Internet Exchange Point Design

ISP/IXP Workshops

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- Bug fixes and improvements are welcomed
  - Please email *workshop (at) bgp4all.com*

Philip Smith

IXP Design

- Background
- Why set up an IXP?
- Layer 2 Exchange Point
- Design Considerations
- Route Collectors & Servers
- What can go wrong?

A bit of history

Where did the IX concept come from?

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
  - New York – run by Sprint
  - San Francisco – run by PacBell
  - Vienna (Virginia) – run by MFS

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:
  - CIX-West – west coast USA (Bay Area)
  - MAE-East – east coast USA (Virginia)
- Routing Arbiter project helped with coordination of routing exchange between providers
  - Traffic from ISP A needs to get to ISP B
  - Now superseded by today's Internet Routing Registries (IRR)
  - The RADB is the remnant of the Routing Arbiter project

More History still…

- End of the NSFnet in 1995:
  - Meant move towards commercial Internet
  - Private companies selling their bandwidth
- The NAPs established late in NSFnet life were some of the original "exchange points"
  - NAP operators were providing commercial Internet access as well
  - Sprint, PacBell and Ameritech NAPs were replaced by neutral/commercial IXPs
  - The MFS hosted MAE-East replaced the Vienna NAP
  - ANS (operator of the late NSFnet) forced to join IXes
- A global Distributed GIX proposed in mid 1990s
  - But never happened (planned to be CIX-West, MAE-East, SE-GIX and a Paris IX)

Even more History

- SE-GIX formed in Stockholm in 1992
  - Three major ISPs 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)
- HKIX formed in Hong Kong in 1995
  - Vibrant Internet community, many small operators
  - Latency, performance, and local traffic benefits

Internet Exchange Point

- What:
  - **A neutral location where network operators freely interconnect their networks to exchange traffic**
- What is the physical IX:
  - An ethernet switch in a neutral location
- How does it work:
  - IX Host provides the switch and rack space
  - Network Operators bring routers, and interconnect them via the IX fabric
- Very simple concept – any place where providers meet to exchange traffic

Internet Exchange Point

- Layer 2 exchange point
  - Ethernet (100Gbps/10Gbps/1Gbps/100Mbps)
  - Older technologies used in the past included ATM, Frame Relay, SRP, FDDI and SMDS
- Layer 3 exchange point
  - *Has had historical status since mid-90s*
  - Router based
    - Best known example was CIX-West
    - Router quickly overwhelmed by the sophisticated requirements of the rapidly growing Internet

Why an Internet Exchange Point?

Saving money, improving QoS,
Generating a local Internet economy

Internet Exchange Point
Why peer?

- Consider a region with one ISP
  - They provide internet connectivity to their customers
  - They have one or two international connections
- Internet grows, another ISP sets up in competition
  - They provide internet connectivity to their customers
  - They have one or two international connections
- How does traffic from customer of one ISP get to customer of the other ISP?
  - Via the international connections

Internet Exchange Point
Why peer?

- Yes, International Connections…
  - Major content may be tens if not hundreds of milliseconds away
  - If satellite, RTT is around 550ms per hop
    - So local traffic between two operators would take over 1s round trip
    - Huge disincentive for a local Internet economy
- International bandwidth
  - Costs significantly more than domestic bandwidth
  - Is congested with local traffic
  - Local traffic on international links wastes money for both operators, harms overall performance for all users

Internet Exchange Point
Why peer?

- Solution:
  - Two competing ISPs peer with each other
- Result:
  - Both save money
  - Local traffic stays local
  - Better network performance, better QoS,…
  - More international bandwidth for expensive international traffic
  - Everyone is happy

Internet Exchange Point
Why peer?

- A third ISP enters the equation
  - Becomes a significant player in the region
  - Local and international traffic goes over their international connections

- All three ISPs agree to peer with each other to:
  - Save money for all three
  - Keep local traffic local
  - Improve network performance
  - Improve service quality for end users
  - Improve value proposition for local content hosting

Internet Exchange Point
Why peer?

- Private peering means that the three ISPs have to buy circuits between each other
  - Works for three ISPs, but adding a fourth or a fifth means this does not scale
- Solution:
  - Internet Exchange Point

Internet Exchange Point

- Every participant has to deploy just one link
  - From their premises to the IXP
- Rather than N-1 links to connect to the N-1 other ISPs
  - 5 ISPs will have to share the cost of 4 links = 2 whole links → already twice the cost of the IXP connection

Internet Exchange Point

- Solution
  - Every ISP participates in the IXP
  - Cost is minimal – one local link covers all domestic traffic
  - International links are used for just international traffic – and backing up domestic links in case the IXP suffers any outage
- Result:
  - Local traffic stays local
  - QoS considerations for local traffic is not an issue
  - RTTs between members are typically sub 1ms
  - Customers enjoy the Internet experience
  - Local Internet economy grows rapidly

Who can join an IXP?

