



GRAND DUCHY OF LUXEMBOURG
Ministry of Foreign Affairs

Directorate for Development Cooperation



European Union Africa
Infrastructure Trust Fund

Introduction to Regional IXPs

Description of a Regional IXP



INTRODUCTION TO IXPS

What is an IXP ?

- An Internet exchange point (IXP) enables local networks to efficiently exchange information at a common point within a country rather than needing to exchange local Internet traffic overseas.
- Therefore an IXP is a component of Internet infrastructure that can increase the affordability and quality of the Internet for local communities.

How IXPs Work

- The Internet is an interconnection of networks, each controlled by separate entities
- Those entities are generally called Internet Service Providers (ISP), and the networks they control are called Autonomous Systems (or AS) [RFC1930](#).
- In order to have connectivity to the "global Internet", the AS of an ISP must be connected to the AS of at least one other ISP which already has "global Internet" connection.
- This is called "buying transit", as the process usually involves an economic transaction.
- Autonomous Systems are interconnected via the BGP protocol [RFC4271](#).

How IXPs Work

- All Internet Service Providers must buy transit, with the exception of a small number of very large ISPs (called "Tier 1" ISPs), who get global Internet connectivity simply by being interconnected with each other.
- In this model, all Internet traffic flowing between smaller ISPs (also called "Tier 2" ISPs) has to pass through their upstream providers' networks.
- Some of the Tier 2 ISPs decide to interconnect their AS directly, in order to reduce the amount of different networks (the number of 'hops') the traffic has to traverse, and at the same time save some transit costs. This practice is called "peering".

IXP Best Practices

- The IXP provides a layer 2 shared switch fabric for peering networks to interconnect
- There must be at least 3 networks (ASNs) connected for a facility to be considered as an IXP
- The IXP should have neutral ownership and or management
- The IXP should be at a secure location
- The IXP should have a website with basic information such as;
 - Contact Information
 - Peering members information
 - Peering statistics
 - Membership and Joining
 - Peering and technical policy

IXP Best Practices

- IXPs are not, generally, involved in the peering agreements between connected ISPs;
- IXPs do not provide services that compete with its members such as;
 - Commercial hosting services
 - Transit services

IXP Technical Aspects

- The IXP technical setup is designed to be “easy to get started”
- ISPs connect to the core of the IXP “a layer 2 switch” using either Ethernet or Fibre optic connections
- The IXP team does not need routing knowledge
- The IXP does not gain routing control of its peering members network
- ISPs free to set up peering agreements with each other as they wish
- More complicated to distribute over wide area

