Stories of IXP Development and the Way Forward

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Disclaimer

- This talk is more about my personal experience and observations from operating the IXP in HK before joining APNIC in Apr 2017
  - Plus a bit of my additional experience and observations from helping the development of a few IXPs in the region
- **The points to be presented may NOT represent the viewpoints of APNIC**
- Try not to name names if possible
- Try to be more interesting, and educational
- There is no “One Size Fits All”
  - Just to provide hints, not answers
- Cannot cover all scenarios here because of limited time

What is an Internet eXchange Point (IXP)?

- An IXP is a shared physical network infrastructure over which various Autonomous Systems can do easy peering with one another
  - One physical connection to IXP can be used for interconnections with multiple networks
  - More cost-effective and scalable

  - *ASes to be served by IXP include Internet Gateways, Internet Service Providers (ISPs), Research & Education (R&E) Networks, Cloud Service Providers, Content Providers and Content Delivery Network (CDN) Service Providers*

Benefits of IXP

- One main objective of an IXP is to keep local traffic local
  - Important to local Internet development
- Helps bypass 3rd-party network infrastructure for easy interconnection and direct traffic exchange among participating networks
  - Reduced cost – cheaper connectivity
  - Enhanced network performance – faster speed
  - Reduced latency – lower delay
- Helps encourage development of more local content and local applications
  - Helps local data centre business and other businesses
- Everybody is benefited
  - The gain for each may be different but all will gain
  - At the end, it is the most important that end users or consumers are benefited
- Often considered as Critical Internet Infrastructure locally, regionally or globally

IXPs are Layer-2 Networks

- Switched Ethernet
  - One physical connection for interconnections with multiple networks
  - Only routers are allowed to connect to the switching fabric directly usually
- IXP participants can do direct Bilateral Peering (BLPA) over the layer 2 infrastructure anytime
- With Route Server added to the layer 2 infrastructure, IXP participants can also do Multilateral Peering (MLPA) for easier interconnections among everybody
  - Traffic exchange is not going through the route server but direct
- Those called themselves “IXes” but serving layer-3 services are mostly transit providers

Value and Attractiveness of an IXP

- Proportional to the number of different networks (ASNs) connected and also the traffic volume
- Snowball effect after reaching critical mass
  - The initial period usually is the hardest
    - Most will take wait-and-see approach
  - Gradually will have good mix of networks of different types
    - E.g. Eyeballs vs Content

Success Factors of the IXP in HK

- Neutrality
  - Helped gain trust from the participants especially the early ones
  - But there is no 100% neutrality…
    - Competition from another university
  - After gaining critical mass, things are much easier
  - No need to do sales work at all
- Free Service Initially
  - In the first 10 years or so
  - Little hesitation for participants to connect
  - But cannot be free forever
- Started Early
  - Earlier than the incumbent telco starting its ISP business
    - They even asked for joining before they launched the service
  - History cannot be repeated that easily…

And also…

- Leveraging telecom deregulation in HK
- Leveraging existing networks
- Passion & persistence
  - And, there was incentive for doing it
- Adaptation to industry changes
  - E.g. opening up to unlicensed networks

- HK people have been enjoying fast local Internet connectivity since almost the beginning

Long-Term Misunderstandings

- Used to mention ”>98% of traffic” a lot
- Government people and general public always think >98% of external traffic is going through the IXP in HK
  - How can that be possibly true?!
  - It is just wishful thinking of those people
- But the more accurate wordings should be:
  - The IXP in HK helps keep >98% of local traffic local

Other Misunderstandings

- The IXP supports Bilateral Peering since the beginning
  - Although it did emphasise Multilateral Peering in the early days
- The IXP is NOT the only IXP in HK
  - There are in fact multiple IXPs
  - The IXP is just the earliest and the biggest
  - The other IXPs together are not really small
    - Perhaps 70:30 in terms of traffic volume
  - But the IXP is the focus of people, most of the time

Multilateral Peering is evil?

- Mandatory MLPA established initially was meant to be for HK routes only
- Mandatory MLPA for HK routes did help attract some overseas ISPs to connect and then gradually made the IXP become Regional IXP
  - Personally think this was probably the most successful MLPA case
- Mandatory MLPA for HK routes was gradually “unmentioned” because of large content / CDN providers
  - Not big transit providers
  - Definitely not related to any other IXPs set up in HK
- Mandatory MLPA is not the norm all around the world now…
  - Large providers will find ways to get around it

- Personally do not like stripping away the ASN of the route server from AS Path as it helps identify the routes learned from MLPA more easily

