The Emerging 21st Century Access Power Peering (*)

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Abstract: From the beginning of the Internet as a government-funded network of networks through the commercialization of the Internet, the Internet ecosystem had gone through tremendous changes. The economic models for charging for connectivity was invented, the interconnection regimes were created and evolved, and Internet Peering was employed as a local routing and business optimization. But how has it changed recently, and what are the trends moving forward into the 21st century?
This paper describes the dramatic evolution of the Internet Peering ecosystem from the economic downturn in 2001 to the massive paradigm shifts playing out right now in 2011. These shifts are "massive" in the sense that the power positions of the players has changed, and the underlying assumptions of peering equity have adjusted accordingly.
Key words: Peering, Internet Transit, Net Neutrality, Paid Peering, CDN.

The Internet is a network of networks arranged into a system of business relationships called the Global Internet Peering Ecosystem. Each Internet Region (typically bounded by a country border) has historically consisted of a set of "players" with positional power and corresponding motivations and observed behaviors. The base set of categories of players are Tier 1 ISPs (that have access to all Internet Region routes solely through their free peering relationships), Tier 2 ISPs (that have to pay someone for access to some destinations within the Internet Region) and Content Providers that do not sell Internet access but rather focus on providing content to be consumed by the end users. It is from this base ecosystem that the Internet evolved.

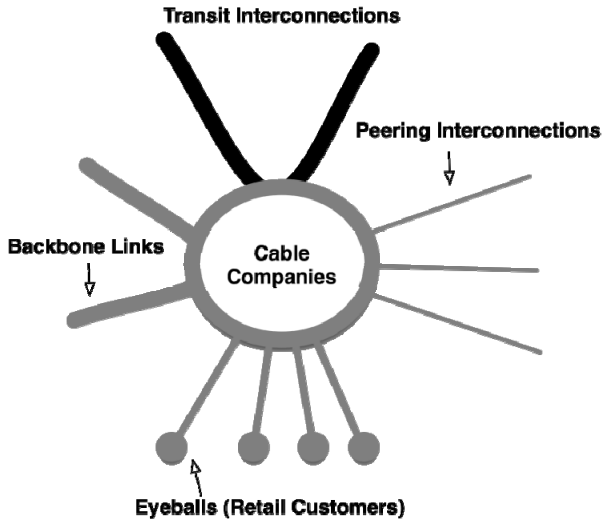
The following six evolutions demonstrate how the players react to the changes in the environment. We will first highlight the evolutions that occurred during the economic downturn in the year 2001.

(*) This paper is an excerpt from *The Internet Peering Playbook: Connecting to the Core of the Internet*, William B. NORTON, (c) 2011).

■ Evolution #1
The cable companies peer with each other

The cable companies were forced to in-source the broadband Internet services that @Home had provided until its bankruptcy in 2001. The cable companies were given only 30 days' notice to establish high-capacity transit relationships and launch their own Internet services. They entered the ecosystem as independent broadband access network providers as shown graphically in Figure 1.

Figure 1 - The Cable Company model



The cable company player model is similar to that for Tier 2 ISPs but is a little different in that the cable companies are regional and don't tend to compete in overlapping areas, and they tend to pull enormous volumes of traffic.

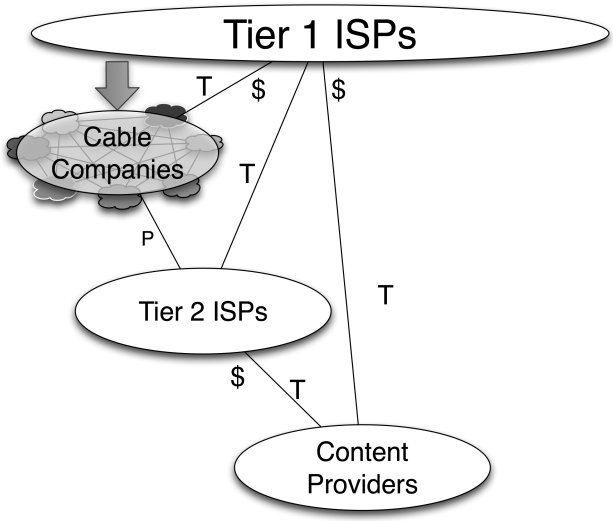
When the cable companies attached to their new upstream ISPs, each cable company experienced the same thing: Internet Transit circuits were congested almost immediately. Each of the cable companies ordered upgrades to these circuits, and almost immediately the Internet Transit connections were again congested!

What was going on here?

After some analysis, the cable companies found that about 40% of all cable company traffic was peer-to-peer traffic; traffic was ultimately destined to other cable company networks. I had been working with the cable companies on the benefits of peering, and as a result, many of them built into multiple regional IXPs and started peering openly with each other and with the other Tier 2 ISPs in the ecosystem.

