

# Internet Exchange Point Design



ISP Workshops

# IXP Design

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- Background
- Why set up an IXP?
- Layer 2 Exchange Point
- Layer 3 “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...

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- NSFnet – one major backbone
  - US “National Science Foundation” funded
  - Connected academic & research institutions
  - Also connected “private company” networks, with acceptable use policy
    - **AUP: No commercial activity**
  - Three Network Access Points (NAPs): Chicago, New York, San Francisco
- Private companies needed to interconnect their networks
  - Requirement to send “commercial traffic”
  - Could not cross NSFnet
  - Resulted in the early “commercial Internet Exchanges”

# More History...

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- Early Internet Exchanges created in early 90s
  - CIX-West – west coast USA
  - MAE-East – east coast USA
  - D-GIX – Stockholm
- End of the NSFnet in 1995:
  - Meant move towards commercial Internet
  - Private companies selling their bandwidth
  - ANS (operator of the late NSFnet) had to join IXes
- Routing Arbiter project helped with coordination of routing exchange between providers
  - Traffic from ISP A needs to get to ISP B

# More History still...

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- The NAPs established late in NSFnet life were some of the original “exchange points”
  - NAP operators supported commercial activities as well
  - (Sprint: NY, PacBell: SF, Ameritech: Chicago, MFS: Vienna/VA)
- The NAPs replaced by IXPs:
  - NAPs didn’t succeed (operated by ISPs), replaced by more neutral IXPs
  - E.g. Virginia NAP replaced by MAE-East (by MFS)
- Mid 90s saw rapid Internet growth, with major providers connecting...

# Even more History

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- D-GIX formed in Stockholm in 1992
  - Three major ISPs interconnected
  - Latency reduction, performance gains
  - Local traffic stays local
- LINX formed in London in 1994
  - Five UK operators interconnected
  - Latency reduction, performance gains
  - Local traffic stays local
- HKIX formed in Hong Kong in 1995
  - Vibrant Internet community, many small operators
  - Latency, performance, and local traffic benefits
- Also AMS-IX in Amsterdam in 1994
  - Same reasons as others

# Internet Exchange Point

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- 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 Operator 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

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- 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 historical status now
  - Router based
    - Best known example was CIX-West
    - Router very quickly overwhelmed by the rapid growth of the Internet

# Why an Internet Exchange Point?



Saving money, improving QoS,  
Generating a local Internet  
economy

# Internet Exchange Point

## Why peer?

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- 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?

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- Yes, International Connections...
  - If satellite, RTT is around 550ms per hop
  - So local traffic takes over 1s round trip
- International bandwidth
  - Costs significantly more than domestic bandwidth
  - Congested with local traffic
  - Wastes money, harms performance

# Internet Exchange Point

## Why peer?

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- 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?

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- A third ISP enters the equation
  - Becomes a significant player in the region
  - Local and international traffic goes over their international connections
- They agree to peer with the two other ISPs
  - To save money
  - To keep local traffic local
  - To improve network performance, QoS,...

# Internet Exchange Point

## Why peer?

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- 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

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- Every participant has to buy just one whole circuit
  - From their premises to the IXP
- Rather than N-1 half circuits to connect to the N-1 other ISPs
  - 5 ISPs have to buy 4 half circuits = 2 whole circuits → already twice the cost of the IXP connection



# Internet Exchange Point

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## □ Solution

- Every ISP participates in the IXP
- Cost is minimal – one local circuit covers all domestic traffic
- International circuits are used for just international traffic – and backing up domestic links in case the IXP fails

## □ Result:

- Local traffic stays local
- QoS considerations for local traffic is not an issue
- RTTs are typically sub 10ms
- Customers enjoy the Internet experience
- Local Internet economy grows rapidly