Snowden Nightmare…

- Started from an article of his interview done in HK published at SCMP on 13 Jun 2013
  - Mentioned the name of the university while not mentioned the IXP at all…
  - But people still thought he was referring to the IXP
- A lot of reporters surrounded the main data centre hoping to find anomalies
- Grilled by media and politicians for months
- Enhanced physical security measures afterwards
  - Stopped all unessential data centre visits
- No findings of anything set up or done by the intelligence agency inside

Vulnerabilities of IXPs

- Proxy ARP
  - Why can’t all router vendors have Proxy ARP disabled as default?
  - Cannot stop it totally because of possible human errors
  - Can only do regular monitoring by checking the ARP table
  - EVPN over VxLAN technology should be able to help but it is not a simple technology
- Unknown Unicast Flooding
  - May happen when there is asymmetric routing seen from an IXP
  - Can be mitigated by sending proactive ARP check to all active addresses every hour or so
  - EVPN over VxLAN technology should be able to help but it is not a simple technology
- Shared Buffer over Multiple Switch Ports
  - Can cause trouble to multiple connections when there is big congestion on one port
    - Unknown to innocent participants which do not have any congestion
  - Just be careful when choosing switch models
    - Also avoid switch models with small buffer

Vulnerabilities of Data Centres?

- Locations are known
  - Same for Landing Stations
  - Can easily be targets of physical attacks
- How can you better protect the fibre lead-ins and manholes which are outside of data centres?
- No such things as absolute security…
  - But let’s still do our best

Visibility of Traffic?

- Support of layer-3 sFlow/NetFlow highly desirable for better visibility of traffic going through the IXP
  - It helps trouble-shooting and understanding of traffic profile/pattern a lot
  - Having visibility of just layer-2 data is of less use
- But participants and general public would be concerned about the perceived surveillance or monitoring
  - Should do the best not to give data away to 3rd-parties

Port Security Is Important

- The IXP in HK allows just one MAC address per port (physical or virtual)
  - Strictly one IPv4 address, one IPv6 address and one MAC address per port (physical or virtual)
  - Static MAC address for full control
  - “Violation Restrict” instead of “Violation Shutdown”
- Minimum protection to the layer-2 broadcast domain
- A few IXPs allow more MAC address per port but still a small number
- Should also do Ether-type filtering and broadcast/multicast traffic filtering

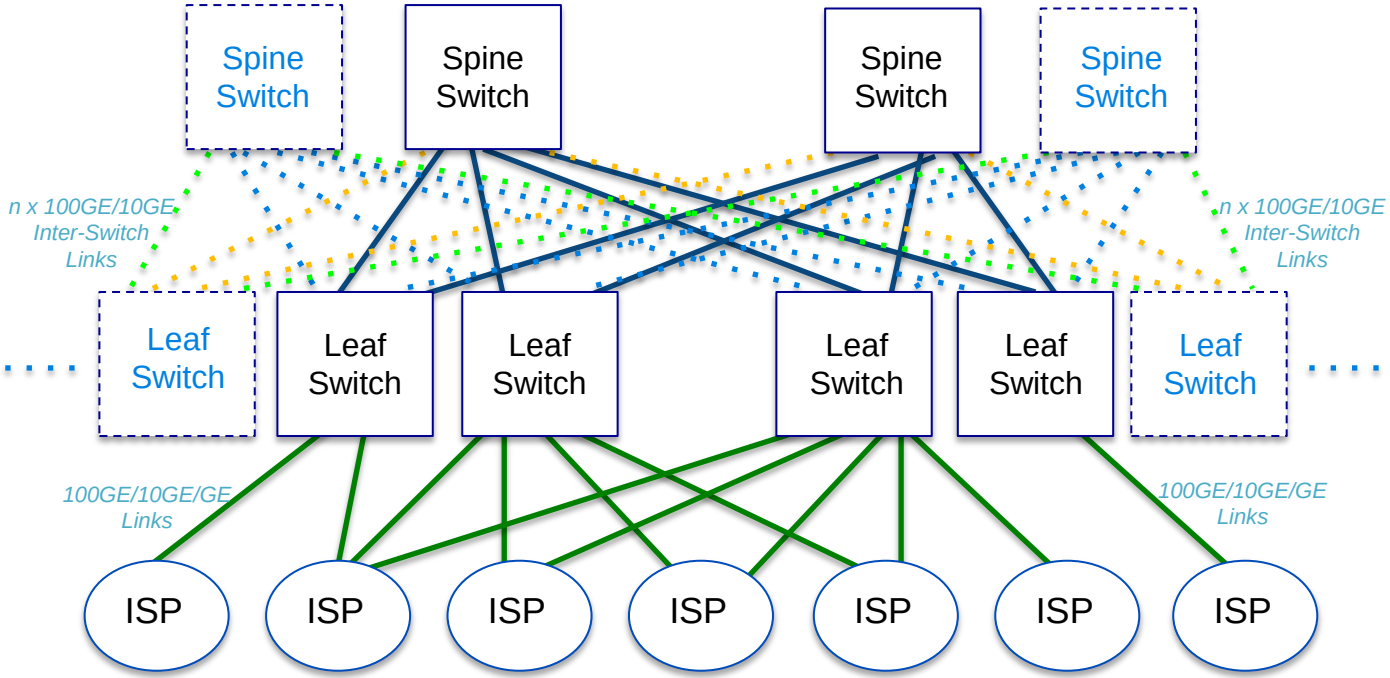
Remote Layer-2 Connections to IXP?

