Benefits of the Internet Association of Australia

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Internet Association of Australia

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INTRODUCTION

Internet Exchange Points (IXPs) are a key part of the Internet ecosystem of any country or region, by lowering the cost and latency of exchanging traffic, including accessing content, and increasing the resilience of the Internet. These benefits increase with the distance of the country to the nearest international Internet hubs, and with the size of the country, and the benefits were magnified with the increased reliance on the Internet during COVID-19 pandemic lockdowns and social distancing. As such, the IXPs of the Internet Association of Australia (IAA), known collectively as IX Australia, and other ancillary services provided by IAA deliver a significant benefit to the Australian Internet ecosystem, including notably ISPs and their users.

BACKGROUND

To create the Internet, which is a 'network of networks', all ISPs must be directly or indirectly connected to one another. As the number of ISPs increased over time, Internet Exchange Points (IXPs) emerged as meeting points where networks exchange Internet traffic with one another efficiently. Historically, they served to lower the cost to exchange Internet traffic within a country and to deliver content to end-users. More recently, as Internet content and services have evolved, an important role is to increase the speed and make the Internet more reliable.

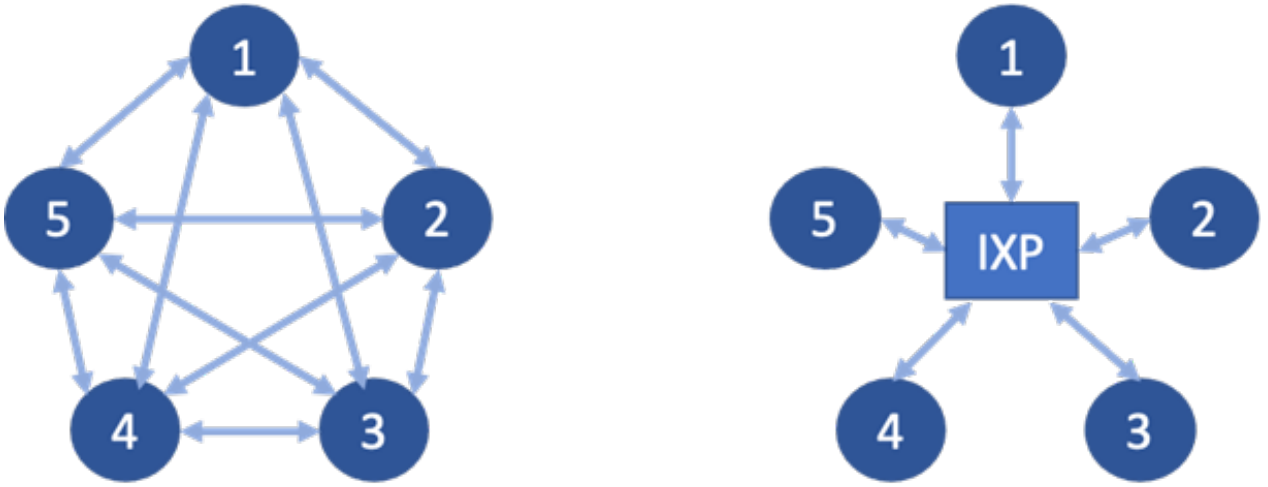
ISPs exchange traffic using peering or transit arrangements. In a peering relationship, each ISP exchanges its own customer traffic with the customer traffic of its peering partner, and typically this is done between ISPs with similar size networks and traffic levels (in other words, peering is between peers) and done without exchanging payments. In the diagram below on the left, ISPs 1 and 2 peer with one another, and ISPs 2 and 3 peer with one another, but ISP 2 would not let traffic between ISPs 1 and 3 transit across its network, because peering is for customer traffic, and not that of other peers. Thus ISPs 1 and 3 would have to establish their own peering relationship.

The other way that ISP 1 could exchange traffic with ISP 3 is through a transit relationship – for instance on the right, if ISP 1 purchases transit from ISP 2, it can have access not just to ISP 2's customers, but also to its peers including ISP 3. Transit is likely if ISP 1 is a small regional ISP and ISP 2 is a national or international one, that is, if they are not peers.

Figure 1: Peering vs. Transit

Peering is a bilateral exchange of traffic between two ISPs, and as the Internet grew, ISPs had to arrange an increasing number of peering relationships to reach all end points.
The cost of the network links to reach each ISP was expensive, particularly in the early days of the Internet when telecommunications was expensive, before competition was introduced. The graph below on the left shows that with 5 ISPs, each must arrange four physical links to connect to the other ISPs, for a total of ten links. An IXP enables each ISP to connect and peer with all the other connected ISPs using one link, as shown on the right. The IXP saves on the cost of links, and the savings grow exponentially with the number of ISPs.