- Requirements are very simple: any organisation which operates their own autonomous network, and has:
  - Their own address space
  - Their own AS number
  - Their own transit arrangements
- This often includes:
  - Commercial ISPs
  - Academic & Research networks
  - Internet infrastructure operators (eg Root/ccTLDs)
  - Content Providers & Content Distribution Services
  - Broadcasters and media
  - Government Information networks

When an IXP is not beneficial

- Legislation: When there is one legislated monopoly transit provider
  - With all other network operators are legislated to be customers of this monopoly provider
- Geography: When the local economy is so small that it cannot sustain more than one network operator
  - Very small nations (maybe less than 10000 population?)
  - Sparsely populated / remote areas

When an IXP is not permitted

- This is still the situation in several countries around the world
- Usually it is a Government operated "national telco"
  - ISP licence mandates connecting to "national telco" for Internet services
- Implications:
  - Expensive domestic connectivity
  - Expensive international connectivity
  - Restricted and poor service offerings
  - No domestic Internet economy
  - Everyone looses, especially the "national telco"

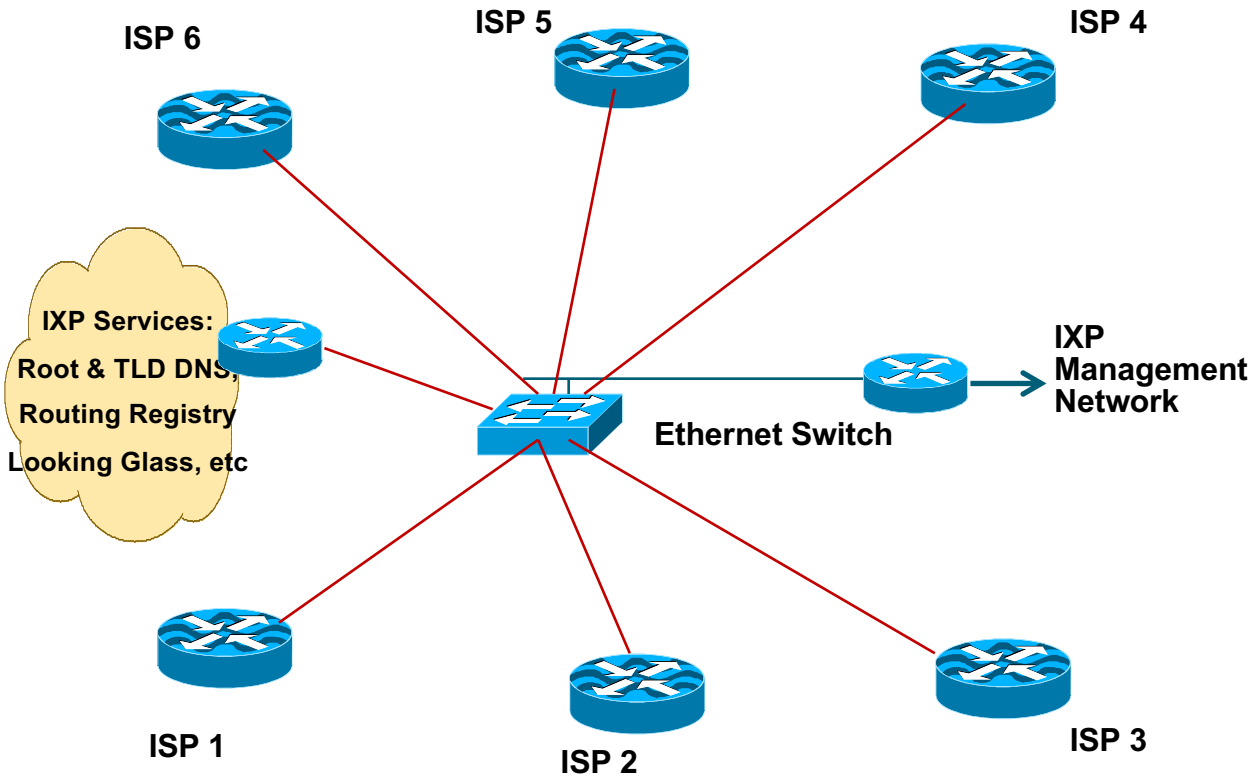
Layer 2 Exchange

The global industry standard IXP

IXP Design

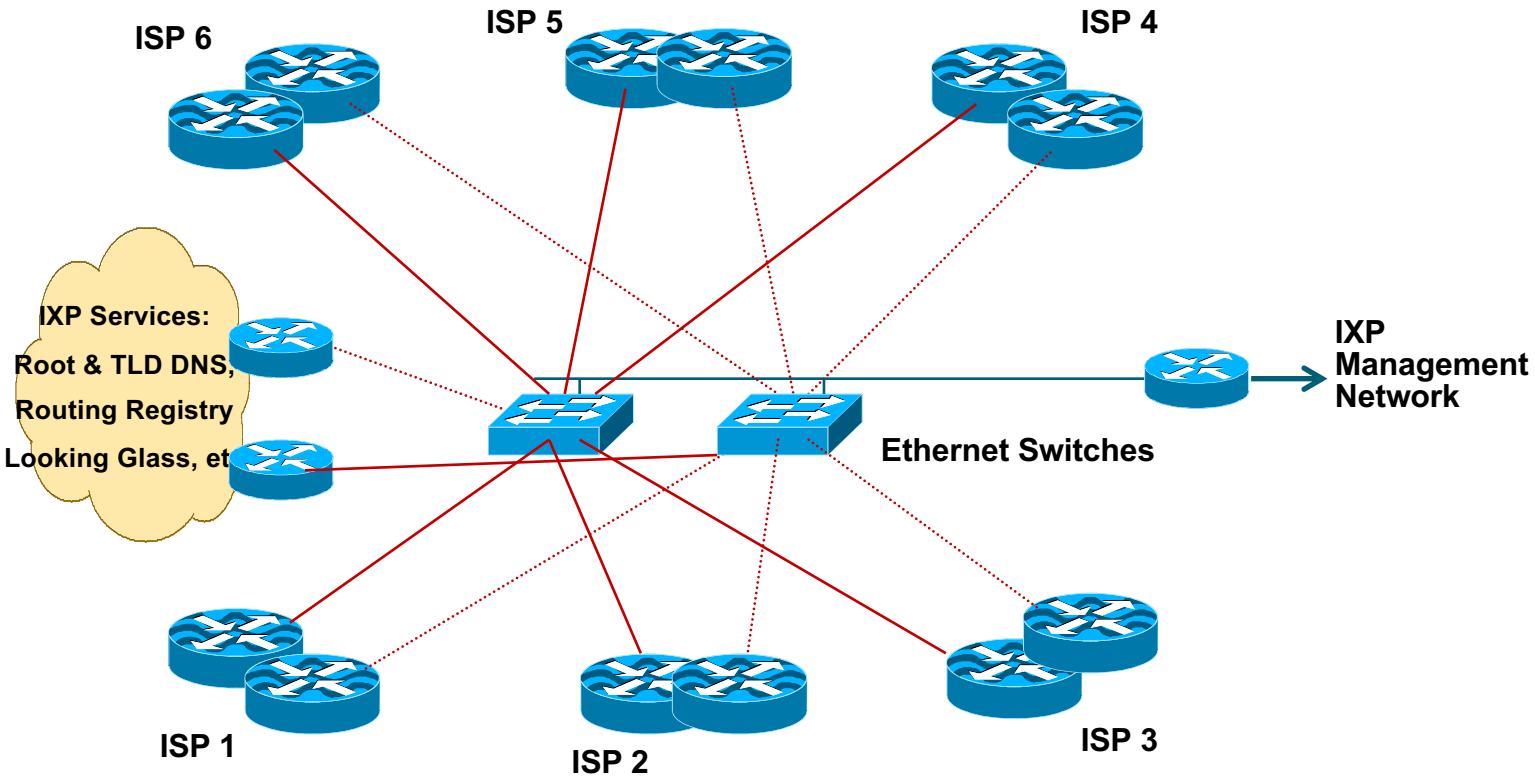
- Very simple concept:
  - Ethernet switch is the interconnection media
    - IXP is one LAN
  - Each ISP brings a router, connects it to the ethernet switch provided at the IXP
  - Each ISP peers with other participants at the IXP using BGP
- Scaling this simple concept is the challenge for the larger IXPs

Layer 2 Exchange



Single site internet exchange point

Layer 2 Exchange



Dual site internet exchange point – not interconnected

Layer 2 Exchange

- Two switches for redundancy
- ISPs use dual routers for redundancy or loadsharing
- Hosts services for the “common good”
  - Internet portals and search engines
  - DNS Root & TLDs, NTP servers
  - Routing Registry and Looking Glass

Layer 2 Exchange

- 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

Layer 2 Exchange

- Operation:
  - Requires neutral IXP management
  - "Consortium"
    - Representing all participants
    - "Management Board" etc
- 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
    - Managed by the consortium

Layer 2 Exchange

- Configuration
  - Recommendation: Public address space for IXP LAN
    - IPv4 (/24) and IPv6 (/64)
  - ISPs require AS, basic IXP does not
- Network Security Considerations
  - LAN switch needs to be securely configured
