Community-Driven IXPs

Enhancing Local Connectivity and Sustainability

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Internet Society

Introduction

An Internet Exchange Point (IXP) is a physical location where Internet Service Providers (ISPs) of various sizes, Enterprise Networks, and Content Delivery Networks (CDNs) connect and exchange Internet traffic between their networks locally. The primary purpose of an IXP is to reduce the cost, latency, and complexity of Internet traffic exchange by keeping local traffic local. This means that instead of sending traffic to far-off data centers, ISPs can exchange traffic with each other more efficiently, resulting in faster and more reliable Internet service for end-users. IXPs play a critical role in the functioning of the Internet by facilitating the exchange of data between different networks.

Internet Exchange Points (IXPs) act like hubs in the Internet ecosystem, enhancing Internet speed, reducing costs, and ensuring reliable service across networks. This report focuses on community-driven IXPs, which are fundamental in supporting sustainable and resilient Internet infrastructure, particularly within developing regions. Despite their critical importance, these IXPs face unique challenges ranging from limited access to financial resources to complex governance and operational issues.

Understanding the various operational models of IXPs is important as there is no "one-size-fits-all" solution in the diverse landscape of global Internet infrastructure. Different regions and network ecosystems benefit from different IXP models, whether commercial, nonprofit, or community-driven. Each model offers distinct advantages and serves specific needs, from maximizing profit and expansion in commercial setups to supporting local development and resilience in community-driven frameworks. This diversity in IXP architecture is necessary for accommodating the unique economic, technical, and social impact of different areas.

Most importantly, having at least one community-driven IXP within any given economy is very important as it ensures that the infrastructure development aligns with the community's specific needs and goals rather than just commercial interests. Community-driven IXPs enhance local Internet connectivity and reduce costs, which is crucial in regions where access to capital and business development resources is limited.

This comprehensive study aims to explore these challenges, explore effective operational strategies, and highlight sustainable financial models adopted by community-driven IXPs across the Asia-Pacific

region. By examining these aspects, we aim to provide actionable insights and guidance to enhance the functionality and impact of community-driven IXPs.

By sharing our findings, we would like to contribute to the global discussion on how best to support and evolve the Internet's backbone infrastructures to meet current needs and support future expansion, ensuring that every stakeholder benefits from a strong, sustainable, and effective IXP presence.

We start by agreeing on benchmarks to help categorize different types of IXPs. There are some obvious linkages between each category, and sometimes, an IXP can also fall under two categories.

Member-Operated IXP

This model adopts a member-driven approach, also called "Community-driven," where the IXP is governed by its members through an elected board (in most cases). The board appoints a CEO or Managing Director who oversees daily operations. The bylaws and the fee structures are established based on member consensus and board decisions, respectively. Professional staff are hired to manage the IXP's operations effectively. These IXPs are non-profit, democratic organizations created to enhance Internet connectivity and redundancy for their members. An example of this type of IXP is the network of exchanges run by the Internet Association of Australia (IAA) known as IX Australia, which operates under a membership structure where a board, elected by the members, manages the operations.

ISP Association-Operated IXP

In this setup, major ISPs collaborate to form a consortium that establishes an IXP. They develop the foundational bylaws and operational procedures collectively. Staffing solutions may include pooling existing staff from the member ISPs or hiring specialized personnel funded by the consortium. These IXPs aim to optimize network interconnectivity and performance regionally, with members contributing resources and sometimes sharing staff to maintain the operations.

For-Profit IXP

This model is structured as a commercial venture aiming to generate revenue, while the IXP may offer a neutral peering environment. Managed by private entities, these IXPs focus on profitability and offer a broad range of services, investing in infrastructure to attract a diverse client base. Equinix exemplifies one of the largest commercial IXP operators, managing data centers and Internet exchanges across various countries, including Asia-Pacific.

Academia/Regulator-Managed IXP

Here, the management of the IXP falls to an academic institution or a higher education commission of some sort in the country, often in collaboration with a regulatory body. This model supports research, education, and development goals while functioning as a neutral peering point for various network operators. Operations are handled by academic entities with the involvement of members or license holders, who together establish bylaws and operational guidelines. Pakistan IX is an example of that.

Informally Managed IXP

Characterized by its informal structure, this model relies on the mutual cooperation and community spirit of networks benefiting from the IXP. Without formal agreements, these IXPs operate based on collaborative understandings among networks, emphasizing shared responsibilities and relying heavily on community goodwill. It is still debatable whether it really works in the long run.