These new players and their peering relationships are shown graphically in Figure 2.

Figure 2 - The cable companies emerge as independent players



One might ask, why is there a separate species of player; isn't the cable company model identical to the Tier 2 ISP model? Why is this evolution significant?

This evolution represented a significant change in the U.S. Internet Peering Ecosystem because:

- The volume of traffic being exchanged directly in a peering relationship, among the cable companies and between the cable companies and the Tier 2 ISPs was huge-second only to the Tier 1 ISPs' traffic exchange volume estimates at the time. Therefore, the amount of traffic that bypassed the Tier 1 ISPs, and therefore the amount of money that peering saved the cable companies, could be measured in millions of dollars.

- In 2003, the cable companies had an Open Peering Policy. The cable companies were not generally interested in selling transit to ISPs or Content Providers, and they generally worked in nonoverlapping regions, so they didn't compete against each other. As a result, there was no reason not to peer openly.

- Peer-to-peer traffic consumed all available bandwidth. The typical ISP sinusoidal demand curve was replaced with a flatter demand curve as peer-to-peer file-sharing software now preferred the higher-bandwidth, lower-latency paths to peered cable company customers.

It was also noted that the peer-to-peer traffic volume grew immediately after the cable companies peered with each other. Peering caused Kazaa to prefer to fetch files across the now peered network path. The Kazaa selection protocol at the time used latency to determine which Kazaa file sharer was "more local", and automatically selected that file sharer. The result was that when cable companies peered with each other, there was an immediate 20% growth in Kazaa-originated peering traffic volume.

■ Evolution #2
Large-Scale Network-Savvy Content Providers peer

Around the same time, a small group of Large-Scale Network-Savvy Content Providers emerged as large volume peers.

Definition: A Large-Scale Network-Savvy Content Provider (LSNSCP) is a content provider that sees networking as strategic enough to build a backbone and peer.

Most of the LSNSCPs peer at least bi-coastally, and some peer more broadly across the country. The dominant three motivations to peer are similar to the Tier 2 ISP motivations to peer:

- *To improve the end-user experience*. Yahoo! for example sees the end-user experience as mission-critical. The company applies considerable resources monitoring (in real-time!) its application network performance characteristics. It identifies congestion, notes the network path, and alters its interconnections so that traffic traverses an alternative network path to improve the end-user experience. Around the world, this motivation is the #1 motivation that leads Content Providers to peer.

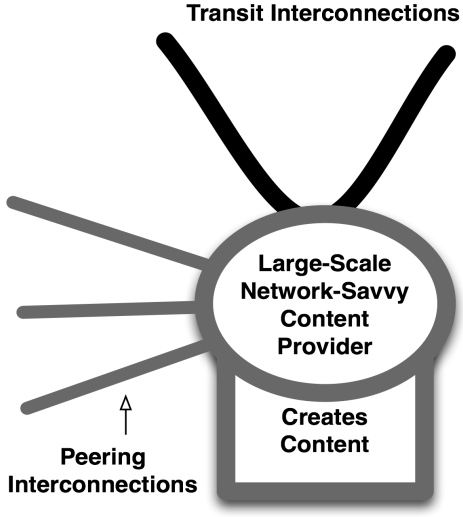
- *To reduce transit costs*. Any traffic that can be sent directly to the access-heavy (also called eyeball) network is traffic that doesn't have to go over the metered transit connection. In a related way, e-mail service providers such as MSN HotMail and Yahoo! can exchange e-mail without incurring any transit charges.
- *They needed to move to a new data center anyway*. Many colocation and data centers were going out of business. Given the opportunity, some content players chose a data center where they could peer as well as buy transit in an open market.

Large-scale content players have always purchased transit to deliver their content to the end users on the Internet. Therefore, their role and behavior in the Peering Ecosystem is similar to the Tier 2 ISPs with the exceptions that Content Players:

- do not sell transit,
- focus on content creation, and if they do operate a network it is for exactly one customer: themselves,
- have visibility into the end-to-end performance characteristics (Tier 2 ISPs see packets, while LSNSCPs can see packets and flows).

The model for the Network-Savvy Large-Scale Content Provider is shown in Figure 3.

Figure 3 - The Large-Scale Network-Savvy Content Provider model



These players still purchase transit (generally from the Tier1 ISPs), but they supplement it by peering openly with anyone and everyone.