  - IXP Management & Services router(s) require well protected access
  - IXP services must be behind router(s) with strong filters

IXP Standards

- Industry Standards documented by Euro-IX, the European IXP Association
  - Contributed to by the Euro-IX members
  - https://www.euro-ix.net/en/forixps/set-ixp/
- IXP BCP
  - General overview of the infrastructure, operations, policies and management of the IXP
  - https://www.euro-ix.net/en/forixps/set-ixp/ixp-bcops/
- IXP Website BCP
  - https://www.euro-ix.net/en/forixps/set-ixp/ixp-bcops/ixp-website/

“Layer 3 Exchange”

Why this is not an IXP

“Layer 3 IXP”

- Layer 3 IXP today is marketing concept used by Transit ISPs
  - Some incumbent telcos call their domestic or international transit businesses “Exchanges”
- Real Internet Exchange Points are only Layer 2
  - L2 is the accepted International standard

“Layer 3 IXP” – what breaks

- One extra AS hop between peers
  - Makes path via IXP suboptimal/less preferred
  - Path between peers usually remains with upstream transit provider
    - Unless both peers actively implement BGP policies to prefer the L3 IXP
- Members cannot peer with whom they please
  - Mandatory multilateral peering
  - Third party (L3 IXP operator) required to configure peering sessions and peering policy

“Layer 3 IXP” – what breaks

- More complicated troubleshooting
  - Troubleshooting peering problems has to involve IXP operator too
- No policy control
  - BGP attributes shared between members get dropped by IXP router
  - (Examples are BGP communities, MEDs)

“Layer 3 IXP” – what breaks

- CDNs won’t join
  - They have requirements to peer directly with IXP members
- Redundancy problems
  - L3 IXPs with dual sites appear as two separate transit providers between peers
  - Traffic engineering?
- L3 IXP Operator requires strong BGP skills

IXP Design Considerations

Exchange Point Design

- The IXP Core is an Ethernet switch
  - It must be a managed switch
  - It must have reasonable security features
  - https://www.euro-ix.net/ixp-wishlist has more details
- Has superseded all other types of network devices for an IXP
  - From the cheapest and smallest managed 12 or 24 port 100M/1G switch
  - To the largest switches now handling high densities of 10GE, 40GE and 100GE interfaces

Exchange Point Design

- Each ISP participating in the IXP brings a router to the IXP location
  - Note that with increased availability of fibre access, ISPs connect directly to the IXP without provisioning a dedicated router at the IXP location
- Router needs:
  - One Ethernet port to connect to IXP switch
  - One WAN port to connect to the WAN media leading back to the ISP backbone
  - To be able to run BGP