# Layer 2 Exchange



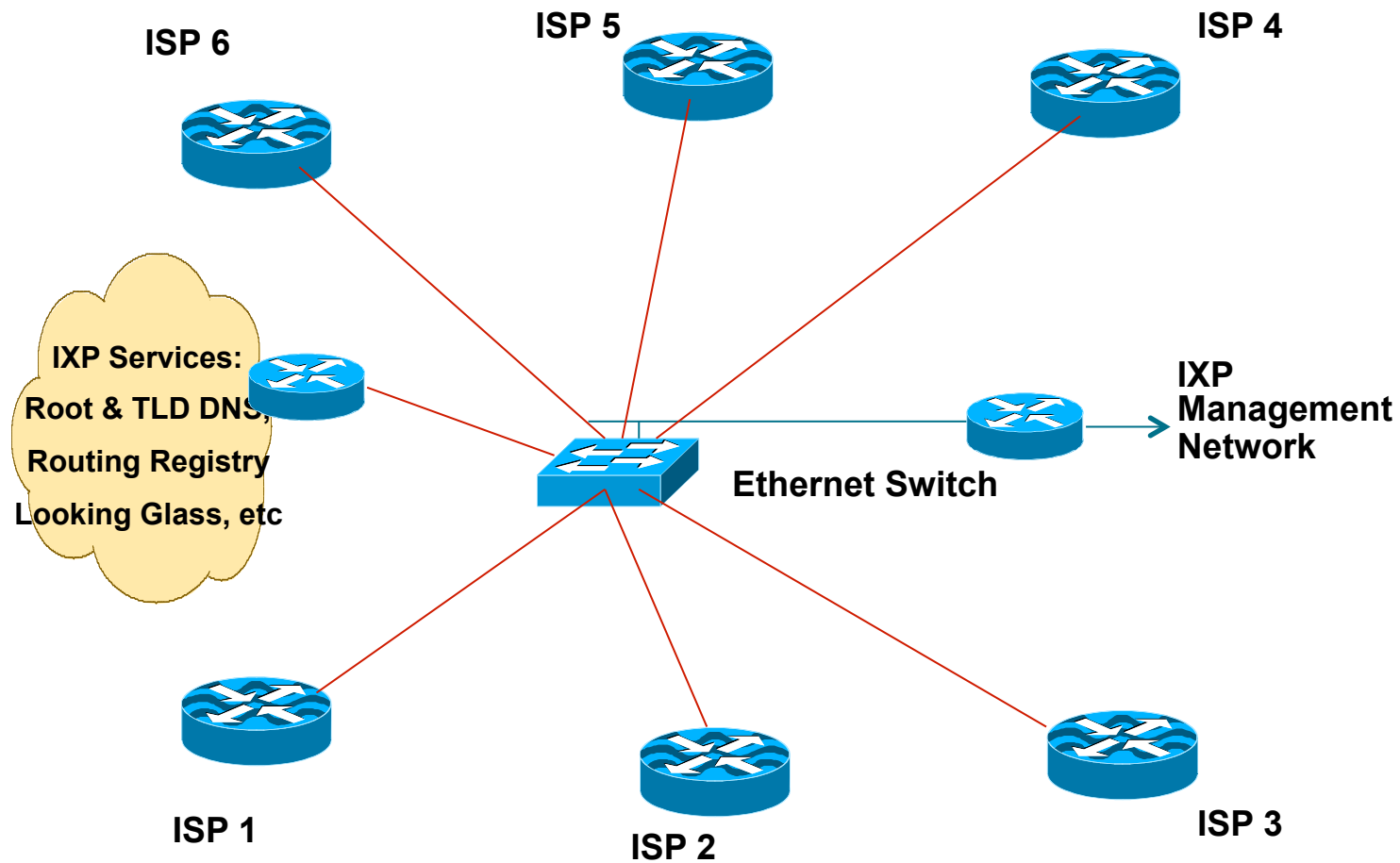
The traditional IXP

# IXP Design

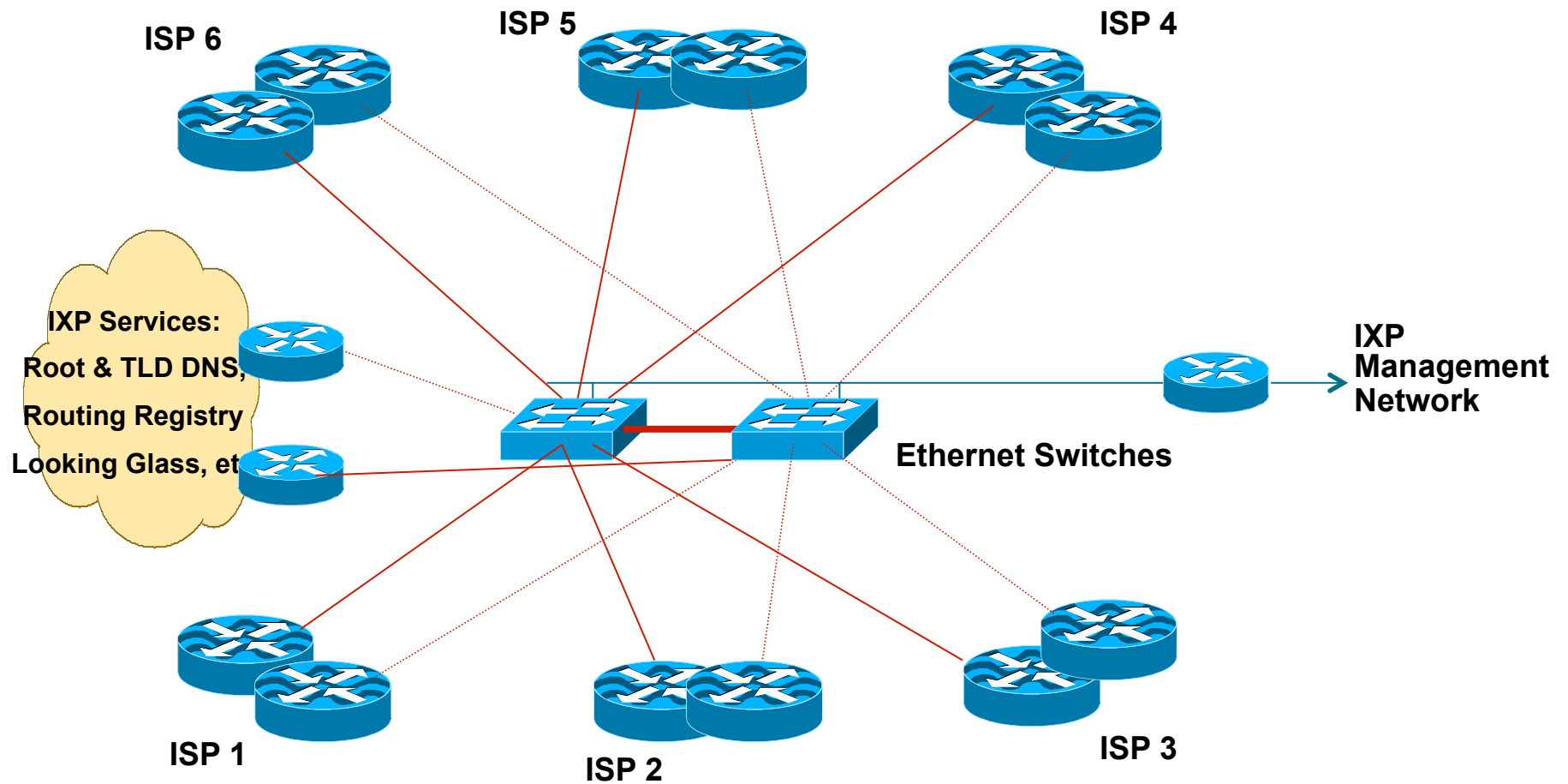
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- Very simple concept:
  - Ethernet switch is the interconnection media
    - IXP is one LAN
  - Each ISP brings a router, connects it to the ethernet switch provided at the IXP
  - Each ISP peers with other participants at the IXP using BGP
- Scaling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

# Layer 2 Exchange



# Layer 2 Exchange



# Layer 2 Exchange

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

# Layer 2 Exchange

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- 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 operators to access
- Expandable location
  - IXPs result in Internet growth, and increasing space requirements

# Layer 2 Exchange

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- Requires neutral IXP management
  - “Consortium”
    - Representing all participants
    - “Management Board” etc
  - Usually funded equally by IXP participants
  - 24x7 cover provided by hosting location
    - Managed by the consortium