Figure 2: The impact of an IXP

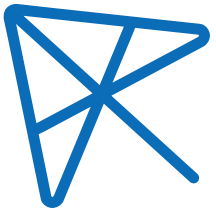


The earliest IXPs were in the US, as the historical hub of the Internet, and while they were created for local ISPs to exchange traffic, they soon began to be used for international traffic. ISPs in other countries all needed to be connected to the US as the main home of users and content, and they soon began to use those connections to exchange traffic with other ISPs from the same country, because it was typically cheaper to send all the traffic through the US rather than set up individual connections to the ISPs at home.

The process of exchanging domestic traffic at a foreign IXP is known as 'tromboning' because the traffic followed the shape of the instrument. While this added significant distance and slowed down the traffic exchange, that had less relevance in the early days. At that time, the usage of the Internet was largely 'asynchronous', in that much of it was used for sending emails, downloading text documents, and viewing relatively simple Web pages, none of which was time sensitive. As a result, tromboning did not make a noticeable difference to perceived performance.

As the amount of tromboning traffic increased, ISPs began to work together to create IXPs in their own countries, to efficiently exchange traffic and lower the cost of international connections. In the 1990s this process began in a few countries in Europe, Asia, and Australia. This accelerated in the 2000s and extended into developing countries around the world, where the process of developing IXPs continues through today.[1]

While the initial benefit of IXPs related to cost savings, soon their impact on performance became at least equally important, as the result of significant changes in the usage of the Internet. Video emerged as a popular service demanding significant amounts of bandwidth; real-time services, including gaming or video calls, were introduced; and cloud computing arose, in which computer resources can be made available to users online, in multiple locations. Companies arose to deliver this content and these services, and became significant users of IXPs to deliver traffic to ISPs and their users.



Video takes a significant amount of bandwidth. If it is delivered over international connections, not only is this expensive, but it can cause congestion, resulting in slow delivery with notable impacts on performance. In order to address these issues, content delivery networks (CDNs) arose to distribute content, including video but also software updates, online newspapers, and other content, to caches, which are servers that store and deliver content to nearby users at lower cost and latency. A number of CDNs including Akamai and Cloudflare distribute content for other providers – in addition, several content providers, including Facebook, Google, and Netflix, have developed their own CDNs. Connecting such a cache to an IXP is very efficient, because the contents of the cache can be shared with all the ISPs connected to the IXP.

Caches are ideal for 'static' content, which is content such as video that is the same for all users. The content can be 'pulled' into the cache by a user, so it is only delivered to the cache once, and then subsequent users can view it from the cache. Or the content can be 'pushed' into the cache by the content provider, so that it is available when the first user seeks to use it. On the other hand, 'dynamic' content, such as social media posts, which vary by user, cannot be stored in a cache since they are personalized. Content providers and CDNs can establish a point of presence (PoP) in a country in order to peer with ISPs to deliver the dynamic content, and to fill nearby caches.

[1]For more details on the growth of IXPs worldwide, see https://www.internetsociety.org/issues/ixps/.

Cloud computing services can also benefit from being made available through an IXP for the same reason as content. In addition, real-time services such as video calls and gaming can take advantage of the IXP to connect local users together and improve the performance of the services. For gaming, for instance, this can make a significant difference in response time and the gaming experience; other real-time services also benefit from not having any stutters if the traffic is delayed by distance or congestion.

"An IXP reduces the hop count by enabling direct connections, it reduces latency."

As a result, IXPs can significantly lower the cost of delivering content and real-time services, while also increasing the performance. A recent study from the Internet Society illustrated the benefits of IXPs on latency, including in Australia.[2] It showed that the average latency for reaching a domain (such as a website) from Australia increases with the number of 'hops' or connections, needed to access the domain. As an IXP reduces the hop count by enabling direct connections, it reduces latency. The study focused on domains with a country code domain name (such as .au for Australia), which typically have content of local interest and should be hosted locally. In one case, the study looked at a local state government website, and showed that it is hosted locally by Amazon, and was accessed through IX Australia with less than 1ms delay, which is excellent.

Finally, an IXP can increase the resilience of the Internet in a number of ways. First, lowering the number of hops not only decreases latency, as noted in the previous paragraph, but it decreases the possibility of congestion or errors resulting in packet loss, which would require retransmission and higher usage. In addition, avoiding international routes results in fewer points of failure, such as from international cable cuts. At the same time, some traffic will always be international, and an IXP can enable providers to easily switch between different international transit providers to route around any international issues.

This result of using a local IXP is important for businesses and other content providers. Studies have shown that users respond positively to lower latency by increasing their usage of improved content and services.[3] Not having to wait for videos to load, or suffering through missed words on a video call, results in more usage, at the benefit of the users and the providers. The IAA has delivered all these benefits to the Internet ecosystem of Australia. In addition, the configuration of IX Australia and additional services provided by IAA have delivered lowered barriers to entry for new players and increased the security of networks in Australia, as discussed below.