Exchange Point Design

- IXP switch located in one equipment rack dedicated to IXP
  - Also includes other IXP operational equipment
- Routers from participant ISPs located in neighbouring/adjacent rack(s)
- Copper (UTP) connections made for 100Mbps or 1Gbps connections
- Fibre used for 1Gbps, 10Gbps, 40Gbps or 100Gbps connections

Peering

- Each participant needs to run BGP
  - They need their own AS number
  - **Public** ASN, **NOT** private ASN
- Each participant configures external BGP directly with the other participants in the IXP
  - Peering with all participants

    or
  - Peering with a subset of participants

Peering (more)

- Mandatory Multi-Lateral Peering (MMLP)
  - Each participant is forced to peer with every other participant as part of their IXP membership
  - **Has no history of success** — the practice is strongly discouraged
- Multi-Lateral Peering (MLP)
  - Each participant peers with the other participants (usually via a Route Server)
- Bi-Lateral Peering
  - Participants set up peering with each other according to their own requirements and business relationships
  - This is the most common situation at IXPs today

Types of Operator Peering Policies

- Open Peering
  - Where an ISP publicly states that they will peer with all parties who approach them for peering
  - Commonly found at IXPs where ISP participates via a "Route Server"
- Selective Peering
  - Where an ISP's peering policy depends on the nature of the operator who requests peering with them
  - At IXPs, operator will not peer with the "Route Server" but will only peer bilaterally
- Restrictive Peering
  - Where an ISP decides who its peering partners are, and is generally not approachable to creating peering opportunities

Operators Peering Activities

- The Peering Database documents ISPs peering policies and contact information
  - https://peeringdb.com
- All operators of ASNs are encouraged to register in the peeringdb
  - All operators who are considering peering or are peering must be in the peeringdb to enhance their peering opportunities
- Participation in peering fora is encouraged too
  - Global Peering Forum (GPF)
  - Regional Peering Fora (European, Middle Eastern, Asian, Caribbean, Latin American)
  - Many countries now have their own Peering Fora

Routing Advice

- ISP border routers at the IXP must NOT be configured with a default route or carry the full Internet routing table
  - Carrying default or full table means that this router and the ISP network is open to abuse by non-peering IXP members
  - Correct configuration is only to carry routes offered to IXP peers on the IXP peering router
- Note: Some ISPs offer transit across IX fabrics
  - They do so at their own risk – see above

Routing Advice (more)

- ISP border routers at the IXP should not be configured to carry the IXP LAN network within their iBGP
  - Use next-hop-self BGP concept
  - Keeping IXP LAN address block in IGP ensures that traceroutes do not break

- Don't generate ISP prefix aggregates on IXP peering router
  - If connection from backbone to IXP router goes down, normal BGP failover will then be successful

Address Space

- Some IXPs use private addresses for the IX LAN
  - Public address space means IXP network could be leaked to Internet which may be undesirable
  - Because most ISPs filter RFC1918 address space, this avoids the problem
- Most IXPs use public addresses for the IX LAN
  - Address space available from the RIRs via specific RIR policies
  - IXP terms of participation often forbid the IX LAN to be carried in the ISP member backbone
- IXPs provide both IPv6 and IPv4 support on IX LANs
  - No need for separate LANs for IPv6 and IPv4

Autonomous System Numbers

- IXPs by themselves do not require ASNs
  - Ethernet switch is L2 device, and does not run BGP
- Some IXPs have a Route Collector
  - This usually runs in a private ASN
- Some IXPs have a Route Server
  - This usually runs in a public ASN
- Some IXPs have “common good services”
  - These usually require Internet transit
  - Meaning the IXP requires a transit router
    - IXP arranges transit for services with a couple of providers
  - And this transit router requires a Public ASN and Public Address space

Hardware

- Ethernet switch needs to be managed
  - Including CLI access rather than only SNMP
  - Unmanaged switches mean an unmanageable IXP
- Insist that IXP participants connect a router (L3) port to the IXP switch
  - Avoid spanning tree and L2 security issues
  - Run port security or MAC filtering to protect the IX
- Insist that IXP participants bring their own router
  - Moves buffering problem off the IXP switch
  - (Fibre access to IX reduces this requirement)
  - Security of ISP connection is responsibility of the ISP, not the IXP

Charging

- IXPs needs to be run at minimal cost to its member participants
- Common examples:
  - Datacentre hosts IX for free
  - IX members pay a flat annual fee (cost recovery)
  - Differential pricing per port (line card basis)
- IXes do **NOT** charge for traffic crossing the switch fabric
  - They are a peering enabler, encouraging as much traffic as possible between members

Charging:
Datacentre hosts IX for free

- Datacentre covers all costs relating to the IX
  - They provide the switch and supporting infrastructure
  - They provide the operator cover
  - They benefit from the business the IX members and their customers bring to the DC
  - They benefit from the "prestige" of hosting the IX and its ancillary services
- The IX does not charge members for anything at all
  - Example: Seattle IX

Charging:
IX Members pay flat fee

- Each member pays a flat annual fee towards their IX membership
- How it works:
  - Cost of switch and ports
  - Cost of operator support
  - Datacentre cost: power, air-conditioning, etc
  - Cost of IX membership association
  - Contingency needed for new equipment and upgrades
- Total annual cost shared equally amongst members
  - The more members, potentially the lower the costs for each