# Layer 2 Exchange

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- Configuration
  - Private address space if non-transit and no value add services
  - Otherwise public IPv4 (/24) and IPv6 (/64)
  - ISPs require AS, basic IXP does not
- Network Security Considerations
  - LAN switch needs to be securely configured
  - Management routers require TACACS+ authentication, vty security
  - IXP services must be behind router(s) with strong filters

## “Layer 3 IXP”

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- ❑ Layer 3 IXP today is marketing concept used by Transit ISPs
- ❑ Real Internet Exchange Points are only Layer 2

# IXP Design Considerations



# Exchange Point Design

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- The IXP Core is an Ethernet switch
  - It must be a managed switch
  - It must have reasonable security features
  - <http://www.ripe.net/ripe/groups/wg/eix/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 10/100 switch
  - To the largest switches now handling high densities of 10GE and 100GE interfaces

# Exchange Point Design

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- Each ISP participating in the IXP brings a router to 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

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- 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 10Mbps, 100Mbps or 1Gbps connections
- Fibre used for 1Gbps, 10Gbps, 40Gbps or 100Gbps connections

# Peering

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- 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)

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- 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 every other participant (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

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- 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 the 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 RS but will only peer bilaterally
- Closed Peering
  - Where an ISP decides who its peering partners are, and is generally not approachable to creating peering opportunities

# Operators Peering Activities

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- The Peering Database documents ISPs peering policies
  - <http://peeringdb.com>
- All operators of ASNs should 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)

# Routing

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- ❑ 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 (more)

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- ❑ ISP border routers at the IXP should not be configured to carry the IXP LAN network within the IGP or iBGP
  - Use next-hop-self BGP concept
- ❑ 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

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- ❑ 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
  - IXP terms of participation often forbid the IX LAN to be carried in the ISP member backbone
- ❑ Typically IXPs now provide both IPv6 and IPv4 support on IX LANs

# Autonomous System Numbers

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- ❑ 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 private 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

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- Try not to mix port speeds
  - If 10Mbps and 100Mbps connections available, terminate on different switches (L2 IXP)
- Don't mix transports
  - If terminating ATM PVCs and G/F/Ethernet, terminate on different devices
- Insist that IXP participants bring their own router
  - Moves buffering problem off the IXP
  - Security is responsibility of the ISP, not the IXP

# Charging

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- ❑ IXPs needs to be run at minimal cost to its member participants
- ❑ Common examples:
  - Datacentre hosts IX for free
  - IX operates cost recovery
  - Different pricing for different ports
- ❑ 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

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- 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

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- 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 to each

# Charging:

## Differential pricing by port

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- IXP Member pays according to the port speed they require
  - 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 expense of provision of the infrastructure they use
  - Example: Netnod IXes in Sweden

# Services Offered

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- 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 Cacti or Observium to produce IX throughput graphs for member (or public) information

# Services to Offer

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- 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
- Root server
  - Anycast instances of I.root-servers.net, F.root-servers.net etc are present at many IXes
- Usenet News
  - Usenet News is high volume
  - Could save bandwidth to all IXP members

# Services to Offer

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- Route Collector
  - Route collector shows the reachability information available at the exchange
  - Technical detail covered later on
- Route Server
  - Helps scale large IXes by providing easier BGP configuration & operation for participants
  - Technical detail covered later on
- Looking Glass
  - One way of making the Route Collector routes available for global view (e.g. [www.traceroute.org](http://www.traceroute.org))
  - Public or members only access

# Services to Offer

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- Content Redistribution/Caching
  - Google Global Cache
  - Akamai update distribution service
  - 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)

# Introduction to Route Collectors



What routes are available at the  
IXP?