- More and more common nowadays
  - Some even from >1,000km away
- Using fibre-only connection is much easier, with much fewer issues
  - ZX/ZR/ZR4 are up to 70-80km
- Clear-Channel remote layer-2 circuits with full transparency are rare
  - Unless you are willing to pay more
  - Wasting a lot of effort to do trouble-shooting with carriers
- But IXPs cannot afford to not support them
  - As they want to have more business, sometimes through resellers
  - Unless their main business is data centre business

Scalability Issue

- IXPs were not supposed to have any packet loss in its infrastructure
  - And with very low latency too
- Become an issue when IXP grow beyond one switch
  - Due to not enough ports or expanding to multiple sites
- Inter-switch links are the risk
  - Over-subscription or not?
- Spine-and-leaf architecture helps a bit but not for all cases
  - Need to determine how much bandwidth from leaf to spine anyway
  - Still not ideal if there are adjacent leaf switches at one site
    - All traffic among 2 adjacent leaf switches has to go to the spine first?

Spine-and-Leaf Architecture



MRTG of Aggregate Traffic

- It is less sensitive of course
  - More an indication of the importance and the growth of an IXP
  - Should not neglect the huge difference between showing 5-min data and 1-min data
  - Should not neglect what traffic data is included – just the main broadcast domain or what?
- Usually incoming = outgoing
- If incoming > outgoing
  - Congestion at at least one port
  - May be DDoS attacks
- If outgoing > incoming
  - May have Unknown Unicast Flooding
- If sudden drop of large traffic volume
  - May have Proxy ARP problem
    - Usually happens when change of router / router software / router config

Other Observations from MRTG

- Situation in HK
  - Holiday Effect
  - Soccer Games Effect
  - Typhoon Effect
- Difference of Culture / Practices
  - E.g. HK vs Japan

IXPs and Data Centres

- They are natural partners
- Common situation in advanced metro cities
  - Multiple IXPs in one Data Centre
  - One IXP in multiple Data Centres
    - Should be the same layer-2 broadcast domain
    - Circuit cost is a burden
  - Healthy competition would be good
    - Customers have choices
    - Also for better resilience

IXP Models

- Developed economies vs developing economies
- Non-profit vs commercial
- Subsidized vs self-financed
- Government-led vs industry-led
- No one single model which can suit all situations
- Relative Neutrality is important

Commercial vs Non-Profit

- Commercial set-up is free to do anything
  - No need to care about neutrality too much
  - IXP is mostly a service to help other business
- Non-profit set-up tends to be more cautious
  - Neutrality is more important, at least to the target participants
  - Tend to be more independent
  - Tend to offer fewer services

IXP across Multiple Cities / Economies

- May not be good for maintaining neutrality
  - Considered as competing with participants which have presence in the same locations
- Commercial IXPs can take this business risk especially if this may help their other business
- But not so good for non-profit IXPs targeting all kinds of networks or providers
  - Those that see competition may not join and then it may affect the goal of “keeping local traffic local”

Interconnections of 2 or More IXPs

- What are the purposes of doing this?
- Not considered a good idea at Layer-2, especially if across cities or countries/economies
- Even at Layer-3, still need to be mindful of whether it affects the original purposes of each IXP involved

Advanced / Developed Economies

- IXPs are mostly business-oriented
  - Even for not-for-profit set-up
  - Less government involvement
- Multiple IXPs
  - Keen competition
- But if they cannot keep intra-economy traffic local, someone needs to step up
  - Government? Industry group? Customer pressure?

