A Fragile Internet: Non-Technical Issues Leading to Internet Blackouts
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1 Introduction

The Internet today has become a critical infrastructure as compared to a decade back. It is the backbone technology on which many major services and industries operate. The Internet has been around for more than a decade, yet its resiliency and reliability is questionable. The Internet is fragile and faces breakdowns, blackouts and outages on a regular basis. These outages are rarely global, mostly being confined to local networks and cause partial blackouts. The effects of these outages on businesses can vary according to the severity and length of the blackout. However, this problem has become grave and requires more urgency in dealing with compared to a decade ago. An Internet blackout, ten years ago, would have disrupted services and would have been annoying. However, today the impact of an Internet blackout or brownout can be extremely severe. Banking systems can suffer partial loss of network and that can heavily impact the operations of a bank, or emergency services and 911 calls being routed using VoIP protocols can be disrupted putting lives in danger. The reasons for the Internet’s failure are not always technical in nature. Efforts are being made and techniques worked upon to make the Internet more resilient in nature. However, these mostly focus on the technological solutions that can be provided without considering the non-technical issues that lead to breakdowns. It is hence, the interest of this project to study and analyze the non-technical reasons for Internet outages. For this, we spoke with some peering experts from the industry and studied the major de-peering cases from the past, both domestic (within US) and international. Based on these, this paper attempts to give recommendations to improve the reliability and resiliency of the Internet and reduce the probability of de-peering between ISPs.

To analyze the breakdowns of the Internet, it is first essential to understand how Internet works. Networks interconnect with each other throughout the world creating a huge internetwork called the Internet. These backbone networks belong to Internet Service Providers (ISP) who then sells access to the Internet to end users. These end users can be home computers, companies using this backbone to interconnect their networks spread across the country or companies hosting web content on their servers. Thus, the connections between the backbone networks owned by different ISPs are vital in providing continuous Internet connectivity for the end users.

The connections between the networks of all ISPs are not random and free, but are governed by a set of terms, conditions and price agreed between the ISPs. ISPs are generally grouped according to the size of their network. Thus, the largest ISPs are tier 1 followed by tier 2 and tier 3. The interconnections of the ISP networks are governed by business deals and economic factors. Generally, when two ISPs decide to connect with each other and give access to
each other’s networks without charging the other any money, it is called peering. However, ISPs do not randomly start peering with any and every service provider. Peering generally takes place between similar sized ISPs. The reason for this is that a tier 1 ISP will have lot more connections with other ISPs and hence more exposure to the Internet as compared to a small ISP. It is hence not profitable for the tier 1 ISP to peer with a tier 3 ISP. Thus, generally all tier 1 ISPs peer with each other, tier 2 with each other and tier 3 with each other. Now, the tier 3 ISP still does not have connections with the rest of the Internet and hence it has to buy access to the tier 2 ISPs. Tier 2 ISPs buy access to tier 1 ISPs and hence all the ISPs get connected to each other forming the Internet which is better understood from the graphic below [1].

![Diagram of ISP connections]

The eight regions where these ISPs connect in the US (Default free zones) are NYC area, Washington area, Atlanta, Chicago, Dallas, Seattle, San Jose and Los Angeles. If there are no peers for an ISP then the only way it can route traffic is by buying access through a transit for which it has to pay [1].

Peering is also classified based on what parameters or methods the ISPs use to peer with each other. For ISPs to peer with each other they need to meet some requirements. A few of the important parameters are traffic volume, broader business arrangements and meeting the peering policies. So after the initial negotiations are over, the peer ISPs get into a mutual Non-Disclosure Agreement (NDA) after which they discuss the peering policies and the prerequisites. The most important prerequisite is the volume of traffic (send/receive ratio) agreed to be sent to each other.
2 Research Question

The Internet was modeled to be a free and open system facilitating exchange of ideas, data and knowledge. The peering structure and model was designed by the early pioneers of the Internet to accomplish this task. They designed the peering model so that the underlying technology would never be a hurdle for the smooth working of the Internet. However, in a real world scenario the peering model does not work in the exact theoretical way it was supposed to. Ideally, all tier 1 ISPs become peers providing transit to tier 2 ISPs. All tier 2 ISPs become peers and provide transit to tier 3 ISPs and all tier 3 ISPs in an ideal world would not need to buy transit from more than one tier 2 ISP. This however is not true. There are cases where tier 1 and tier 2 ISPs have become free peers because the tier 2 ISP had critical infrastructure at strategic points like transatlantic undersea fiber. Thus, the ideal rules of the peering playbook do not apply in the truest sense in the real world.

