Acknowledgements

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- Use of these materials is encouraged as long as the source is fully acknowledged and this notice remains in place.

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

Philip Smith
Agenda

- Peering Priorities
- Transit Provider Peering at an IXP
- Traffic Engineering for an ISP connected to two IXes
- Traffic Engineering for an ISP with two interfaces on one IX LAN
- Traffic Engineering and CDNs
Peering Priorities for a Network Operator
Peering Priorities

As network operators move from having a single upstream to deploying BGP with multiple external connections, they need to:

- Establish priorities for BGP customers
- Prioritise different peering partners
- Establish cost/benefits for participating at different IXPs
- Establish cost/benefits for different transit connections
Peering Policy

- **Typical prioritisation:**
  - Most preferred – BGP customers
    - We would like traffic from us to our BGP customers to go directly, not via our peers or transits
  - Next preference – private peers
    - Connect by direct cross-connection
  - Next preference – local IXP
    - Keep local traffic local
  - Next preference – regional IXP
    - Keep regional traffic regional
      - Will cost money for physical connectivity to regional IXP
  - Last preference – paid transit
    - Will cost money for physical connectivity and for traffic
Peering Policy – Local Preference

- Example Local Preference Table

<table>
<thead>
<tr>
<th>Peering Policy</th>
<th>Local Preference</th>
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</thead>
<tbody>
<tr>
<td>BGP Customer</td>
<td>250</td>
</tr>
<tr>
<td>Private Peer</td>
<td>200</td>
</tr>
<tr>
<td>Local IXP</td>
<td>170</td>
</tr>
<tr>
<td>Regional IXP</td>
<td>140</td>
</tr>
<tr>
<td>(default)</td>
<td>100</td>
</tr>
<tr>
<td>Paid Transit</td>
<td>50</td>
</tr>
</tbody>
</table>
Additional Considerations for NRENs

- National Research & Education Networks have additional considerations:
  - R&E networks are high availability and low latency
  - Traffic to R&E networks needs to prefer R&E paths over commodity Internet paths

- NRENs generally prefer:
  - Local peering & local hosted content first
  - Then R&E transit (via RREN)
  - And lastly commodity Internet transit
Peering Policy – NREN Local Preference

- Example Local Preference Table

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IXP Peering: When a Transit Provider is Also a Peer
IXP Peering, when Transit Provider is also a Peer

- Relatively common situation
  - Several local ISPs providing access to the local market
  - One or two licensed transit providers
  - Licensed transits also wish to peer at the IXP

- Desired outcome:
  - Transit provider wants to:
    - Peer domestic traffic at the IX
    - Sell transit access for all other destinations

- How to ensure that:
  - Transit traffic only goes on transit link
  - Peering traffic only goes on peering link
IXP Peering, when Transit Provider is also a Peer

To the Internet

Transit Provider

Link to Upstream ISP

Local Access Provider (AS100)
IXP Peering, when Transit Provider is also a Peer

- **Outbound traffic from AS100:**
  - Upstream sends full BGP table to AS100 on direct peering link
  - Upstream sends domestic routes to IXP peers
  - AS100 uses IXP for domestic traffic
  - AS100 uses Upstream link for international traffic

- **Inbound traffic to AS100:**
  - AS100 sends address block to IXP peers
  - AS100 sends address block to upstream
  - Best path from upstream to AS100 preferred via the IXP (see previous scenario)

- **Problem:** how to separate international and domestic traffic towards AS100?
Solution: AS Separation

AS 100

To the Internet

Transit AS160

Domestic AS150

Link to Upstream ISP

IXP

AS 100
Solution: AS Separation

- The transit provider needs to separate their network:
  - Domestic (AS150: local routes)
  - Transit (AS160: non-local routes)
- Transit customers connect to transit AS (AS160)
  - Receive default route (or full BGP if desires)
  - Send just their address blocks
- Domestic AS (AS150) peers at the IX
  - Receives local routes from other IX peers
  - Sends AS150 originated routes to IX peers
Solution: AS Separation Outcome

- Inbound traffic to AS100 now:
  - AS100 sends address block to IXP peers (including AS150)
  - AS100 sends address block to upstream (AS160)
  - Best path from upstream to AS100 preferred via the transit link