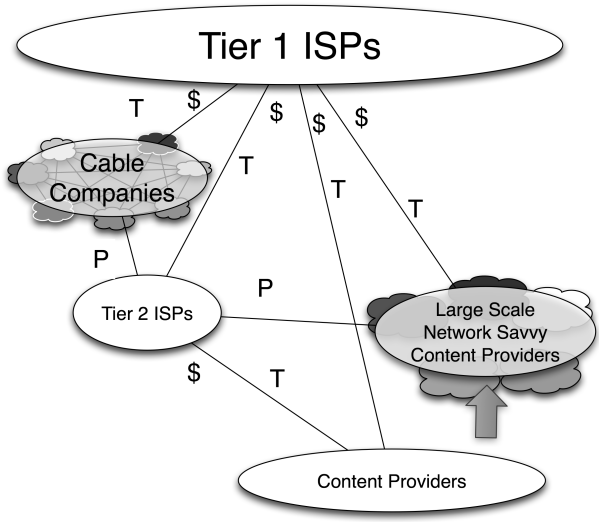
Examples of these Large-Scale Content Players are Yahoo!, Google, Microsoft, Amazon, Walmart.com, Apple, Electronic Arts, and Sony Online.

This evolution represents a significant change to the Peering Ecosystem because:

- The volume of traffic being diverted to peering was huge, and it represented traffic that previously was sent through and available only from the Tier 1 ISPs.
- The LSNSCPs had an Open Peering Policy, and even actively promoted peering with them so this large amount of traffic would be freely available to peers.
- These leading players paved the way for other Large Scale Content Companies and Enterprise companies to examine Peering as a cost reducing / performance improving strategy.

We can see a graphic depiction of this evolution below in Figure 4.

Figure 4 - The Large-Scale Network-Savvy Content Providers peer openly

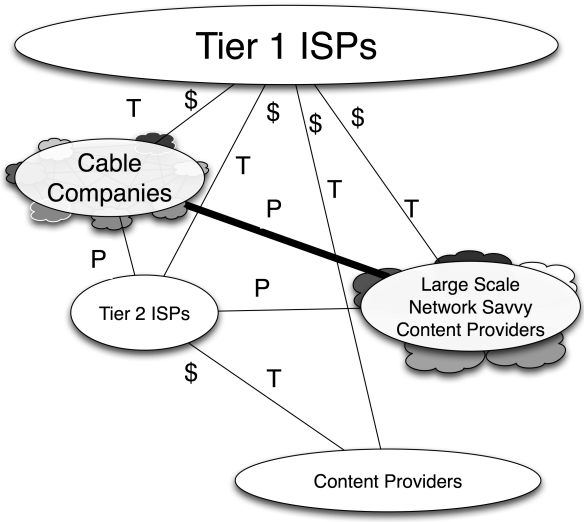


■ Evolution #3 – Cable companies peer directly with large-scale Network-Savvy Content Providers

The peering of the Network Savvy Large Scale Content Companies with the Cable Companies put the most popular content on the Internet directly onto the same network as the broadband eyeballs. The end result was a major disruption in the Internet Ecosystem, resulting in network performance improvements and significant cost savings from peering!

And the middle of the Internet Peering Ecosystem got a little bit fatter as shown in Figure 5.

Figure 5 - Content peers with eyeballs. The Tier 2 ISPs and the cable companies peer with the content companies that entered the peering ecosystem

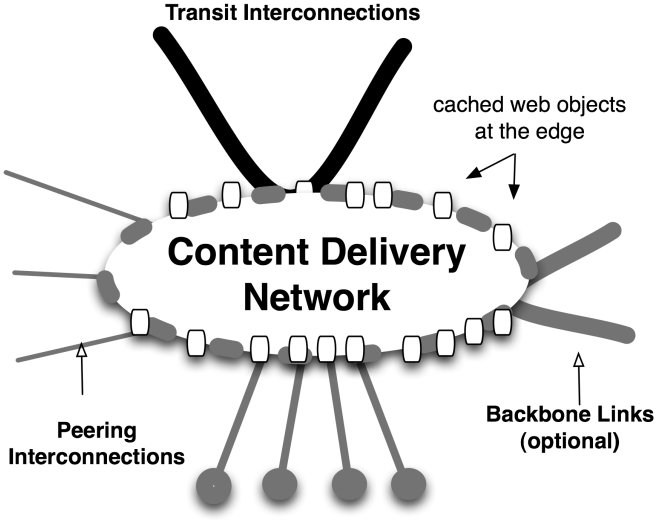


This represents a significant dynamic shift in the peering ecosystem since the Tier 1 ISPs are being cut out of a high volume traffic exchange loop. The hierarchy of the Basic Internet Peering Ecosystem has evolved into a flatter mesh, with the Tier 1 transit providers required only as the route of last resort. Traffic destined to locations too far away or too expensive to reach will ultimately need the services of an international transit provider. At this stage, the Tier 1 transit providers have lost their grip on the U.S. Internet Peering Ecosystem.