Charging: Differential pricing by port

- IXP Member pays according to the port speed they require (big IXP switches)
  - One linecard may handle 4 100GE ports
  - Or one linecard may handle 24 10GE ports
  - Or one linecard may handle 96 1GE ports
  - 96 port 1GE card is tenth price of 24 port 10GE card
  - Relative port cost is passed on to participants
  - Plus share in the cost of the switch
  - Plus all the costs mentioned in the flat-fee model
- IX members pay according to the cost of provisioning their port speed
  - Example: Netnod IXes in Sweden

Notes about charging

- Smaller or new IXPs:
  - Free, or flat fee, for members
  - 1RU switch supporting 100/1G/10G on all ports
  - Members are responsible for providing suitable optics

- Larger or longer established IXPs:
  - Chassis based switches, linecards have different costs
  - Members pay contribution to cost of linecard (hence port charge), often including cost of optics too

Services Offered

- Services offered should not compete with member ISPs (basic IXP)
  - e.g. web hosting at an IXP is a bad idea unless all members agree to it
- IXP operations should make performance and throughput statistics available to members
  - Use tools such as LibreNMS to produce IX throughput graphs for member (or public) information

Services to Offer

- Root server
  - Anycast instances of F, I and L root nameservers are present at many IXes
- ccTLD DNS
  - The country IXP could host the country's top level DNS
  - e.g. "SE." TLD is hosted at Netnod IXes in Sweden
  - Offer back up of other country ccTLD DNS
- gTLD DNS
  - .com & .net are provided by Verisign at many IXes

Services to Offer

- Route Server
  - Helps scale IXes by providing easier BGP configuration & operation for participants with Open Peering policies
  - Technical detail covered later on
- Looking Glass
  - One way of making the Route Server routes available for global view (e.g. www.traceroute.org)
  - Public or members-only access

Services to Offer

- Content Redistribution/Caching
  - Various providers offering content distribution services
  - Broadcast media
- Network Time Protocol
  - Locate a stratum 1 time source (GPS receiver, atomic clock, etc) at IXP
- Routing Registry
  - Used to register the routing policy of the IXP membership (more later)

Notes on IXP Services

- If IXP is offering services to members:
  - Services need transit access
  - Transit needs to be arranged with one or two IXP members (cost shared amongst all members)

- Consider carefully:
  - Should services be located at the IXP itself?
    - How to arrange and pay for the transit to those services?

    -or-
  - Should services be hosted by members and shared with the others?

Introduction to Route Collectors

What routes are available at the IXP?

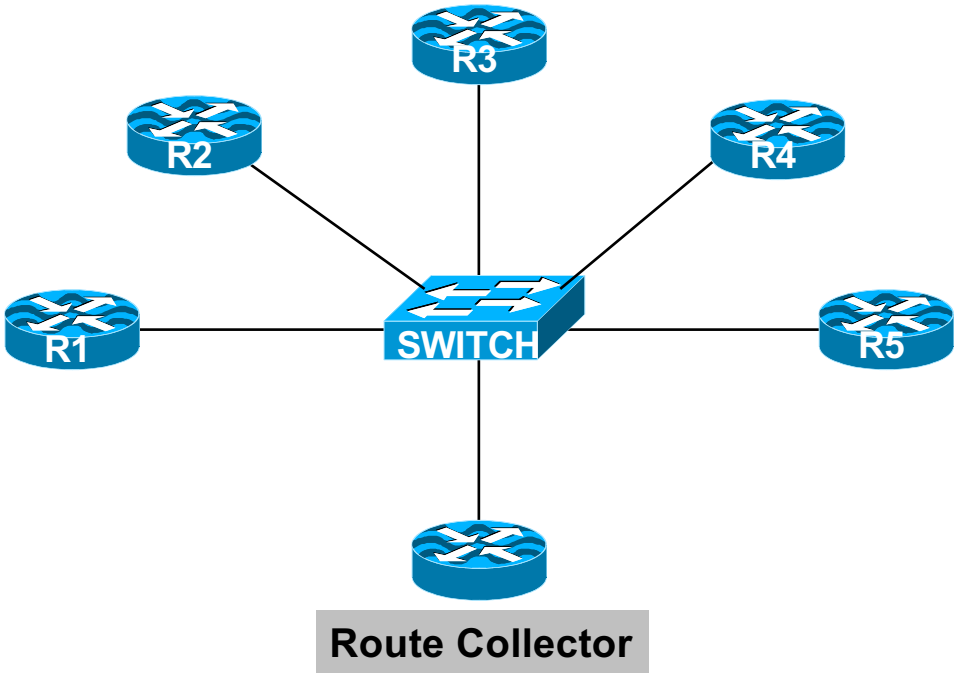
What is a Route Collector?

- Usually a router or Unix system running BGP software
- Gathers routing information from service provider routers at an IXP
  - Peers with each ISP using BGP
- Does not forward packets
- Does not announce any prefixes to ISPs

Purpose of a Route Collector

- To provide a public view of the Routing Information available at the IXP
  - Useful for existing members to check functionality of BGP filters
  - Useful for prospective members to check value of joining the IXP
  - Useful for the Internet Operations community for troubleshooting purposes
    - E.g. **www.traceroute.org**

Route Collector at an IXP



Route Collector Requirements

- Router or Unix system running BGP
  - Minimal memory requirements – only holds IXP routes
  - Minimal packet forwarding requirements – doesn't forward any packets
- Peers eBGP with every IXP member
  - Accepts everything; Gives nothing
  - Uses a private ASN
  - Connects to IXP Transit LAN
- "Back end" connection
  - Second Ethernet globally routed
  - Connection to IXP Website for public access