- Important notes:
  - AS150 must NOT pass prefixes learned from IX peers to AS160
IXP Peering, when Transit Provider is also a Peer

- Transit providers who peer with their customers at an IX for local routes need to split their ASNs into two:
  - One AS for domestic routes
  - One AS for transit routes

- Two ASNs are justifiable because the two ASNs have completely different routing policies
  - Domestic AS peers at IXP
  - Transit AS connects transit customers and upstreams
IXP Peering, when Transit Provider is also a Peer

- This solution is scalable
- This solution is much easier to implement than other solutions such as complex source address policy routing

Remember:
- An Autonomous System is used for representing a distinct routing policy
- An Autonomous System doesn’t necessarily map onto an organisation
- A transit business WILL have different routing policy from an access business or a hosting business, and therefore will quite likely need a different ASN
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Traffic Engineering over two interfaces connected to one IXP
Two connections to one IXP

- In early stages of IX development:
  - IX has one ethernet switch
  - Members have a single ethernet connection to IX switch

- As IX grows:
  - It becomes critical infrastructure for local Internet economy
  - More members join
  - IX adds second switch for extra capacity and to provide redundancy for members
  - Second switch is on same L2 infrastructure as original

- How to configure BGP & Traffic engineering for two connections to the IX?
Two connections to one IXP

- Diagram shows two ethernet links from separate switches to two routers
Two connections to one IXP

- **IXP LAN configuration:**
  - Second connection is on same subnet on IXP
  - Member receives another IP address from the same subnet

- **BGP configuration:**
  - Second eBGP session is established
    - With the IXP Route Server (if present)
    - With the other IXP members (with their second router, if they have one)
    - With IXP services infrastructure (if applicable)
Two connections to one IXP

- **Outbound Traffic Engineering configuration:**
  - By default, the link chosen will follow BGP best path rules
    - In the absence of any other member policy (e.g. MEDs), best path will be lowest neighbour IP address
    - Which most likely means that one link carries all the traffic; the other link remains relatively empty
  - AS100 could load balance over the two physical links by:
    - Setting local preferences on particular announcements from peers
    - Using any BGP community policy implemented by other members
Inbound Traffic Engineering configuration:

- By default, the link chosen will follow BGP best path rules
  - In the absence of any local policy (e.g. MEDs), best path will be lowest IP address on the IX LAN
- AS100 could load balance over the two physical links by:
  - Setting MEDs on particular announcements to peers
    - Half the peers could have announcements of MED 10 on one link and MED 20 on the other link
    - And the other half of the peers have the MED values reversed
    - Which assumes that peers even respect MEDs
  - Implementing a BGP community policy available for other members to use
    - Sometimes IXPs recommend what a community policy might be
  - Using AS-PATH prepends (care needed so the IX path doesn’t have longer AS path than via paid transit links)
Two connections to one IXP

- Bonding two ethernet connections
  - In some circumstances, the IXP may offer the facility of creating an aggregated link (LAG – Link Aggregation Group)
  - This provides redundancy at L2
    - For example, two GigabitEthernet links will effectively present as 2Gbps on a single connection on the router
    - The BGP session is established over the LAG rather than on individual links
    - Load balancing is at L2, contained within the LAG itself

- Note: this is only possible if the member only provisions one router for the IXP connection
  - And not desirable if the IXP provisions the two links on separate switches (assuming the switch vendor supports creating a LAG shared over two switches)
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Traffic Engineering when connected to two IXPs
Traffic Engineering when connected to two IXPs

Several variations possible on this theme

- Peering at two local IXPs
  - Shouldn’t really happen as an IXP is intended to be a collaborative effort between members/participants to peer local traffic
  - Two IXPs serving the same local market doubles the costs for all operators and makes the traffic engineering more challenging

- Peering at local IXP and regional IXP
  - Very common where an ISP participates in the local IXP and also turns up at one or more regional IXPs for greater peering opportunities

- Peering at two regional IXPs
  - Occurs in the absence of a local IXP
Peering at two local IXPs

- Diagram shows ISP connecting to two different IXPs
  - Could also be the case where one IXP operates two independent sites
Peering at two local IXPs

- **Second IXP LAN configuration:**
  - Connection to the second IXP set up in the same way as the connection to the first IXP
  - Member has access to same facilities (Route Server, IX services, etc)

