BGP Case Studies

ISP Workshops

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Acknowledgements

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- 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

Peering Policy	Local Preference
BGP Customer	250
Private Peer	200
Local IXP	170
Regional IXP	140
(default)	100
Paid Transit	50

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

Peering Policy	Local Preference
R&E BGP Customer	250
Private Peer	200
Local IXP	170
Regional IXP	140
Regional REN	120
(default)	100
Paid Transit	50

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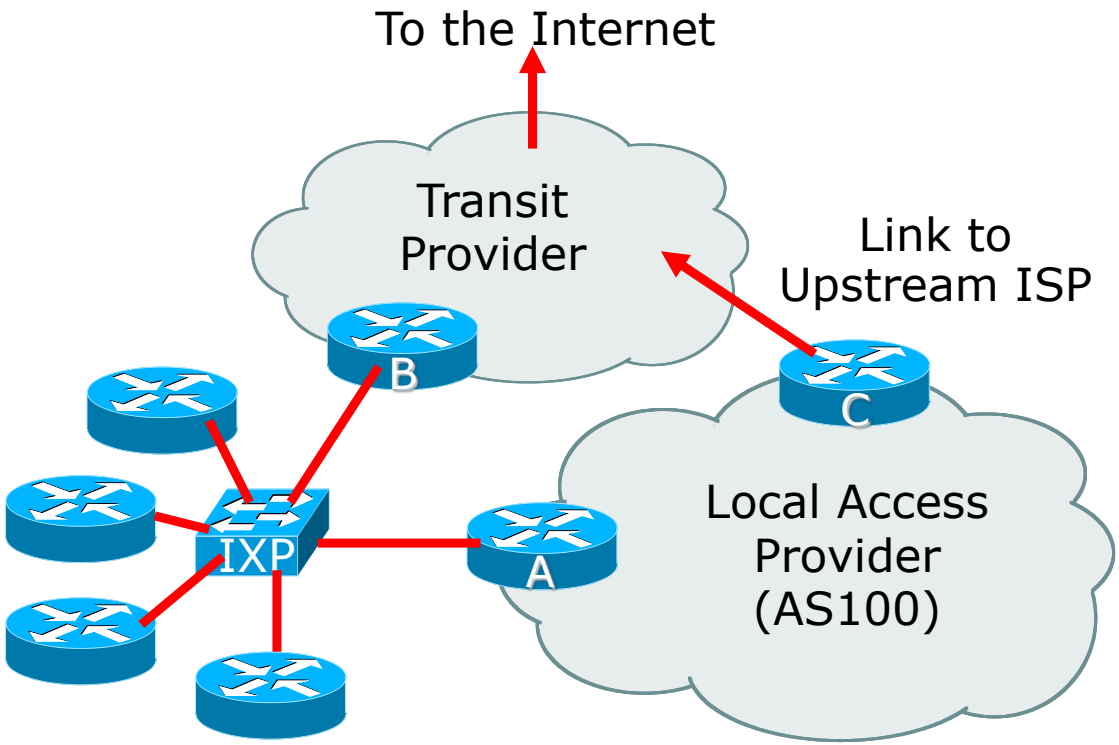
IXP Peering: When a Transit Provider is Also a Peer