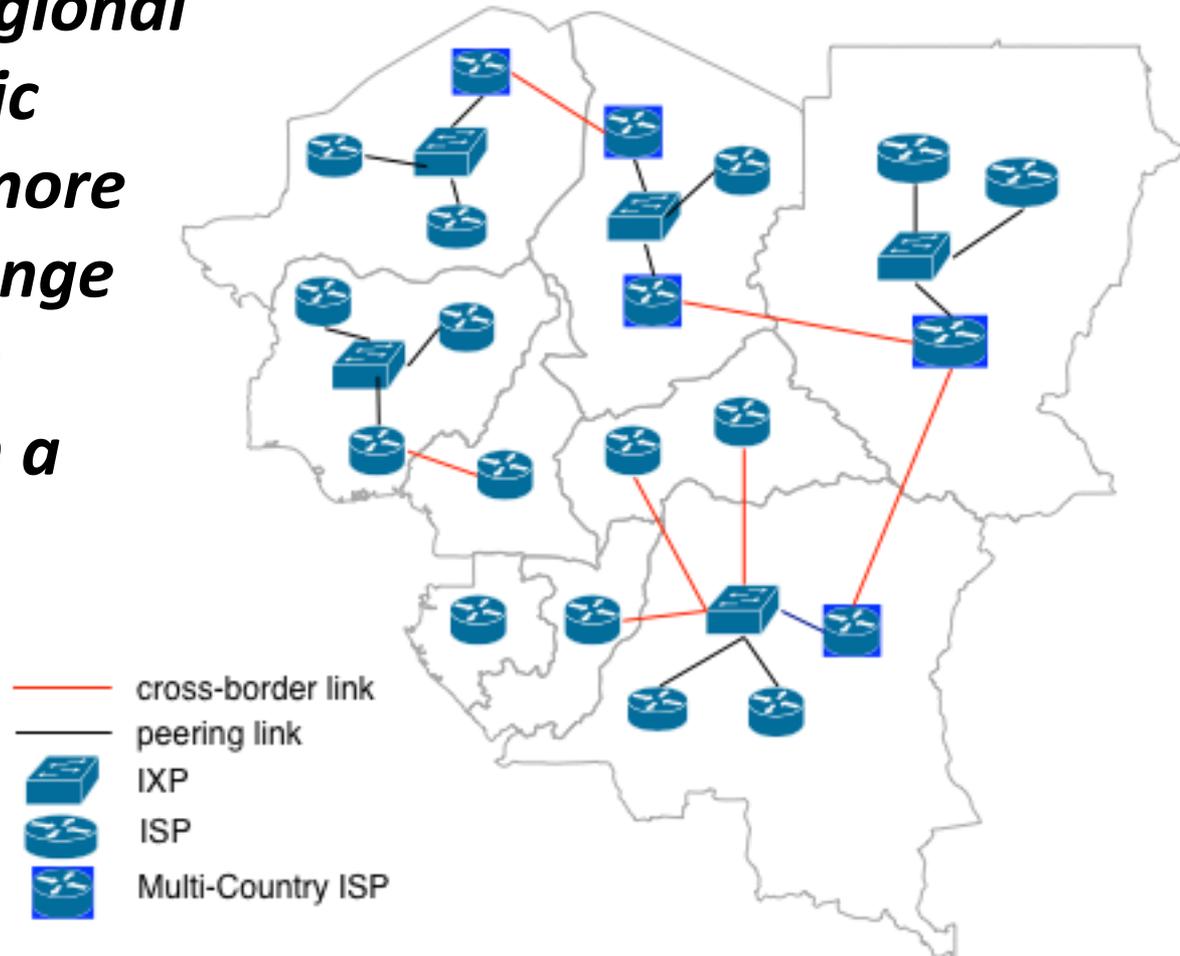
REGIONAL IXP

Description Considerations

- ① The large IXPs in around the world do not define themselves any differently from smaller IXPs (such as regional or global), despite having ISPs from other continents i.e Africa, Asia and Europe as peering members.
- ② The large IXPs today were initially established as local IXPs and they managed to grow and attract peers from outside their geographic locale
- ③ An IXP can have peers from a country, region or different time-zone
- ④ The word “region” in this context is used to refer to the grouping of countries under one geographic area. The African Union has grouped African countries under 5 geographic regions.

Description of a Regional IXP

- Description: *“A regional IXP is where traffic between two or more countries is exchanged via public (IXP) or private peering in a third country”*



Establishing Regional IXPs

- There are three (3) proposed approaches to establishing regional IXPs;
 1. Interconnecting existing IXPs to create a regional IXP
 2. Building a Regional IXP
 3. Evolving national/local IXPs into Regional IXPs.
- Lets review each one independently.