ISP-Operated IXP

Run by a single ISP, usually the incumbent or a major provider, it is hard to differentiate between a fabric providing transit or peering. This type of IXP may share similarities with commercial for-profit IXPs to some extent. This setup can lead to concerns regarding neutrality since the operator is also a market competitor. Although it aims for profitability, this model often necessitates additional measures to ensure fair access and neutrality for all participants and may be regulated to prevent anti-competitive practices.

Research Methodology

The research paper will conduct an in-depth interview with IXPs, focusing on critical topics such as the operational challenges faced by community-driven IXPs, such as limited financial resources, technical expertise, and governance issues. It will also explore their sustainability strategies and their role in the local and global Internet ecosystem.

Below are the key topics being discussed with IXPs:

1. Organization Structure and Operation
2. Financial Model
3. IXP Policies
4. Technical Challenge & Best Practices
5. Technology Partners
6. Value-added Services

Five community-driven IXPs—Bangkok Neutral Internet eXchange (BKNIX), Singapore Internet Exchange (SGIX), Malaysia Internet Exchange (MyIX), Internet Association of Australia (IAA), and Hong Kong Internet Exchange (HKIX)—were invited to participate in this research. The sessions are conducted via face-to-face meetings or virtual meetings via Zoom, depending on the IXP's availability.

Special Thanks

We want to thank Packet Clearing House for their valuable feedback and comments. They have provided important insights for sustainable community-driven IXPs.

Thank you, Internet Society, for allowing us to work on this project and collect valuable information from community IXPs in the region.

Foreword

This Research study is not just about investigating and enhancing Internet Exchange Points' resilience, sustainability, and competitiveness (IXPs). It's about understanding the unique challenges that member-driven OR community-driven and operated IXPs face.

Unlike commercially run IXPs, they often have limited access to capital and business development resources. They operate on a cost-recovery basis, with any surplus typically reinvested in the IXP or its associated community. This unique operation model presents its own set of challenges that we need to address.

Community IXPs are vital in the Internet ecosystem, especially in developing economies and underserved areas. They also act as hubs for the local technical community, connecting with and to the peering community regionally and globally.

Sustainability of Community-driven IXPs

Organization Structure

Determining the organizational structure of a community-driven IXP is essential. Most of the feedback from the IXPs suggested starting with the organization by registering as a nonprofit organization.

This is to clearly communicate to the community that the IXP's main objective is community-driven. The IXP is not driven by commercial interest. The organization's focus is always on the members. This will also be a clear objective or goal of the IXP: to reduce the cost of connectivity and improve the Internet latency for members who are connected to the IXP.

Additionally, starting a new community-driven IXP initially requires investment in equipment, cross-connects, backhaul, data center co-location, and staffing. If the IXP operates as a non-profit organization, this status can facilitate access to available regional funding. Most established community-driven IXPs are eager to help new initiatives succeed. Beyond financial support, they often offer the expertise needed to operate an IXP effectively.

Regarding internal structure, it is important for an existing community-driven IXP to include board or committee members from similar organizations. For instance, the New Zealand Internet Exchange (NZIX) has appointed two committee members from IAA, which aids in operating and establishing the initial structure for a community-driven IXP.

Operation

Most community-driven IXPs started on a volunteer basis. Some volunteers have industry experience, and some don't. Some need to undergo training by other IXPs to familiarize themselves with the IXP's operation. It could start with one or two people during the initial stage.

An employee at the Chinese University of Hong Kong volunteered at the Hong Kong Internet Exchange (HKIX) and became a full-time engineer. The HKIX team currently consists of ten individuals who handle daily operations.

The Bangkok Neutral Internet eXchange (BKNIX) started with one engineer. Initially, the engineer wasn't equipped with the knowledge to manage an IXP; he was sent for training and knowledge sharing for one month. BKNIX has a team of four, with two engineers running the day-to-day operation.

Some IXPs have outsourced 24/7 monitoring and support to a vendor or partner to keep the team small and lean during the start-up stage. Partner roles and responsibilities include monitoring the network 24/7 and handling first-level support from IXP members. It's common to outsource 24/7 monitoring and support to a partner to minimize operation expenditures and human resources.

Financial Model and Support

One of the major expenses for an Internet Exchange Point involves capital expenditures (CAPEX). A community-driven IXP, particularly those structured as non-profit organizations, can secure start-up funding from various industry institutions, such as the Internet Society, Packet Clearing House, APNIC Foundation, APIX, NSRC, and more. These funds are typically allocated towards purchasing essential infrastructure like switches, servers, co-location services, and cross-connect at the facilities.

