Response to the Consultation Paper on 'Regulatory Framework for Promoting Data Economy Through Establishment of Data Centres, Content Delivery Networks, and Interconnect Exchanges in India'

Please find attached a joint response from Packet Clearing House (Bill Woodcock and Moez Chakchouk) and the Organization for Economic Cooperation and Development (Verena Weber). The authors may be reached at, respectively, woody@pch.net, moez@pch.net, and verena.weber@oecd.org.

For your convenience, we have flagged incorrect statements in red, and issues which require attention in yellow.

Chapter 4. Interconnect exchanges

Section	Page	Comments
4.1. Internet Exchange Points (IXPs) are the physical internet traffic exchange nodes, wherein ISPs and other Autonomous Systems (AS) exchange traffic between themselves. IXPs are regarded as a key component of modern internet infrastructure and contribute to global network resilience and efficiency. By keeping domestic internet traffic local, IXPs help reduce transit costs, reduce latency in the network and provide a better user experience. This is even more relevant when complementary services such as CDNs exist within the country. In the absence of an IXP, the Internet Service Providers (ISPs) should either directly interconnect with each other or exchange their local traffic through an IXP abroad. In addition, in the absence of a national IXP, the ISPs would need to connect with international ISPs for accessing the global Internet cloud.	105	While the section highlights the important role of IXPs for traffic exchange within a country, it does not fully account for the centrality of IXPs in the Internet's economy. This section should highlight the fact that IXPs are **the site of Internet bandwidth production, and the ultimate source of Internet the bandwidth which ISPs sell to customers**. **CDNs are not "complementary to" IXPs**. They, like ISPs, are dependent upon IXPs for the bandwidth they consume. CDNs and ISPs are simply two kinds of network operator, "content" and "eyeball" respectively. Also, the existence of an IXP (whether "national" or smaller in scope) does not alleviate the need to purchase transit to reach distant locations.

4.2. Internet Exchange Points (IXPs) have the physical infrastructure to allow two or more ISPs, CDNs, or Enterprises to transfer data between their respective networks. IXPs facilitate the transmission of data between end-users of two different provision networks. Members connected to IXPs can rent out ports, which are the physical gateways to the exchange of information. Ports may have varying speeds, which influence the rents paid for them. TRAI has previously defined an IXP as : “A network infrastructure operated by a neutral, not-for-profit entity, with the purpose to facilitate the exchange of Internet traffic between Internet Service Providers (ISPs). The number of ISPs connected to an IXP is required to be a minimum of three. There must be a transparent open, and non-discriminatory policy for any ISP to join the IXP.” Figure 4.1 depicts a data transfer through an IXP	105	Your language should not imply that rents are normally paid, as that is not the case, nor that differences in port speed imply differences in rents paid, as that is also often not the case, and should not be the case in a well-managed exchange. Commercial IXPs exist as well, e.g. Equinix and Digital Realty, although they are typically adjunct to commercial datacenter operations. Purely commercial stand-alone IXPs have typically not gotten off the ground, since the market does not recognize the need to pay an external party a profit margin on layer-2 traffic exchange. **A simpler diagram would be more compelling and accurate.** It would show how the customers of two networks, each interconnected via their transit provider networks and the IXP at which those networks peer. Thus: Customer 1 — ISP 1 — IXP — ISP2 — Customer 2. An even simpler diagram would **simply show the two customers and two networks, the peering connection between the two networks, and denote the location of the peering session as being inside an IXP**. The current figure in the document conflates layers 1, 2, 3, and 7, and assumes that traffic always has one endpoint in a CDN, which is often not the case.

4.3. For a developing country like India, which has the second-largest population globally but has low wireline Internet penetration, Internet exchanges are essential. As more and more users demand fast, reliable, and consistent Internet connections at homes for fulfilling their entertainment, work, and educational needs accessed over multiple devices, delivering high-quality connectivity is necessary for which Internet Exchanges are required.	106	Indeed, IXPs are essential to any Internet economy; it's perhaps worth explaining that **the specific issue relative to emerging economies is the export of capital**. If bandwidth is not being produced in domestic exchanges in quantities greater than it is consumed by the domestic population, the shortfall is made up through **importation of bandwidth from IXPs in other countries**, in the form of transit purchased in a foreign currency and thus capital outflow. Conversely, if the produced bandwidth in domestic exchanges exceeds consumption, the freed capital could instead be used for other domestic purposes such as investments in skills and education, the digital transformation of the economy, and the improvement of living conditions, which together promote economic growth and reduce inequalities. A positive example of a country that does this well is the Netherlands. Dutch IXPs are an important net exporter of bandwidth while their population, at the same time, receives more bandwidth for domestic consumption at a low cost.

4.4. IP transit and Peering:

IP transit is when one entity pays another for the right to transit its upstream network. In this arrangement, one entity has a higher status than the other in the hierarchy, so there is no longer a peering relationship from an internet standpoint because both parties do not benefit equally from the exchange.

When enterprises or smaller ISPs connect to a bigger ISP to reach the entire internet, it is known as IP transit. Whereas IP peering is a mutual exchange of data between two ISPs, and the amount of data exchanged is typically close to equal. The respective ISPs do not charge for this arrangement as both parties benefit equally – this type of data exchange is known as settlement-free.

IXPs provide the necessary infrastructure to allow 'peering' between members connected to it. Internet exchange points thus facilitate public peering between multiple stakeholders. Connected via ports, peers are usually ISPs but can also include CDNs and Data Centres among other service providers, who have rented ports on the IXP. The costs associated with operating IXPs are usually shared between the participating infrastructure and network providers.

IXPs facilitate public peering arrangements between multiple stakeholders, permitting exchange of internet traffic for free. Some large networks, with greater market share, may charge smaller networks for peering services.

Public peering via IXPs continues to grow in terms of traffic carried and the number of ports required at IXPs. As the amount of data exchanged between two stakeholders increases, they may think of private peering. These stages have been shown in Figure 4.2.

Figure 4.2: A Peering Life Cycle model

106 **What's important about peering is not *equal* benefit, but instead *mutual* benefit**. In a peering connection, each party gives the other access to, and only to, its customers (its downward "transit cone").

Who is a customer and who is a provider in a transit relationship is not defined by size, but by direction of the flow of payments (from customer to provider) and the counter-flow of services (from provider to customer). This is independent of and unrelated to the respective size of the entities. One party is a customer, and gives the other party money, while the other party is a provider, and gives the customers two related services: the right to deliver packets to any destination on the Internet, and the right to receive packets from any source on the Internet. As in any commercial transaction, the value of the money proffered and the goods exchanged is, on average, equal.

The amount of data flowing in each direction is not typically similar in opposite directions. "Eyeball" networks typically have large net inflows of data, while "content" (CDN) networks typically have almost exclusively outflows of data. **Direction of net flow of volume of data does not correspond with cost or value**.

The value that the two parties to a peering connection receive is not equal nor, even, is it necessarily similar, unless by happenstance. It merely needs to have **positive net value for each**.