Since, the peering model does not follow the ideal rules in real life; the Internet does not necessarily function smoothly all the time. The economics of peering in today’s world have become so important that it has overshadowed the true purpose of peering, which was to achieve global connectivity. Hence, money now dictates the peering agreements based on ratios of data and bandwidth ISPs agree to share with each other. For some of the ISPs which have a profit driven motive, de-peering has become an option using which it can threaten the smaller providers.

For unequal sized ISPs to peer with each other and share data for free there needs to be a strong profit driven motive. There are many cases in which a tier 2 ISP having a network much smaller than a tier 1 ISP but will peer with each other. However, most of the tier 3 network consists of end users with a personal computer. These end users are called eye -balls, because these are the eyeballs accessing the web content. As a result, a tier 1 ISP hosting a lot of web content realizes it is profitable to get these eyeballs to view its content and in turn generate revenue from the company owning the content. Thus, peering with a much smaller ISP is profitable to it. The smaller ISP in turn gets access to a tier 1 network and profits from it. Thus, it is a mutually beneficial arrangement for both the tier 1 and tier 2 ISPs.

Problems arise when these peering agreements stop being mutually beneficial to each other. In most cases, it is the bigger player which feels that they are no longer gaining much from the deal as compared to the smaller player which is getting free peering with a tier 1 ISP. The bigger ISP then reevaluates the deal and asks the smaller ISP to bring more to the table or loose the status of a free peer and start buying transit. The two ISPs try to negotiate and resolve the dispute. When these negotiations fail, one of the ISPs, mostly the bigger ISP disconnects and de-peers the relationship suddenly. This sudden disconnection affects the end-users to a great extent as they don’t have any idea about what has happened. But the smaller ISP which was disconnected will be sent a notice in most of the cases by the larger ISP. In rare cases, de-peering is done without any prior notice which leads to major financial losses for the smaller providers. The sudden move is meant to catch the other ISP unaware and demonstrate the loss the de-peered ISP could be in if it does not agree to the terms and conditions set by the bigger ISP. This leads to blackouts and partial breakages in the Internet.

There are also cases where smaller ISPs buying transit from bigger ISPs are dominated and subject to pressure tactics by the bigger ISPs to keep their network intact. One of the ways of such pressure tactics is to demand the smaller ISP more money for using the larger ISP’s resources for sending traffic. Smaller ISPs have to abide by the rules set by bigger ISPs in order
to survive in the industry. If not, they will be de-peered leaving the smaller ISP’s customers without any access to the internet.

It was hence, the focus of this study to find out how often do peering disputes go to the extreme possibility of de-peering, blackouts and to understand the pressures that smaller ISPs go through to survive in the Internet industry. It was also the aim of this study to analyze how direct intervention by the FCC (which currently doesn’t participate much in peering agreements) might change things and bring some balance to the practice of peering.

3 Interviews with Industry Experts

We conducted interviews (phone, face-to-face) with some industry peering experts working at well known ISPs and asked them about their peering policies, what factors they consider in a peer to form a peering relation, how often does de-peering take place in the industry. We also discussed the peering disputes that they have witnessed and the intricacies of peering disputes. They requested their names not be disclosed and the views they shared not be published under their company’s name. Hence, we have kept the naming convention of “person 1”, “person 2” and “person 3” in the remainder of the paper.

