presented by

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Uncovering Remote Peering Interconnections at IXPs

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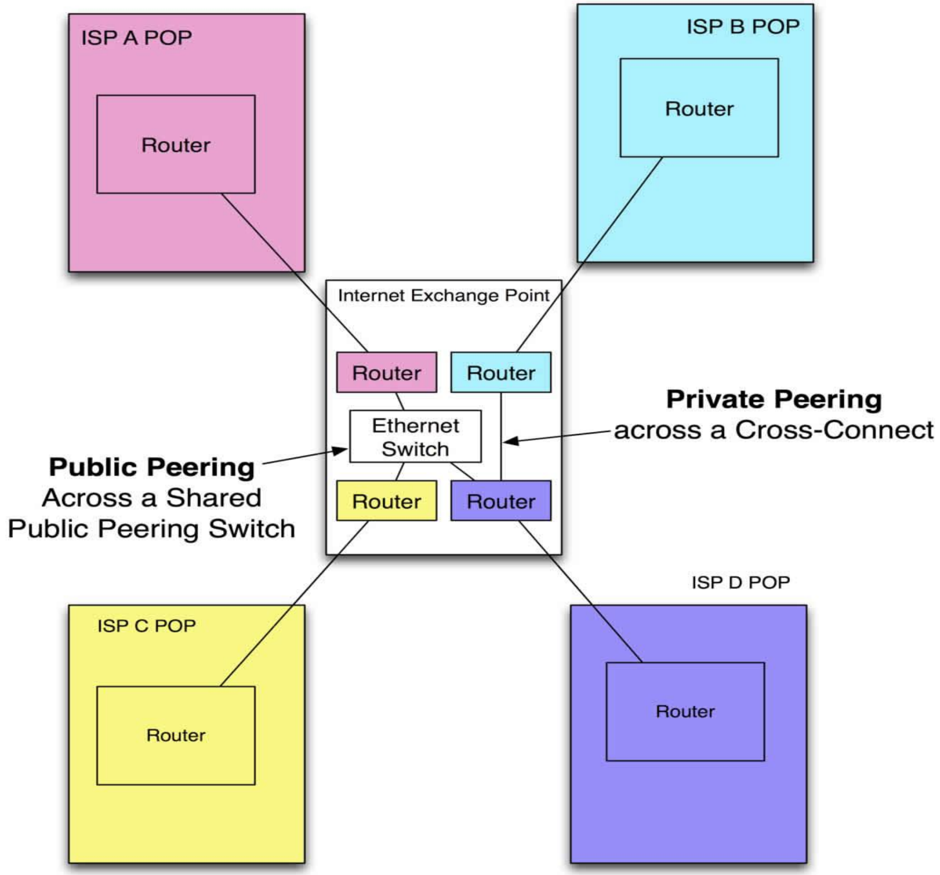
What is an Internet eXchange Point (IXP)?

- A layer-2 infrastructure to exchange Internet traffic
- Provides direct interconnection among ASes
- Keeps local traffic local