■ Evolution #4 – CDNs dominate traffic volume [1]

We have learned that Internet traffic volume is a key determinant as to whether peering makes sense financially. Video represents a proportionately larger amount of traffic when compared against e-mail, web browsing, and other traditional request-response messages. Amplifying the importance of video traffic is the fact that not only is it a larger amount of traffic, but it is also an increasingly popular type of traffic across the Internet. As it turns out, CDNs are really good at distributing video to the edge for offloading to the last mile consumers.

Figure 6 - The Content Delivery Network model



The CDN player (Figure 6) is similar to the Tier 2 ISP but instead of handling a steady stream of content, they distribute any "web objects" to caches at the edge. Today the service is priced the same as Internet Transit,

[1] Notes from the field - CDNs Pushing Massive Traffic volumes:
Around 2006, as YouTube was starting to gain popularity and started using CDN services for the most popular most viral content. The community started noticing the CDN guys were deploying massive peering gear. At the time, most were peering at 1Gbps, and perhaps an occasional 10Gbps connection. I was traveling the peering speaking circuit with the CDN guys who were deploying 10G and occasionally multiple 10G connections to the peering infrastructure. To some CDNs, videos are just another web object to be distributed at the edge of their network. These objects however are very large, so the wakes set off by movement by the CDNs were starting to be felt in a big way. The CDNs, as very large volume open peers, quickly became significant players in the Internet Peering Ecosystem.

so for modeling purposes we will make the simplifying assumption that the CDN is essentially providing transit - just a much better performing one due to the caching at their edge.

■ Evolution #5 – The video Internet is activated

It may have been YouTube that activated the video revolution around 2006, but there was an entire underlying Video Internet Ecosystem that conspired to enable it starting back as far back as 2002.

Consider one slice of Internet Video category is User-Generated Content. To enable content creation side, small easy-to-use video cameras came onto the market. Home video editing software (like iMovie) was inexpensive or bundled with the sale of new computers. Next in the supply chain, video distribution became free and easy thanks to YouTube, a service that leveraged the inexpensive transit and CDN services. These services leveraged volume pricing with ISPs that interconnected with last mile providers that upgraded the last mile infrastructure (to DOCSIS-3 for example). All of this would not have mattered if it wasn't for the high-speed wireless plug-and-play networks deployed in every home today. Innovations along each link of the supply chain were required for end-to-end video distribution to work well. Once these services matured, Internet backbones quickly became dominated by video.

Cisco estimates that by 2013, about 80% of all Internet traffic will be video, leading me to coin the phrase, the "Video Internet." Friends in Japan tell me the Internet in Japan is already 80% video, while others in the U.S. say conservatively 40%-50% of all U.S. traffic is video in 2011. While this "Video Internet" term is still gaining acceptance, I believe it more accurately reflects the dominant traffic type across the Internet today.

It was the innovations across the entire supply chain that activated the Video Internet, a system that is now positioned to service the video distribution needs of the planet.

■ Evolution #6 – Access power peering

The Internet Peering Ecosystem in the U.S. appears to be morphing again, this time positioning the access networks into a much stronger power position. [2]

Video dominates the Internet

In 2010, at least 40-50% of all Internet traffic today is video, according to conversations with ISPs. Separately, the movie industry people emphasized that video is unlike other applications. They said that disruptions (pixilation, freeze frames, audio garbling, etc. called "artifacts" in industry jargon) in a movie video stream cause a break in the "suspension of disbelief." This effectively destroys a video watching experience for the end user. Video traffic dominating the Internet and the requirement for flawless video, taken together, highlight the importance of an optimized Internet Peering Ecosystem. Content distributers need to be able to deliver increasing volumes of video traffic with very high quality.

At the same time, significant change occurred in the U.S. Internet Peering Ecosystem.

Comcast Peering Policy

Comcast put in place a Peering Policy stating that they require (among other things) that traffic volumes exchanged be roughly balanced. Traffic in the inbound direction (to Comcast customers) had to be (roughly) balanced with the outbound direction (from Comcast customers). Some in the industry have said that the specific not-to-exceed-ratio is around 2:1. This peering ratio prerequisite and the ratio value is somewhat common in the industry.

However, consider that:

- Internet video is, or soon will be, the dominant Internet application, and
- Internet video tends to be massively asymmetric (as high as 30:1), and

[2] We are naming Comcast explicitly when illustrating this evolution. There are other examples of this maneuver, but there is far more data available about the Comcast-Level 3 dispute. By walking through this story we can more succinctly and concretely demonstrate Access Power Peering.