According to person 1, when we look into the issue of de-peering, there have never been regulations in regards to peering because the big players in the market have tried to maintain peering relationships as a free market till date. ISPs have extensively used deep packet inspection (DPI) for traffic shaping as no ISP wants to carry more traffic through their network than what they hand over to their peer. The peering relationships are evaluated with the help of DPI which does real time evaluation of traffic that is being sent across the demarcation points. Peering is closely related to net neutrality as both involve inspection of packets across the network, but pose different set of risks to the end users. Generally, when two companies decide on their relation they either choose an unpaid settlement free agreement or pay at negotiated commercial rates depending on their policies. Person 1’s company required its interconnection candidate to provide a backbone of 40 Mbps, 10 Points of Presence (POP) in at least three major time zones in the United States, and transit services to at least 500 Autonomous Systems (AS). We verified and validated these peering requirements from the website of person 1 [2].

In many cases, when the interconnection candidate failed to meet the requirements of a peering policy, the bigger players tried to settle the dispute by making them a commercial customer rather than de-peering and disturbing the balance of the relationship. According to person 1, as de-peering is like dropping a nuclear bomb, the network administrators who are in charge of the peering policies should in fact make sure that: they reevaluate their policies and determine potential peering partners; make intelligent transit purchases to maintain the peering relations and also back up the route to the Internet; make sure the network is not de-peered under any circumstances.

In a conversation with person 2, we discussed the operational requirements and impacts of peering policies. Several basic requirements were: maintaining a Network Operation Center (NOC) 24x7x365, 48 hour notice for a schedule maintenance, and proper ticketing system. In his opinion, on-net and off-net rates played a vital role in peering issues. On-net is when traffic originates and terminates in your own network and off-net is when traffic originates in your network and terminates in other service providers’ network. Interconnected candidates have a bi-directional flow of 10 Mbps with the traffic ratio of 1.5:1 and a 95% peak.
In his opinion, as an ISP, when considering peering with any service provider, the important thing to focus on is your back up routes. Suppose, if your peer is not able to carry your traffic you need to have a back-up route to the Internet through some other service provider that does not depend on your peer for its connection to the Internet. According to person 2, de-peering is a more aggressive way to settle disputes between two peering service providers which are generally settled by notices and conversion of a peering relationship into pay per commercial rates. Focusing on de-peering is very essential for the Internet as this is a planned and deliberated action as compared to a technical issue like a bug in the router, which is something which can’t be controlled. De-peering issues are regulated in his company by accurately examining the traffic exchanges on a periodic basis, and by evaluating the alternate to the largest peering partners who will peer with you so your network can reach your customers. Traffic ratios are the main point of contention when we talk about a peering relationship. The de-peering issues should be big enough to alarm the concerned, mandating agencies to look into these issues and regulate the peering relationships until it can be handled in a smoother way by the service providers and maintain the resiliency of the Internet. De-peering generally leads to breaking up of links between the ex-peers which in turn give no Internet routes to the customers who are using that route to reach the Internet. Price and your ability to spend play an important role in peering relationships.

Interview with Person 3 gave us knowledge about the peering policies that his company follows. He explained how his ISP follows these policies and how these policies would be effective in maintaining a good peering relationship. One of the basic policies was that the peer should have a NOC which is operational 24x7. They also have policies different for US based and non-US based companies. According to their policy, the US based companies should build peering sessions in as many locations as possible. Whereas, the non-US based companies should have at least 2 peers in diverse regions and near the coast. He also told that the policies also include the traffic volume that should be available and it varies for public and private peering. The aggregate traffic should be at least 350M for public peering and 500M for private peering. According to the policies of his company, one of the reasons for de-peering to happen is standard responses to technical emergencies and non-emergencies. He mentioned that for a company to be a peer, it should be able to respond immediately to technical emergencies and within 2 business days for non-emergencies. They evaluate the standard of their peer’s response by observing how quickly they are able to respond to an emergency and solve it. He also mentioned that his company doesn’t peer with someone who is already a transit. These were the policies that he had explained to us and at the end of the discussion he explained that even if the peers follow the policies properly, it is always advisable to have backup which is a solution for both technical and non-technical issues of de-peering.