[2] "Measuring the Impact of IXPs: Understanding Hostinng Trends in the Asia-Pacific Region from the Regional Domain Perspective: Australia, Bangladesh, Indonesia, India, Japan, Malaysia, Nepal, Phillipines, Singapore, and Thailand," by Terry Sweetser, Internet Society, 2021. https://www.internetsociety.org/resources/doc/2021/measuring-the-impact-of-local-ixps/

[3] See, for instance, https://www.gigaspaces.com/blog/amazon-found-every-100mx-of-latency-cost-them-1-in-sales.

THE INTERNET ASSOCIATION OF AUSTRALIA

The IAA has its roots in Western Australia, when a group of Internet pioneers organized the Western Australian Internet Association (WAIA) in 1995. In 1997 the Association setup the Western Australian Internet Exchange (WA-IX) between several ISPs who had previously been exchanging traffic in the US. The cost of international traffic at that time was about AUSD 1.50 per megabyte (MB), representing a significant amount of ISP revenues. Other IXPs across Australia were opened in the following years, and the WAIA became the IAA in 2016.

Given the geographic size of Australia, the same argument for developing one IXP in a country, to avoid the costs of international tromboning, repeated itself across the regions of Australia, to avoid domestic tromboning. The result is that today IX Australia consists of six IXPs across Australia. Further, given the concentration in the cities, each of the regional IXPs is spread across multiple data centers in the city. This configuration enables each member of the IXP in one data center to seamlessly exchange traffic with members in the other data centers.

The following table provides details for each IXP, including the number of connected data centers, the number of peers connected to the IXP, and the total speed of the connections taken by all the peers.

Table 1: IX Australia Details (Source: PeeringDB, March 2022)

Name	Location	Number of Data Centers	Number of peers	Total Speed
ACT-IX	Australian Capital Territory, Canberra	2	5	60 Gigabits per second (Gbps)
NSW-IX	New South Wales, Sydney	6	220	4.8 Terabits per second (Tbps)
QLD-IX	Queensland, Brisbane	5	77	1.2 Tbps
SA-IX	South Australia, Adelaide	6	43	378 Gbps
VIC-IX	Victoria, Melbourne	6	107	2.0 Tbps
WA-IX	West Australia, Perth	5	88	1.3 Tbps

IAA offers four main services, including peering:

PEERING:
Peering is the traditional service offered at an IXP, allowing networks to exchange their own traffic with the traffic of their peer, typically without any payments. Members can choose the bandwidth of their connection port depending on the amount of traffic that they exchange. At IX Australia the choices are 10Gbps, 40Gbps, or 100Gbps, and the monthly charge depends on the size of the port.

VIRTUAL LEASED LINE (VLL):
With the VLL, peers at one IXP can exchange traffic with a limited number of peers at any of the other five IXPs, or within their own network at another location to develop a network with national coverage.

CLOUD CONNECT:
This service enables members to access large cloud providers – Microsoft, Google, or Amazon Web Services (AWS) - using their existing IXP port. This is an efficient way to access cloud services that are becoming ever more critical to private and enterprise Internet usage.

EXTENDED REACH:
This service enables a peer at one IXP to connect to one of the other IXPs and peer at that location as if they were directly connected to that IXP, effectively providing access to all the peers at another location without having to establish a presence there.

As a not-for-profit entity, IAA can set rates for these services based on costs, rather than to maximize profits. This lowers costs for members, which can be passed on in turn to users.

The IXPs can also facilitate other types of connectivity. They can be used to access international IP transit from carriers such as Hurricane Electric, which is easy to arrange and enables providers to access a significant amount of their domestic and international connectivity through the IXP. In addition, two members of the IXP who are in the same data center can choose to arrange a private network interconnection (PNI) to exchange traffic outside the IXP. This typically happens when the amount of traffic exchanged passes a certain threshold.

While this traffic no longer shows up in the IX Australia accounts, a PNI clearly follows from connections that initiated through the IXP, and both providers will remain on the IXP for other traffic exchange.

In addition, IAA provides other ancillary services at IX Australia locations:

DOMAIN NAME SYSTEM (DNS) LOOKUPS.
While it is easy for us to remember website names such as internet.asn.au, the Internet routes traffic using corresponding IP addresses. The resolution of the names to addresses can add time to looking at a webpage or accessing other resources. IAA has instances, or copies, of the complete root server attached to IX Australia, including an ICANN Managed Root Server (IMRS) in order to improve performance for members.[4]

NETWORK TIME PROTOCOL (NTP).
This is a networking protocol to enable accurate clock synchronization for connected computers. IAA offers access to NTP through IX Australia as a service. It helps all the peers maintain accurate time for their services, and clearly benefits from the low latency of being accessed through the IXP.

CONTENT SERVERS.
IAA hosts an extensive open-source repository, providing access to Linux, Ubuntu and other operating systems and software. This content is available to all users in Australia, not just those attached to the IXPs, and is made available at no charge to non-members through a transit connection paid by IAA as a public service.