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

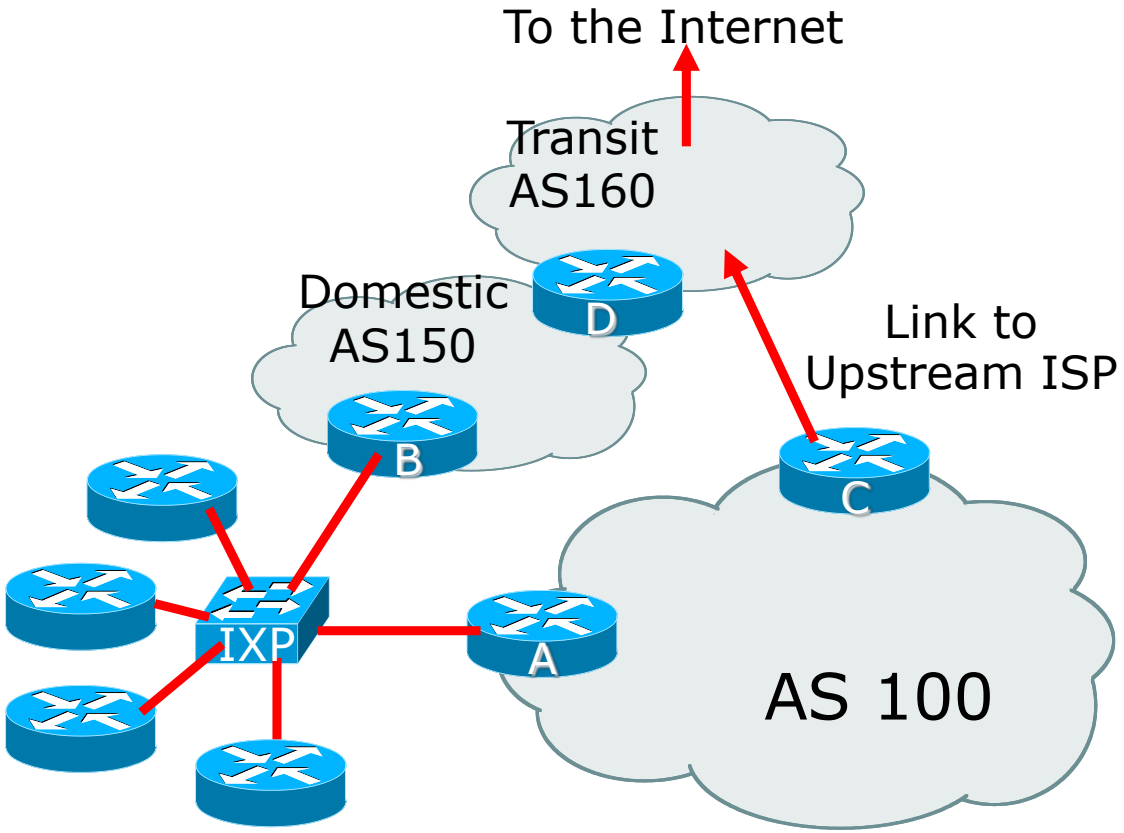
IXP Peering, when Transit Provider is also a Peer



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



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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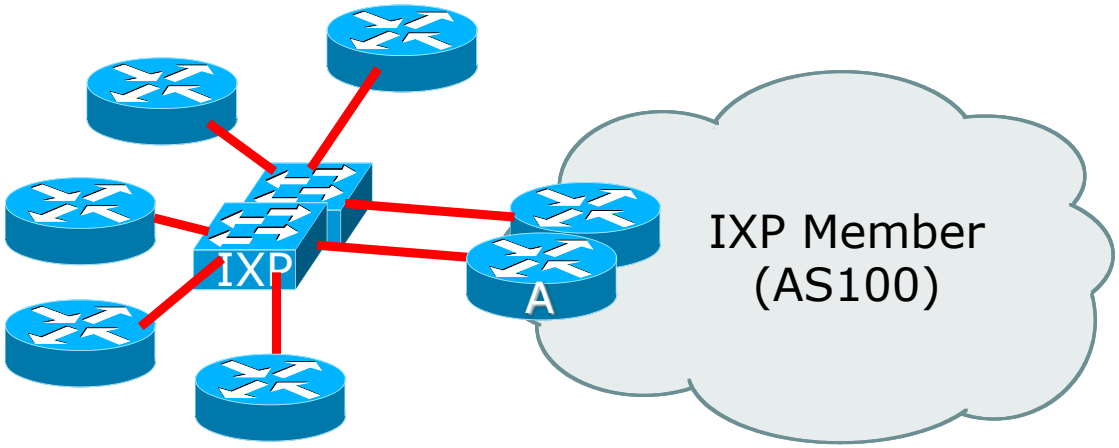
- Traffic Engineering and CDNs