Developing Economies

- Some do not have any IXPs yet
- Local traffic does not stay local
  - A lose-lose situation for everybody
- IXPs can help Internet development a lot
  - Better to be non-for-profit set-up
  - May need to start with subsidized model
  - May not be a business at all
  - Help from government is mostly needed
  - Active participation of the biggest players is also very important

Examples of Pacific Islands

- Far from any other places
- External connectivity is very expensive
  - More submarine cables are being built for them
- Small markets because of small population
- Usually just a few ISPs but they may not be interconnected locally
- Local traffic across ISPs usually routed through US or Australia
- Local IXP is very much needed
- Observed immediate benefits on Day 1 of set-up of one Pacific Island IXP
  - Much improved latency and high volume of traffic

- Small land-locked economies have more or less similar issues

Politics Involved in Early IXP Development

- Usually larger ISPs like IXP less than smaller ISPs because smaller ISPs are mostly target customers of larger ISPs
- Larger ISPs refuse to connect to IXP making the value of IXP lower
- There are multiple possible mitigation options for that but in any case, larger ISPs need to collaborate
  - Separating access networks from Internet gateway or transit network
- If hurting the goal of “Keeping Local Traffic Local”, then it is lose-lose to everybody
- Government involvement may help or may hurt the case
  - It depends on the relationship between the industry and the government
  - Forcing large ISPs to do peering may not achieve the expected outcomes
- But having an IXP is NOT a magic wand to solve all the issues

Government Funding for IXPs?

- Is it good or bad?
- More needed during infancy stage of IXP development
- But for long-term, it is probably better to have bottom-up industry-led governance for IXP
  - Align with bottom-up multi-stakeholder approach
  - Need to have a long-term sustainable financial model

Possible Steps for IXP Development

- Can be gradual, step by step
- Layer-2 network is the bare minimal
  - Can use private IP addresses if small amount of participants
- Public IP addresses next
  - Legal entity issue
- Site resilience is IMPORTANT while equipment resilience is already included
  - Has to have site resilience sooner or later
- Route server(s) with ASN follows
  - RPKI consideration
- Other value added services
  - DNS: Root / TLDs / Recursive
  - Shared Content Caches?

Shared Content Caches Offered by IXP?

- A lot of misunderstandings about the use of caches
- A lot of local IXPs want to provide shared caches for their participants to increase their value
  - Cost recovery and cost sharing / accounting are major issues to them though
- Content / CDN providers are still sceptical about this model
  - They still mostly look at cache efficiency and traffic volume for justifications

IXP Participants

- Unfortunately, a lot of IXP participants do not make the best use of the IXP(s) they have connected
- IXP Participants without enough knowledge and skills may disrupt the operations of IXP from time to time
- IXP operators need to do a lot of education or push to their participants
- So, IXP engineers would be busy and dedicated resources would be needed
  - Volunteering type of operations mode cannot sustain for too long

Myth of Neutrality

- There is NO absolute neutrality
- Different organisation has different perspective of neutrality
  - A university?
  - A carrier-neutral data centre?
  - An IXP?
  - A government department?
  - A membership-based organisation?
- We can only be “very neutral” for a defined group of companies or organisations, but not for all…
- But maintaining higher relative neutrality is still better for IXPs

Which Models Can Sustain?

- Usual business model
  - IXP alone cannot make big money
  - Or IXP may just be a value added service
- Subsidized Model
  - Government funding may be more reliable?
- Model relying on sponsorship and/or volunteers
  - Most risky as sponsorship or support of volunteers is not guaranteed
- Membership-based Model
  - Open Membership vs Closed Membership
  - Proper governance is important
  - Most neutral but still need to have good financial model for long-term sustainability

Threats to IXP Business

- /Mbps pricing of IP transit bandwidth is dropping continuously
  - Partly because of price drop of submarine cable capacity
  - /Mbps pricing of IXPs cannot be dropped as fast because of different cost base
    - Equipment cost doesn't drop a lot especially for high-end switches
    - Local loop cost involved for interconnecting multiple sites does not drop as fast
- More and more content caches are being set up inside the access networks
  - But bandwidth is still needed for cache-fill
- Private peering will take away traffic from IXPs
  - If traffic volume warrants between any two parties

The Way Forward for IXP Business

- It is tough business if you only do IXP business
  - Fighting for survival
- Adding Value Added Services may help
  - PNNI over VLANs, GRX, Cloud Exchange, GXP and etc
- Partnership
  - Partnering with multiple Data Centres
  - Partnering with multiple local loop providers
  - Recruit resellers – local & overseas/global
- Expand overseas
  - A few European IXPs are doing this
- Merger and Acquisition
  - Even non-profit set-up should get ready for this

Closing Remarks

- IXPs will continue to play a key role for easy interconnections among networks
  - Especially for developing economies
  - But IXP is NOT a magic wand to solve all the issues
- Need to find a suitable model for long-term sustainability
- Relative neutrality is still important
  - So still better to maintain it as much as possible
- After all, “Keeping Local Traffic Local” is the most important thing