The parties connected to an IXP switch do include both network operators (encompassing both ISPs (eyeball) and CDNs (content)) and datacenter operators (who are operating IXP switch fabric extensions in their own facilities), but **only the former group (network operators) are peers**. The datacenter operators are operating at layer 1 and layer 2, but not layer 3, and are therefore not peers

4.6. Growing domestic IP traffic: The role of Internet Exchange became prominent during the pandemic as most of India's workforce and students worked from home and data traffic and use of the internet increased heavily. The domestic IP traffic has surged tremendously; there was a significant increase in traffic in categories like gaming, OTT streaming services, ed-tech, and Cloud services, among others. One of the Internet exchanges in India has mentioned that during the lockdown, OTT traffic surged 198.68 percent, hosting traffic (storage space and access for websites) went up by 62.78 percent, ISP traffic increased by 54.38 percent, among others.	108	Reference is made to “OTT streaming services,” by which one guesses you mean video streaming CDNs which don't happen to be owned by the customers of an ISP. Since this is the normal case, and you're not saying anything which would not also equally apply to any video streaming CDN which did happen to share common ownership with an ISP, it seems unnecessary to distinguish it. We suggest avoiding the term “OTT traffic”. “OTT” is understood to mean “Over The Top,” meaning a higher-layer service delivered over a lower-layer service. Which is what the Internet is. So the term “OTT traffic” is not really a distinction from Internet traffic generally. If what you mean is “video streaming traffic,” this term would be clearer. Likewise, we caution against the use of the term “ISP traffic.” There is no traffic which is not “ISP traffic.”

4.7. Applications requiring reduced latency and enhanced broadband speeds: The demand for video streaming, gaming, virtual reality, etc., warrants high broadband speeds and low latencies. The transmission of data over long distances to foreign IXPs often leads to a significant increase in latency. The data would have to travel upstream to the IXP and then again downstream to the end-user. The long transmission path causing increased latency affects services relying on low latency connections. With the creation of a local IXP, the transmission path reduces and leads to reduced latency. Experiences have shown that for ISPs, local links offer up to 10 times faster transmission speeds, as the data makes fewer hops to reach its destination. The working paper of the United Nations ESCAP (Economic and Social Commission for Asia and Pacific), highlighted a statistically significant and positive relationship between the number of IXPs and fixed-broadband performance parameters like speed and latency. For every 1% increase in the number of IXPs per 10 million inhabitants, the download speed (Kbps) of fixed broadband is expected to increase by about 0.8%. In addition, the preliminary findings emphasized a significant and negative correlation between the number of IXPs and latency that for every 1% increase in the number of IXPs per 10 million inhabitants, the latency (delay in milliseconds) of broadband is expected to decrease by about 0.4%. As the latency decreases it ultimately increases the upload and download speeds.	108	Section 4.7 is particularly good; it conveys useful and correct information concisely and clearly.

4.8. Network benefits: The network operators using IXPs will have more autonomy and control over their own resources, including routing and traffic management because it decreases a network's dependency on third-party networks. IXPs play an important role in providing better networking capabilities and strong network connections. As technology advances the QoS expectations, performance, scalability, control and rising speed of the internet exchanges, the requirement of new IXPs will arise. A secondary effect of IXPs is that they improve competition, which is often a key policy objective of liberalized telecom markets and policymakers.	109	Section 4.8 is likewise very good. However, it might be possible to further improve it by making clear the directionality of the transport of bandwidth from IXPs through ISPs: the two options are that ISPs may procure **a portion** of the bandwidth they sell by connecting directly to an IXP (ISPs in stages 3 or 4 of growth) or they may procure bandwidth **exclusively** by means of purchasing transit from another ISP, in which case they're getting the transit indirectly from the IXPs that their up-stream transit provider connects to.
4.9. Improved resilience: IXP improves the stability and continuity of internet access by redirecting the Internet traffic when there are connectivity issues. In the context of service interruptions, IXP improves a country and region's overall resiliency that can occur outside their area. When an upstream service provider experiences an outage, the stability and continuity of local traffic can be maintained because the IXP can provide additional flexibility in redirecting internet traffic when these connectivity problems occur. Big Enterprises also connect to IXPs because of these direct network advantages. This partnership between enterprises and IXP operators is mutually beneficial and amplifies the need for IXP establishment.	109	Your overall point is correct, and a good one to make. However, **IXPs do not redirect traffic**. They provide sites where traffic can be exchanged. An increased number of IXPs in use increases the density of interconnection, decreases the average distance between points on the topological graph, and increases the number of paths between any two points on the graph, creating **additional resilience**.

4.10. National Security: As the data remains local, interception by foreign agencies over the internet is avoided and hence security is improved. Once IXPs achieve critical mass, they become the centre of a vibrant Internet ecosystem in the country, involving most of the ISPs, content providers, business, academics, and Government users through better, faster accessible services.	110	Likewise, this point is a good one, and well made. However, we would go further, pointing out that an important amount of the surveillance and privacy-violation done on the Internet is **private and commercial** in nature, so the danger to Indian citizens' privacy is not solely due to traffic inspection by agencies of foreign governments, but also and mainly by the thousands of companies which inspect Internet traffic, extract users' data and identities from it, and resell it in a network of data-brokerage. We suggest adding this point to this section.

4.11. Reduced costs and savings of Foreign Exchange: The flow of data to upstream foreign internet service providers requires payment to the IXP located abroad, losing foreign exchange for every transmission that is made, as for both, i.e., sending the ISP as well as receiving the domestic ISP have to pay their upstream foreign service providers. A local IXP can aggregate requirements of Indian ISPs and exchange international traffic at lower negotiated rates saving foreign exchange.	110	This is a critical point, and perhaps deserves to be promoted higher in the document. To clarify, however, the **foreign payments are made to the ISPs which transport the bandwidth** from the overseas IXPs to the domestic customers, **not to the overseas IXPs**. In addition, **IXPs do not negotiate purchase prices** of international transit on behalf of their participants (except perhaps in some unique and problematic occasion). Instead, IXPs entice the participation of international network operators, who are thus able to deliver traffic which they receive at the domestic exchange to international destinations at their own cost, rather than at the cost of the domestic customer. **Understanding this sharing of costs is key to understanding the overall economy of the Internet**, so it deserves a diagram showing the difference between participation of an Indian ISP in an overseas IXP, in which the Indian consumer bears the cost of international transport in both directions, versus participation of an international ISP in a domestic Indian IXP, in which the Indian consumer bears the cost of the inbound international transport, while their overseas counterpart bears the cost of the outbound international transport, “fairly” sharing the cost, symmetrically. This is how equity in division of costs works, and **the key to it all is having attractive domestic IXPs**. If you do not have attractive domestic IXPs (as India has only very recently begun to), overseas networks are not lured into participation, and thus do not undertake to cover the cost of transport of traffic out of India. Understanding this requires delving one level further: bandwidth consists of queries and responses, which flow in opposite directions across different paths, and the cost of carriage on those paths may be divided symmetrically or the cost of both directions may be met by one of the two parties to the exchange. The trick, as a nation and a government and a telecommunications regulator, is to make sure that the ISPs in your country don't choose to pay both directions, rather than building IXPs which will attract foreign participation. **We highly suggest moving this section up to reflect its importance** as well as the crucial role of your work as the Indian regulator. A diagram illustrating this would furthermore be a powerful tool in conveying these concepts clearly.

