Inferring Multilateral Peering

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Motivation and goals

- Topology sources capture only a small fraction of Autonomous System (AS) p2p links
  - 41% p2p links missing from public BGP data (Chen 2009)
  - At least 50K IXP links (Augustin 2009)
  - 50K peering links in a single IXP (Ager 2012)
  - 142K peering links (PCH survey 2011)
  - This work: 206K peering links, 88% missing from public BGP data
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- Topology sources capture only a small fraction of Autonomous System (AS) p2p links
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  - This work: 206K peering links, 88% missing from public BGP data

- Goals:
  - Collect and make publicly available data
  - Low measurement cost \(\rightarrow\) repeatability
IXPs facilitate peering

- 95% of missing peering links in IXPs (*He 2005*)
- IXP: A physical infrastructure to facilitate direct traffic exchange
- Two operational models:
  - Non-profit (European) → open data sharing
  - Commercial (N. American) → restrictive data sharing
IXPs facilitate peering

- 95% of missing peering links in IXPs (He 2005)
- IXP: A physical infrastructure to facilitate direct traffic exchange
- Two operational models:
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Two peering paradigms

- Bilateral peering
  - Separate BGP session per peering
  - Tight control of peering
  - Poor scalability

- Multilateral peering (MLP)
  - BGP session only with Route Servers (RS) for all links
  - Loose control of peering
  - Great scalability/flexibility
Route Servers enable dense peering

- Abundance of peering links because of multilateral agreements
- Very limited public data
  - Links
  - Policies
Route Servers enable dense peering

- Abundance of peering links because of multilateral agreements

- Very limited public data
  - Links
  - Policies

- **Goal:** Infer MLP links that we cannot observe
How MLP links are established?

**Connectivity**
ASes connected on the same Route Server

**Reachability**
Allowed by import & export BGP filters

MLP AS link
How MLP links are established?

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MLP AS link

Cannot observe 😞
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Can observe 😊
- IXP websites
- PeeringDB
- EuroIX
- PCH
- RPSL

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Cannot observe 😞
Default Route Server behaviour

Advertise to all
Advertisement Control BGP Communities

- **Transitive** BGP attribute
- Tags prefix advertisement with metadata
- 32-bit values divided in two parts:
  - ACTION:TARGET

- **MSK-IX example:**
  - 8635:8635 → Allow:All
  - 0:123 → Block:123
  - 0:8635 → Block:All
  - 8635:123 → Allow:123
Route Server Advertisement Control

Advertise to all except specific ASes

ALL:ALL
BLOCK:B

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Route Server Advertisement Control

Advertise to all except specific ASes

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Measurement through RS Looking Glasses

- show ip bgp summary
  - Get ASes connected on Route Server
  - Query once

- show ip bgp neighbor
  - Get prefixes advertised by each Route Server member
  - Query $\text{members}$ times

- show ip bgp
  - Get BGP Communities set for a prefix
  - Query $\text{prefix}$ times
Measurement through RS Looking Glasses

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  - Get prefixes advertised by each Route Server member
  - Query \#members times
- show ip bgp
  - Get BGP Communities set for a prefix
  - Query \#prefix times
Measurement through passive BGP data
Measurement through passive BGP data

E A B | ALLOW:ALL BLOCK:D
E A C | ALLOW:ALL
E A D | BLOCK:ALL ALLOW:A ALLOW:C

BGP Route Collector

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- BGP RS Redistribution Communities

MLP AS link
How MLP links are established?

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Allowed by import & export BGP filters

- Can observe 😊
  - IXP websites
  - PeeringDB
  - EuroIX
  - PCH
  - RPSL

- Cannot observe 😞

Can observe 😊
- BGP RS
  - Redistribution Communities

😊 Import filters?
Reciprocity Assumption

- Two ASes that allow each other to receive their traffic at the export filters will not block each other’s traffic at the import filters
- Validation based on AMS-IX IRRdb filters:
  - Compared import/export filters from 230 AMS-IX Route Server members
  - Import filters never more restrictive than export filters
  - 50% of export filters more restrictive than import
    - Asymmetric (single direction) MLP peering
    - False negatives
Results

- Collected presence and permissions data for 13 large European IXPs
- 206,667 MLP links inferred between 1,362 ASes
- 14,276 links appear in more than one IXPs
  - Largest overlap between DE-CIX and AMS-IX

<table>
<thead>
<tr>
<th>IXP</th>
<th>Members*</th>
<th>Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSK-IX</td>
<td>348</td>
<td>58,501</td>
</tr>
<tr>
<td>DE-CIX</td>
<td>369</td>
<td>54,082</td>
</tr>
<tr>
<td>AMS-IX</td>
<td>351</td>
<td>49,249</td>
</tr>
<tr>
<td>PLIX</td>
<td>211</td>
<td>21,911</td>
</tr>
<tr>
<td>LINX</td>
<td>176</td>
<td>14,759</td>
</tr>
</tbody>
</table>
Validation

- Tested inferences against links collected from AS paths of 70 RS member looking glasses
- Validation repeated twice, May 2013 and October 2013
- 26,392 links tested, 98.4% successfully validated overall
- Highest validation: 100% (TOP-IX)
- Lowest validation: 96.9% (FranceIX)
- Average for all IXPs: 98.6%
Limitations of validation

- Links part of less preferred paths are hidden from looking glasses that display only the active paths.
- ASes left Route Server or changed policy between inference – validation.
Comparison against observable p2p links

- 12% overlap with passive BGP measurements (Routeview+RIPE RIS+PCH)
- 2% overlap with active traceroute (Ark + DIMES)
Majority of MLP links involve stub ASes
Extremely high MLP density

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Limitations

- Cases where our methodology cannot be applied:
  - IXPs without Route Servers
  - Route Servers that do not use BGP Communities for advertisement control
  - Route Servers that strip out BGP Communities before propagating advertisements
- Coverage of European IXPs only (for the moment)
Conclusions

- Propose and implement a new approach to infer Multilateral Peering links
- Utilize only public data sources
- Apply algorithm at 13 IXPs to infer 206K links
  - 88% missing from RouteViews/RIPE RIS BGP data
- Validate 26K links with 98.4% success rate
Thank you!

Questions?

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Self-reported Peering Policy can be Misleading

![Graph showing fraction of peers for different peering policies](image)

- **Open**: 96.7%
- **Selective**: 80.4%
- **Restrictive**: 69.2%
Peering policies can depend on location

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Backup slide 3: Prefixes advertised by multiple Route Server members