IAA also provides other broader services to the Internet ecosystem, with corresponding benefits. IXPs epitomize the ethos of the Internet, with (sometimes competing) networks coming together and cooperating to build the Internet through traffic exchanges, and this ethos extends to developing a general sense of community. IAA helps build the community through events and other networking opportunities, including Unplugged with IAA, which was started to connect industry professionals, and then Life Under Lockdown webinars during the pandemic to maintain contacts.

In addition, IAA has been a host of regional events, including four times the Asia Pacific Regional Internet Conference on Operational Technologies (APRICOT) in 2006, 2020, 2021, and 2022, bringing together multi-stakeholder participants from the technical community, operators, and policymakers, among others. Such events help to build community within Australia and the region to share information and resources to help operate the Internet. Outside Australia, IAA provides administrative, technical, and business support to the New Zealand Internet Exchange (NZIX), which further validates the trust and reliability that IAA has developed and the public service benefits of IAA across the region.[5]

[4]The Internet Corporation for Assigned Names and Numbers (ICANN) is a non-profit responsible the domain name system (DNS) management. See www.icann.org.

[5]See https://internet.asn.au/industry-news/iaa-committed-to-supporting-nzix/

Further, the IAA promotes women in tech. For instance, in April 2022, IAA sponsored the inaugural IAASysters@AusNOG program.[6] IAASysters@AusNOG was a one-day workshop held prior to the AusNOG conference. It is based on the international systers.org and systers@ietf programs. The program is designed to support women in the Internet industry, to help attendees acquire technical and presentation skills and knowledge, and attend a career planning session to help them navigate their future careers. Chosen applicants had their costs covered by the sponsors to facilitate attendance.

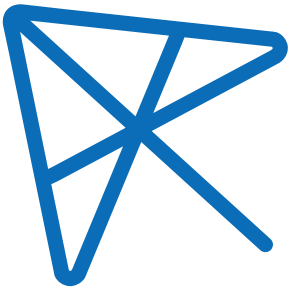
Finally, IAA engages in public policy advocacy, providing expert inputs on a wide variety of topics including wholesale conditions for ISPs, data privacy, cybersecurity, and access issues at the NBN. In order to ensure a wide range of viewpoints, IAA recently formed a Public Policy Advisory Panel consisting of IAA members. IAA also provides capacity building, including supporting women in the tech industry, as noted, and support for learning more about peering.

[6]See https://internet.asn.au/events/iaa-systersausnog-information/.

BENEFITS OF THE IAA

In general, IXPs range in size from three members to hundreds, and from one location to multiple. Each brings measurable benefits to their members, which extends to the customers of those members, as well as to the general Internet. Given the size of IX Australia and its reach, paired with the geographic challenges of Australia and its Internet market structure, the benefits of IAA are significant and extend beyond the members and their users to all the Internet in Australia. These benefits are direct and indirect, economic and non-economic, quantifiable and non-quantifiable.

Significant economic benefits derive directly from the original drive to setup an IXP to avoid the cost of international tromboning of traffic. When the first IXP was setup in Perth in the 1996, the cost of international IP traffic was $1.46 per megabyte (MB) of traffic. In text terms, that is about 500 pages, equivalent to a book, so the cumulative cost for exchanging emails and downloading documents was significant for early ISPs, particularly when all traffic was accessed from abroad. As usage became multimedia, the costs rose significantly– each minute of an MP3 audio file is about 1 MB, which means that one song would have cost around $5 to download, and then video would be yet more costly, depending on the resolution.



The first IXP in Western Australia, and then the others in the other regions, clearly saved a significant amount of money for the ISPs and other networks who connected. While it is true that the cost of IP transit has fallen significantly in the subsequent 25 years, it is still relatively high, while the amount of traffic has exploded in the same time period, based both on more users and increased usage. As a result, the cost savings from the IXP are still significant. According to TeleGeography, the current average cost of IP transit is USD 27,304 per month for 10Gbps.[7] By contrast, a 10Gbps port connection to IX Australia costs USD 256 per month (AUSD 350). The peak amount of traffic exchanged through the IXPs is 827 Gbps, so the yearly savings is roughly AUD 36 million.

Similar savings are available for domestic traffic exchange within Australia. The cost of domestic transit or connectivity is almost as high as international transit costs, for several reasons. First, the size and population density of Australia requires significant expense to deploy connectivity infrastructure between the cities. Second, the largest ISPs in Australia, notably Telstra, TPG, and Optus, do not peer at any of the Australian exchanges, in favor of selling transit to the smaller ISPs and other organizations within Australia. The result is that the distributed nature of IX Australia across Australia, along with its national connectivity services, save the ISPs significant money for domestic traffic, savings they can pass on to their users.