4.12. Promotes local economy: IXPs build up confidence in providers by attracting key internet infrastructure providers for hosting the content locally. Local IXPs improve the existing digital infrastructure connectivity and have the potential to become a hub for local and international operators. As more people come online, the demand for hosting internet services locally rises, which necessitates the presence of local IXPs.	110	This is a matter of **consecutive building blocks in the foundation of the Internet economy**. Until the location of an IXP has been decided, nobody knows what the anchoring endpoint of any fiber run should be, and nobody knows where to build datacenters. Until the fiber is run to the customers and the datacenters have been built, there's nowhere to put the CDNs. Until local instances of the CDNs are functioning, there's nowhere to put the data locally. **All of these things need to happen before data can be hosted locally at a scale sufficient to benefit the economy**.
4.13. Lower bandwidth utilization costs: Networks that need to lease connections from licensed TSP to reach an IXP faces a local bandwidth cost, especially in a developing country73. Creating local IXPs enables efficient bandwidth utilization for routing of the domestic traffic. More choices become available to ISPs for sending upstream traffic to the rest of the internet contributing to a more competitive wholesale transit market. Further, the IXPs have the potential of lowering the operating costs for local ISPs, while increasing the traffic, which leads to optimization of revenues of ISPs.	110	This section is hampered by unclear terminology: “local bandwidth” and “bandwidth utilization.” These phrases could be understood by one versed in the art, but would probably **not be understood in the sense that we believe you're intending**. Simpler language, relying on clearly-defined terms, would get your meaning across less ambiguously. Our understanding of “local bandwidth cost” is the cost of the telecom infrastructure leased from the telecom operator to ensure the connectivity of a network to an IXP.

4.15. Content peering: The majority of the content consumed by end-users is available presently by peering with the big content providers (like Google, Facebook, etc.). At an IXP, CDNs connect with each other where local internet traffic is exchanged and routed locally. Content providers and CDN operators globally are pushing service providers to connect to IXPs for faster content movement. With huge content consumption and evolving markets, more CDN providers would connect to IXPs and this, in turn, will increase demand for a greater number of private IXPs in near future. There is a need for Data Centres, ISPs, CDN operators, content creators, and even consumers to come together to overcome challenges like connectivity, resiliency, and security, adopt new IX models and enforce new IXPs to improve the landscape of internet peering and interconnect.	110	At an IXP, CDNs connect with ISPs. CDNs do not connect (except incidentally, and this has no economic effect) with each other. The rest of the paragraph accurately characterizes the situation.
4.17. Globally, a number of approaches and implementation methods are being realized to boost the IXP establishment and traffic exchange operations. Many independent IXPs have been set up for ISP peering, for the purpose of routing the local IP traffic within the country. The international best practices of a few successful case studies have been discussed in this section based on the information from the IXP websites, case studies that serve to demonstrate the benefits of expanding the IXPs, and what policy or recommendations the countries have implemented for supporting private IXPs.	112	The purpose of IXPs is to produce bandwidth. ISPs selling locally-produced bandwidth, rather than imported bandwidth, has the beneficial effect of keeping traffic within the country; but that's a consequence, not the goal. The diversity of IXP models (including economic, technical, and governance) has decreased over time. A vast diversity of experiments were performed between 1992 and 2000; since then, convergence has lead to a much narrower range of practices that are viewed favorably by the community of international network operators who have to participate at a wide range of exchanges. So, there are lessons to be learned from every exchange out there, but the range and diversity are slight, now, so the lessons are typically ones of fine distinctions, not gross.

a) Singapore: Singapore Internet Exchange (SGIX), 201074 4.18. To promote Singapore as a major information hub for the region, the Singapore Internet Exchange (SGIX), a not-for-profit exchange, was established in 2010 as a neutral Internet exchange to enhance the environment for local and international network traffic. SGIX (Singapore Internet Exchange) is one of the largest not-for-profit Internet exchanges (IXs) in the region. Launched in 2010 as an initiative under the Singapore government's Intelligent Nation 2015 (iN2015) master plan. Offering an efficient central point of traffic exchange for ISPs, the SGIX has catalyzed the growth of Singapore's information industry by encouraging content hosting and related developments such as the establishment of Data Centres. The new IXP arrangements enabled customers of the ISPs to access local content from other ISPs even during cable outages, which occur on the international network. Using a local exchange like SGIX also helped cut connectivity costs and improved the resiliency of their networks. It also reduced the latency their customers experienced when accessing local content.	112	It seems like a sentence or two about the other (preceding) Singaporean IXPs may have been deleted here. Since there's a bit about participants before, and a bit about SGIX fitting into a competitive marketplace of other IXPs after. SGIX is the third exchange in Singapore. SOX, the Singapore Open Exchange, was first, and Equinix was second.

b. London: UK – London Internet Exchange (LINX), 1994 4.21. London Internet Exchange (LINX) is one of the world's largest and oldest internet exchanges. LINX was founded in 1994 by a group of ISPs and educational networks and is a founder member of Euro-IX, an Europe-wide alliance of Internet Exchanges. It is currently one of the largest neutral IXPs in Europe in terms of average throughput. Initially, LINX membership was restricted to operators of traditional ISPs. In 2000, this restriction was relaxed and today a wide variety of networks peer at LINX exchanges, including Google, Akamai, Yahoo, and the BBC. The LINX network consists of Ethernet switching platforms installed across various United Kingdom locations. As of March 2021, LINX facilities have about 1700 connected member ports with more than 950 member ASNs, interconnecting high traffic volumes. The products and services at LINX are designed to reflect the changing network and interconnectivity requirements, to help members expand and grow their own networks.	113	Current (January 13, 2022) figures for LINX are **901 participants** and **2.7tb average bandwidth production**.
c. Equinix: United States, US-IX, 1996 4.24. A great deal of global traffic traditionally passes through the United States. Traffic from Europe joins traffic from the U.S. on the West Coast, where a series of landing stations feed traffic to Asia. The Atlantic submarine cable systems are home to the most advanced and densely served subsea links on the planet. While Europe has double the number of exchanges than any other region, the United States has more exchanges than any single economy.	114	Equinix is **not referred to as "US-IX"** and has many independent IX switch fabrics throughout the US and the rest of the world. Equinix was established in **1998**, not 1996.