- **BGP configuration:**
  - eBGP sessions established
    - With the IXP Route Server (if present)
    - With the other IXP members
    - With IXP services infrastructure (if applicable)

- **Traffic Engineering**
  - Load balancing across IXP links needed when members are present at both IXPs
Peering at two local IXPs

- Outbound Traffic Engineering configuration:
  - By default, the link chosen will follow BGP best path rules
    - In the absence of any other member policy (e.g. MEDs), best path will be lowest neighbour IP address
    - Which most likely means that the link to one IXP carries all the traffic; the other link remains relatively empty
    - Could end up with situation with outbound traffic going through one IXP, and return traffic coming through the other IXP
  - AS100 could load balance over the two IXPs by:
    - Setting local preferences on particular announcements from peers
    - Using any BGP community policy implemented by other members
Peering at two local IXPs

- **Inbound Traffic Engineering configuration:**
  - By default, the link chosen will follow BGP best path rules
    - In the absence of any local policy (e.g. MEDs), best path will be lowest neighbour IP address (i.e. entirely dependent on the address block the IX has received from the RIR)
  - AS100 could load balance over the two IXP links to other members by:
    - Setting MEDs on particular announcements to peers
      - Half the peers could have announcements of MED 10 on one link and MED 20 on the other link
      - And the other half of the peers have the MED values reversed
      - Which assumes that peers even respect MEDs
    - Implementing a BGP community policy available for other members to use
      - Sometimes IXPs recommend what a community policy might be
    - Using AS-PATH prepends (care needed so the IX path doesn’t have longer AS path than via paid transit links)
Diagram shows ISP connecting to one local and one regional IXP
Peering at one local IXP and one regional IXP

- Regional IXP LAN configuration:
  - Connection to the Regional IXP set up in the same way as the connection to the Local IXP
  - Member has access to same facilities (Route Server, IX services, etc)

- BGP configuration:
  - eBGP sessions established
    - With the IXP Route Server (if present)
    - With the other IXP members
    - With IXP services infrastructure (if applicable)

- Traffic Engineering
  - Load balancing across IXP links needed when members are present at both IXPs
Peering at one local IXP and one regional IXP

- **Outbound Traffic Engineering configuration:**
  - By default, the link chosen will follow BGP best path rules
    - In the absence of any other member policy (e.g. MEDs), best path will be lowest neighbour IP address
    - Setting local preference on BGP routes learned from different classes of BGP neighbours becomes very important
  - **AS100 could prioritise between the IXPs by:**
    - Setting local preferences (see earlier table)
    - Using any BGP community policy implemented by other members
Peering at one local IXP and one regional IXP

- **Inbound Traffic Engineering configuration:**
  - By default, the link chosen will follow BGP best path rules
    - In the absence of any local policy (e.g. MEDs), best path will be lowest neighbour IP address (i.e. entirely dependent on the address block the IX has received from the RIR)
  - AS100 needs to prioritise incoming traffic over the local IXP rather than the regional IXP (considered backup)
    - Outbound traffic follows the local preference table in earlier slides
    - Prioritisation can be done by
      - Using AS-PATH prepend (carefully – don’t want path to be longer than through transit provider)
      - Subdividing address blocks (de-aggregating) for private peer and local IXP connections, and not subdividing for regional IXP and Transit
Peering at two regional IXPs

- Diagram shows ISP connecting to two different IXPs
  - Could also be the case where one IXP operates two independent sites
Peering at two regional IXPs

- **Second IXP LAN configuration:**
  - Connection to the second IXP set up in the same way as the connection to the first IXP
  - Member has access to same facilities (Route Server, IX services, etc)

- **BGP configuration:**
  - eBGP sessions established
    - With the IXP Route Server (if present)
    - With the other IXP members
    - With IXP services infrastructure (if applicable)

- **Traffic Engineering**
  - Load balancing across IXP links needed when members are present at both IXPs
Peering at two regional IXPs