**1. Interconnecting existing IXPs
to create a regional IXP**

Interconnecting IXPs

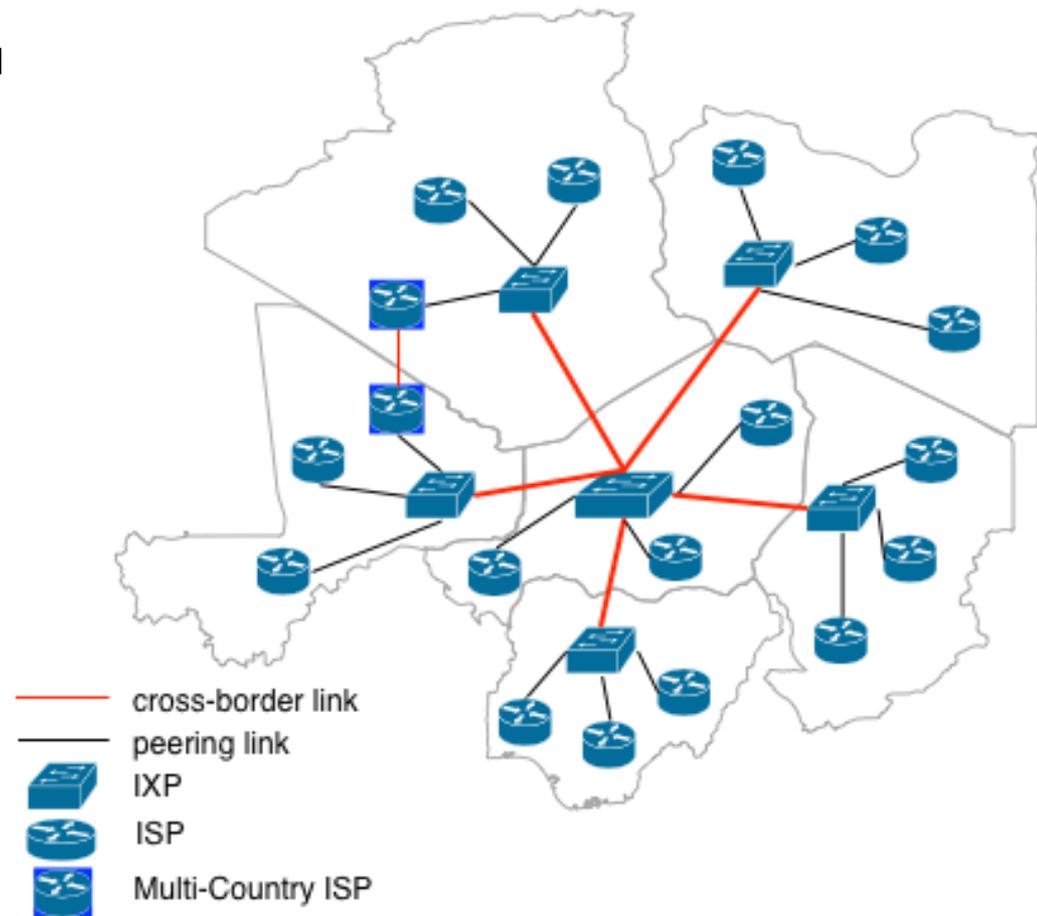
- **Assumptions;**
 - At least some or all countries in the region have an operational IXP
 - There is cross-border terrestrial infrastructure in place
- **Considerations;**
 - Technical Architecture
 - Business Model and Sustainability
 - Policy and Governance

Interconnecting IXPs: Technical Architecture

- Layer 2 vs. Layer 3 considerations;
 - Most IXPs in Africa operate a layer 2 network
 - Extending layer 2 networks over long distances has technical challenges
 - Layer 3 is easier to extend but introduces undesired elements to the network
 - i. Introduces a transit ASN
 - ii. Loss of routing control for ISPs
- Interconnecting IXPs and networks can be accomplished using three (3) design topologies;
 - Star Topology
 - Ring Topology
 - Mesh Topology