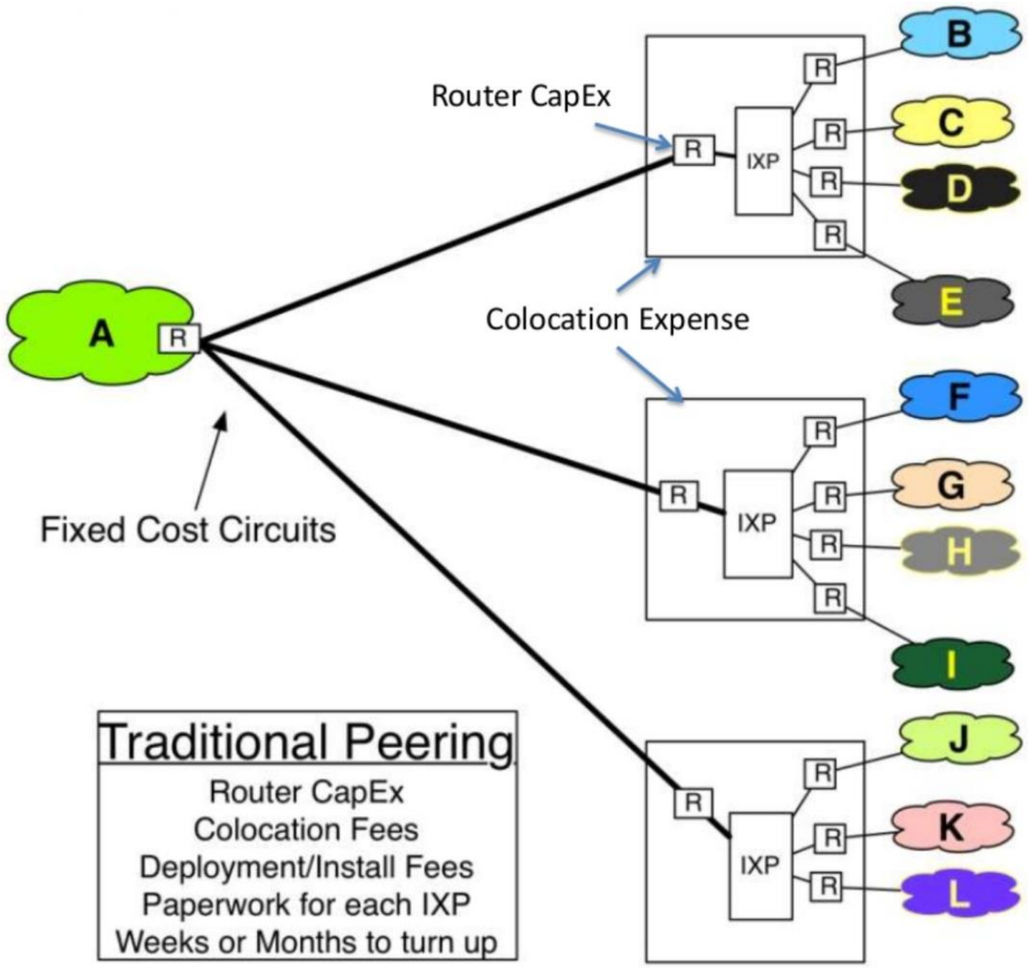
http://drpeering.net/FAQ/What-is-an-Internet-Exchange-Point.php

Benefits of Internet eXchange Points*

- **Keeps** local Internet traffic within a local infrastructure**, and** reduces costs associated with traffic exchange between networks.
- Builds local Internet community **and develops** human technical **capacity** – better net management skills and routing
- **Improves the quality of Internet services and drive demand** in by reducing delay and improving end-user experience
- **Convenient hub for attracting hosting key Internet infrastructures** within countries – **content is key and confidence** builds in local infra when delivery is consistent and reliable
- **Catalyst** for overall Internet development

*Jane Coffin and Christian O'Flaherty. Internet Exchange Point (IXP) – Global Development Work. ISOC. IETF 90. July 2014

