

An Analysis of the Development of IXPs

BKNIX Peering Forum

Bangkok

21st & 22nd May 2018



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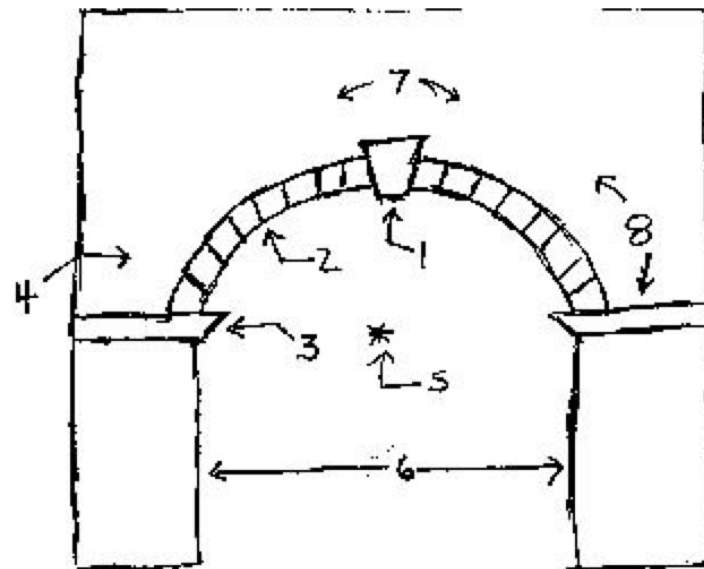
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Last updated 22nd May 2018



IXP is the Keystone to E-Commerce

Cisco.com

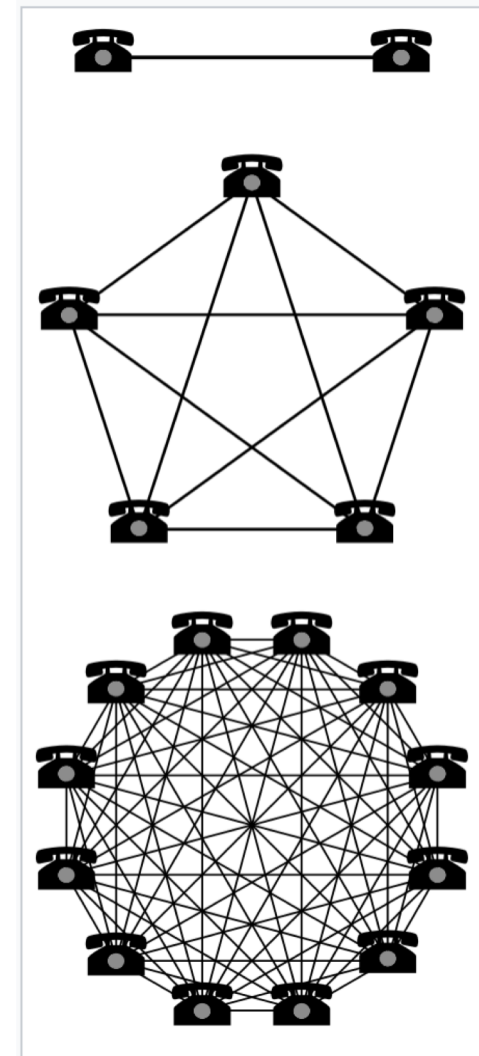


- ① KEYSTONE
- ② VOUSOIRS
- ③ IMPOST
- ④ ABUTMENT
- ⑤ CENTER
(a point)
- ⑥ SPAN
- ⑦ CROWN
- ⑧ HAUNCH

2002 Cisco ISP/IXP Workshop Slide

Metcalfe's Law

- Metcalfe's law states:
 - the effect of a **telecommunications network** is **proportional to the square** of the number of connected users of the system (n^2)
 - Originally to describe ethernet, but now commonly applied to the global Internet
 - Source: https://en.wikipedia.org/wiki/Metcalfe%27s_law