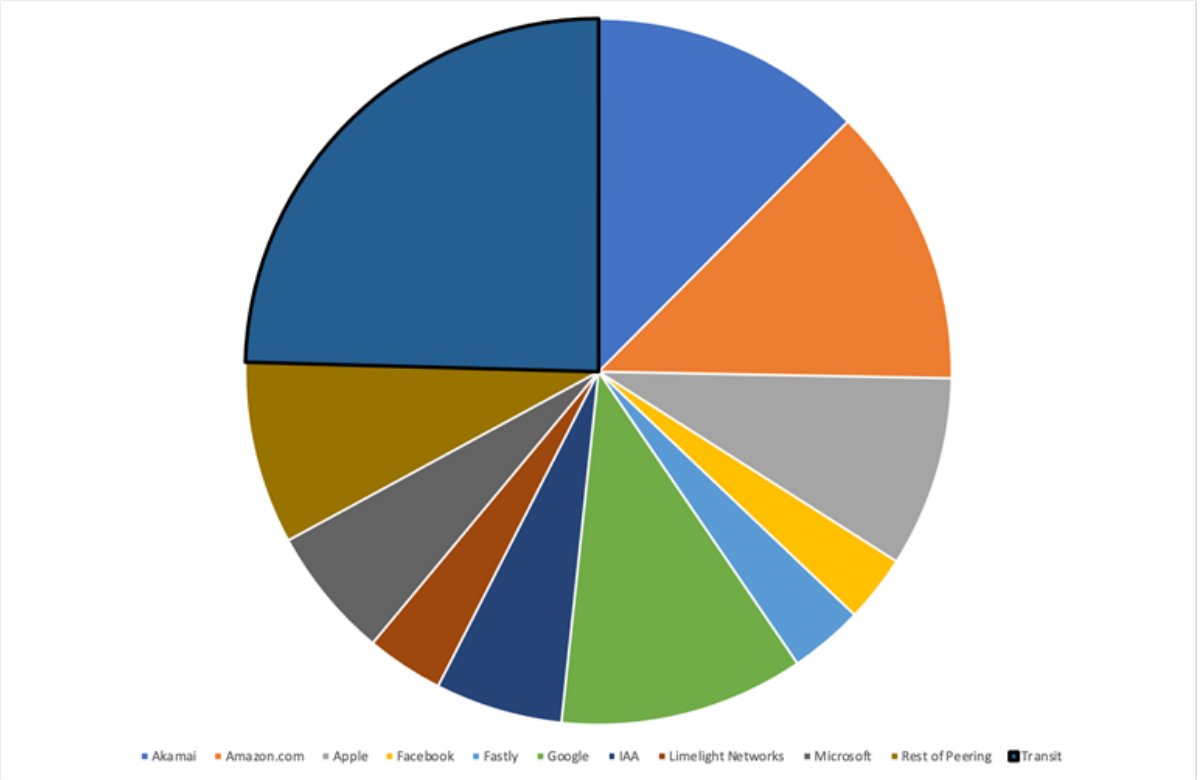
[7] The cost per megabit per second (mbps) for a 10GigE IP Transit connection to Melbourne with a CDR of 5000 is US $2.73, for Q4 2021.

The economic benefits are greater than this, however. As discussed above, as video increased in usage, IXPs were increasingly used to distribute content – this helps to explain the significant amounts of traffic that pass through the IXPs. In particular, every large international content provider (also known as hyperscaler) is connected to IX Australia in at least one location – Amazon, Google, Facebook, and Microsoft, along with other major content providers – including Netflix, Twitter, and Yahoo – and large CDNs – Akamai, Cloudflare, Fastly, and Limelight. All have caches connected to the exchange, and as their traffic grows, several have upgraded their connections to PoPs that can provide a broader range of content than just the static content contained in the caches.

These connections do not just lower the cost of accessing the content by using domestic peering. These connections also lower the latency, by making the content accessible through domestic connections close to the users, rather than through international routes. In addition, the resilience of the Internet is improved, because there are fewer points of failure, and often multiple ways to access the content through the different IXPs across Australia. For instance, Cloudflare is connected to 5 out of the 6 IXPs, providing significant redundancy of connections.

These connections have a significant impact on ISPs for accessing content. For instance, one ISP provided the following chart showing that 75% of their traffic is exchanged with peering, while the remaining 25% is accessed through transit. While the bulk of the peering is with the largest CDN and content providers, the ISP has a total of 230 peers, which can be efficiently arranged through IX Australia. The result is that it only pays transit to reach 25% of the Internet, at a significant cost saving.