# What is a Route Collector?

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- ❑ Usually a router or Unix system running BGP
- ❑ 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

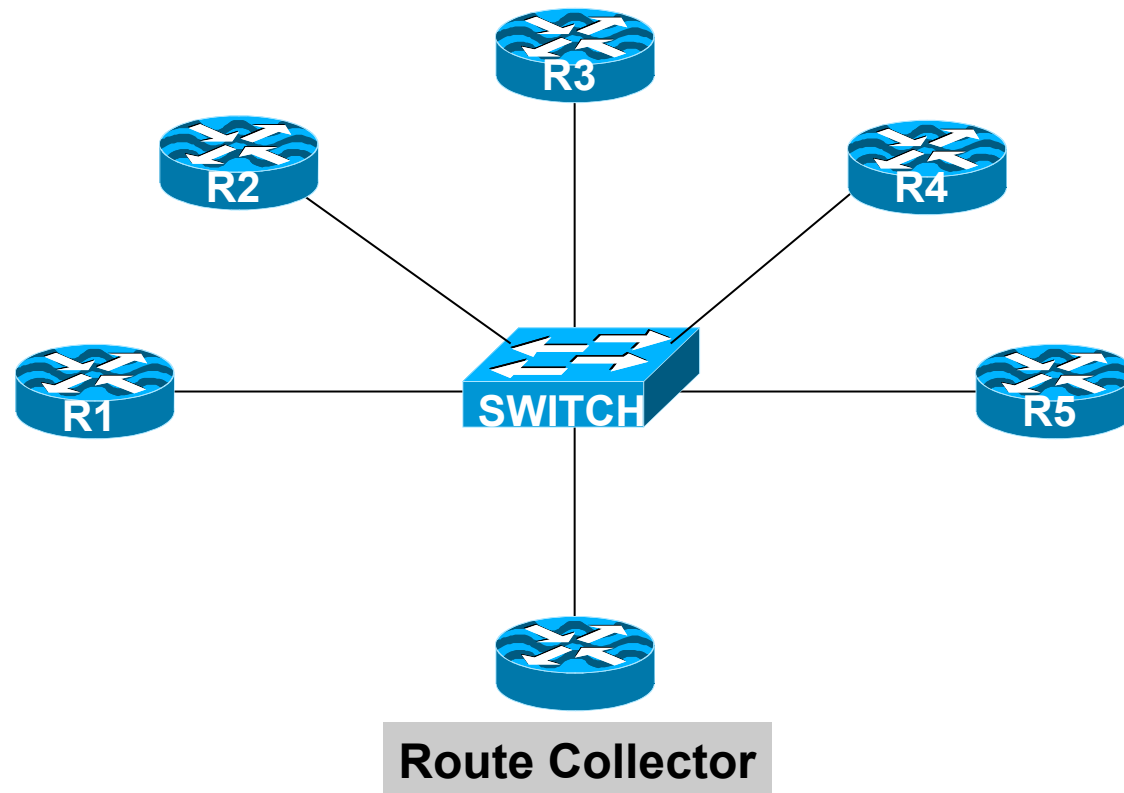
# Purpose of a Route Collector

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- 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](http://www.traceroute.org)

# Route Collector at an IXP

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# Route Collector Requirements

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- 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

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- ❑ Most IXPs now implement some form of Route Collector
- ❑ 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?

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- 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