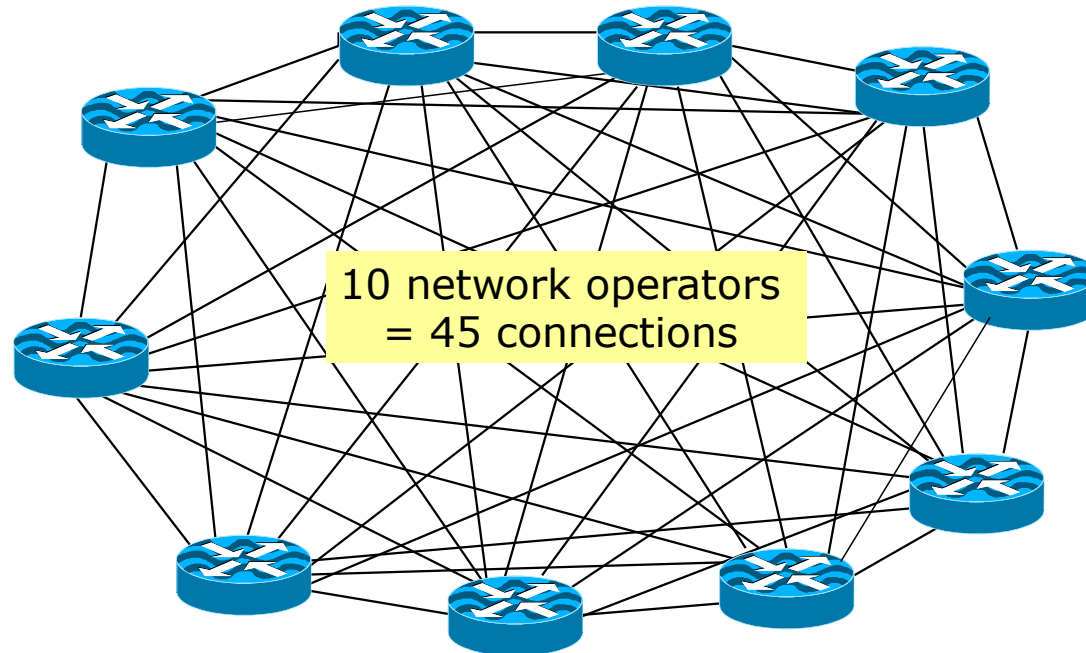


Two telephones can make only one connection, five can make 10 connections, and twelve can make 66 connections.



N-squared Interconnect

- For large numbers of network operators, direct links to each other does not scale