Pressure for Diverse Peering

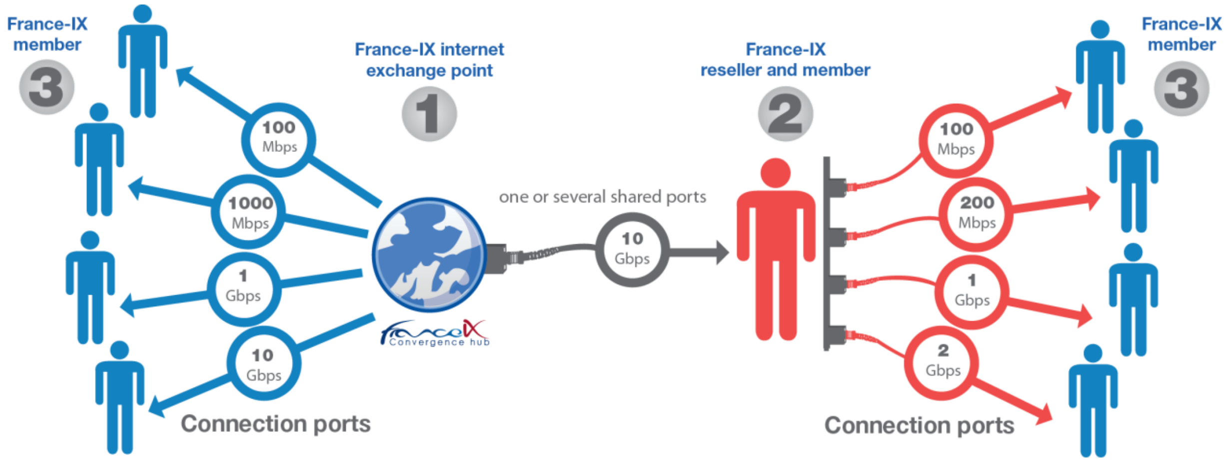


- Volume of traffic is constantly increasing
  - CDNs, Cloud, IOT
- Pressure on ASes for denser and more diverse peering connectivity
- A fundamental shift in peering practices is required

Remote Peering over IXPs

- ***Remote Peering*** is when a network peers at an IXP:

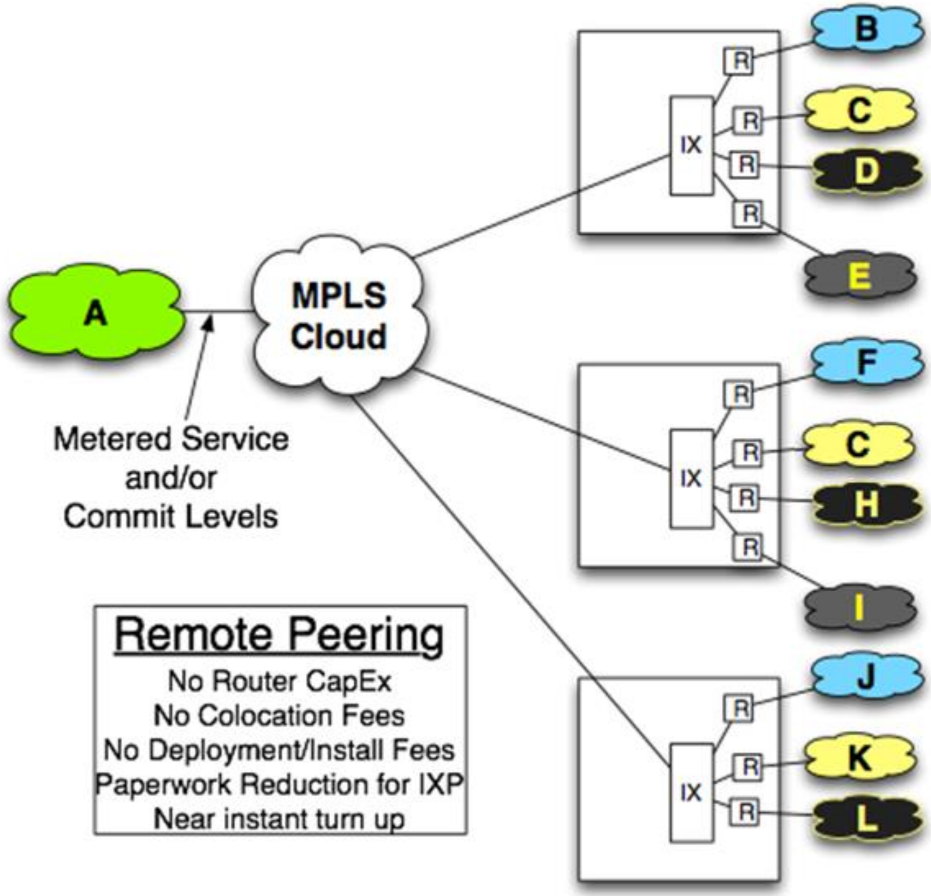
1. without having physical presence in the IXP's infrastructure
2. and/or through resellers



https://www.franceix.net/en/solutions/reseller-program

Peer Remotely?