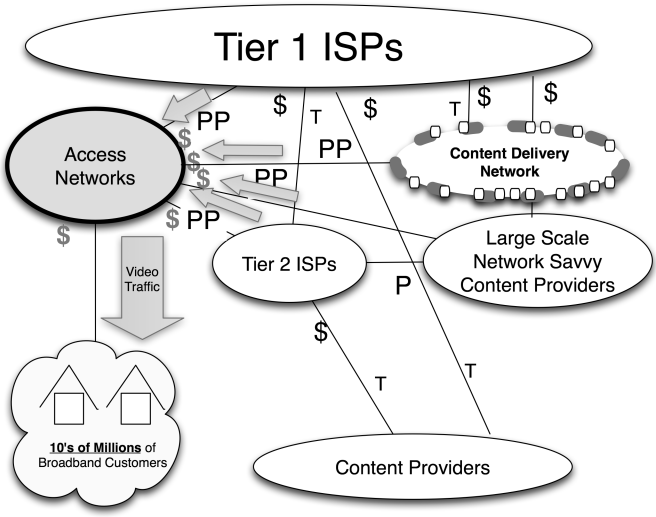
- Comcast customers consist of tens of millions of eyeballs primarily pulling down content from the Internet.

Very few peering candidates have or will ever have a balanced ratio to offer to access network. Video content delivery companies such as Content Delivery Networks (CDNs) and content-heavy ISPs certainly won't have balanced peering ratios with access networks. These companies are in the business of getting video objects to the eyeballs and have very little traffic to pull from Comcast. Since a large portion of Internet traffic is destined to be video traffic asymmetrically delivered to the access networks, this Peering Policy effectively ensures that this traffic cannot be freely peered.

Comcast Paid Peering

Comcast started offering a Paid Peering service for those that did not meet their peering prerequisites. They priced the service at about the market price for Internet Transit. Companies with content to send to the tens of millions of Comcast customers could send their traffic through their upstream ISP, or they could send it directly to Comcast for about the same price. At this price point, it is a good value proposition and several CDNs have gone down this path and purchased Paid Peering from Comcast. Let's look at the affect on the dynamics in the ecosystem.

Figure 7 - The Access Power Peering paradigm



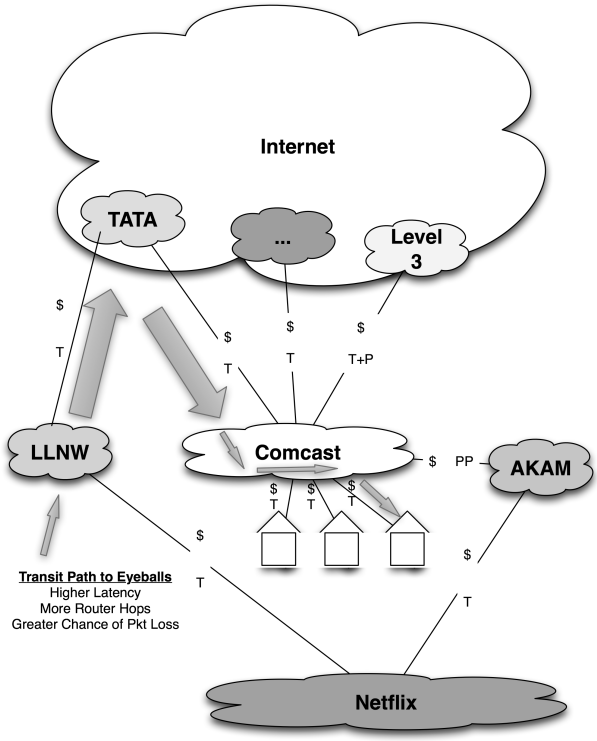
There is only one way to get to the Comcast customers – all traffic must directly or indirectly make its way through the Comcast network to reach the Comcast customers. Some in the industry call these customers "captive" customers since there is no alternative path to reach them. This captive customer base is the source of potentially great positional power in the Internet Peering Ecosystem as shown in Figure 7. With this Access Power Peering, all traffic destined for access network customers (and all corresponding Paid Peering revenue) flows directly to the access networks.

We will see some more Access Power Peering dynamics with the Comcast-Level 3-Netflix dispute discussed next.