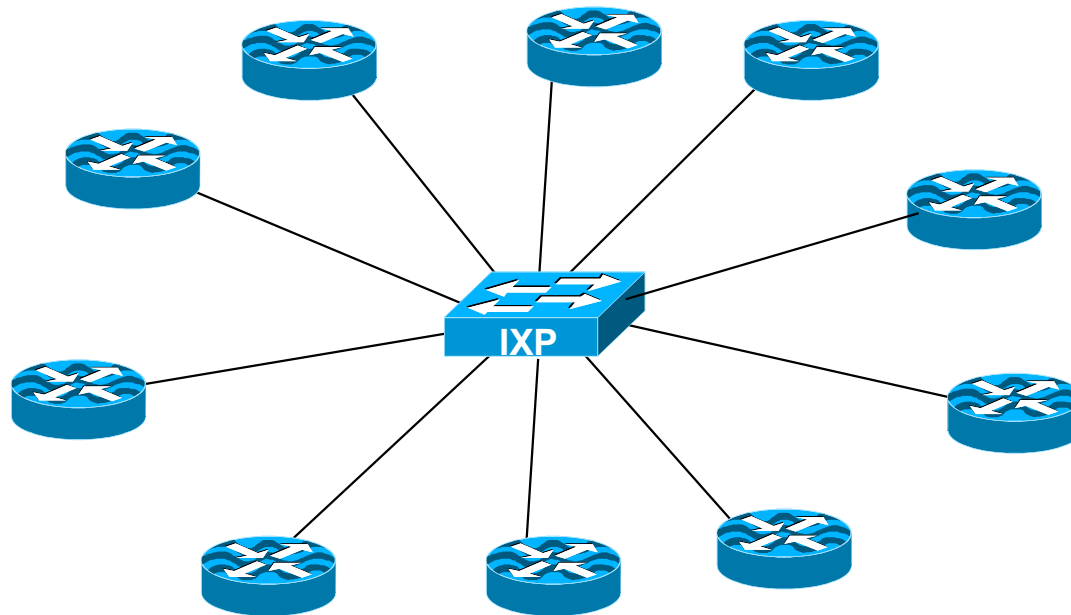


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IXP

- With an IXP the network operator routers connect to each other via the IXP fabric



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A Bit of History...

- NSFnet – one major backbone
 - US “National Science Foundation” funded
 - Connected academic & research institutions
 - Also connected “private company” networks, under acceptable use policy (AUP), at network access points
 - AUP: No commercial activity
- Four Network Access Points (NAPs)
 - Chicago – run by Ameritech
 - San Francisco – run by PacBell
 - New York – run by Sprint
 - Vienna (Virginia) – run by MFS



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More History...

- Private companies needed to interconnect their networks too
 - Requirement to send “commercial traffic”
 - Could not cross NSFnet due to AUP
- Resulted in the first “commercial Internet Exchanges” in the early 1990s:
 - FIX-E (Virginia) was the first true IXP, FIX-W (Bay Area) also followed
- Leading to:
 - MAE-East – Virginia + CIX-West – Bay Area



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More History still...

- End of the NSFnet in 1995:
 - Meant move towards commercial Internet
 - Private companies selling their bandwidth
 - Transit / Peering model we know today
- These NAPs were among the original “exchange points”
 - NAP operators were providing commercial Internet access as well
 - All NAPs were replaced by neutral/commercial IXPs
- A global Distributed GIX proposed in mid 1990s
 - But never happened (planned to be CIX-West, MAE-East, SE-GIX and a Paris IX)



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Latency

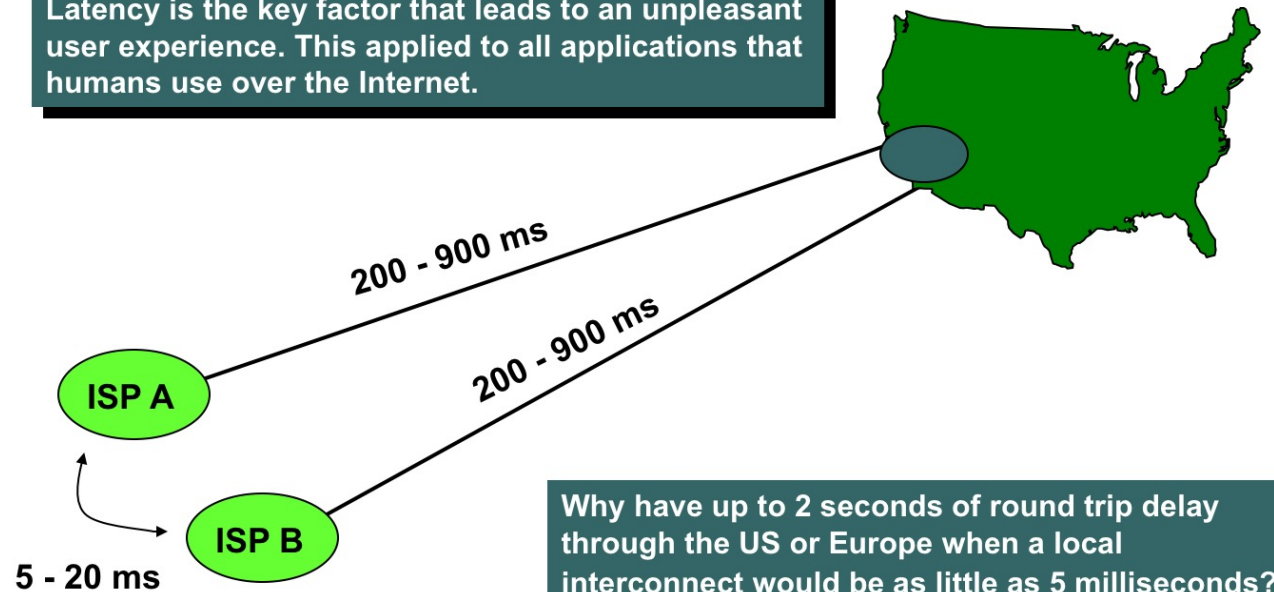
2002 slide!