Route Collector Implementation

- Most IXPs now implement some form of Route Collector
  - Usually as a Route Server (see next section)
- Benefits already mentioned
- Great public relations tool
- Unsophisticated requirements
  - Just runs BGP

Introduction to Route Servers

How to scale IXPs

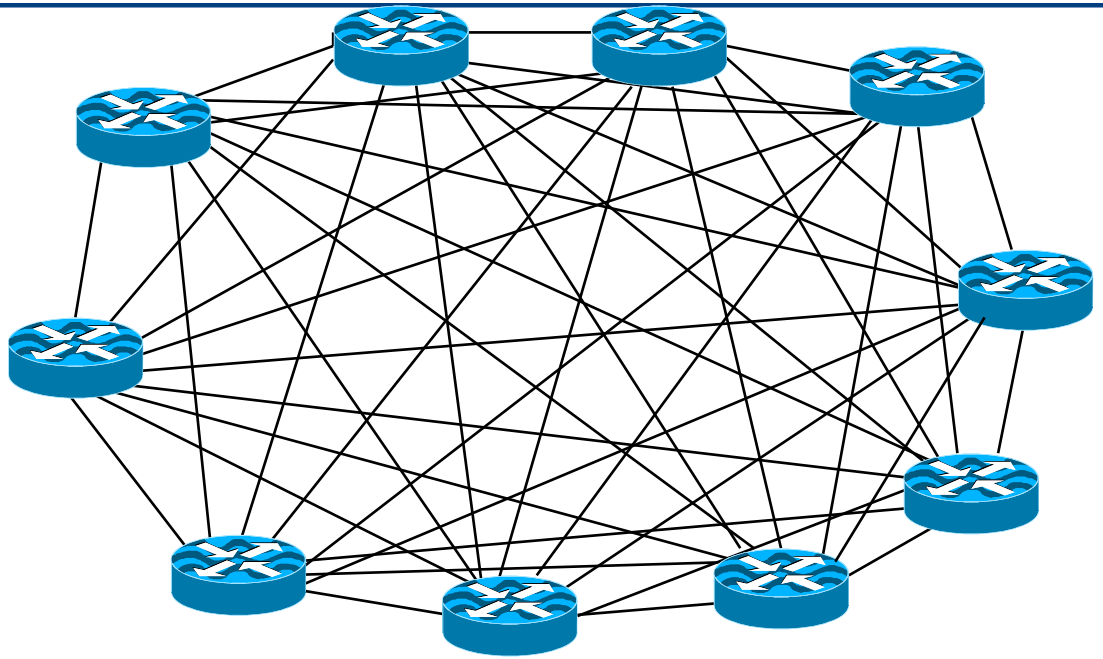
What is a Route Server?

- Has all the features of a Route Collector
- But also:
  - Announces routes to participating IXP members according to their routing policy definitions
- Implemented using the same specification as for a Route Collector

Features of a Route Server

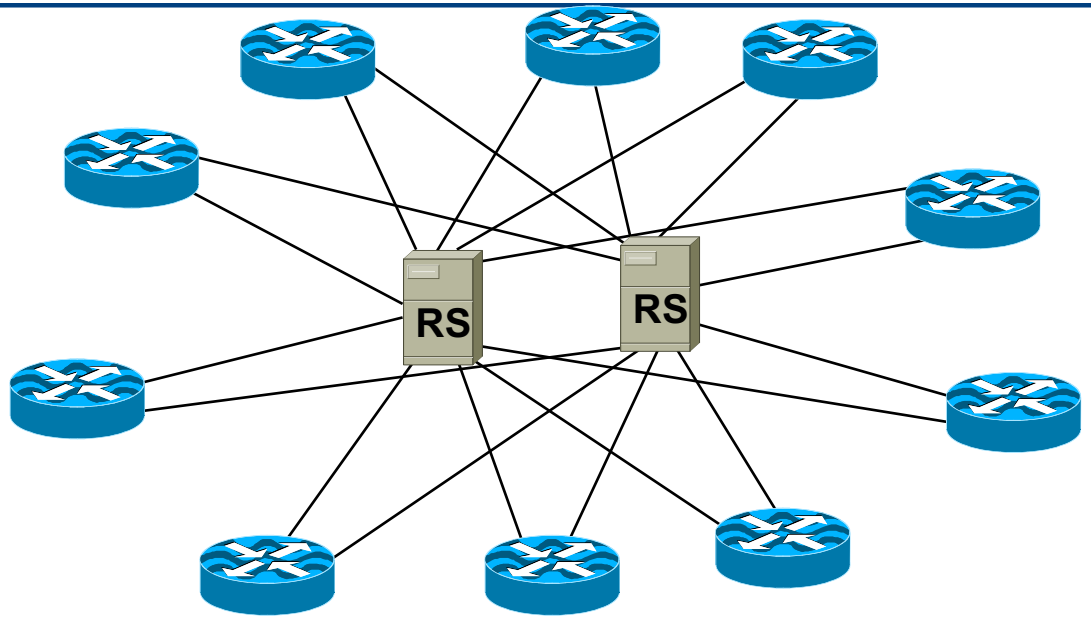
- Helps scale route distribution for IXPs
  - Forwarding of packets is unaffected
  - Makes use of BGP functionality known as “third party next-hop”
- Simplifies Routing Processes on ISP Routers
- Optional participation
  - Provided as service, is NOT mandatory
- If traditional router used, will result in insertion of RS Autonomous System Number in the AS Path
  - To be avoided
- Optionally could use Policy registered in the Internet Routing Registry