4.25. United States is the home of the earliest Internet exchanges. PAIX, the Palo Alto Internet exchange, was the first commercial, carrier-neutral exchange point in the United States. Launched in 1996, it was owned and operated by Digital Equipment Corporation. Today it is owned and operated by Data Centre operator Equinix. The North American market is dominated by commercial exchanges, but there are community-led open exchanges also in the USA of which the Seattle Internet Exchange (SIX) is the largest with more than 270 peers. The not-for-profit Seattle IX (SIX) handles more traffic than any other public exchange in the U.S., with peak speeds approaching 2 Tbps as of May 2021.	115	**PAIX (1996) was *not* the first commercial carrier-neutral IX**, that would be the MAE (1992), four years earlier. https://en.wikipedia.org/wiki/MAE-East We would say that the *United States* market is dominated by commercial exchanges in terms of volume of traffic handled (though they are far outnumbered by smaller, not-for-profit ones), but we would not generalize to North America, since **Canada and Mexico more closely follow global norms and are almost entirely noncommercial**. As of January 13, 2022, the Seattle IX has peak traffic of **2.16 tbps and 344 members**.
4.26. As Equinix runs a commercial operation, it has certain advantages over associations and other not-for-profit exchanges. Equinix bundles a range of Data Centre and interconnection services. Equinix has quickly become the leader in the Internet exchanges. As a commercial exchange, Equinix doesn't publish traffic statistics. It is not known how much traffic is being exchanged under either its bilateral or multilateral peering services, however, Equinix's global traffic is substantial.	115	We would not say, one-sidedly, that Equinix has advantages conferred upon it by its commercial status. While that may, in some senses, be true, those **advantages are definitely more than counterbalanced by commensurate disadvantages**, and the commercial model that Equinix follows has demonstrably not predominated globally, no matter their individual success as a single company. So we **wouldn't say that its commercial status gives it an advantage**, but rather, that it has exceptionally succeeded despite its departure from the norm.

d. Kenya: KIXP, 2000 4.27. In Kenya, the Kenya Internet Exchange Point79 (KIXP) grew rapidly and now ranks among the world's top 15 IXPs in terms of growth in traffic exchanged. After nearly a year of preparatory work, including the design and implementation of a capable technical operation, funding model, and legal framework, the KIXP was launched in late November 2000 and is located in Nairobi. To leverage the value of KIXP, Google installed a Google Global Cache in Kenya, which can be seen as an instance of a local Data Centre. This had a significant impact on traffic levels in Kenya and a dramatic surge in traffic exchange was seen after the Data Centre was installed. The benefits of the KIXP extend beyond the Kenyan borders, KIXP members are beginning to attract customers from neighbouring countries due to the increased bandwidth and low latencies. In addition, Kenya is starting to attract external ISPs to exchange their own traffic at the KIXP further boosting its revenue.	115	As of January, 2022, KIXP is **10th globally in terms of percentage growth** in bandwidth produced. https://www.pch.net/ixp/summary_growth_by_country#!mt-sort=bandwidth_percent_change%2Cdesc!mt-pivot=bandwidth_percent_change Notably, six of the other top ten are in Africa, at the moment. However, I'd be careful citing this statistic, because **they're number 31 by absolute growth** … Still good, but percentage figures often place small countries high on the list because they're starting from low numbers. You say that "KIXP is starting to attract external ISPs," but in fact, **more than half of the participants were international within less than three years of establishment, twenty years ago**. It is a sign of market maturity that the number of domestic networks has increased as the IXP has grown to 58 networks, yet that 50/50 balance of domestic and international participation has remained basically stable for the past two decades.

e. The Bahamas 4.28. The Bahamas regulator the Utilities Regulation and Competition Authority (URCA) released a consultation on 'Framework for Establishment of IXPs in the Bahamas' in May 2019. At that time, there were no IXPs in The Bahamas. As a result, local ISPs routinely routed locally generated internet traffic destined for local users through intermediary networks and digital infrastructure in another country. URCA initiated the Consultation intending to stimulate the market entry of IXPs in The Bahamas and set out its initial thinking on the regulatory measures for the setting up of IXPs. The creation of a local IXP was cited as one of the critical factors if the Government is to realize the Grand Bahama 'technology hub' ambitions. The consultation aimed to promote public awareness of the contributions that IXPs can make to the development of the internet and digital economy in the Bahamas; to alert potential IXP users of URCA's framework for the entry of IXPs in the market, and to ensure that the regulatory framework is favorable for IXPs to operate successfully. For this URCA proposed strategies regarding IXP location, governance and decision-making, participation, business model, and funding.	116	The highlighted wording is confusing. We believe that what you mean to say is that **local ISPs routinely sourced Internet bandwidth from overseas IXPs to sell to their customers**. As a consequence of that, yes, packets which both originated in, and were destined to, domestic source and sink, would cross the national border and pass through exchanges in other countries. It's reasonable to use the Bahamas as a counter-example to your others, a country where the regulator is more forward-thinking than the network operators. But **it would be good to clarify that their efforts have not yet succeeded**, and that **they did not just begin trying in 2019**. indeed, PCH began working with them sporadically in 2003, and actively since 2014. https://thenassauguardian.com/urca-not-surprised-by-reluctance-to-establish-local-ixp/ https://thenassauguardian.com/telecoms-firm-explains-why-internet-exchange-points-not-currently-feasible/ http://www.tribune242.com/news/2019/may/06/bahamas-failing-leverage-internet-innovation/ In essentially every country, either the regulator (or communications ministry) is out ahead of the ISPs or, more commonly, the ISPs are out ahead of the regulator, but this is far from a unique situation. Jamaica and Egypt are other countries where the regulator has been notably stymied in their desire for domestic bandwidth production by recalcitrant ISPs.

4.30. Several countries have an independent body like the IXP Association (IXPA) for coordination of all the IXP operators and regional IXPs for easy management, interconnection, cooperation, knowledge sharing, promoting competition, and global development. The IXPAs are established on a regional basis: AFIX for Africa, APIX for Asia and the Pacific, Euro-IX for Europe, and LAC-IX for Latin America and the Caribbean. Along with the internal functioning of the exchange, the external environment to the exchange is equally important. An IXP grows with its large geographical user base, the service providers that address that user base, and the infrastructure and regulatory environment in which it finds itself. A compilation of Global practices in IXP services from other countries is given in Annexe III.	117	Only a very few things that could be described as national IXP associations exist, notably in **Argentina**. In other countries (Brazil, New Zealand) there are **central organizations which administer the majority of the IXPs in the country, but those are not associations or confederations of independent IXPs**, they're operations of a central organization. As you point out, however, regional associations of IXP operators exist in Africa (Af-IX), Asia-Pacific (APIX), Europe (Euro-IX) and Latin America and the Caribbean (LAC-IX). National ISP associations (ISPAs) are common, on the other hand, while regional ISP associations don't really exist (in large part because that role is partially served by both Regional Internet Registries and Network Operators Groups).
4.31. An IXP is an essential part of the internet ecosystem in countries with multiple ISPs and other content service providers. Operation and maintenance of a high-capacity and robust IXP is crucial for providing low-cost internet to end-users. With no IXP, internet traffic will go outside the country to foreign IXPs for peering. As the number of ISPs as well as their traffic is increasing, there is a need to localize the internet traffic and avoid using foreign IXPs to peer domestic ISPs. According to ITU, the Government can further encourage the creation of IXPs by advising ISPs and other service providers on the benefits of connecting to an IXP. This can aid both ISPs and non-ISPs to rent ports to connect to IXPs.	117	This section heads in the right direction, and comes to the right conclusion, but does not support the conclusion clearly. Internet traffic does not seek out IXPs. Instead, **IXPs produce Internet bandwidth, which ISPs transport to the sites at which customers wish to consume it**. If insufficient supply is being produced in IXPs near the customers, ISPs are forced to seek further afield, hauling bandwidth in from distant IXPs at higher cost (and consequently lower performance).