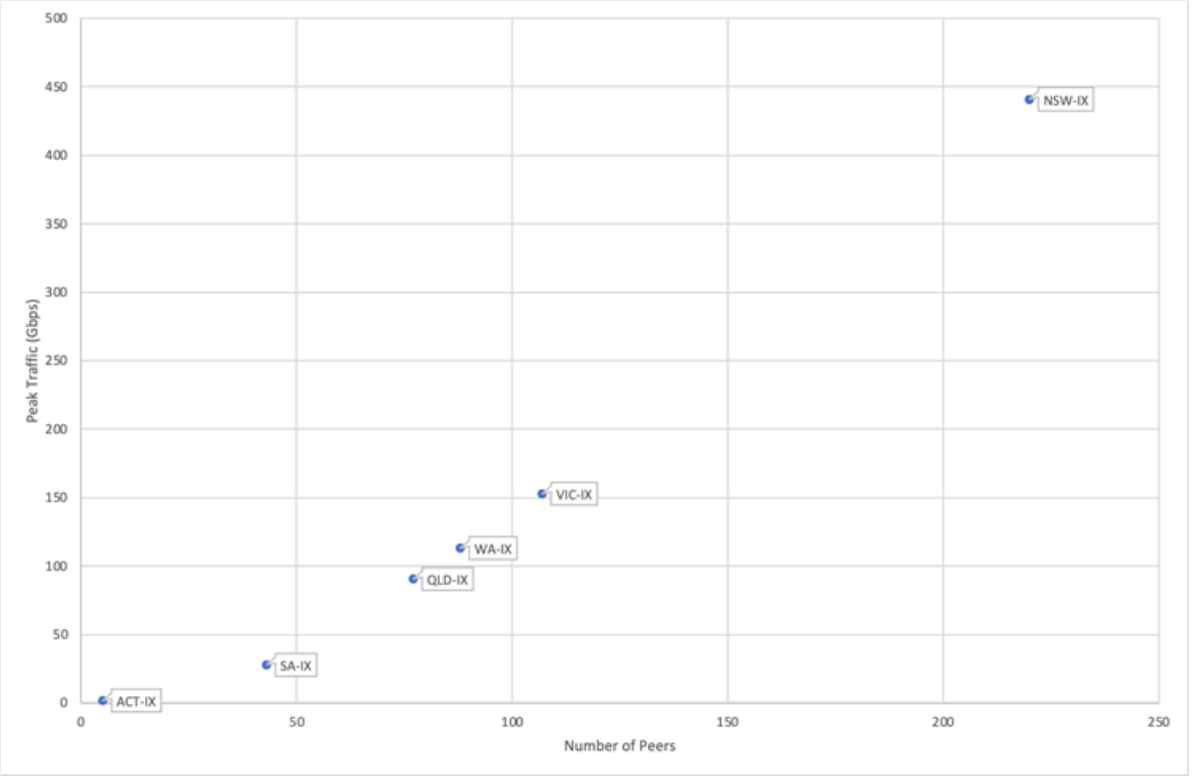
Figure 3: Sample ISP traffic exchange (Source Real World Technology Solutions, April 2022)



Further, by enabling access to transit through the IXP connections, IX Australia can further lower the cost and increase the resilience of the Internet in Australia. First, as it is easy to switch transit providers through a connection to an IXP there will be competition for transit services, resulting in lower prices. Second, and related, if a transit connection goes down, because of a problem with submarine cable or for another reason, it is easy and quick to arrange transit through another route, thereby limiting the impact on users in Australia.