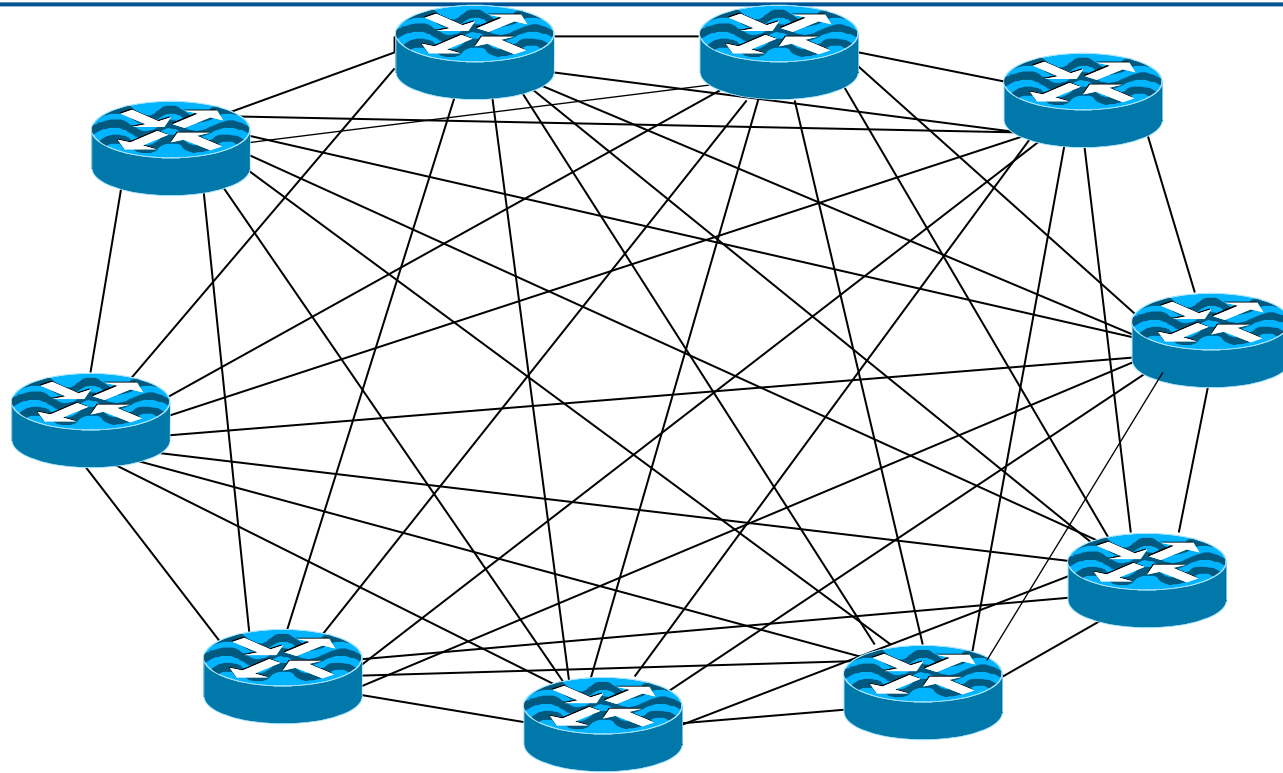
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- ❑ Helps scale routing for large IXPs
  - Forward of packets is unaffected
- ❑ Simplifies Routing Processes on ISP Routers
- ❑ Optional participation
  - Provided as service, is **NOT** mandatory
- ❑ If traditional router used, will result in insertion of RS Autonomous System Number in the Routing Path
- ❑ Optionally uses Policy registered in IRR



# Diagram of N-squared Peering Mesh

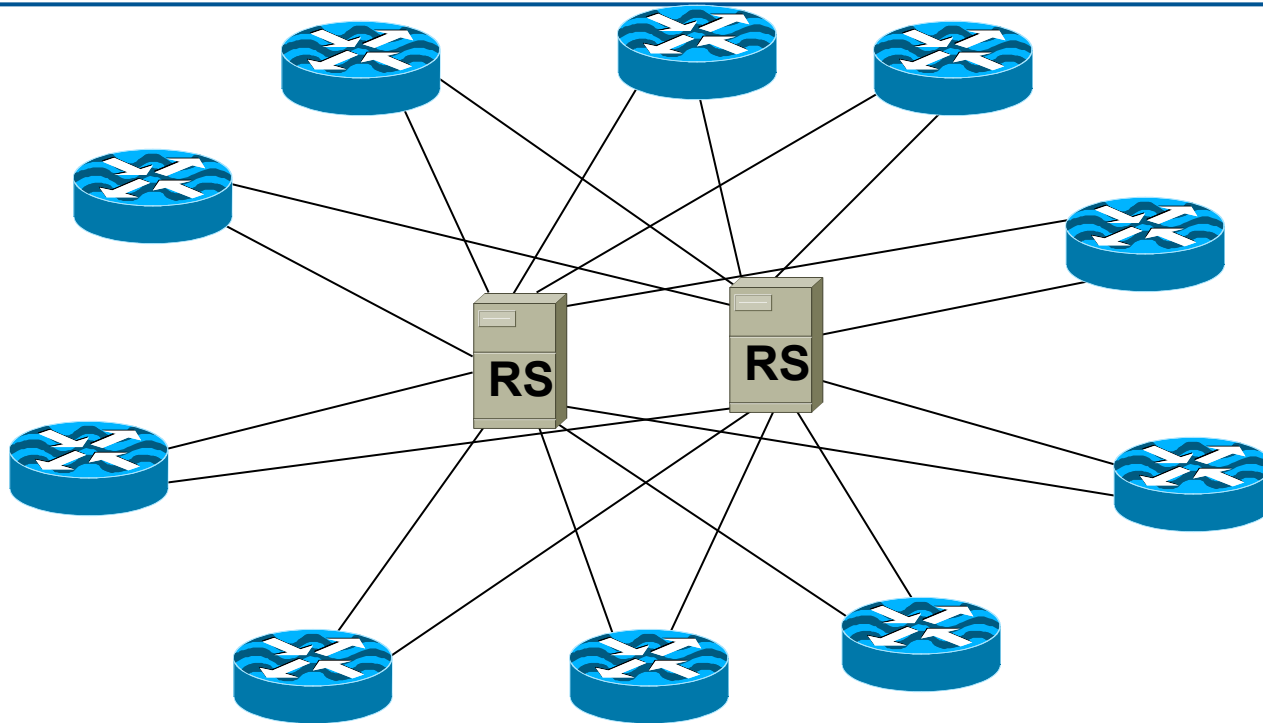
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- For large IXPs (dozens for participants) maintaining a larger peering mesh becomes cumbersome and often too hard