To ensure financial stability and manage resources efficiently, it is critical for an IXP to develop a comprehensive financial plan that forecasts both CAPEX and operational expenses (OPEX) over a minimum of three to five years. This plan should be revisited and adjusted quarterly to address any needs for capacity upgrades, a big challenge highlighted during the COVID-19 pandemic from 2020 to 2022, when many IXPs faced difficulties in scaling up their equipment capacity due to various financial constraints.

While initial funding helps cover start-up costs, community IXPs must also strategize for long-term financial sustainability. The main sources of ongoing revenue should include port fees, educational training sessions, and a range of value-added services that enhance the functionality and appeal of the IXP. Correct pricing of port fees is essential, balancing the need to be cost-effective for members while ensuring the IXP has sufficient income to support its operations and future development needs.

The development of Internet Exchange Points (IXPs) such as HKIX, the Internet Association of Australia (IAA), and Malaysia Internet Exchange (MyIX) illustrates the evolution from initially offering free

services to adopting a sustainable fee-based model to manage growing bandwidth demands and operational costs.

Hong Kong Internet Exchange (HKIX)

Initially, HKIX offered its members free ports at capacities of 100 Mbps or 1 Gbps. This approach was aimed at rapidly boosting participation and network traffic. However, as bandwidth-intensive applications proliferated and the number of regional service providers increased, this model proved unsustainable. The need for frequent hardware upgrades to accommodate rising data throughput necessitated a shift in strategy. Consequently, after several years, HKIX introduced a tiered fee structure based on different port speeds in 2013. Within approximately 2-3 years of implementing port charges, HKIX achieved financial sustainability, effectively covering its operational and upgrade costs through these fees.

Singapore Internet Exchange (SGIX)

SGIX was incorporated in 2009 and fully funded by the Singapore regulator during its initial years. It adopted a full outsourcing model for its billing, finance, network operations, network operations center (NOC), and other aspects. There were two full-time staff managing the company back then. SGIX peering points have grown to 18 as of 2024 compared to two since incorporation. In 2022, it increased its in-house operations headcount and continues to engage the services from its outsourced partner.

SGIX port fees are chargeable since going into operation as it recognizes the need for business sustainability. However, operating as a not-for-profit company, the company conducts voluntary reviews of its port prices periodically to ensure members consistently enjoy maximum savings when subscribing to the service.

Internet Association of Australia (IAA)

IAA began as an industry association first in 1995 and then started offering exchange services in 1997 at a location where it still delivers services today. The Internet Association of Australia's approach to IXP implementation involved starting with donated equipment from its members and providing free ports during the initial phase. This strategy helped to cultivate a foundational network and demonstrated the tangible benefits of an IXP, including reduced bandwidth costs and better local connectivity. Recognizing these benefits, members were more amenable to introducing port fees. Today, the IAA operates multiple IXPs across Australia, with some locations like TAS-IX still offering free ports to incentivize connection in areas with fewer service providers.

Malaysia Internet Exchange (MYIX)

Like HKIX and IAA, MYIX began by offering free ports to its members, a strategy that facilitated early growth and attracted significant Content Delivery Network (CDN) participation. As the network matured and the benefits became apparent, MYIX transitioned to a paid model. This shift ensured operational sustainability and supported ongoing improvements and expansions. MYIX continues to thrive, sustaining its operations through member port fees.

For community IXPs, the decision to start with either a paid or free port model depends largely on the economic conditions and support at the location. It's crucial for members to understand that free ports are not a long-term solution and that fees will eventually be introduced. Effective member engagement and support are vital, as they contribute to the IXP's sustainability through service fees. Community IXPs must focus on demonstrating value to ensure members are willing to transition to a paid model, thereby securing the IXP's future financial stability.

While free port offerings can effectively kickstart IXPs by boosting initial engagement and network traffic, the long-term sustainability of these exchanges depends on transitioning to a fee-based model. This approach ensures that the infrastructure can support increasing demands and ongoing improvements, ultimately benefiting all members through better services and connectivity.

IXP Policies

Ideally, to maximize network efficiency and reduce transit costs, all members of an IXP would adopt an Open Peering Policy, which encourages unrestricted interconnection among all participants. However, challenges arise when incumbent ISPs, often due to existing business arrangements or strategic interests, prefer not to engage in open peering. Instead, these ISPs might opt for a Selective Peering Policy.