Diagram of N-squared Peering Mesh



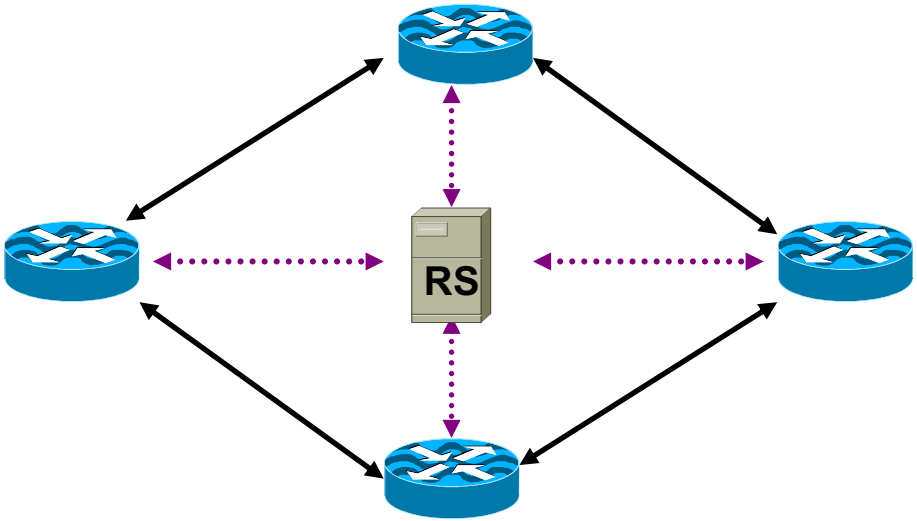
- For large IXPs (dozens of participants) maintaining a larger peering mesh becomes cumbersome and often too hard

Peering Mesh with Route Servers



- ISP routers peer with the Route Servers
  - Only need to have two eBGP sessions rather than N

Route Server based Exchange Point Routing Flow



TRAFFIC FLOW

ROUTING INFORMATION FLOW

Using a Route Server: Advantages

- Advantageous for large IXPs
  - Helps scale eBGP mesh
  - Helps scale prefix distribution
- Separation of Routing and Forwarding
- Simplifies BGP Configuration Management on ISP routers
  - Don’t need to maintain a large number of eBGP peers
  - eBGP peering only with the Route Server

Using a Route Server: Disadvantages

- ISPs can lose direct policy control
  - If RS is the only peer, ISPs have no control over who their prefixes are distributed to
    - (Okay if ISP has Open Peering Policy though)
- Completely dependent on 3rd party
  - Configuration, troubleshooting, reliability, etc…
- Possible insertion of RS ASN into routing path
  - (If using a router rather than a dedicated route-server BGP implementation)
  - Traffic engineering/multihoming needs more care

Typical usage of a Route Server

- Route Servers may be provided as an **OPTIONAL** service
  - Most IXPs now offer a Router Server as a service to members
- ISPs peer:
  - Directly with significant peers

    -and-
  - With Route Server for the rest
- ISPs with an Open Peering Policy usually prefer to peer with a Route Server

Route Server implementations

- Linux/FreeBSD server:
  - BIRD – the standard & works best
    - http://bird.network.cz
  - GoBGP
    - https://osrg.github.io/gobgp/
  - Quagga (LINX fork)
    - https://github.com/bbonev/quagga.euro-ix/
  - Quagga fork:
    - https://www.opensourcerouting.org/
- Router:
  - Any router (but has RS AS in the AS-path)
  - Cisco IOS 15.2 and IOS XE 3.7 onwards has route-server-client configuration:

```
neighbor 172.16.1.1 route-server-client
```

Things to think about…

- Would using a route server benefit you?
  - Helpful when BGP knowledge is limited (but is NOT an excuse not to learn BGP)
  - Avoids having to maintain a large number of eBGP peers

What can go wrong…

The different ways IXP operators harm their IXP…

What can go wrong? Concept

- Some Service Providers attempt to cash in on the reputation of IXPs
- Market their Internet transit services as “Internet Exchange Point”
  - “We are exchanging packets with other ISPs, so we are an Internet Exchange!”
  - So-called Layer-3 Exchanges — they really are Internet Transit Providers
  - Router(s) used rather than a Switch
  - Most famous example: SingTelIX

What can go wrong? Financial

- Some IXPs price the IX out of the means of most providers
  - IXP is intended to encourage local peering
  - Acceptable charging model is minimally cost-recovery only
- Some IXPs charge for port traffic
  - IXPs are not a transit service, charging for traffic puts the IX in competition with members
  - (There is nothing wrong with charging different flat fees for 100Mbps, 1Gbps, 10Gbps etc ports as they all have different hardware costs on large chassis switches)

What can go wrong? Competition

- Too many exchange points in one locale
  - Competing exchanges defeats the purpose
- Becomes expensive for ISPs to connect to all of them
  - So they don't, or won't, and local traffic suffers, defeating the viability of the IXPs
- An IXP:
  - is **NOT** a competition
  - is **NOT** a profit making business

What can go wrong?
Rules and Restrictions

- IXP tries to compete with their membership
  - Offering services that ISPs would/do offer their customers
  - **In reality, IXPs are operated by the members for the members**
- IXP is run as a closed privileged club e.g.:
  - Restrictive membership criteria
  - **In reality, a participant needs to have an ASN and their own independent address space**
- IXP located in a data centre with restricted physical/transmission access
  - **IXP must be a neutral interconnect in a neutral location**