# Peering Mesh with Route Servers

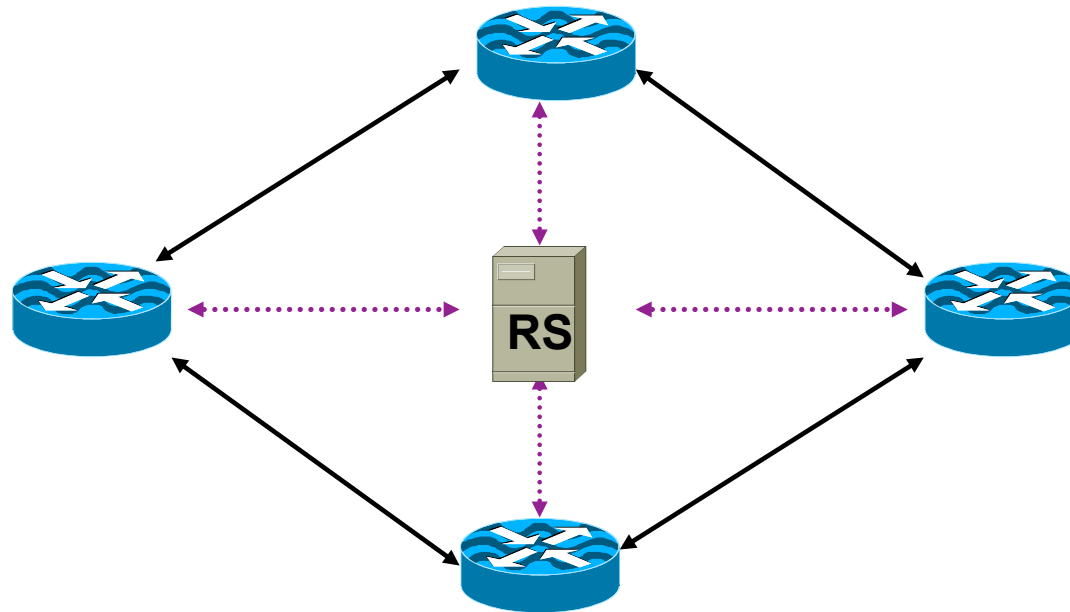
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- ISP routers peer with the Route Servers
  - Only need to have two eBGP sessions rather than N

# RS based Exchange Point Routing Flow

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**TRAFFIC FLOW**



**ROUTING INFORMATION FLOW**

# Advantages of Using a Route Server

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- Advantageous for large IXPs
  - Helps scale eBGP mesh
  - Helps scale prefix distribution
- Separation of Routing and Forwarding
- Simplifies BGP Configuration Management on ISP routers

# Disadvantages of using a Route Server

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- ISPs can lose direct policy control
  - If RS is only peer, ISPs have no control over who their prefixes are distributed to
- Completely dependent on 3<sup>rd</sup> party
  - Configuration, troubleshooting, 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

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- Route Servers may be provided as an **OPTIONAL** service
  - Most common at large IXPs (>50 participants)
  - Examples: LINX, TorIX, AMS-IX, etc
- ISPs peer:
  - Directly with significant peers
    - and-
  - With Route Server for the rest

# Route Server implementations

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- Linux/FreeBSD server:
  - BIRD, Quagga, OpenBGPD
- 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...