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

Two connections to one 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 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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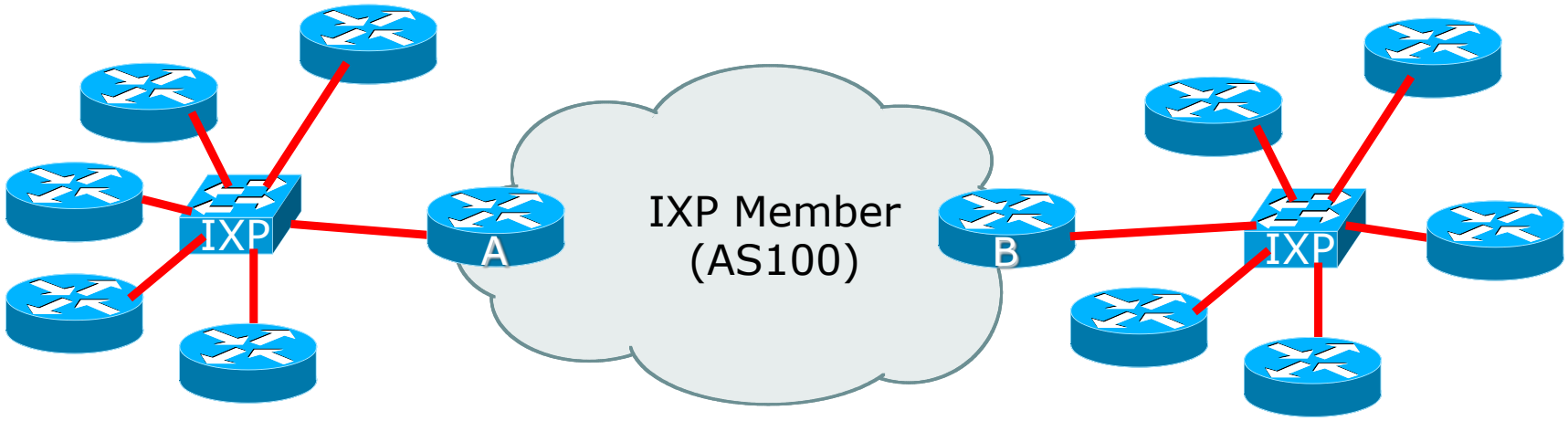
Traffic Engineering when connected to two IXPs

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

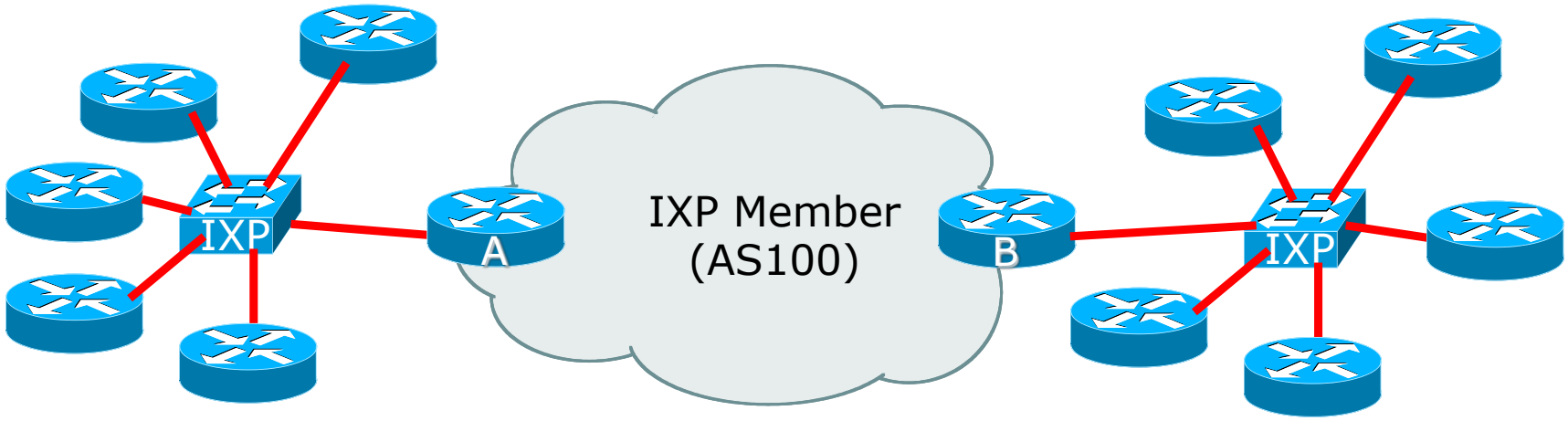
Peering at two local IXPs

- 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)