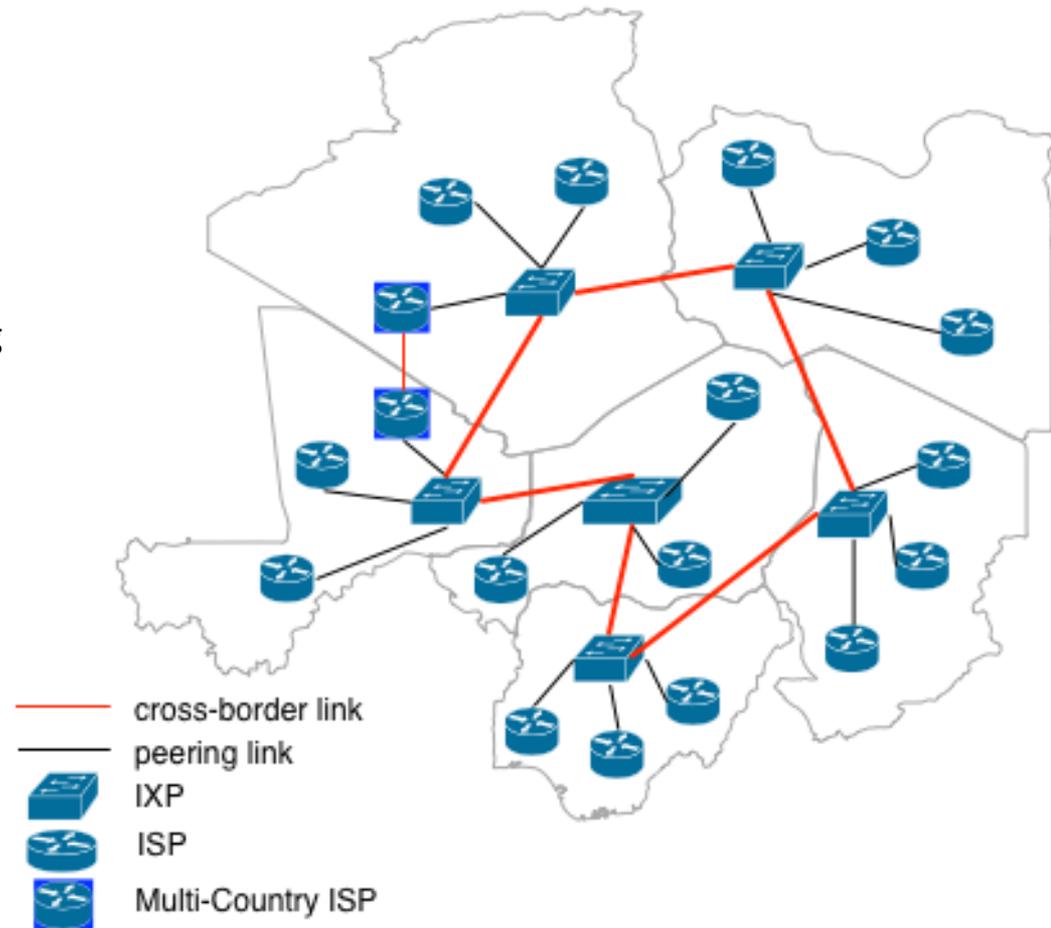
Technical Architecture: Star Topology

- **Considerations**
 - Location of IXP would have to be central for all to Interconnect
- **Pros;**
 - The regional IXP has reduced administrative task of managing a large ISP base.
 - Most of the responsibility lies with the local IXPs
- **Cons;**
 - The regional IXP is a single point of failure.
 - Implementing redundancy on the links may be costly
 - High cost of implementation for interconnection, hardware, human resource at local and regional IXPs
 - ISPs that have invested in cross-border infrastructure may be disadvantaged