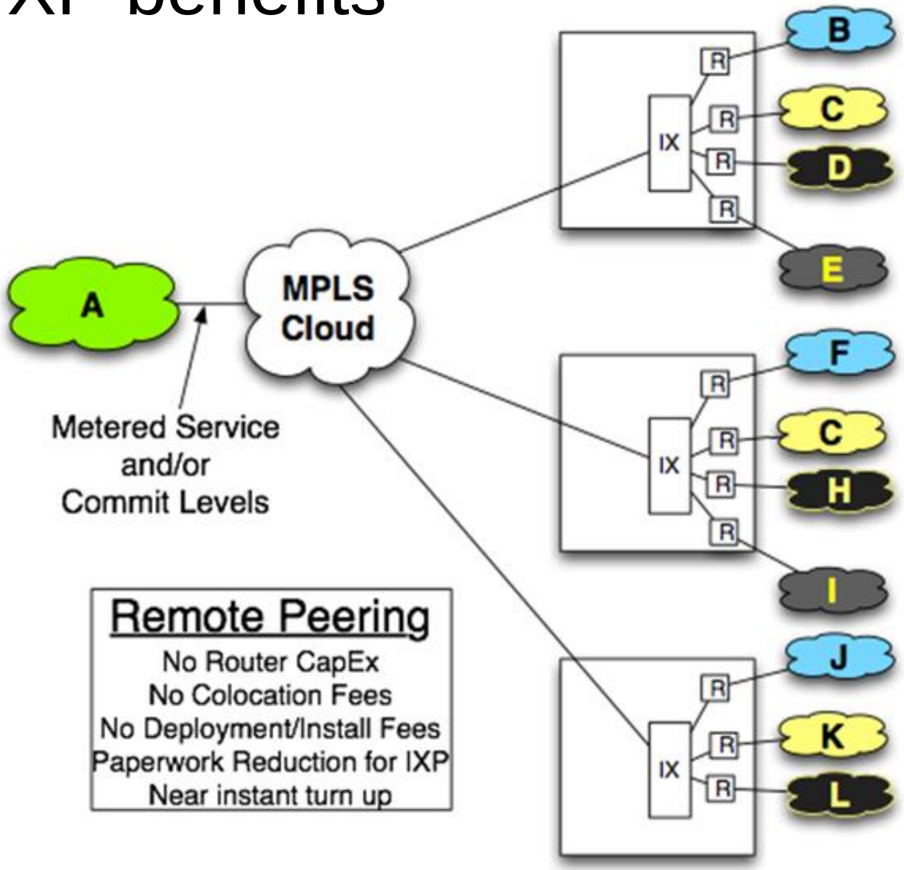
- Connect to IXP peering fabric without collocating a router at an IXP facility
  - Cut equipment, deployment, operational costs
  - Connect to multiple IXPs through a single router



Yes, but...

Remote Peering cancels out many IXP benefits

1. Introduces third parties
   - Opaqueness
   - Harder to monitor and debug
2. Reduces resilience and reliability
3. Increases latency