Peering at one local IXP and one regional IXP



- 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

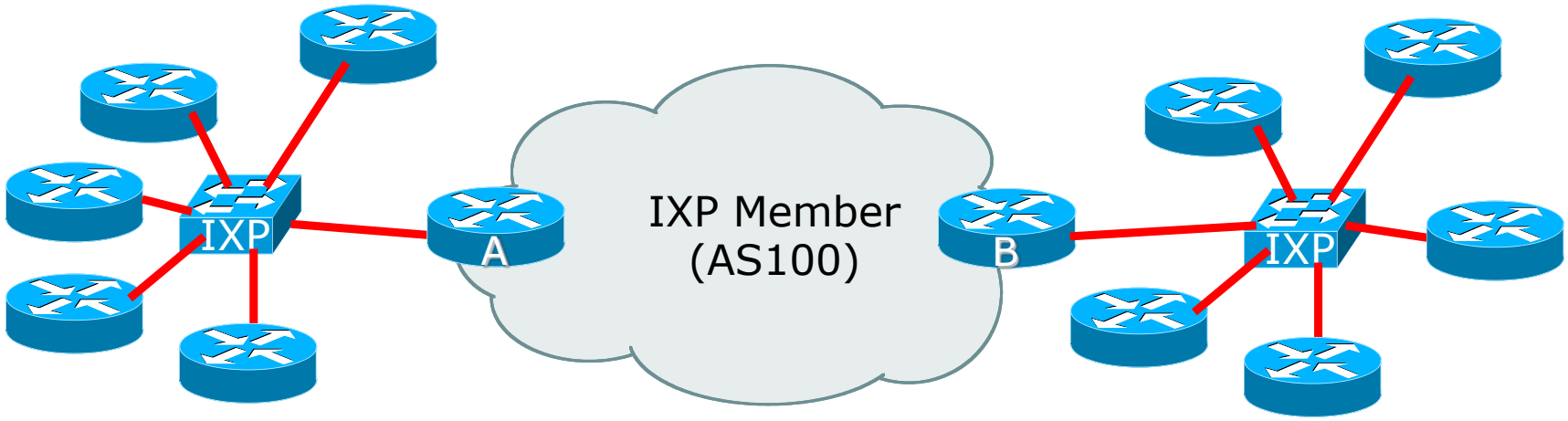
Peering at one local IXP and one regional IXP

- 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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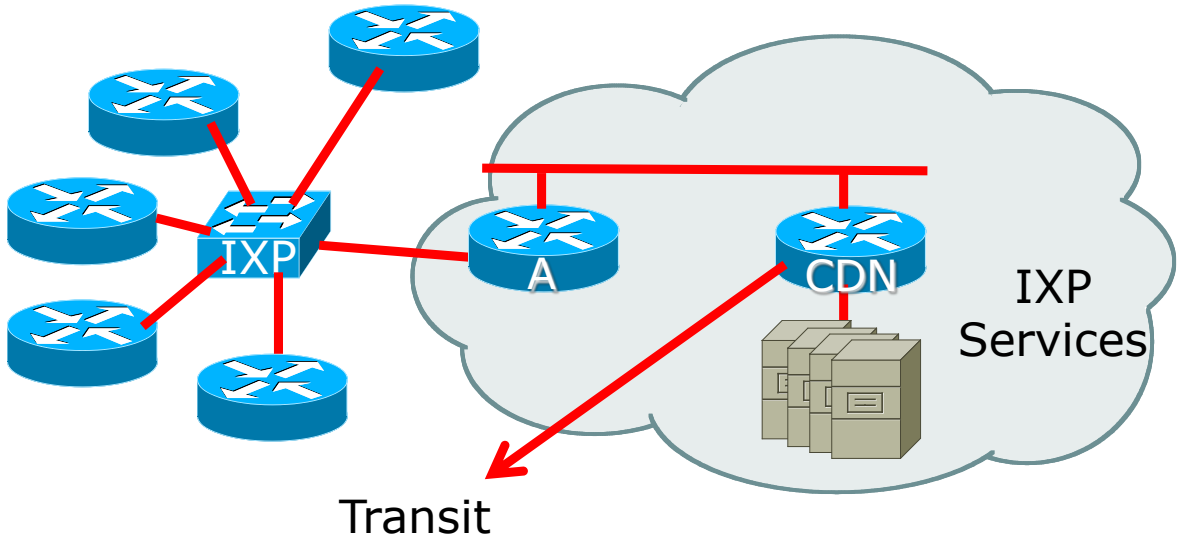
Traffic Engineering and CDNs