- In 1990s, Europe was using US for interconnects – 100ms to 200ms away!
- Up to early 2000s, Asia was using US and Europe for interconnects – 200ms to 900ms (satellite) away

Using the US as a Internet Hub

Cisco.com

Latency is the key factor that leads to an unpleasant user experience. This applied to all applications that humans use over the Internet.



Why have up to 2 seconds of round trip delay through the US or Europe when a local interconnect would be as little as 5 milliseconds?

The IXes

- SE-GIX formed in Stockholm in 1993
 - Three network operators interconnected
 - Latency reduction, performance gains, local traffic stays local
 - (Proposed to be part of the D-GIX)

- LINX formed in London in 1994
 - Five UK operators interconnected
 - Latency reduction, performance gains, local traffic stays local
 - (Proposed to be part the D-GIX when Paris fell through)



The IXes

- HKIX was formed in Hong Kong in 1995
 - For intra-Hong Kong traffic
 - Within a decade, more than 60 ISPs were participating
 - Latency reduction, performance gains, local traffic stays local
- AMSIX (Amsterdam) and DE-CIX (Frankfurt) in 1996
 - Followed LINX model
 - Latency reduction, performance gains, local traffic stays local
- JINX (Johannesburg) in 1996
 - Initially for ISPA members only, later open to all
 - Latency reduction, performance gains, local traffic stays local



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Transit

- Paying another network operator for access to the Internet
- Significant operational cost
 - Data/traffic charges
 - Physical connectivity charges
- Transit provider determines onward connectivity, including
 - Diversity of service, and
 - Quality of service



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Peering

- Peering takes place between two network operators
 - To exchange traffic between each other's customers
- Minimises operational cost
 - Peering is for free
- Provides:
 - Improved customer experience (reduced latency, increased bandwidth)
 - Access to each other's hosted content



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Internet Exchange Point

- What it is:
 - A **neutral location** with **unrestricted access** where **network operators freely interconnect** their networks to **exchange traffic**
- What is the physical IX:
 - An ethernet switch
- How does it work:
 - IX Host provides the switch (IX fabric) and rack space
 - Network Operators interconnect via the IX fabric



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Why an IXP: Costs

- Internet transit costs money
 - For physical media, and
 - For Data/Traffic
 - (Even though transit costs are reducing all the time)
- IXP is “almost free”
 - Local access fibre
 - Optical interface costs
 - Data/Traffic is free
 - Contribution to IX operation costs (varies from IXP to IXP)



Why an IXP: Capacity

- Transit often involves limited capacity
 - Operators run paid-for transit links “almost full”
 - Reduces user experience (more waiting, slower responses)
- Local interconnect at IXP
 - Bandwidth as large as that of the chosen IXP port
 - Quality of experience dependent on operator infrastructure only



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Why an IXP: Latency

- Transit often involves higher latency
 - Reduces relative throughput
 - Reduces user experience (more waiting, slower responses)
- Local interconnect at IXP
 - Negligible latency
 - Quality of experience dependent on operator infrastructure, not interconnect