Person 4 spoke to us about his experience of de-peering issues. In one of such instances, they were de-peered without any prior notice. But, they were able to tackle the situation easily as they had more than one route to connect to the larger ISPs. So, their customers were not affected. He also explained about his company’s network infrastructure. Their infrastructure was a very conservative one. They utilize around 60 to 70 percent of their resources during normal circumstances whereas most of the other ISPs utilize around 80 to 90 percent. This was another advantage for them other than the backup routes which helped them survive the de-peering act without prior notice. Due to the lesser utilization of the network, they could easily shift the traffic causing minimum latency to the end users. He suggested that the FCC’s control over these
issues would be good if it had a bureaucratic oversight over things to avoid monopolistic behavior and encourage competition.

4 De-peering Instances (Domestic Cases)

Let us now look at the de-peering cases that have taken place in the United States of America. There have been cases of de-peering seen in the US with Cogent being one of the ISPs involved in most. One of cases was when Level 3 Communications de-peered Cogent in 2005 [3]. This lead to the isolation of millions of IP addresses of the different enterprises. The reason stated by Level 3 was that Cogent was using Level 3’s network more than what they were using of Cogent. Level 3’s representative, Sureel Choksi, executive VP stated that Cogent had been using far more of Level 3’s network for an extended period of time than reverse [3]. He also stated that, they had informed Cogent about this and the impending effects of de-peering but it seems Cogent did not react to it with the required urgency. Finally, Level 3 severed the connection believing that Cogent must have made backup arrangements with some other ISP and asked Cogent to pay more for the connection to be reestablished. Cogent’s CEO Dave Schaeffer had his own views on this matter [4]. He refuted the claims of Level 3 that there was a traffic ratio problem from Cogent’s part but mentioned that Level 3 themselves had requested Cogent to send more traffic Level 3’s network since that would help them financially as they charge per bit. Behind all this political tug of war, the customers of Cogent and Level 3 had to bear the brunt of it. As per Cogent, 5% to 10% of its customers were affected [4]. Level 3 restored the connection after 2 days of blackout and asked Cogent to strike a deal with them or to peer with some other ISP. The time given for Cogent to make a decision was till November 9, 2005 [5].

There was another instance of de-peering which involved Cogent in December, 2002 [6]. Cogent had a “test” peering agreement with AOL in 2002. This meant AOL would agree to make Cogent a peer only if Cogent met the traffic ratio requirements. Cogent did not meet the required requirements and hence AOL decided to de-peer. AOL asked Cogent if they accepted the transit agreement and were ready to pay, but Cogent refused. Due to the de-peering, many educational institutions which were customers of Cogent had to suffer and were denied Internet access. Cogent claims that they met the traffic ratio as per the agreements with AOL, but AOL declined the claims. As per the test peering agreement, the acceptable ratio for traffic was 2:1 and Cogent sent at a rate of 3:1 on numerous instances [6]. Due to this, AOL decided to discontinue the free test peering relation with Cogent and asked Cogent to pay if they were to remain peers [7].

There was another de-peering instance between Level 3 Communications and XO Communications in 2005. XO and Level 3 were in a peering relation for some time. XO sent lesser traffic on Level 3 network than it received back from Level 3. Level 3 wanted XO to pay for the interconnection but XO declined since the traffic ratio was well within the limits legally agreed upon when the two ISPs entered into the peering agreement. This is when Level 3 used aggressive tactics and threatened to de-peer XO in September 2005. This caused problems to XO customers as they couldn’t access the Internet. XO finally had to relent and accept Level 3’s demands of payment so that the end users got connectivity and there was no further damage [8].

Another case of de-peering was a recent case between Cogent and Sprint [9]. On October 30, 2008, Sprint decided to cut the connection with Cogent. This happened because Cogent breached the peering contract and refused to pay for the established connection with Sprint even after repeated reminders from Sprint [10]. To make sure that the customers of both networks are not drastically affected, Sprint decided to reconnect temporarily on November 2, 2008. From
Cogent’s side of things, CEO Dave Schaeffer said that Sprint wanted to change how utilization was measured and this is what Cogent were protesting against and hence unwilling to pay. Due to this de-peering of Sprint, 289 single homed autonomous systems behind Cogent and 214 autonomous systems behind Sprint were unable to connect to each other [11][12].