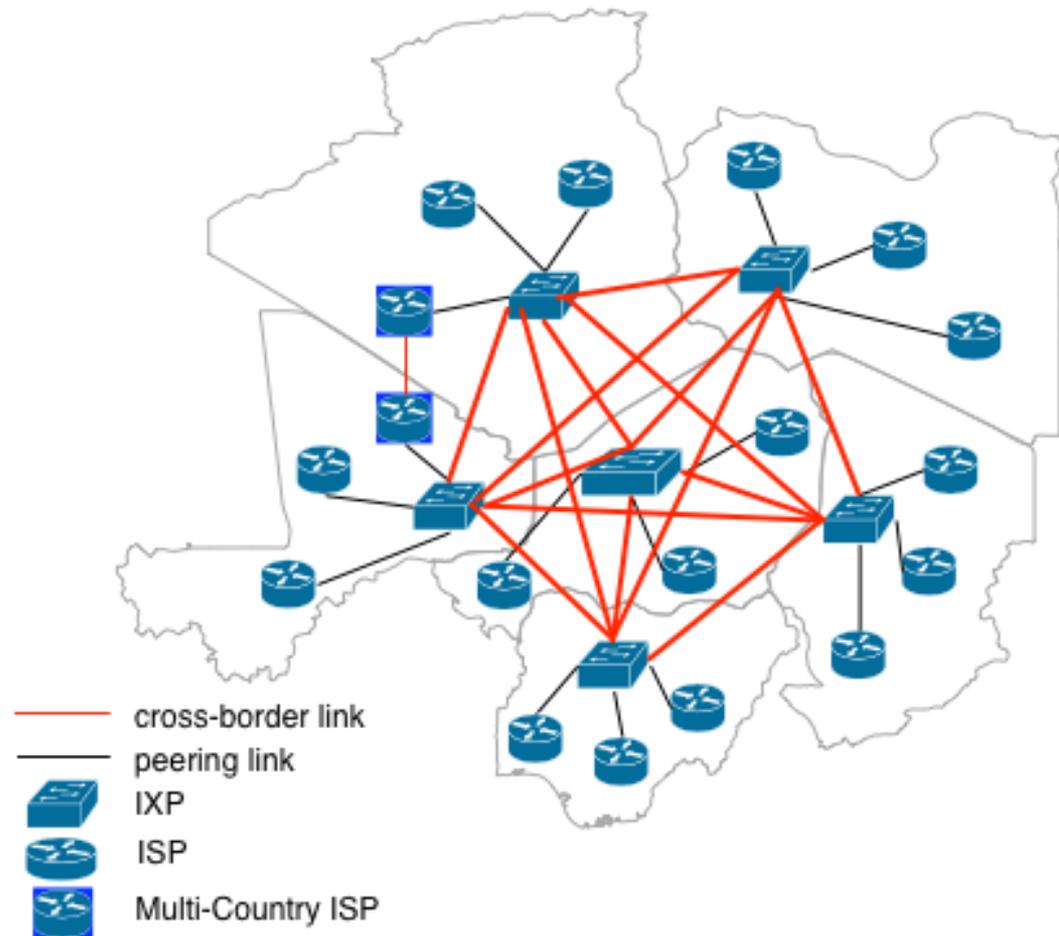
Technical Architecture: Ring Topology

- **Considerations;**
 - Each IXP is critical for efficiency
 - The capacity between any two IXPs must be greater than the highest peak traffic between any of the IXPs
- **Pros;**
 - Minimal setup requirements for existing IXPs
 - Built in redundancy should one IXP fail
 - Low cost of implementation
- **Cons;**
 - IXP member policies would need to be harmonized for consistency
 - Outage at one IXP or link may affect quality of service
 - Outage on two IXPs or two links would isolate at least one IXP completely
 - Small IXPs would be required to acquire high capacity links to



Technical Architecture: Mesh Topology

- **Considerations;**
 - Each IXP will have independent connections to each IXP in the region
 - The capacity to each IXP will vary based on the traffic between the two IXPs
- **Pros;**
 - Very efficient in delivering traffic
 - Highly redundant due to alternative paths
 - Highly scalable model
- **Cons;**
 - Expensive to setup and maintain
 - Require skilled staff at each IXP to maintain and support the operations
 - Alternative paths (transiting via an IXP when direct links have an outage) may affect quality of service - similar to ring topology