Selective Peering Dynamics

Incumbent ISPs may choose a Selective Peering Policy to avoid conflicts of interest that could arise from existing business units within their company. These units might already have established profitable direct connectivity with potential IXP members, which could be undermined by open peering.

Comparison with Other IXPs

Other IXPs, such as MYIX and HKIX, similarly do not enforce an Open Peering Policy upon entry. They recognize that encouraging a larger membership base, even with varying peering policies, ultimately contributes to the community's growth and fosters better relationships among network operators.

In Thailand, BKNIX exemplifies a different approach by practicing open peering for all joining members and positioning itself as a neutral and inclusive Internet exchange point. This openness is a key differentiator in a landscape where most ISPs typically establish IXPs primarily to serve their customers rather than foster broader network interconnectivity.

Educational Role of Community-Driven IXPs

It is essential for community-driven IXPs to educate their members about the core purpose of an IXP, which is to facilitate local traffic exchange to improve connectivity and reduce costs, rather than to serve as IP transit or an upstream service provider. Clear communication about the role and benefits of the IXP, coupled with guidelines on appropriate use, can help set the right expectations and ensure that the IXP meets its objectives effectively.

Technical Challenge & Best Practices

It is important to have the basic technical know-how to manage an Internet Exchange Point (IXP) effectively. Fortunately, many organizations supporting this ecosystem recognize this need. For example, the Internet Society (ISOC), Packet Clearing House (PCH), the Network Startup Resource Center (NSRC), and APNIC offer specialized technical training programs. These programs are essential for maintaining and operating an IXP and are particularly beneficial for community-driven IXPs in their formative stages.

Training and Capacity Building

The training the associations above provide covers a wide range of best practices crucial for the operational success of an IXP. Participants learn about the technical aspects of onboarding new members, including policy application, provisioning processes, and preparation of network resources such as AS-set, reverse DNS, IPv4/IPv6 configurations, and updating the PeeringDB database. They also gain insights into configuring and managing route servers based on BIRD or other routing daemons. This comprehensive training ensures that IXPs are well-equipped to handle both routine management tasks and complex technical challenges.

Leveraging Open-Source Tools

Fortunately, the growth and sustainability of new IXPs are supported by various open-source tools available online, which help streamline operations and reduce overhead costs. For example, IXP Manager, developed by INEX, is an acclaimed tool that facilitates efficient member management and provides a structured workflow for IXPs. By adopting such tools, IXPs like MYIX, BKNIX, and SGIX have standardized their operational processes, allowing them to offer a robust provisioning flow and member portals without having to develop these systems from scratch.

Customization and Monitoring

Beyond standard tools, IXPs can customize solutions to fit their unique needs. Tools like Grafana can be utilized to create dashboard interfaces that provide real-time visualizations of traffic utilization and service uptime, enhancing transparency and usability for IXP members. This customization capability allows IXPs to tailor their technology stack to better serve their community and to provide a high level of service continuity and reliability.

Adopting Industry Standards

By adopting widely recognized and tested industry standards and tools, IXPs can ensure that they remain competitive and capable of providing high-quality service. This approach not only facilitates easier management and scalability but also promotes interoperability and collaboration among different IXPs globally.

Technology Partner

Support from technology partners or vendor support is important for setting up and operating an Internet Exchange Point (IXP). The choice of equipment largely depends on the IXP's budget, the technical expertise available, and regional support from other organizations like Internet Society, PCH, NSRC, etc. However, maintaining relationships with technology partners or having vendor support is also important for the long-term success of an IXP. Many IXPs begin with donated equipment, and close collaboration with the supplier can extend the lifespan of this equipment.

IXPs may choose to work with multiple technology partners, a decision that often depends on how well the different technologies can interoperate. On the other hand, some IXPs opt for a single technology partner due to the benefits of a long-standing partnership and consistent support. Each approach has its trade-offs: partnering with multiple technology providers can enhance the resilience of IXP operations but may also complicate maintenance. Conversely, having a single technology partner simplifies network management but could leave the IXP dependent on one provider for solutions, which might be a limitation if issues arise.

HKIX has established a long-term good relationship with technology partners. They can work on long-term projects, which allows them to obtain good support from technology partners.

MYIX has a similar relationship with its technology partner. Since its establishment in 2006, the same technology partner has supported MYIX until today.