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

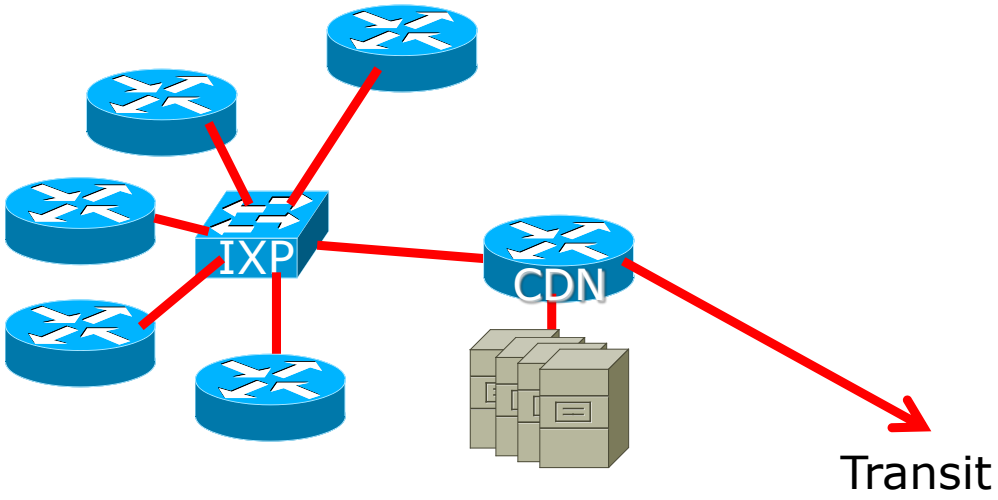
CDN at an IXP – on Services LAN

- 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

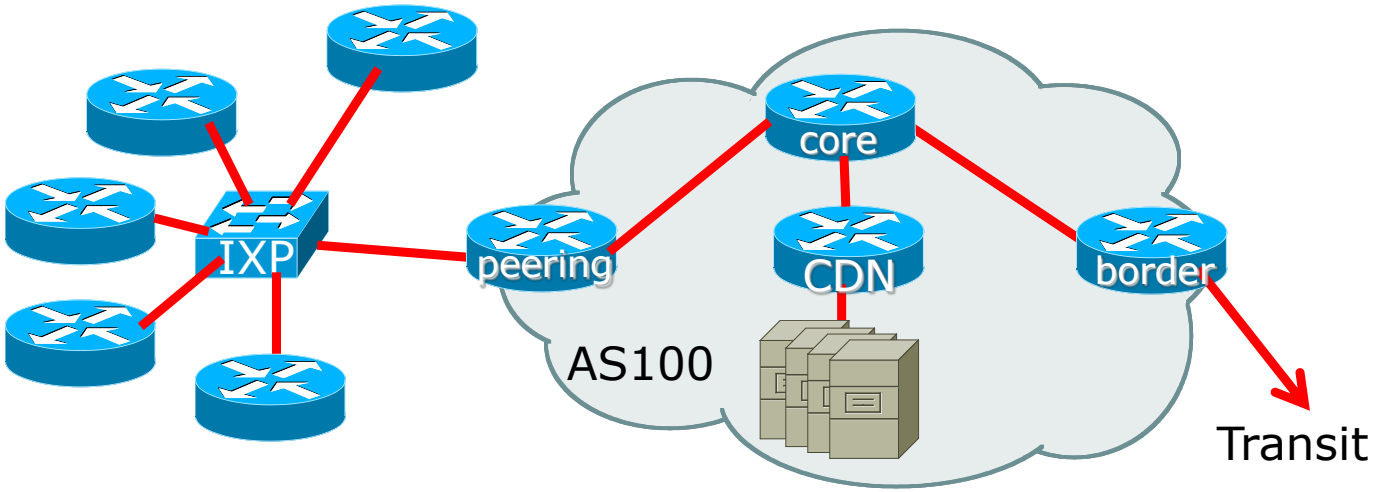


- Diagram shows content provider peering directly at the IXP
  - Transit connection for Cache Fill

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

CDN at an IXP – hosted by a member



- 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

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