Interconnecting IXPs: Business Model

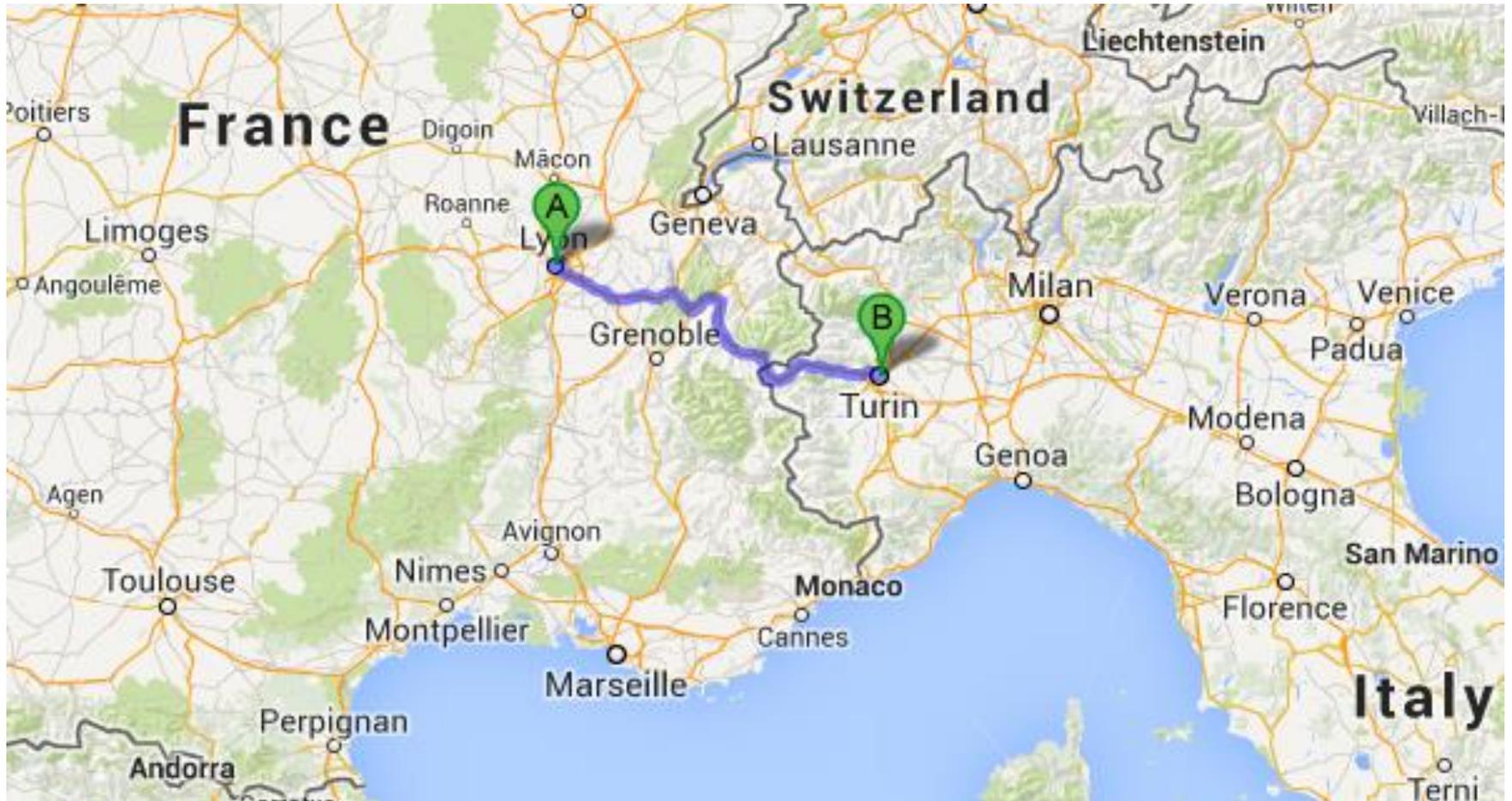
- Some IXPs do not have a self sustaining business model. Interconnection would require the IXP to have a sustainable revenue source
- In the 3 topology architectures there are increased operational overheads on;
 - Connectivity cost between IXPs
 - Equipment upgrade costs
 - Skilled staff
- **Business and billing aspects**
 - Service Level agreements would have to be signed between the IXPs
 - Cost of sending traffic via IXP links (peering) vs. International links (transit) may be skewed in favor of transit
 - Billing ISPs based on their traffic to other IXPs is complex
 - Cost sharing of connectivity costs between two IXPs with unequal traffic volumes will be complex
- **Growth Potential**
 - Each IXP is limited to membership from its local country
 - Only IXPs that have access to submarine cables can grow International membership
 - IXPs in a small economy and with few members would struggle with operational sustainability

Interconnecting IXPs: Policy & Governance

- **Ownership and Neutrality**
 - The star topology location of the regional IXP may be subjected to political interests.
 - The star topology has significant concerns on ownership and neutrality
 - The Star topology ownership and governance structure would need to be discussed
- **Policy Harmonization**
 - Each IXP has unique policies on membership, technical, peering, fees, etc.
 - Cross-cutting policies on membership, technical, peering, etc. would have to be harmonized between the IXPs
- **Governance**
 - Some IXPs lack a structured/formal local governance and management structures. Interconnection would require them to implement the structures and formalize the IXP
 -

Interconnecting IXPs: Case Study

Interconnection between Lyon-IX in Lyon, France and TOPIX in Torino, Italy



How it works: Technical Setup

Technical Setup

- There is a 10Gbps connection between Lyon and Torino
- The link uses WDM technology
- Layer 2 service
- Route-Server is used to for interconnection
- Members of Lyon-IX can get ToPIX IP and vice versa