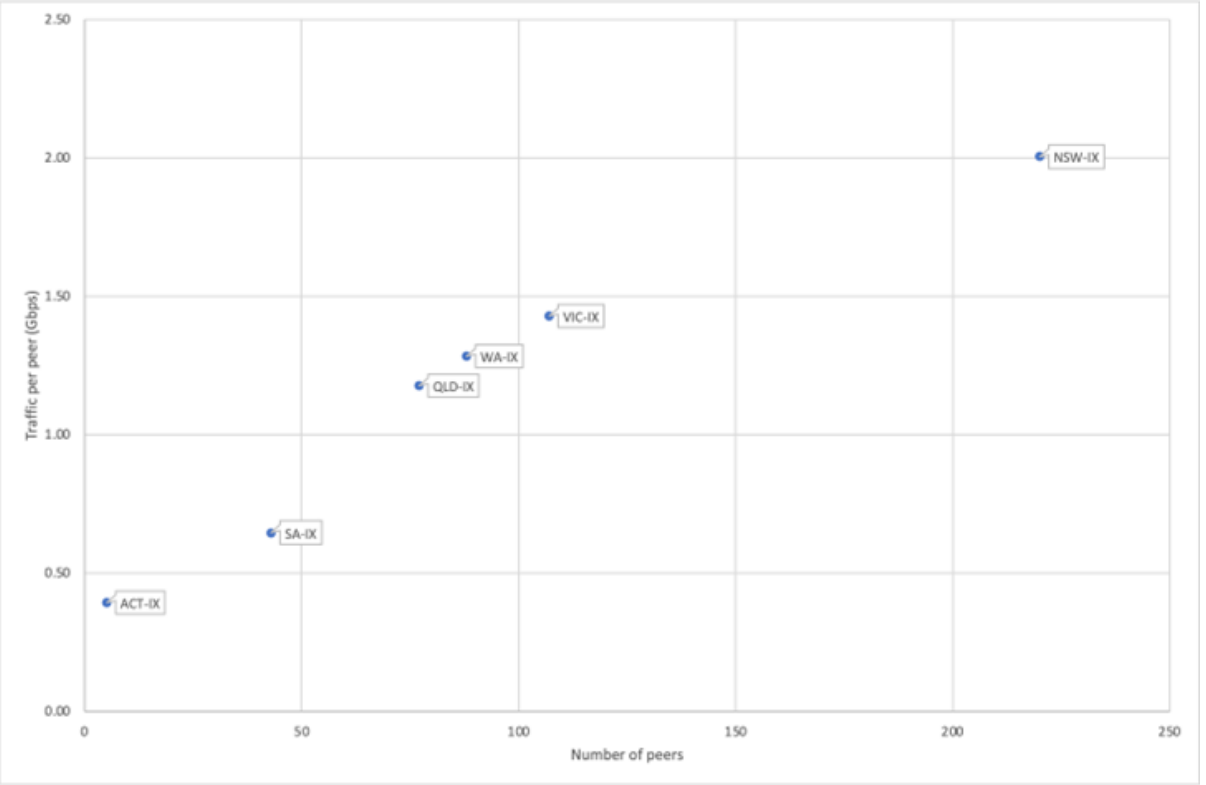
The benefits of the IX Australia IXPs not just large, they are also generative. As one would expect, there is a strong correlation between the number of members at each of the six exchanges and the peak amount of traffic that is exchanged at that exchange, as shown in Figure 4 below.

Figure 4: Relationship between peers and traffic exchange (Source: IAA March 2022)



While one would expect that the amount of traffic exchanged would increase as the number of peers increases, the amount of traffic per peer also increases with the number of peers, as shown in Figure 5. This relationship shows that the benefits of the IX is generative – the more peers, the more content is attracted, and the more traffic is exchanged through peering, to the benefit of all the peers.

Figure 5: Relationship between peers and traffic exchange per peer (Source: IAA March 2022)



By way of example, note that ACT-IX has the fewest number of peers, with just five, and the lowest traffic per peer. One CDN interviewed mentioned that they are considering peering at that IXP. When they do that, it will clearly increase the amount of traffic per peer, as they access that CDN's content locally. Over time, that is likely to make the IXP more attractive to other peers, thereby increasing the number of peers, and making it more attractive for other content providers to peer there, setting off a cycle of growth that can be seen in comparing the different IXPs today (above) and their growth over time (below).

One of the significant advantages of IAA is in terms of aggregating demand from their members, and converting that into tangible benefits that resonate across the ecosystem. These benefits include the following:

PEERING WITH CONTENT PROVIDERS.

The large CDNs and hyperscalers often embed their caches directly with ISPs depending on the amount of traffic exchanged with the ISP. Many of the ISPs at the IX Australia locations are not large enough to warrant their own cache instance, which would normally leave them paying for access to the content through transit with a larger ISP. However, as noted all the large content providers have caches connected to at least one location of IX Australia to provide access to all the ISPs through peering. As an ISP grows it can then qualify for a private network interconnect (PNI) with a cache at one of the data centers.

AFFORDABLE DOMESTIC CONNECTIVITY.

Given the geography and telecom market structure in Australia, the cost of national connectivity would be significant for small providers. Instead, IAA can aggregate demand and purchase connectivity between its IXPs at a lower cost, in order to offer connectivity services such as VLL at more affordable rates, without commercial considerations. In addition, by enabling traffic exchange through peering, IAA acts to put pressure on the domestic transit prices charged by the large Australian ISPs who do not choose to peer. These lower costs are then passed on to users.

EFFECTIVE ADVOCACY.

By representing a large group of members, IAA can provide more effective representation than any individual member might be able to achieve, which interviewees noted was a big change, particularly for the smaller companies. This advocacy includes with the Australian Competition and Consumer Commission (ACCC) and the National Broadband Network (NBN). In addressing issues including data privacy and cybersecurity, the benefits can spillover to all Internet users in Australia, and not just those accessing traffic through the IXP.

CAPACITY BUILDING.

Providing for opportunities to train women in technology increases opportunities and diversity in the industry, which benefits all of the Internet in Australia. IAA is also providing documents to assist small providers in setting up standard contracts and service terms.

Without the benefits of the IX Australia, it would be difficult for smaller ISPs to enter the market and grow, because much of the traffic volume can be reached by peering with the large content providers at the IXP. This also reduces the collective market power of the large ISPs who sell transit in the market, because their transit is only used to get to their customers, not to access video and other high bandwidth content. The result is more competition among ISPs, resulting in lower costs, more diversity, and innovation, with corresponding benefits for users.