4.32. Most of the developed countries already have IXPs operating in their network. The developing countries are in the process of deploying self-sufficient IXPs and saving the foreign exchange. Figure 4.3 represents the number of IXPs by countries per 10 million habitants wherein India is having less than 1 IXP per 10 million habitants. Having more than 800 million internet users at present and expected to reach 975 million by 2025, the existing number of IXPs in India may not be sufficient to meet the internet traffic demands. Establishing more IXPs not only helps in managing traffic but encourages more local content development, creates incentives for local hosting of Internet services due to the larger pool of local users, who will be able to access online content faster and cheaper. Need for setting up more IXPs in the country arises, so that the ISPs peer together to route the domestic IP traffic within the country.	117	It's good to see a quantitative analytical approach being used here. But rather than number of IXPs per population, we would go one step further and look at amount of bandwidth being produced per population. Using the data here: https://www.pch.net/ixp/summary_growth_by_country We can correlate with national population and GDP. The developed countries which do not have IXPs (e.g. Monaco, Oman, Uruguay) are principally small ones which are adjacent to countries which have plentiful bandwidth at low cost, available across uncontested borders. https://www.pch.net/ixp/summary

4.34. IXPs help in improving network design and infrastructure for service providers. However, the IXPs in India are situated in Tier-1 cities only, resulting in a scalability issue of individual interconnections and confining the peering and internet landscape to limited areas. As traffic exchange is required closer and closer to the edge, more exchanges might be needed in smaller cities and locations. Alternatively, an ISP can connect directly to content providers, resulting in lower costs and helping smaller ISPs compete with larger players. As the data traffic is increasing in the country, more IXPs will be required to meet the growing traffic demands.	119	It's definitely true that India should be pursuing many parallel efforts in “tier 2” cities, in order to improve the economic and business-formation conditions in those cities, encourage the development of knowledge-work in those cities, et cetera. But also, **India should not treat the IXPs in major cities as solved problems**. Relative to many places, the **IXPs in India tend to be quite stagnant**, and fail to attract as much international participation as would be healthy. That, in turn, has mostly been a consequence of business friction, which is less of a problem in competing markets. The consequence of that is that India continues to export capital to cover the cost of sending traffic to overseas exchanges. So when someone in the logistics chain makes an unexpected demand for money, this creates friction, backs up the relatively fragile logistics processes that are necessary to provision new bandwidth into an IXP from elsewhere, and the consequence is an economic detriment to the nation that's out of all proportion with the amount of money that the individual hoped to receive. So, along with encouraging the formation of many new small exchanges in smaller cities, our recommendation is that you also create streamlined processes, akin to free trade zones, permitting international network operators to get their routers, switches, and servers into already-existing IXPs in India, so they can grow and

Comments on IXP business models (4.35 — 4.37)

We don't actually know of any for-profit IXPs that aim to be profitable, so we think most of the assertions you make about them are not, in the real world, true.

For-profit IXPs are almost invariably adjunct to datacenters, designed as “loss leaders” to entice tenants into the datacenter, where they may purchase other, more profitable, services, such as racks, electricity, cross-connects, and smart hands. Once you discount the governance and community that for-profit IXPs don't provide, what you're left with is an Ethernet switch. Operating Ethernet switches is a core competency of network operators, the constituents of an IXP, so network operators are loath to pay anyone else a profit to do what they know they can do for themselves at lower cost and without the risk of an externality. Thus there is essentially no excess rent to be had, and no profit margin to be extracted, from the operation of an IXP. So, instead, commercial IXP operators price them below cost, to draw in network operators who know that they're being offered something at a lower cost than they would themselves incur if they tried to operate it on their own behalf.

While, after reading your explanation, we understand the distinctions you're making, you should be aware that the terms “free, subsidized, and independent” are not recognized terms-of-art in the field, and carry a host of value-laden connotations.

Your characterization of “free” exchanges is accurate, and well explains why they're the predominant model globally, and have been the most stable and successful.

Your description of “subsidized” exchanges might benefit by distinguishing them from “free” exchanges by dint of the subsidies being in the form of cash, rather than in-kind goods and services. When a building owner cedes space in a building to a “free” exchange, that could be considered a subsidy; likewise when a network operator donates a new switch, that could be considered a subsidy. The critical difference is that in-kind donations are typically of things which are actually needed, in the quantity actually needed, and they are thus not fungible, cannot easily be turned to other, unintended uses, and thus do not require significant oversight, governance, or trust among the participants. If someone provides the electricity necessary to power the IXP switch, the likelihood of that donation being abused in some way that creates liability or ongoing cost to the other participants is essentially nil. But when cash is donated to (or used to subsidize) an exchange, the expenditure of that cash must be supervised, and that requires governance and accounting methods. It requires a bank account. It requires tax filings, and corporate registration. In all likelihood, the expenses incurred in receiving and managing the cash will exceed the amount of the donation, which means that more cash will be required. This vicious cycle drags many IXPs down. But most importantly, none of it produces any additional bandwidth, which is the sole valuable function of an IXP. Thus, handling money is an unfortunate distraction from the goal, and has been the downfall of many of the IXPs which have stagnated or failed.

Your description of “independent” exchanges doesn't appear to differ too much from your description of “subsidized” exchanges. You describe it as a condition which only emerges in “mature” exchanges. We suggest that what you're describing is merely excess rent, which is only possible in

exchanges which are no longer effectively disciplined by competition. Once an IXP has become sufficiently entrenched, it may begin wasting resources with less fear of consequences. When that happens, its governors may be called on the carpet, as happened with the two votes-of-no-confidence to which the AMS-IX membership subjected the AMS-IX board and executives.

We would suggest that you view IXP business models in light of their impact on APBDC. All else held equal, an IXP that spends any significant amount of money on anything other than forwarding packets (like offices, staff, travel, marketing) is, by definition, less effective than one which does not. The cost of maintaining one press relations staffer, for instance, could build a new IXP every six weeks. Each of those new IXPs will produce additional bandwidth. A press relations staffer will never produce any bandwidth, they'll just consume budget. Your goal should never be for one IXP to succeed or persist at the expense of others, but instead to see as many IXPs succeeding as possible. Along the way, some will fail, but that shouldn't be because they were subjected to anticompetitive forces by larger, older, less efficient exchanges.