- **Outbound Traffic Engineering configuration:**
  - By default, the link chosen will follow BGP best path rules
    - In the absence of any other member policy (e.g. MEDs), best path will be lowest neighbour IP address
    - Which most likely means that the link to one IXP carries all the traffic; the other links remains relatively empty
    - Could end up with situation with outbound traffic going through one IXP, and return traffic coming through the other IXP
    - Not good if the two IXPs have a significant geographical separation
  - AS100 could load balance over the two IXPs by:
    - Setting local preferences on particular announcements from peers, paying close attention to geographical or regional interconnect issues
    - Using any BGP community policy implemented by other members
Peering at two local IXPs

- **Inbound Traffic Engineering configuration:**
  - By default, the link chosen will follow BGP best path rules
    - In the absence of any local policy (e.g. MEDs), best path will be lowest neighbour IP address (i.e. entirely dependent on the address block the IX has received from the RIR)
  - AS100 needs to prioritise incoming traffic between the two regional IXPs according to geographical needs/issues
    - Outbound traffic afterall follows the local preference table in earlier slides
    - Prioritisation can be done by
      - Using AS-PATH prepend (carefully – don’t want path to be longer than through transit provider)
      - Subdividing address blocks (de-aggregating) for private peer and regional IXP connections, and not subdividing for Transit
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Traffic Engineering and CDNs
Traffic Engineering and CDNs

- Each CDN has its own configuration recommendations
  - These slides are only a guideline – it is best to consult directly with the CDN in question about their operational and traffic engineering policies

- CDN implementations:
  - Present at IXP via the IXP Services Infrastructure
    - Transit (backhaul/cache-fill) via one of the IX members or a transit provider or their own infrastructure
  - Peering directly at the IXP
  - Hosted at IX member, and made available to other IX members
CDN at an IXP – on Services LAN

- Diagram shows content provider hosted on IXP Services LAN
  - Transit connection for Cache Fill
CDN at an IXP – on Services LAN

- **BGP configuration:**
  - IXP members peer with IXP Services Router (Router A)
  - Receive the routes originated by the CDN
  - IXP Services announces routes to be served to the CDN
  - CDN has its own transit arrangements
    - Either via IXP member or separate infrastructure
CDN at an IXP – on Services LAN

- CDNs usually serve content to operators based on a combination of:
  - Lowest round trip time (latency)
    - End users expect “instant access”
  - BGP announcements of the peer
    - Following most specific announcements
    - AS-path length
    - BGP MED

- Operators need to:
  - Talk to CDN operator about BGP policy!
  - Watch the bandwidth to the CDN
  - Pay attention to BGP announcements
CDN at an IXP – direct peering

- Diagram shows content provider peering directly at the IXP
  - Transit connection for Cache Fill
CDN at an IXP – direct peering

- **BGP configuration:**
  - IXP members peer with CDN Router
  - IXP members receive the routes originated by the CDN
  - CDN has its own transit arrangements
    - Either via IXP member or separate infrastructure

- **Operations:**
  - Same as for the previous example
Diagram shows content provider hosted by IXP Member
- Transit connection for Cache Fill
CDN at an IXP – hosted by a member

- **BGP configuration:**
  - IXP members peer with AS100 (Peering Router A)
  - IXP members receive the routes originated by the CDN (as well as those originated by AS100)
  - AS100 announces routes to be served to the CDN
    - This could depend on AS100’s agreement with each of its peering partners
      - AS100 may charge for access to the CDN content (they have to pay for the backhaul)
      - AS100 may limit access to the CDN content to certain peering partners
CDN at an IXP – hosted by a member

- In addition to the previous advice:
  - Pay attention to the AS path length – CDNs may pay attention to BGP attributes
    - Make sure shortest path to the CDN is via the IXP member, rather than your own transit links (similar case to when the IXP hosts the CDN)
  - Stay in touch with the member who is giving you access to the cache/CDN
    - Especially for any change in policy
    - Especially for any bandwidth or latency issues
Finally: Connection to a CDN in two locations

- Circumstance happens to many operators
  - See the CDN via the local IXP (or local IXP member)
  - See the same CDN through their transit provider
  - How do they ensure that their end-users access the local CDN, and not the one hosted via the transit provider??

- CDNs normally:
  - Pay attention to BGP announcements
    - But will they accept traffic engineering?
  - Pay attention to RTTs

- Solution:
  - Talk to the CDN and discuss the situation
  - They want the best for their “eyeballs” – like the operator wants the best of end-users
BGP Case Studies

ISP Workshops