Case study: Comcast-Akamai-Limelight and Paid Peering

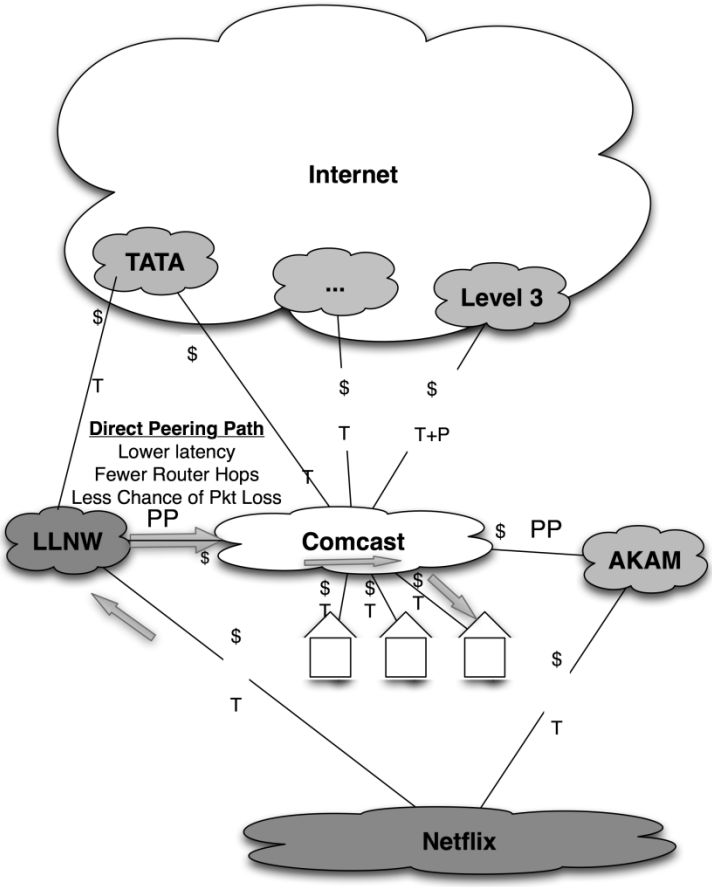
In late 2010, Comcast was purchasing Internet Transit from several ISPs as shown in Figure 8.

Figure 8 - Alternative to peering is a more circuitous path



Akamai was purchasing Paid Peering from Comcast and enjoying low-latency high-capacity access to Comcast customers. Limelight Networks, a competitor to Akamai had a choice to make. Should it continue to send its traffic through its upstream ISP to reach Comcast customers? By doing so, Limelight traffic will suffer higher latency and potentially greater packet loss than its competitor. Philosophically, Limelight feels that it shouldn't have to pay Comcast to deliver the content that Comcast customers requested!

Figure 9 - The more direct Paid Peering path to the eyeballs



Limelight's hand was forced however when one of Comcast's upstream networks experienced chronic congestion. When this occurred, Limelight content traffic destined to Comcast customers experienced performance problems (packet loss). Since Limelight is being paid by the content

providers to distribute the content to the edge for a better quality end-user experience, its customers began to complain. The cause of the problem seemed to be the links between Comcast and Comcast's upstream transit provider. Limelight's upstream transit provider is powerless to fix this problem. As a result of this context, Limelight has to purchase Paid Peering from Comcast (Figure 9).

From a practical perspective, if you are paid to deliver video to Comcast customers, there is no choice but to purchase Paid Peering from Comcast. This is a potentially huge shift in power in the ecosystem. This power is demonstrated in the Netflix, Comcast and Level 3 story next.

The Netflix, Comcast and Level 3 story

Setting the stage. Continuing this example, the relationship between Level 3 and Comcast is a bit more complex than simple transit. According to the ISPs familiar with the situation, Comcast entered into a broad business relationship that included as a condition of the agreement "free on-net" access. This is a well-known peering tactic. With this "free on-net" or peering relationship, Comcast got free access to Level 3 customers (which happened to include most of the other cable companies) and Level 3 in return got free access to Comcast customers. This was shown in previous Figures 8 and 9 as "T+P." The point is, this broader business relationship enabled Comcast to have settlement-free peering with Level 3, a Tier 1 ISP in the U.S. region.

Act I. Netflix, a large scale video distribution company had gained considerable traction with its video delivery over the Internet and used CDN services from both Akamai and Limelight. Netflix was experiencing a near exponential growth in traffic. As shown in Figure 9, most of the '$' symbols are on Comcast's side, so as Netflix traffic grew, so did the Paid Peering fees paid to Comcast.

Act II. Also in late 2010, Level 3 bid for and won the Netflix video delivery business, undercutting Akamai. As a result, Netflix traffic moves from Akamai to the lower-priced CDN that Level 3 offers (Figure 10).

Act III. Level 3, since they have a "peering" relationship with Comcast, informs Comcast that there will need to be some additional interconnect capacity. This is a common thing that peers do (Figure 11).