You assert that differential pricing “allows for better margins.” If we were talking about something that had a positive price and positive margins, sure, but generally speaking, we're not, so I'm not sure that it makes sense to make this assertion. And it doesn't build toward any conclusion, in any event.

Last, you attribute some “advantages” to “independent” IXPs which we don't believe are warranted. First, you assert that “neutrality is guaranteed.” Quite the opposite. The Miami IX is a perfect example. It took this path, and was bought by Verizon, which made it non-neutral. Participants began to flee, and Verizon sold it to Equinix to stem the exodus. Likewise, the Sao Paulo exchange was operated this way; it was bought by Terremark, and all the participants left and formed a new, free exchange. Second, you cite “sustained revenue to meet operational expenses.” Again, this is excess rent. Since exchanges demonstrably operate at least as well without “sustained revenue,” the operational expenses you cite and the “sustained revenue” required to pay for them are inefficiency, which makes it a detriment, not an advantage. They increase APBDC rather than decreasing it. Third, you say “easy to scale and grow.” We would argue the opposite. When a free exchange needs a new switch, it asks for one, and it arrives. When an exchange which charges needs a new switch, it launches a procurement, receives bids, tenders, waits, and eventually gets a switch. That's not the easy way of doing things, that's the hard way of doing things. Again, it increases APBDC relative to not doing it, therefore it's a bad thing to do.

In section 4.36, we would like to notice that community-led exchanges do not have to treat all members equally. Most exchanges, and indeed many regulators choose to enact rules guaranteeing that all participants be treated equally, because that's been found to work well, in IXPs, in markets, and in society.

Avoiding competing with members, participants, or customers, is just good business, and that's equally true regardless of who you are or whether non-profit or for-profit.

An IXP cannot, typically, “make itself an attractive colocation site.” We point to Bahrain as a location where that was tried. An IXP can make a colocation site much, much more attractive, and that's why colocation facility operators are always desperate to get IXPs in, or to start one if necessary.

While it's true that society and markets view equal treatment of all participants as a virtue, you're also absolutely right that an IXP which does not have that rule, whether for-profit or non-profit, also has a countervailing benefit in being able to adjust prices individually as necessary to entice additional participants. Note, however, that since the default price is zero, a more enticing price is, pretty much by definition, negative. Which means that it costs money to have this policy, and that money has to come from somewhere. If it comes from other participants, it will, first of all, outrage many of them that they have to pay so that someone else can be paid. This is an affront to the sense of fairness upon which markets and societies operate, since it penalizes fair-dealers and rewards sociopaths. So, although this happens often enough, it's almost always done in secret, so as to avoid flaunting the sociopathic behavior and attracting outrage. But beyond that, if the money comes from other participants, it will increase APBDC, which makes the exchange less effective.

If, on the other hand, as you point out in your final sentence, it comes from raising capital or taking debt, it's a subsidy from elsewhere, to one (or more) of the participants, and then it lowers APBDC, which makes the IXP more effective. At someone else's expense, sure, but that doesn't change matters from the point of view of the party who received the subsidy. A lot of Internet infrastructure has been built this way, in fact, someone builds something that's economically unsustainable, and they cannot attract customers, and go bankrupt. A second party buys the distressed assets from the bankruptcy court at ten cents on the dollar, and offers services at a much-reduced price. Now they attract a few customers, but they're still economically unsustainable, and they go bankrupt. A third party buys the distressed assets, and the customer relationships, from the bankruptcy court at ten cents on the dollar (now one cent relative to the initial investment) and is finally able to turn a profit, because they have a $250M datacenter and only $2.5M in debt to service. Along the way, the previous investors and the public take a loss, but the eventual customers of the datacenter win. All of this applies to datacenters and fiber plant, but not to IXPs, though, which don't have infrastructure, they have a very cheap, or free, Ethernet switch, which can be replaced in a matter of minutes.

Comments on policy and regulatory initiatives in India (4.38 — 4.49)

The fundamental problem with the initiative is that it was at the end realized by government. Even in 2002, it was clear that there were no successful government-led exchanges, and we now have an additional twenty years of further confirmation. There are many reasons why this is the case but the lack of multi-stakeholder skin-in-the-game is generally foremost. In India's case, other factors played a larger part. Suffice it to say that, only in the last two or three years, has India begun to benefit from the effects of competition in this space, and additional competition would yield further benefit.

More government intervention as described in sections 4.43 and 4.44, further decreasing the possibility of competition and creating a licensing scheme to prevent competition, will yield setting India further back in comparison to a lot of countries in the region and excludes it being among the leading economies in internet development.

Regarding NIXI, we think that, in nineteen years, they've grown their flagship exchange in Mumbai to 44 participants and 11 gbps of bandwidth. By contrast, Extreme IX's Mumbai location has grown from nothing to 204 participants and 430 gbps in five years. Without government assistance, the Albuquerque IX was established ten months ago, and is already larger than NIXI. Another significant difference between NIXI and most IXPs around

the world is that IXPs in most of the rest of the world don't have a government preventing anyone from providing better services than they do in India.

We also think that “stepping up of investment in NIXI” won’t be the right solution to remedy to all those problems that ISPs are concerned with.

We express also concerns about a governmental scheme for IXPs and we are quite sure that there is no successful implemented example of a governmental licensing scheme for IXPs. We believe that India does not need to emulate again failures instead of emulating all other countries where things work.
As you highlighted the issue of IXPs who are operating under Internet Service Provider licence to provide interconnect exchange facility to other ISPs, it is important to notice that this is a kind of issue which solves itself in a competitive marketplace. In fact, this problem occurs when you artificially restrict choice and new market entry.

Q.38: Do you think that presently there is lack of clear regulatory framework/guidelines for establishing/operating Interconnect Exchanges in India?
It appears to be clear from the outside that there are frameworks, guidelines, and licenses for the establishment and operation of IXPs in India, and that's what's holding India back compared to other countries in the region. If India were to abolish all of these and operate in a market economy, like other countries, India could benefit from the same prevalence of competitive IXPs that many other countries enjoy.
Q.39: What policy measures are required to promote setting up of more Internet Exchange Points (IXPs) in India? What measures are suggested to encourage competition in the IXP market?
Cease governmental “picking winners.” Cease creating licensing schemes. Cease awarding monopoly sinecures. Allow the market to operate. Allow bad things to fail.
Q.40: Whether there is a need for separate light-touch licensing framework for operating IXPs in India? If yes, what should be the terms and conditions of suggested framework? Do justify your answer.
Nope, absolutely not. There is no example of this working anywhere, ever. By contrast, *every* successful market has no such scheme. If you're really desperate to regulate, and you want more IXPs, just use the old tried-and-true “you may not pass traffic which has both domestic source and destination across the [regional or national] border” in an ISP class license.
Q.41: What business models are suitable for IXPs in India? Please elaborate and provide detailed justifications for your answer.
Any and all. Bad ones will fail, if the government allows them to, making the market better and more effective. In a healthy market, people will be trying all kinds of crazy things, and everybody will learn from, and benefit by, that experimentation.