Value-added Services

With more commercial IXPs entering the Asia Pacific region, community-run IXPs recognize the need to set themselves apart by providing value-added services. Such services, often introduced in response to suggestions from current members or requests from potential ones, significantly enhance the appeal and functionality of the IXP. For instance, should a member or a prospective member express a requirement for remote peering services, the IXP may contemplate incorporating this option to attract and retain their membership.

To effectively offer or design these services, a mechanism should be in place for gathering feedback from both members and potential members. This could involve regular surveys, feedback sessions, or an open forum for suggestions. Being open to ideas and actively seeking out member input can lead to developing services that genuinely meet the needs of the network community.

Some of the value-added services that can be offered for members in the IXP are DNS service, cached server services, NTP services, cloud connect service, and DDoS mitigation services.

In some cases, these services are directly offered by members who have specific expertise in the area. This collaborative approach not only diversifies the services offered but also leverages the unique skills within the community.

Offering DNS services will give IXP the upper hand in convincing the root server to join the IXP. IXP can provide free space and power to connect to the root server. Besides the DNS root server, there are also possible cache servers for domain registry providers such as Verisign, ICANN, etc.

More members coming from different areas of expertise will help IXP create an active community, which is the best part of having a community-driven IXP. Leveraging this, IXPs can organize seminars, training sessions, conferences, and meetups, which not only serve as educational opportunities but also facilitate networking among members. That will create the stickiness of an IXP.

IXPs such as SGIX, MYIX, IAA, BKNIX, and HKIX offer value-added services. IAA provides cloud connections for members to easily connect to content delivery networks or cloud service providers. Some members who need the expertise to maintain an NTP server can always use the NTP service offered by IXP.

However, some IXPs believe that members should demand value-added services. Ideally, it's better not to offer value-added services that are not required by members, as this will waste resources for a community-run IXP.

In general, community-run IXPs should consider learning from other IXPs, including those operated commercially. Observing and adapting successful strategies from both similar and commercially-run entities can provide valuable insights and innovative approaches to service delivery and enhancement. This continuous learning and adaptation will not only improve the services offered but also ensure that the IXP remains competitive and relevant in the evolving digital landscape.

Conclusion

This study has utilized feedback gathered from community-run Internet Exchange Points (IXPs) within the APAC region. We have found that many resources are readily accessible to newly established, or 'greenfield,' community-run IXPs. The robust network of communities across various regions is eager to assist and provide resources to these nascent IXPs as well.

Organizations such as the Internet Society, PCH, NSRC, APIX, and APNIC play an active role in supporting community-run IXPs and aiding them in maintaining day-to-day operations. Numerous instances of community-run IXPs have successfully achieved self-sustainability. This ongoing support from these organizations not only helps in the operational stability of new IXPs but also contributes to a broader, collaborative ecosystem where knowledge and resources are shared for mutual benefit.

While there are many resources available and considerable support from external partners, a significant gap remains in guidance for the next steps. Plenty of information exists on how to establish an Internet Exchange Point (IXP), but detailed resources on how to expand and enhance an existing IXP are

comparatively limited. This lack of comprehensive guidance can hamper the development and sustainability of IXPs after their initial setup.

On the other hand, these external partners should also allocate resources to evaluate which value-added services are making a significant impact globally, identify which services could be offered, and assess which services may not be justifying their cost. This type of support and analysis is really important, perhaps even more so than merely supplying equipment and technical training. The business aspects of IXP operations also require substantial support to ensure overall sustainability and effectiveness. Unfortunately, this support and guidance which touches on these points is lacking in the current landscape.

Now, the question about "How many are too many"? There are important considerations regarding the optimal number of community-run Internet Exchange Points (IXPs) a country should support. The decision largely depends on the specific demands of the economy and the existing network infrastructure. If a country already has a sufficient number of IXPs, whether commercial or community-run, establishing additional IXPs may not be advisable. This could lead to an inefficient use of resources and efforts, which other communities might otherwise support.

Moreover, having too many IXPs can create challenges for the ecosystem. It can place content providers and cloud operators in a dilemma about where to connect, complicating their network strategies. These entities are businesses that must make decisions based on potential business opportunities. Therefore, while supporting community-run IXPs is important, it is equally important not to foster an environment where multiple community-run IXPs struggle to survive.

At some point, it becomes necessary to assess whether continued support for a community-run IXP is viable or if it would be more beneficial for the overall network ecosystem to consolidate or reduce the number of IXPs. This strategic decision should aim to maintain a balanced and efficient network infrastructure that supports robust connectivity and business opportunities without oversaturating the market.

A healthy peering and interconnection ecosystem benefits everyone involved.