Figure 10 - The shift of video traffic from a paid peer to a settlement-free peer

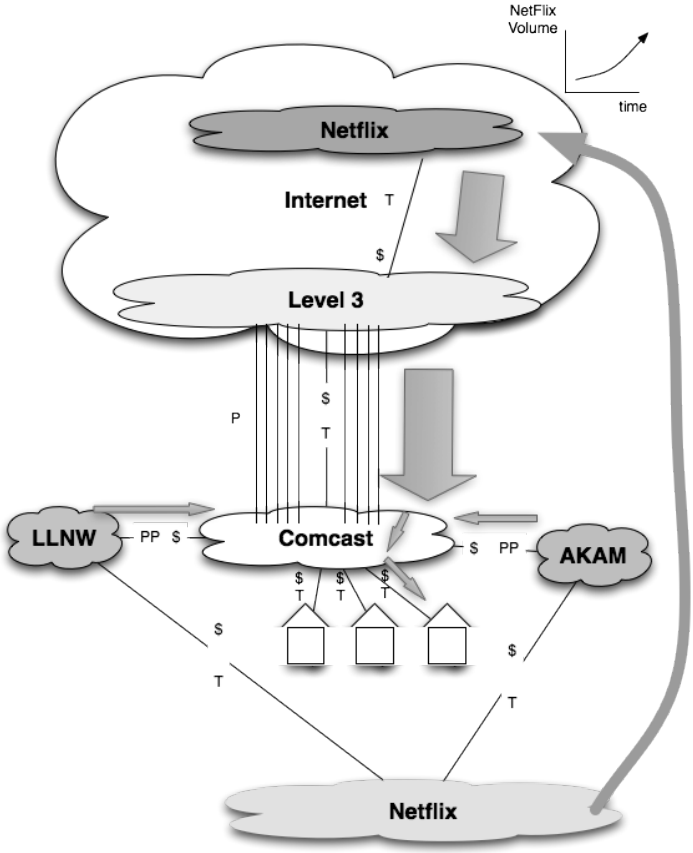
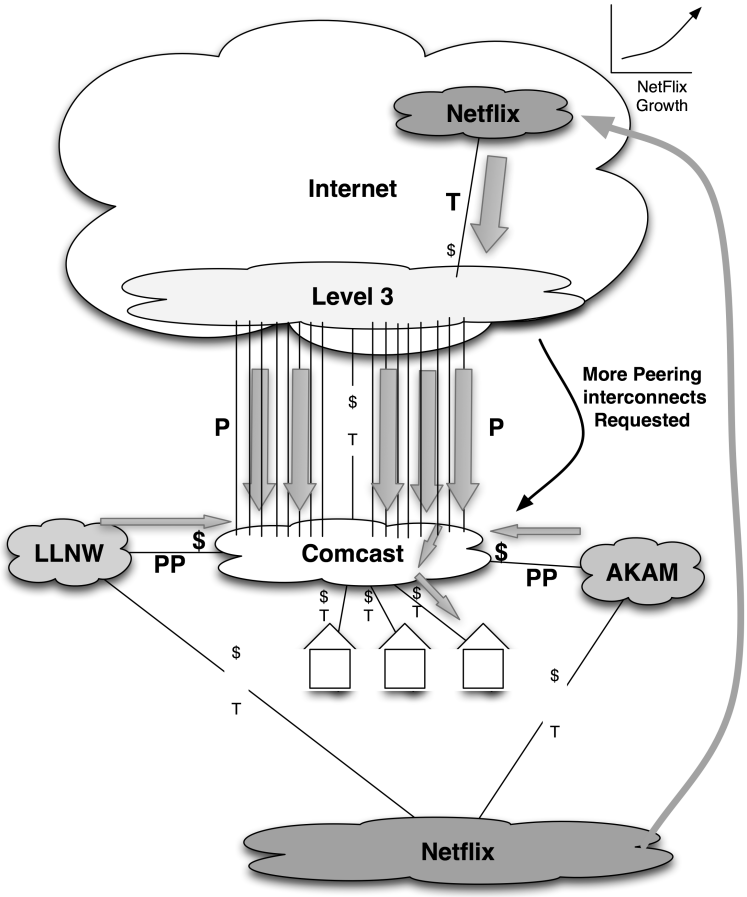
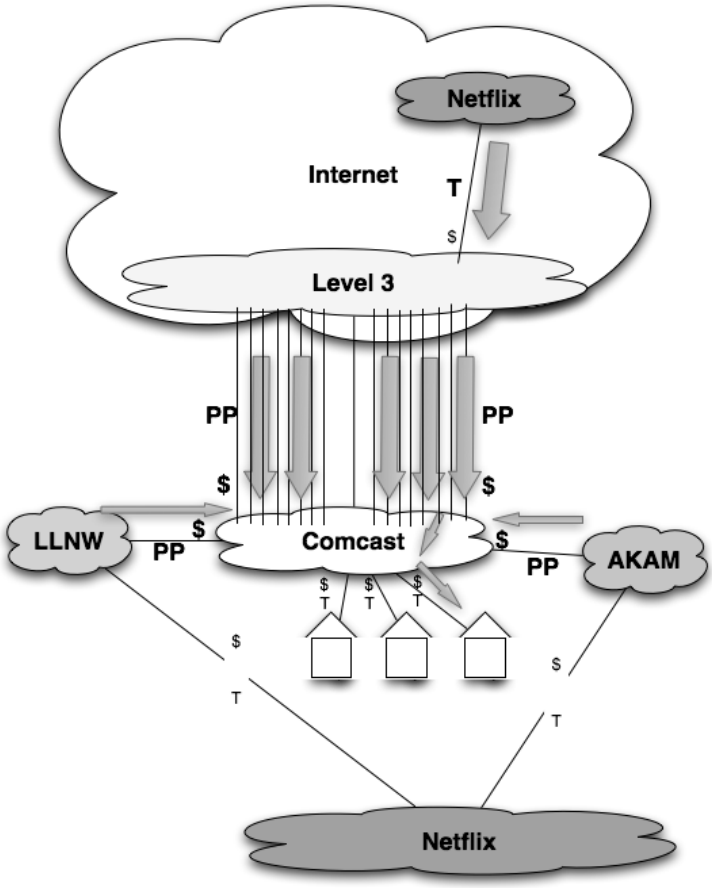