5 Differences in America and Others

The bigger players in the US have always tried to maintain the resiliency of the Internet by converting the interconnected partners who do not meet the peering agreements as commercial payers who buy transit and avoiding de-peering. There have been de-peering cases outside US seen mostly because of impractical business plans adopted by these service providers. Some of the de-peering examples are Egypt, Cogent-France Telecom, Cogent-China Telecom, AOL-MSN, and Cogent-Telia.

In March 2008, there was de-peering between Cogent USA and Telia in Sweden which led to an outage that lasted from 13th March, 2008 to 28th March, 2008. This de-peering mostly impacted US customers of Cogent and North-Central Europe customers served by Telia. This dispute was mainly due to the asymmetric traffic ratio exchanged between these two ISPs. The asymmetry was in such a way that, Telia had 3000 more prefixes via Cogent and Cogent had 600 fewer prefixes through Telia. As a result of this de-peering 1.6% of the routes in the global routing table were partitioned [13].

Another de-peering case in Egypt was seen for the first time in the history of Internet, the country de-peered themselves and their ASNs from the rest of the Internet in January, 2011. ISPs were asked to stop routing information between international ISPs by the Egyptian government to suppress the spring revolution taking place in the country. This was the main reason for Egypt to de-peer themselves from the rest of the Internet. All Egyptian providers, business, bank, websites, embassy and the government were cut off from the rest of the world. Around 3500 individual BGP routes were withdrawn from the global routing table because of which no country in the world was able to exchange Internet traffic with Egyptian service providers [14].

In April 2005, there was a de-peering dispute between Cogent and France Telecom where France Telecom de-peered Cogent. The problem which led to this de-peering was; France Telecom wanted Cogent to pay to reach its customers in its dominant territory. This is a clear example of a bigger player trying to have control over the smaller player by creating a peering dispute. Cogent and France Telecom have had several disputes till date [15].

Most recently on March 5th, 2012 there was a de-peering issue between Cogent and China Telecom. Prior to this dispute, China Telecom had announced 3000 prefixes to Cogent. After this dispute, peering adjacency no longer exists. China Telecom uses its transit providers namely Sprint and Level 3. This dispute is yet to be critically analyzed by the two ISPs to confirm it as another Cogent de-peering issue or a technical bug. This dispute will lead to increased transit costs for China Telecom and a loss for Cogent. Unlike other de-peering issues, this did not lead to a complete blackout for any of the ISPs customers as China Telecom and Cogent had backup to reach each other’s customers [15].

As peering relationships are regularly evaluated by both service providers, it is important that both the service providers have a symmetric traffic exchange and if not they should pay negotiable commercial rates for the excess traffic. In US, except Cogent all the major service providers have maintained reliable peering relationships, so that this market is open and free. Whereas, in countries such as China and France where the incumbent service providers like
China Telecom and France Telecom have a monopoly market with poor business strategies, no competition, the pricing is higher and several disputes arise leading to de-peering in most cases.

6 Observations and Inferences

We have seen in the last two sections of the paper the different de-peering instances in the world. Based on those cases, we researched what additional factors must be considered before de-peering happens or what the ISPs must also look at before signing the peering agreement. It is clear that when France Telecom de-peered Cogent, they used their monopoly and size. Cogent had aggressive pricing and attracted more customers which threatened France Telecom. This is a classic example of how a monopoly ISP would try to make the other ISPs peer as per their whims and wishes. Cogent was debating that they carry France Telecom’s traffic over its transatlantic link and even if Cogent sends lesser traffic this factor must be considered.

In the de-peering case of Cogent vs. AOL, traffic ratios played a major part[6]. Cogent and AOL were under a test peering agreement and AOL had made it clear to accept peering only if Cogent meet the acceptable traffic ratios. After the trial period, Cogent didn’t meet them and AOL decided to de-peer. Cogent were adamant that they had the proper traffic ratio and injustice was done against them. This is an example where all factors were not taken into account before entering into a peering agreement.