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- 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
  - But can you afford to lose policy control? (An ISP not in control of their routing policy is what?)



# What can go wrong...



The different ways IXP operators harm their IXP...

# What can go wrong?

## Concept

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- ❑ 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 Point!”
  - 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

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- ❑ 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 the switch.)

# What can go wrong?

## Competition

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- ❑ 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

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- 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

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- 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

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- 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

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- 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

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- Route Server implemented from Day One
  - 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 to help scale peering at LARGE IXPs

# What can go wrong?

## Routing Design Errors (cont)

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- ❑ iBGP Route Reflector used to distribute prefixes between IXP participants
- ❑ Claimed Advantage (1):
  - Participants don't need to know about or run BGP
- ❑ Actually a Disadvantage
  - IXP Operator has to know BGP
  - ISP not knowing BGP is big commercial disadvantage
  - ISPs who would like to have a growing successful business need to be able to multi-home, peer with other ISPs, etc — these activities require BGP

# What can go wrong?

## Routing Design Errors (cont)

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- Route Reflector Claimed Advantage (2):
  - Allows an IXP to be started very quickly
- Fact:
  - IXP is only an Ethernet switch — setting up an iBGP Route Reflector mesh with participants is no quicker than setting up an eBGP Route Server mesh
    - But the latter scales, and works

# What can go wrong?

## Routing Design Errors (cont)

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- ❑ Route Reflector Claimed Advantage (3):
  - IXP operator has full control over IXP activities
- ❑ Actually a Disadvantage
  - ISP participants surrender control of:
    - ❑ Their border router; it is located in IXP's AS
    - ❑ Their routing and peering policy
  - IXP operator is single point of failure
    - ❑ If they aren't available 24x7, then neither is the IXP
    - ❑ BGP configuration errors by IXP operator have real impacts on ISP operations

# What can go wrong?

## Routing Design Errors (cont)

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- Route Reflector Disadvantage (4):
  - Migration from Route Reflector to “correct” routing configuration is highly non-trivial
  - ISP router is in IXP’s ASN
    - Need to move ISP router from IXP’s ASN to the ISP’s ASN
    - Need to reconfigure BGP on ISP router, add to ISP’s IGP and iBGP mesh, and set up eBGP with IXP participants and/or the IXP Route Server

# More Information



# Exchange Point Policies & Politics

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- 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

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- ❑ 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](http://www.ripe.net/ripe/docs/ripe-399)
    - [www.ripe.net/ripe/docs/ripe-532](http://www.ripe.net/ripe/docs/ripe-532)
- ❑ Filter! Filter! Filter!



# Exchange Point Examples

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- ❑ 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)

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- 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 such as Google Global Cache
  - Content redistribution systems such as Akamai
  - Route Collector – Routing Table view

# Features of IXPs (2)

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- 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

# More info about IXPs

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- Euro-IX
  - European Internet Exchange consortium
  - All the information needed to start an IXP
  - <https://www.euro-ix.net/starting-an-ixp>
- PCH
  - <https://www.pch.net/resources/papers.php>
  - Excellent collection of IXP locations, discussion papers, IXP statistics, etc
- Telegeography
  - <http://www.telegeography.com/telecom-resources/internet-exchange-map/>
  - A collection of IXPs and interconnect points for ISPs

# Summary

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- L2 IXP – universally deployed
  - The core is an ethernet switch
  - ATM and other old technologies are obsolete
- L3 IXP – is just a marketing concept used by wholesale ISPs
  - Does not offer the same flexibility, neutrality or effectiveness as L2
  - Not recommended unless there are overriding regulatory or political reasons to do so
  - **Avoid!**

# Internet Exchange Point Design



ISP Workshops