Figure 11 - Additional ports requested from Access Network



At this point, who wins and who loses? Netflix wins a lower cost for video distribution. Akamai obviously loses the Netflix business, so the revenue from Netflix to Akamai decreases. Comcast also loses a corresponding amount of Paid Peering traffic and revenue. Level 3 wins the business and the additional revenue from Netflix. But Comcast loses again, because not only is it is giving up the Paid Peering revenue from Akamai, it is also being asked to spend money on additional peering ports to handle that same Netflix traffic over their free peering relationship with Level 3.

Figure 12 - Level 3 acquiesces and becomes a Paid Peering customer



Act IV. In response to Level 3's request, Comcast refuses to add interconnect capacity and points out that Level 3 is "out of ratio" and needs to pay Comcast for Paid Peering. They argue that it wouldn't be fair not to charge them since they charge the other CDN partners for Paid Peering. It would be an unfair competitive advantage if Level 3 (which offers a competing CDN service) didn't pay as well.

This dispute was very public and much like my airplane story in the beginning of the book, (not in this text) there are opinions across the spectrum as to who is good and who is evil.

To complete the story, Level 3 acquiesces and pays Comcast for Paid Peering as shown in Figure 12.

This result further strengthens Comcast's power peering position, since now even a Tier 1 ISP is paying for Paid Peering with Comcast to access its eyeballs. As stated in the beginning of this section, this Comcast story is merely a good demonstration of Access Power Peering evolution, and by no means the only example.

■ Conclusion

Over the past decade the U.S. Internet Peering Ecosystem has morphed. The players and the relationships, the power positions and behaviors evolved with the context.

First, the Tier 1 ISPs were in charge and received a piece of the traffic that directly (from a customer) or indirectly (from a customer of a downstream customer) traversed the Internet region. In this case, the Tier 2 ISPs could peer their traffic between themselves to bypass their transit provider. The Tier 2 ISP could also select a different upstream ISP if they thought they could get a better price. There were choices, and both peering and buying transit in an open market led to cost and performance efficiencies. The Internet Peering Ecosystem evolved into a more efficient "fat middle" in which a large chunk of ecosystem traffic is peered between willing Tier 2 ISPs, Content Providers, CDNs, etc. and bypassing the Tier 1 ISPs at the top of the hierarchy.

The Access Power Peering scenario however is problematic in that it leverages the lack of alternative paths to the eyeballs.

Since 80% of the Internet traffic is destined to be video, a large and massively asymmetric stream, the peering ratios clauses will prevent settlement-free peering from happening for 80% of the Internet traffic. Anyone with video content to send to the eyeballs will not qualify for free peering.

So you might say that there are alternatives to free peering: Internet Transit and Paid Peering. However, since 80% of the Internet traffic will be video, video delivery companies must get the content close to the eyeballs. The Internet Transit path is inferior and the video delivery competitors all pay for peering to get direct access to the eyeballs. If you are delivering video, from a practical perspective, there is no choice but to buy paid peering from the access network.

So then you might ask "What is the problem? Eyeballs have a choice - if they don't like the performance of cable they can move to DSL and vice versa." Performance would have to be very bad for all access customers to switch. During this time, the content companies will get complaints from the access customers, and the CDNs will hear those complaints as well. It is easier for the few content companies to purchase paid peering or purchase from a CDN that purchases paid peering than for the access customers to all pick up and move to a competitor. The context is such that the video delivery companies will give in first and pay the access networks. The problem is that all traffic and revenue in this model leads to the access networks, solely because they have the power position based on a captive customer base.

And how about Network Neutrality?

In the earlier example, Comcast charged market transit prices for Paid Peering. But what prevents them from charging a higher price? What is the alternative for CDNs whose business is to get the web objects as topologically close to the eyeballs as possible?

Is the next Internet Peering Ecosystem model really that everyone pays the access networks to deliver the 80% video Internet traffic?