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Why an IXP: Local Economy

- Content is located where most end-users have best (biggest bandwidth & lowest latency) access to it
- With no Internet Exchange Point:
 - Content is located out of country or out of region
- With an Internet Exchange Point:
 - Content clusters around the IXP
- Content hosting and related Internet businesses locate closest to where the maximum number of users can access the content



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Internet Exchange Point Features

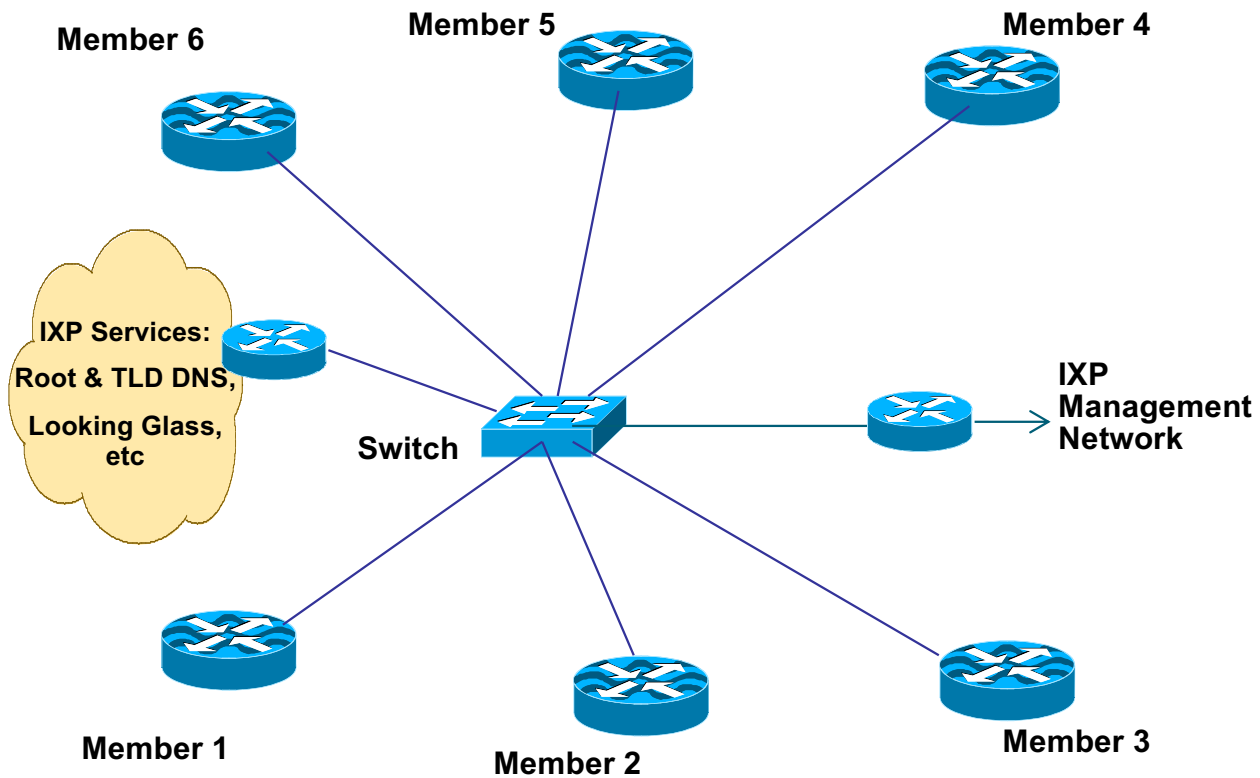
- Unrestricted access:
 - Neutral location, neutral operator
 - Many connectivity access options (fibre etc)
- Maximum bandwidth:
 - Ethernet switch
 - 1G, 10G, N*10G, 100G ports
 - 400G and 1T now “in the works”
- Scaling:
 - Redundant switches
 - Redundant sites



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IXP Detail



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Who can join an IXP?