Policy and Business Model

- Monthly recurrent cost (MRC) on the link is €2,000/pm
- IXP interconnection service is provided as value added service to members (no additional charges)
- Traffic is not limited between the IXPs

Interconnection growth path

- The service started with a 100mbps link. This only attracted smaller members. Traffic between the two IXPs was 20mbps
- The link was upgraded to 1Gbps. This attracted additional members. Traffic grew to 300mbps.
- The link was upgraded to 10Gbps. This has received the attention of larger operators. The traffic is now at 500mbps.

Summary

- The distance between Lyon and Torino is over 300Kms
- There is cross-border interconnection between France and Italy
- There is competition on cross-border interconnection hence the low cost of 10Gbps for €2,000/pm

Conclusion

- Interconnection of existing IXPs has high recurrent costs implications
- Successful interconnection would require increased commitments from the existing IXPs
- There are few instances where IXPs have interconnected successfully.
- Where interconnection has been successful, the IXPs were already well established
- Interconnection is largely dependent on having an enabling environment for;
 - Competition on cross-border interconnection

2. Building a Regional IXP

Considerations

- To build a regional IXP the following considerations should be assessed carefully;
 - **Location Viability**
 - Market Potential
 - Infrastructure Investments
 - Political environment
 - Policy and Regulatory Framework
 - Social & Economic
 - **Operational Aspects**
 - Financial and business model
 - Competition and threat to creation of and existing IXPs
 - Ownership, Neutrality and Governance

Location

- **Market Potential**
 - Number of ISPs/Operators in market
 - Growth opportunities of new members
 - Content providers attraction potential
 - Local aggregate eyeball potential
- **Infrastructure Investments**
 - National Long haul terrestrial Infrastructure
 - Metro terrestrial infrastructure
 - cross-border terrestrial infrastructure
 - Multiple submarine cables
 - Data centers
- **Political Environment**
 - Political stability
 - Political interference

Location

- **Policy and Regulatory Framework**
 - License requirement to setup an IXP
 - Cross-border interconnection policy
 - Peering requirements – i.e licenses, local operation, etc.
 - Transit requirements – i.e licenses, local operation, etc.
 - Critical Infrastructure protection
 - Telecommunications taxation
 - Licensing requirement for content providers
- **Social Economic**
 - Skilled human resource
 - Infrastructure security
 - Local currency stability
 - Cross-border financial services (forex, bank-transfers, etc)

Operational Aspects

- **Financial and business model**
 - Setup costs
 - Funding sources
 - Revenue potential
- **Competition and threat to creation of or existing IXPs**
 - Implication to creation of new national/local IXPs in countries without IXPs
 - Medium to long term threat to existing national/local IXPs
 - The incentives for ISPs to peer at regional IXP over the national/local
 - High cost of regional/cross-border interconnection compared to transit
- **Ownership, Neutrality and Governance**
 - Ownership of regional IXP
 - Maintaining neutrality of the regional IXP
 - Open and transparent operations

