforcement?

The way forward?

- Clear need to better understand the possible problems that may arise and what factors could affect them.
- Better tools are needed to measure the “customer experience” in a way that is directly relevant to actual patterns of use.
- BEREC work programme establishes a clear analytical framework to use in considering traffic management, net neutrality and IP interconnect issues but need clarity of policy objectives and/or clear evidence of consumer detriment to intervene at this point.
- Best approach is to establish ongoing monitoring programme of relevant metrics and industry practice with an explicit commitment to intervene when necessary.
- IN UK, Ofcom programme of Infrastructure Reporting offers a mechanism to do this, and provide feedback to stakeholders and consumers.