- Requirements are very simple:
 - Any organisation which operates their own autonomous network
- Member needs to have:
 - Their own address space
 - Their own AS number
 - Their own transit arrangements



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Who can join an IXP?

- Members include:
 - Commercial Network Operators
 - Academic & Research networks
 - Internet infrastructure operators (eg Root/ccTLDs)
 - Content Providers
 - Content Distribution Services
 - Broadcasters and media
 - Government Information networks



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Benefits: Europe

- Internet success story is because of IXPs
 - Early paid transit model was expensive, restrictive, low bandwidth, and high latency
- London:
 - LINX resulted in major companies locating their content with ISPs connected to LINX, before connecting to LINX themselves
 - Now one of the world's largest interconnects
- Amsterdam & Frankfurt
 - AMS-IX and DE-CIX established soon after LINX, following similar model



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Benefits: Nepal

- In 2002, NPTelecom, Mercantile & Worldlink connected to the Internet via satellite
 - Nepalese content was hosted in Europe and the US
 - No domestic content
 - No incentive for local content
- NPIX established
 - Most ISPs connected at launch, big performance improvements, and new business opportunities for Nepalese content development
 - Incumbent reluctantly joined later



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Benefits: Singapore

- Until 2009, Singapore was bypassed
 - There was no open neutral interconnect
 - Incumbent operator owned all access
- Today, after change in policy, Singapore is the interconnect for South and South East Asia
- IXPs & a Carrier Neutral Data Centre
 - Domestic and international interconnects
 - Popular location for major international content providers
 - Popular location for global Tier-1 operators



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Benefits: Vanuatu

- VIX launched in 2012, first IXP in the Pacific
- Prior to submarine fibre, local traffic was over satellite between the 5 Network Operators
- Now the IX brings low latency, high bandwidth, and on-island content caches



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The IXP Success Story

- Neutral location
 - Anyone can install fibre or other connectivity media to access the IXP
 - Without cost or regulations imposed by location
- Secure location
 - Thorough security, like any other network data centre
- Accessible location
 - Easy/convenient for all participants to access
- Expandable location
 - IXPs result in Internet growth, and increasing space requirements within the facility



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The IXP Success Story

- Operation:
 - Requires neutral IXP management
- Funding:
 - All costs agreed and covered equally by IXP participants
 - Hosting location often contributes – the IXP brings them more business
- Availability:
 - 24x7 cover provided by hosting location



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The IXP Success Story

- Industry Standards documented by Euro-IX, the European IXP Association
 - Contributed to by the Euro-IX members
 - <https://www.euro-ix.net/en/>
- IXP BCP
 - General overview of the infrastructure, operations, policies and management of the IXP
- IXP Website BCP
 - Description of what an IXP website should contain



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What can go wrong?

- Network Operators using the “IX” to market their transit services
 - Cashing in on the good name of the IXP ☹️
- Internet Gateways being called IXPs
 - Cashing in on the good name of the IXP ☹️
 - IGs are commercial for-profit transit services
 - Whether they provide Local or International connectivity



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What can go wrong?

- IXPs pricing the membership fee out of reach of operators
 - IXP is meant to benefit all members
- Multiple IXPs serving the same locality
 - An IXP is not a competition
 - Too expensive for network operators to connect to all of them



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What can go wrong?

- IXP trying to compete with membership
 - Offering services the member would normally sell to customers
 - IXP services need to be agreed by all members
- IXP run as a closed privileged club
 - The only membership requirements are address space, ASN and independent transit
 - Competition regulators usually take a dim view of restrictive practices



What can go wrong?

- IXPs charging for traffic
 - This competes with members
 - Port charges are normal
 - Annual membership fee / cost contribution is normal
- Mandatory Peering
 - Forcing all members to peer, against their own business requirements
 - Drives potential members away



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What can go wrong?