What can go wrong? Rules and Restrictions

- IXP charges for traffic
  - So do transit providers – **charging for traffic is a sure way of ending the viability of the IXP**
- IXPs providing access to end users rather than just Network Operators & Service Providers
  - **A participant at an IXP needs to have their own address space, their own ASN, and their own transit arrangements**
- IXPs interfering with member business decisions
  - **The most common error: Mandatory Multi-Lateral Peering**

What can go wrong? Technical Design Errors

- Interconnected IXPs
  - IXP in one location believes it should connect directly to the IXP in another location
  - Who pays for the interconnect?
  - How is traffic metered?
  - Competes with the ISPs who already provide transit between the two locations (who then refuse to join IX, harming the viability of the IX)
  - Metro interconnections work ok

What can go wrong?
Technical Design Errors

- ISPs bridge the IXP LAN back to their offices
  - "We are poor, we can't afford a router"
  - Financial benefits of connecting to an IXP far outweigh the cost of a router
  - In reality it allows the ISP to connect any devices to the IXP LAN — with disastrous consequences for the security, integrity and reliability of the IXP

What can go wrong? Routing Design Errors

- Route Server mandated
  - Mandatory peering has no history of success
  - ISPs have no incentive to learn BGP
  - Therefore have no incentive to understand peering relationships, peering policies, &c
  - Entirely dependent on operator of RS for troubleshooting, configuration, reliability
    - RS can't be run by committee!
- Route Server is designed to assist with scaling peering at IXPs

What can go wrong?
Routing Design Errors (cont)

- iBGP Route Reflector used to distribute prefixes between IXP participants
- Claimed advantages:
  - Participants don't need to know about or run BGP
  - Allows an IXP to be started very quickly
  - IXP operator has full control over ISP activities
  - ISP participants routers sit inside IXP's ASN
- All are disadvantages!
  - Participants never learn BGP
  - Participants have no policy control, IXP policies could impact the participants networks
  - IXP is an ethernet switch, not an Internet operator
  - IXP operator is single point of failure
  - Migration to true IXP with RS is very difficult

What can go wrong: Summary

- Not a transit business, just an L2 switch
- If charging, fair cost recovery only
- Not a competitive service
- No oppressive rules & restrictions
- No Mandatory Peering
- No bureaucratic management
- No interconnection with other IXPs
- No bridging of IX LAN back to members
- No Route Reflector, use a Route Server to scale

More Information

Exchange Point Policies & Politics

- AUPs
  - Acceptable Use Policy
  - Minimal rules for connection
- Fees?
  - Some IXPs charge no fee
  - Other IXPs charge cost recovery
  - A few IXPs are commercial
- Nobody is obliged to peer
  - Agreements left to ISPs, not mandated by IXP

Exchange Point etiquette

- Don’t point default route at another IXP participant
- Be aware of third-party next-hop
- Only announce your aggregate routes
  - Read RIPE-399 and RIPE-532 first

    www.ripe.net/ripe/docs/ripe-399

    www.ripe.net/ripe/docs/ripe-532
- Filter! Filter! Filter!

Exchange Point Examples

- LINX in London, UK
- TorIX in Toronto, Canada
- AMS-IX in Amsterdam, Netherlands
- SIX in Seattle, Washington, US
- PA-IX in Palo Alto, California, US
- JPNAP in Tokyo, Japan
- DE-CIX in Frankfurt, Germany
- HK-IX in Hong Kong

…

- All use Ethernet Switches

Features of IXPs (1)

- Redundancy & Reliability
  - Multiple switches, UPS/Generator
- Support
  - NOC to provide 24x7 support for problems at the exchange
- DNS, Route Collector/Server, Content Caches & NTP servers
  - ccTLD & root servers
  - Content caches
  - Content redistribution systems
  - Route Collector – Routing Table view

Features of IXPs (2)

- Location
  - Neutral, secure & accessible co-location facilities
- Address space
  - Public address for Peering LAN
  - Public address for IXP Services LAN
- AS Number
  - Private ASN needed for Route Collector/Server
  - Public ASN needed for IXP Services
- Route servers (for larger IXPs)
- Statistics
  - Traffic data – for membership

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 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

Eco System Development

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

Local Internet Exchange Point

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

Regional Internet Exchange Point

- These are also “local” Internet Exchange Points
- But also attract regional ISPs and ISPs from outside the locality
  - Regional ISPs peer with each other
  - And show up at several of these Regional IXPs
- Local ISPs peer with ISPs 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 ISPs of disparate sizes and influences will happily peer – to defray transit costs

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
  - Members from Europe, associate members from around the world
  - Website has all the information needed to start an IXP
  - https://www.euro-ix.net/starting-an-ixp
  - IXP Best Practice documentation:
  - https://www.euro-ix.net/euro-ix-bcp

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/

More info about interconnects

- Telegeography
  - http://www.telegeography.com/telecom-resources/internet-exchange-map/
  - A collection of ISP interconnect points
  - Beware!! Not all of the Telegeography listings are IXPs!
- Packet Clearing House
  - IXP Directory: https://www.pch.net/ixp/dir
- Internet Society
  - IXP Toolkit: http://www.ixptoolkit.org/

Summary

- IXP is a Layer 2 infrastructure
- At least three players required (two is okay too)
  - Meeting in an open and neutral location
- Minimal rules
- Minimal bureaucracy
- Cost recovery
- Encourage participation by all autonomous networks
- Develop the local Internet eco-system

Internet Exchange Point Design

ISP/IXP Workshops