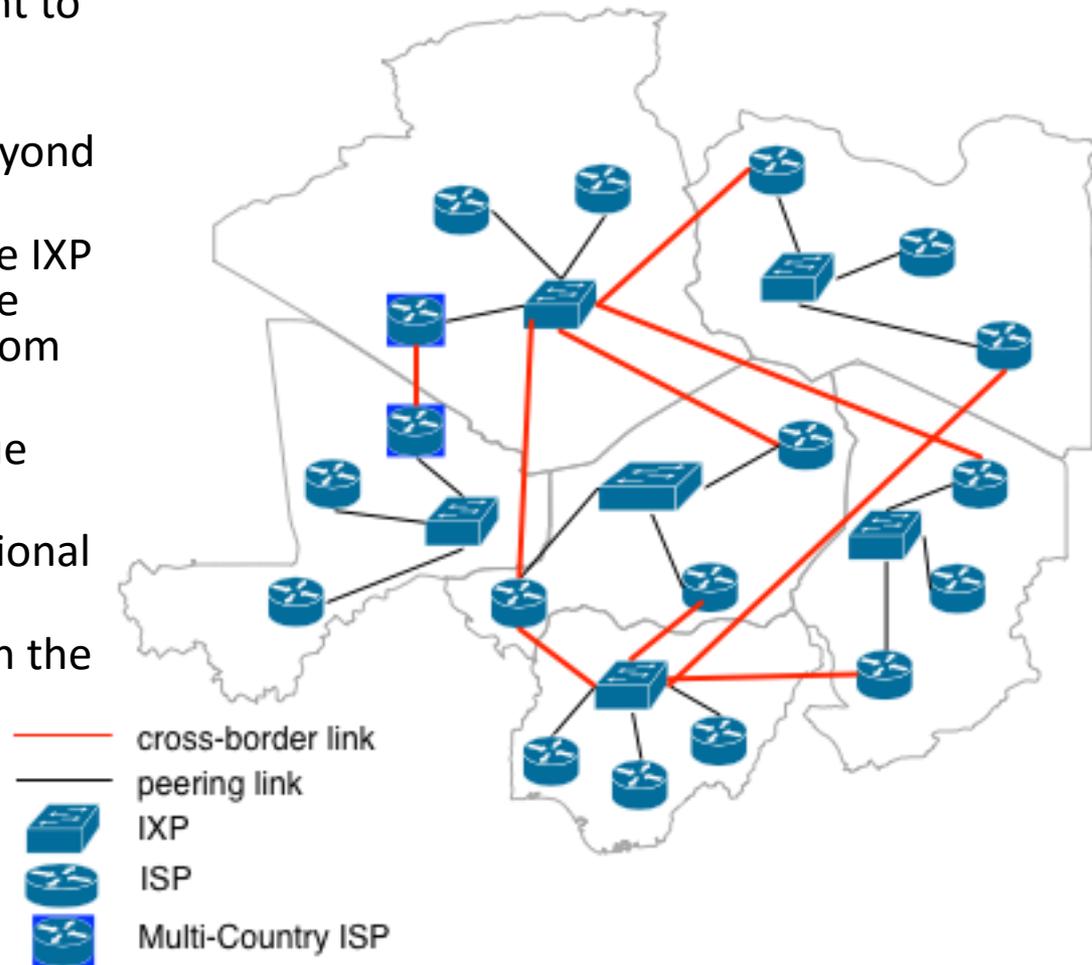
Observations

- Building a regional IXP from the bottom up requires high investment
- The region and market may not be ready for an additional IXP (where local IXPs exist)
- The regional IXP may undermine efforts to develop local peering in favor of regional peering

3. Evolving national/local IXPs into Regional IXPs.

The approach

- The evolution of a national IXP requires an enabling environment to support its growth
- The IXPs compete to attract for membership from within and beyond their geographical locale
- An ISP can peer in more than one IXP in different cities/countries in the region based on value derived from each IXP
- The IXP that offers the most value attracts more members
- There can be more than one regional IXP in the region
- The regional IXPs can be either in the same country/city or in different country/city



Advantages

- Each IXP has an equal opportunity to become a regional IXP.
- In a thriving and competitive regional environment, there can be more than one regional IXP without any negative market implications
- Therefore the threat to existing IXPs or the creation of new IXPs in countries without is eliminated.
- Ownership and Neutrality are inherently designed into most established IXPs
- Any initial investments aimed at supporting the IXP grow to become regional would have an a base business model that has growth potential
- Each location has a strategic advantage
- IXP growth opportunity exists, as an ISP can peer at all IXPs in its region



LINX - **France-IX** - **AMS-IX** - **DE-CIX** - **Netnod**

Conclusion

- The evolution of national/local IXPs into Regional IXPs provides a low entry barrier to resolving regional interconnection
- The emergence of the regional IXPs also presents opportunities for ISPs to grow and become regional carriers
- The emergence of regional IXPs attracts international operators such as transit providers, content providers, etc.
- The benefits are more long term with opportunities for more than one IXP growing to become regional
- The enabling factors can be classified into 3 areas;
 - Policy and Regulatory Environment
 - Commercial Environment
 - Operational and Technical Environment
- This will be discussed at length during the course of the workshop



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