In addition, the connectivity services provided by IAA lower entry barriers for ISPs, by offering smaller capacity links at affordable rates, and enabling easier and faster provisioning of these services. This also further reduces the market power of the larger telecom operators who would otherwise sell these connectivity services. The smaller ISPs also benefit from the advocacy provided by the IAA, which among other things can help to facilitate entry and foster competition.

Likewise, smaller local content providers benefit from lower cost access to their users, including for government agencies. Rather than having to pay for transit to deliver content to users, it can be delivered directly through peering at IX Australia. This includes for the Australian Broadcasting Corporation as well as other government users including the NSW Department of Education.

Finally, IAA contributes to the resilience and security of the Internet in Australia. Exchanging traffic locally could reduce the possibility of surveillance of the traffic by governments and other actors. In addition, given that IX Australia has multiple locations in Australia, there are multiple points of redundancy, adding to the resilience of the Internet in Australia. The community of users can help to promote secure practices, while the IAA as a not for profit has no commercial conflict of interest in taking all necessary steps to ensure security and resilience in the network.

CONCLUSION

The IAA delivers significant benefits to the Internet ecosystem in Australia, both through IX Australia and also through the other activities provided by IAA. Many of the benefits are common to all IXPs, but some result from the specific configuration of IX Australia, the connectivity services provided, the not-for-profit status reflected in its pricing, and the community formed among members.

A significant set of beneficiaries is the smaller ISPs, and ultimately their end users, who benefit from lower entry barriers and the resulting increased competition and diversity in the market. These smaller ISPs benefit in a number of ways.

- The cost savings of attaching to IX Australia are significant. A 10Gbps port to peer at the IXP costs AUD 350 per month; accessing the same content abroad using 10Gbps of IP transit would cost AUD 36,715 per month, over 100 times more expensive. As noted above, an ISP may be able to access 75% of its traffic through IX Australia. The total cost savings for all the ISPs equals AUD 36 million.
- There is also a latency benefit as content and services can be delivered faster through the IXP with fewer hops rather than using transit connections. This provides benefits for the content providers as lower latency generally leads to higher usage, but ultimately end users are the beneficiaries as their increased usage results from increased satisfaction with the content and services.
- Further economic benefits result from the various connectivity services provided by the IAA, delivering economies of scale to the smaller ISPs who would not get the same volume discounts on connectivity and could not afford to build their own. This enables them to extend their networks between the cities of Australia at lower costs.
- Further benefits come from the advocacy provided by IAA with multiple government and regulatory bodies, including Home Affairs, Treasury, the Department of Communications, the Australian Communications and Media Authority, and the NBN. The IAA can provide a voice to the smaller providers with more weight than any individual provider could have.
- IX Australia also helps to promote security and resilience, by localizing traffic exchange, which reduces the number of hops that could increase traffic loss, restricts outflows of traffic that could be subject to foreign surveillance, and provides redundancy which reduces the impact of international cable cuts or other disturbances.
- Finally, promoting diversity in the industry through efforts to promote women in tech, and hosting networking events and large conferences helps to build the Internet community in Australia, with benefits that extend beyond the members of the IAA.

While the members using the IAA and their users are the direct beneficiaries of IAA, all of the ecosystem benefits. Enabling smaller ISPs in the market increases competition, with the lower costs passed on to end-users. This competition can also help to lower prices from the ISPs not using the IXP. In turn, the increased use of the Internet resulting from the lower costs and latency represents benefits for the users. The benefits of increased usage have particular significance during the pandemic lockdowns when reliance on the Internet increased, a reliance that is likely to continue into the future as everyone has adapted their lives online.

ABOUT THE AUTHOR

Michael Kende is a globally recognized expert and thought leader on issues relating to Internet interconnection and Internet Exchange Points. He began to work on Internet interconnection issues as a Senior Economist and Director of Internet Policy Analysis at the United States Federal Communications Commission, where he analyzed the competitive impact of Internet backbone mergers and wrote a working paper entitled "The Digital Handshake: Connecting Internet Backbones". As a partner at Analysys Mason, Michael continued to work on Internet interconnection issues and helped to develop Internet Exchange Points in Singapore and several Africa countries. On behalf of the Internet Society, where he was Chief Economist for several years, he wrote a number of papers on the benefits of IXPs in Kenya and Nigeria, including most recently a study entitled "Moving Toward an Interconnected Africa." As a Senior Advisor to Analysys Mason recently, he worked on a project to assess the need for a regional IXP in Panama and wrote a paper entitled "IP interconnection on the internet: a white paper," that assessed interconnection policies that were proposed in Korea. Finally, his book "The Flip Side of Free: Understanding the Economics of the Internet" was recently published by MIT Press.

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"Working for the benefit of the Internet and the people who build and operate it."