In another case of de-peering between Level 3 and XO in 2005, Level3 de-peered XO on the pretext that XO sent lesser traffic to Level 3 than it received[8]. XO argued that the traffic was well within the peering contract but Level 3 didn’t budge and de-peered XO. This is an example where a larger ISP tries to superimpose its power on a smaller ISP. The smaller ISP has to finally budge as witnessed in this case; XO had to pay up so that their end users would not have had to bear blackouts. It is here, we believe partial intervention of FCC would have helped.

The case of de-peering in Egypt also throws light on important aspects of this topic. In this case there were multiple problems faced by the people and many services came to a standstill because Internet today has become one of the needs to mankind. The Egyptian government took a stand which was too extreme and the country had to pay [14]. This shows that not only do factors such as business and economics but politics also play a major role when it comes to peering. From preceding parts, we saw how de-peering was caused due to the traffic ratio mismatch, monopoly ISP demanding a pay for peering, larger ISP trying to bully a smaller ISP and also the political factors of a country.

7 Recommendations

Based on our research with the de-peering cases and speaking with some industry peering experts we have come up with a list of recommendations which we feel would reduce the occurrence of de-peering in the future giving the ISPs a clearer understanding on the peering agreements.

1) An ISP must try and ensure that they have redundancy and are connected to multiple ISPs if one ISP decides to pull the plug (multi-home). The ISPs must have peering relationships but also have backups in place to buy transit. This would ensure few or no blackouts and the end users are not affected unnecessarily due to a peering dispute between ISPs.
2) Traffic sharing, infrastructure and other critical factors must be taken into consideration before signing a peering agreement. Also, the peering agreement must be a little flexible but not too vague. As we saw in one of the cases, that even though Cogent was sending lesser traffic than agreed as per the peering policies but it did send the traffic passing over multiple continents and hence there were costs added. These all factors must be made clear before the peering contract is signed.

3) ISPs should have stable business plans and be responsible enough not to disturb the traffic balance on the Internet. The tactics of aggressive pricing made by Cogent could be good for the short run but would be harmful in the long run and cause envy in the market where prices are determined by open market structure.

4) We have seen cases where larger ISPs have dominated smaller ISPs and enforced them to pay for the peering relationship even when the traffic ratio was well within limits of the agreement. Peering agreements are normally voluntary and depend on economic benefits and power. This is where; we believe some guidelines must be provided by FCC so that there is no injustice towards the smaller ISPs. We don’t recommend FCC to completely regulate peering but some minimum intervention would be needed from them to provide guidelines.

5) There have been several cases of international de-peering and we recommend that there must be means to resolve these disputes in the international courts when ISPs are dealing with monopolist national providers. If this doesn’t happen, the monopoly provider would always be in a win-win situation and the other providers would have to go by what they say. The international body must be given the power limited to advising and not be a final decision making authority.

6) There is a concept called “Bit-Mile” introduced by Level 3 Communications, which has been in the industry for about 10 years, has not been used much by the ISPs for peering agreements. This takes into account how far the traffic is sent by the ISP with the amount of bits sent. In early days, the request for traffic and the actual traffic were of similar data sizes, whereas today, the traffic to request a service (for example FTP, HTTP) may be very meager compared to the actual data that is to be delivered for the service. In such cases, bit mile is very essential. We propose the use of this concept over the classical “send/receive ratio” which was devised when Internet was first introduced to the world.

8 Conclusion

Our project about the non-technical issues of de-peering was completed using online research, interviews with people from different ISPs and a comparative study about those issues in the US and other countries. From this research we have learned that, in the US even though there are a significant number of disputes between ISPs, they try not to de-peer as much as possible by negotiations and new deals. In comparison in countries like France and China, de-peering cases and issues were different as seen in the paper. The paper also discusses the different non-technical issues that lead to de-peering by mentioning various examples under the international disputes section. This paper cites various incidents proving that Internet can not only be broken by technical issues but also by non-technical issues like politics, finance, and policies. Even though there is a no clear solution to avoid de-peering, the effects of de-peering can be reduced substantially by arrangements like a backup route, limited control of the FCC over the ISPs and standard policies and codes to be followed when peering takes place internationally. We believe, there is a need to adopt Bit-Mile to bring more clarity to the peering contracts.
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