Comments on other challenges for growth of IXPs: Location and resource availability

Section	Pages	Comments
4.51. The internet exchange must be located in a building that is can fulfil its space, power, cooling, and security needs. Before setting up IXP at a location, availability of electric power, backup supply or generator, availability of reliable telecom links to the site, access to fiber facilities or rights-of-way, ability to build antenna towers or dig trenches for fiber, ease of access, etc., need to be ensured among others. Identifying potential site locations and managing them is one of the primary issues faced by an IXP.	128	This section is very well-written and to-the-point. Many excellent exchanges operate in spaces which were previously janitors' mop closets. Most buildings have a janitors' mop closet which can be spared. As you point out, the location of the building, and its accessibility are important, and the policies which govern expansion out of the building in order to prevent monopoly rent extraction by a landlord, those are all important.
4.52. In India, the majority of IXPs are located in coastal states and metropolitan cities where submarine cable infrastructure exists for connecting to foreign exchange. Figure 4.5 and table 4.3 shows that very few IXPs are located in the northern, central, and northeast regions, though there is significant penetration of internet and use of digital services in these areas. The growth of IXP in India has been confined to Tier-1 cities like Mumbai, Chennai, Kolkata, Delhi, etc., only.	128	**IXPs are never connected to other IXPs**, so that's not why IXPs are in those locations. Also, backhauling a single circuit from a landing station to an inland exchange is not expensive. Contrast Nairobi (very successful) with Mombasa (not so successful) to understand this. **What's important is that the IXP be located in the heart of a dense and well-connected population**. The UAE is also instructive in this regard. In many places, the densest populations happen to be coastal cities, and your international fiber landing stations may also come right in to those cities, which makes it appear that there's a correlation. But there's not, as can be seen in places where the population and the landing station are separate. India has far less of a “coastal concentration” problem than the United States does, for instance. We agree that it's good to aspire to even things out, but relative to many countries **we don't think this is a big problem** in India. Certainly not in your top ten.

4.53. India is a vast country with many internet service providers, who serve around 800 million internet users. Such operating scale requires highly distributed IXP locations and sites. However due to lack of connectivity and infrastructure, most states and Tier-2 cities do not have IXP presence, and they miss on the incidental benefits that an IXP presence can give. Companies or small exchange operators need to be encouraged/ incentivized to set up IXPs at locations closer to the Tier-2 cities. This would lead to more efficient and economical interconnection and will serve the customers at the edge itself.	130	Exactly. The incentivization needs to be directed toward the ISPs, who are the ones who normally form IXPs, not at IXPs which, when successful, are just an Ethernet switch sitting in a closet somewhere. So, again, **consider the usual "must not pass traffic across the border" language**. It's technology-neutral, and gives everybody what they need.
4.54. The content distribution and media networks often attempt to reduce their transit traffic by deploying peering relationships as much as they can through implementing an open policy with many IXPs, allowing other providers to peer with them. On the other hand, ISPs require connection to IXPs for the exchange of local IP traffic and resilience purposes. To derive the advantages of IXPs and public peering relationships, their growth, and sustainability, the number of connected members should be a good percentage. The successful vast country with many internet service providers, who serve interconnect exchanges will then progressively expand from their initial Tier-1 site, to create new nodes in second-tier metro areas.	130	This section goes off the rails at "a good percentage" and doesn't recover. It's not clear what it's trying to say, but it seems to be suggesting that IXPs spread out somehow, which is rarely a good idea.

Q.42: Whether TSPs/ISPs should be mandated to interconnect at IXPs that exist in an LSA? Do justify your response.
Absolutely not. You tried that, and it failed. Don't beat a dead horse. Just do what's worked well elsewhere, and prohibit them from passing traffic elsewhere, leaving them to sort it out. Since they can sort it out by creating IXPs, they'll do so.

Q.43: Is there a need for setting up IXP in every state in India? What support Govt. can provide to encourage setting up new IXPs in the states/ Tier-2 locations where no IXPs exist presently?
There is not inherently a need for an IXP in every state in India, because from the point of view of the Internet, the state boundaries are arbitrary and meaningless. But in fact there is certainly a need for at least one IXP in every state in India. In the long run, it would probably make sense to have an IXP in every city of more than 100,000 population, and many smaller ones if they're separate and distinct from any larger metropolitan aggregation. Conversely (as in Toronto and its suburbs) it doesn't make sense to have ten IXPs in ten cities if those cities are all part of the same contiguous metropolitan area. The best support the government can provide is education. Making sure that small ISPs in small towns understand where their bandwidth comes from, and that they needn't import all of it from elsewhere. That building an IXP is easily within their capabilities and that it's the next reasonable step in their growth. But most of all, the government can support them by not picking winners. Doing so discourages everyone else, and disincentivizes the one that was picked. And that's what's been happening in India for most of the past twenty years.

Comments on other challenges for growth of IXPs: Connectivity and Infrastructure limitations

Section	Pages	Comments
4.55. Once an IXP is established, ensuring connectivity with Internet Service Providers is the first important step. IXP operators just provide ports on their switches to the respective ISP to form a connection. ISP should bring their own fiber or buy point-to-point links from some telco and reach the exchange. However, the cost of this connectivity up to IXP is at times prohibitive, and most small ISPs are left with no other option but to transit their traffic through bigger ISPs who may interconnect at a location that suits their own traffic rather than the small ISP's. In the bargain, smaller ISPs lose the advantage of control over their network design and also on reduction in latency. Further, the major internet service providers (ISPs), with selective policy, try to increase the cost of transit traffic of smaller ISPs. For a well-functioning IXP local IP transport capacity must be available for a reasonable price to allow stakeholders to connect to the exchange.	131	This section assumes a placing of the cart before the horse. The locations of most IXPs are selected based on the **preexistence fiber at the location**. They're generally buildings where three or more ISPs already have fiber, and where the building owner agrees to favorable terms. Your points about disadvantage to smaller ISPs aren't wrong, but they're also not a problem in a competitive market, since in a competitive market, there's nothing preventing the smaller ISPs establishing their own smaller exchange at a location that's more convenient for them.

Q.44: Whether leased line costs to connect an existing or new IXP is a barrier for ISPs? If yes, what is the suggested way out? What are other limitations for ISPs to connect to IXPs? What are the suggestions to overcome them?
Yes, if an ISP has to use a leased line to connect to an IXP, it's not worth connecting to that IXP, because the operator of the leased line will now be able to extract excess rent from the ISP, removing any benefit he might have had from the connection. It's only worth connecting to an IXP if you can light your own fiber, IRU, or lambda to that IXP.