- Interconnecting IXPs
 - IXP in one locality connecting its LAN to an IXP in another locality
 - Competes with members
 - Who pays for the link and the traffic?
- Technical errors
 - IXP is an ethernet switch, not a router
 - Members must only connect using routers (no switches)
 - Routing design errors (e.g. not using BGP for route exchange)



IXP Creation

- No economy or circumstance is unique or different
 - The first excuse for not creating an IXP is “we don’t need one”
 - The second excuse for not creating an IXP is “oh, it is different here”
- Every locality has its differences
 - But surely every locality wants to:
 - Keep local traffic local
 - Improve network performance and QoS
 - Improve local Internet economy
 - The available technology is the same for every network operator everywhere
 - There is no excuse for not improving the local Internet



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Eco System Development

- IXP association usually created
 - Formed by members who have a port on the IXP
- IXP association members meet regularly
- IXP Technical community could also meet
 - Network operators meeting, involving network and systems operations technicians & engineers
 - Aligned with IXP Association/member meetings
- IXP could facilitate the creation of a Network Operators Group
 - The same technicians & engineers are involved in both!



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Local Internet Exchange Point

- This is a public peering point serving the local Internet industry
- Local:
 - where it becomes cheaper to interconnect with other operators at a common location than it is to pay transit to another operator to reach the same consumer base
 - can mean different things in different regions!

Regional Internet Exchange Point

- A “local” Internet Exchange Point which has grown to become very popular outside the local area
 - Easy access
 - Inexpensive access
 - Favourable regulatory environment
 - Neutral co-location facilities
- This helps attract network operators from outside the local area
 - Regional Providers peer with each other and sell transit to smaller operators
 - Many show up at several of these Regional IXPs



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Regional Internet Exchange Point

- Also where local operators peer with operators from outside the locality
 - They don't compete in each other's markets
 - Local ISPs don't have to pay transit costs
 - ISPs from outside the locality don't have to pay transit costs
 - Quite often operators of disparate sizes and influences will happily peer – all to defray transit costs
- Singapore and Hong Kong are considered the regional interconnects for SE Asia



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Industry Associations

- IX-F
 - The Internet Exchange Federation
 - <http://www.ix-f.net/>
 - The federation of Internet Exchange Associations
- Euro-IX
 - The European Internet Exchange Association
 - <https://www.euro-ix.net/en/>
 - Members from Europe, associate members from around the world
 - Detailed information documented by member IXPs:
 - On how to start an IXP
 - What the IXP Best Practices are



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Industry Associations

- APIX
 - Asia Pacific Internet Exchange association
 - Meets twice a year, during APRICOT and APNIC conferences
 - <http://apix.asia>
- Af-IX
 - The African IXP Association
 - Meets along with the African Peering Forum
 - <http://www.af-ix.net/>
- LAC-IX
 - The Latin American & Caribbean IX Association
 - <http://www.lac-ix.org/>



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Activities

- Almost every country needs an IXP
 - (Even, each major city needs an IXP)
 - Will grow the domestic Internet economy
- Over the years, many activities to help improve interconnection
 - From the start there have many organisation based efforts
 - Peering Simulation Game at various NOGs in early 2000s
 - Today, the various Peering Fora



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Activities

- Many Peering Fora now
 - From the Global Peering Forum
 - To regional events (AfPIF, EPF, Asia Peering Forum, etc)
 - To Country Peering events
- Peering Fora are there to encourage and help operators to interconnect
 - Privately (direct cross connect)
 - Publicly (at IXPs)



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Summary

- Peering is vital for:
 - The growth of the Internet economy
 - Improvement in user experience by reduction of latency and increase of throughput
- IXPs are a fundamental part of the Peering EcoSystem
- Without peering and without IXPs, the Internet would be a very different place today



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