Comments on other challenges for growth of IXPs: Autonomous System Numbers (ASN)

Section	Page	Comments
4.56. An autonomous system number is necessary for any interconnection between two peered networks at IXPs. ASNs are important because the ASN uniquely identifies each network on the Internet. A unique ASN is allocated to each ISP for use in Border Gateway Protocol (BGP) routing.	132	Yes, all of that's true, and in most places none of that is a problem. Last we knew, however, it was more difficult in India, because India had a mandatory NIR. You don't mention that in 4.56 - 4.60 though, so perhaps you've fixed that already?
4.60. In its earlier Recommendation on “Improvement in the Effectiveness of NIXI (2007)”, TRAI suggested an option to overcome the AS number allocation problem is by using private AS numbers from the upstream provider. As discussed above, small ISPs usually depend on larger ISPs for their upstream connectivity to International Internet Gateways. Therefore, these ISPs are expected to take unique private AS numbers from their upstream providers. However, the present status of NIXI and the number of ISPs joining over the years (refer to Table 4.2), is not very encouraging.	133	Using private ASNs in the public Internet isn't a good solution to anything. That's a work-around. Instead, address the problem directly.

Q.45: Is the high cost of AS number allocation an impediment for small ISPs to connect to IX? If yes, what is the suggested way out?
It's actually the cost of IP address blocks which is high. APNIC gives members all the ASNs they want at no cost. Membership is free to IP address recipients, or AUD 500 (INR 27,000) per year otherwise. The minimum fee for address space is AUD 1,180/year (INR 63,000) for a /56, which comes with all the free ASNs you need. However, a /56 of address space could potentially be subdivided among quite a few ISPs, reducing that cost. Fundamentally, though, what you need is an APNIC fee schedule which places more burden on large users and less on small users. A large ISP with a /30 of address space, 67 million times larger, pays only AUD 3,370/year, an effective rate twenty million times lower. This creates a vast economic imbalance between large and small ISPs, and is a formidable barrier to entry. This is APNIC policy, so you fix it inside APNIC. Hypothetically, a benevolent NIR could be created to solve this problem for India at the expense of small ISPs in other countries, but that's both an unfair externalization of costs and a big leap since it was already tried once and the “benevolent” part was too much of a stretch. Better to just solve the problem, which can only be done by act of the APNIC board. Apply pressure there.

Comments on other challenges for growth of IXPs: Incentivizing establishment of more IXPs

Section	Page	Comments
4.61.1. **Fiscal incentives:** To attract start-ups into the emerging domain of IXPs, various schemes can be introduced, including but not limited to tax exemptions, investment benefits, and credit facilities. As the IXPs are usually non-profit entities, financial aid can also assist market growth, especially in small cities. Easy accessibility to bank loans may be made possible at cheaper rates, i.e., with lesser interests and collaterals. Promoting local investment opportunities via tax benefits, and reduced duties on the operational equipment needed to build IXPs will encourage the new entrants to get involved in the IXP business.	133	All of the fiscal incentives mentioned presuppose the nascent IXP has already gone down the rabbit-hole of handling money, which pretty much dooms them to failure. An actual fiscal incentive would be to set up an account with APNIC and **get ASNs for all of the participants** that don't yet have them. Or **lay fiber** in the ground between the IXP location and the ISPs, and then hand it over to them to manage and maintain.

4.61.2. **Focus on priority regions:** As seen in Figure 4.5, IXPs are clustered in few Tier-1 cities where undersea cables and infrastructure is adequately available. The upcoming digital explosion and data localization will surely increase the traffic load in the IXs serving these areas, leading to inefficient traffic management. The priority areas need to be proactively identified considering various scalable factors for infrastructure creation and IXP establishment in such areas needs to be incentivized. The private IXPs would in turn necessitate the expansion of new peers such as Data Centres, CDNs, Content Providers in these areas heading to their overall digital ecosystem development. More incentives for such priority areas can be an option.	134	The IXPs aren't in coastal cities because there are landing stations there, they're in coastal cities **because there are Internet users there**. But there are Internet users in inland cities as well, just presumably somewhat fewer in number. But this is India; those are huge numbers also. So IXPs would form if they were free to do so, and ISPs knew what IXPs were and that they were allowed to build them. We think you need to be looking less at how to create incentives, and more at how to **reduce disincentives**. Battling incentives and disincentives just scares sensible people away.
4.61.3. **Peering incentives:** Peering at multiple IXPs can increase reliability, help reduce latency and increase overall QoS. Direct peering can also be encouraged with content providers and hosting Data Centres. By giving incentives in terms of peering costs and port charges for interconnection to more than one IXPs, an ISP will be able to competitively expand its connections beyond a single exchange.	134	First, you mean "**quality**," not "QoS," which is, in many ways, the opposite of quality. And again, you're presupposing that there will be money involved here, which is kind of giving up before you've even started. If you have a free market, IXPs which do not charge fees will predominate by dint of having the most attractive value proposition, and none of this will be a problem. And **datacenters don't peer**, they're buildings, not networks.
4.62. **Data Centre and IXPs coordination:** The synergy between Data Centres and IXPs can promote cost-effective strategies for an IXP establishment. Hosting an IXP in an existing Data Centre facility can substantially reduce the operating expenses associated with leasing space, purchasing power, and hiring staff, etc. Moreover, data hosting Centres already include the facilities that may be considered and used for an IXP establishment.	134	Yep, all of that is true. The problem is that datacenters are, by definition, not where Internet users are, they're near where Internet users are, so while datacenters love to have IXPs in them, **datacenters are not the best locations for IXPs**. The fact that datacenters will pay to have IXPs locate in them is a big clue that they're avoiding a greater cost of backhauling from the actual optimum location of the IXP.

4.63. **The right ecosystem:** An Internet exchange in an emerging competitive telecommunications market requires technical skill, participant trust, community engagement, and operational excellence to succeed. There needs to be a willingness to commit long-term budgeted funding, and plans need to be put in place to make the exchange self-sustaining and preferably self-governing. Finally, the Internet-aware subscriber base will attract local or international content companies. Achieving this relies on the availability of supportive aspects in the ecosystem, access to diverse infrastructure, a competitive service-provider market, and a capable workforce. As the majority of the initial IXP expenditure is on the training of staff to establish and maintain the facility, free, or subsidized skill development programs can help in this direction.	134	This section is particularly excellent!

Q.46: What other policy measures are suggested to encourage investment for establishing more number of IXPs? Any other issue relevant with IXP growth may be mentioned.
It really comes down to educated people being free to act in their own, and their communal, self-interest. So, there are two components to that: first, they have to be free to act. If they perceive that there's a license to get, or someone else has a monopoly or a “friend in government” then they won't act, because they'll be (quite reasonably) afraid that their investment of energy will not have a fair chance of success. Second, they need to know that IXPs exist, their bandwidth-production function, and how the ISP business model works. And that's actually surprisingly rare. Only a small portion of the people involved in operating ISPs have any idea what they're selling, what their input costs are, or how to calculate their profitability or losses. A little education goes a long way.