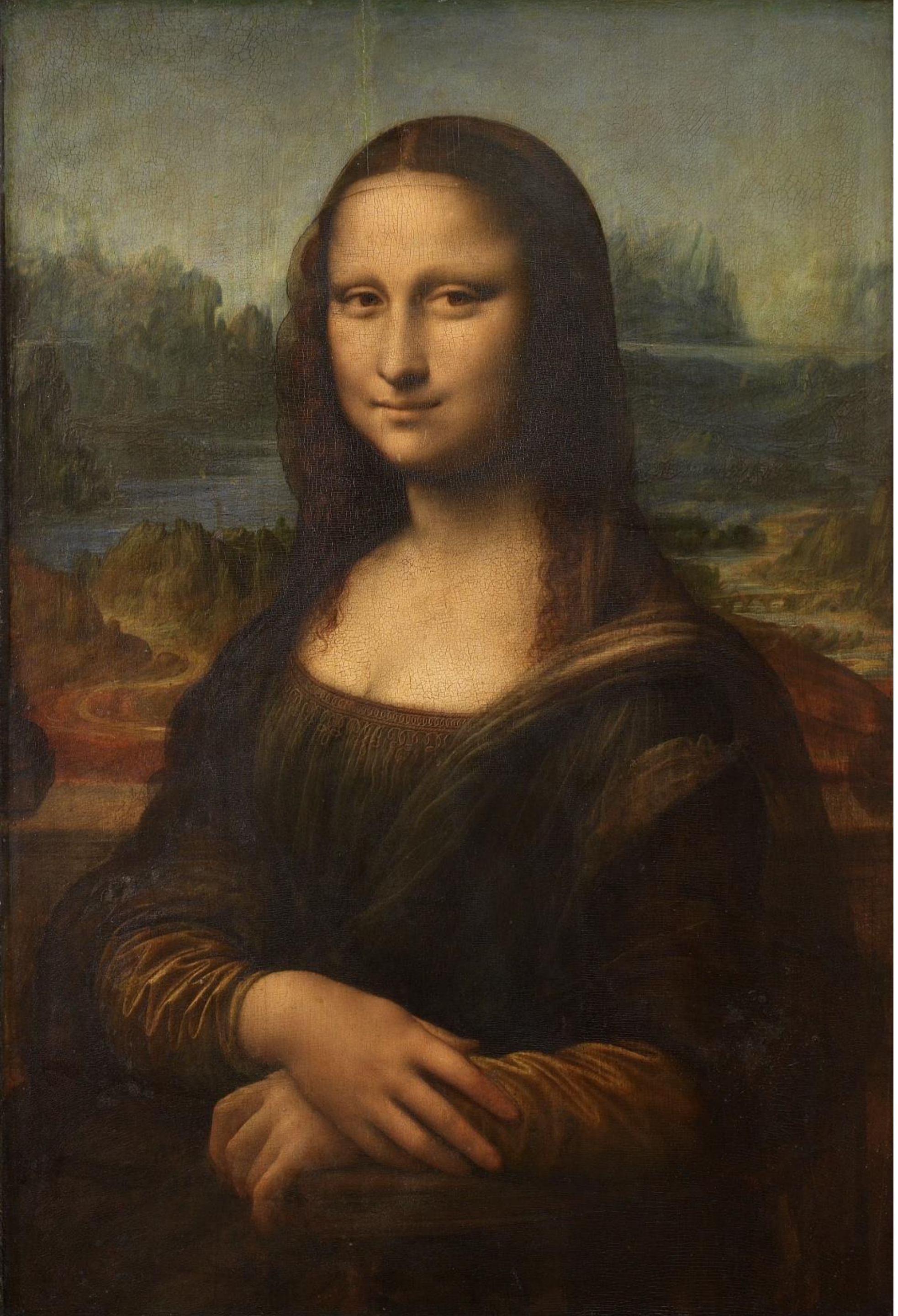


OUR GOAL

"What goes on beyond that cable?"

- Transparency
  - Identify remote/local peers
  - For both IXP operators and customers point of view

- Features of Remote Peering
  - Study if/how remote peers' characteristics can differentiate from local peers



State-of-the-*art*

RTT-based Remote Peering Inference

- Detect remote peers based on RTT measurements

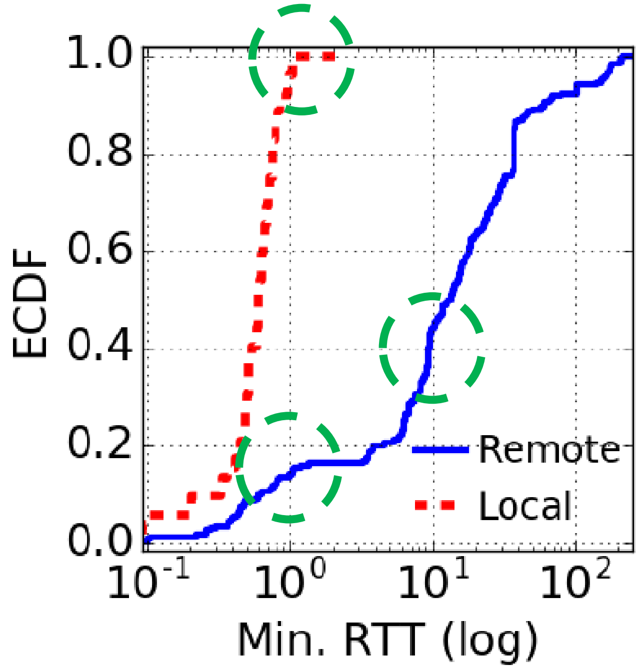
- Execute ping from Looking Glass inside the IXP to the peering interfaces

- **RTTs > 10 ms** indicate remote peers
  - Conservative threshold for local / regional IXPs

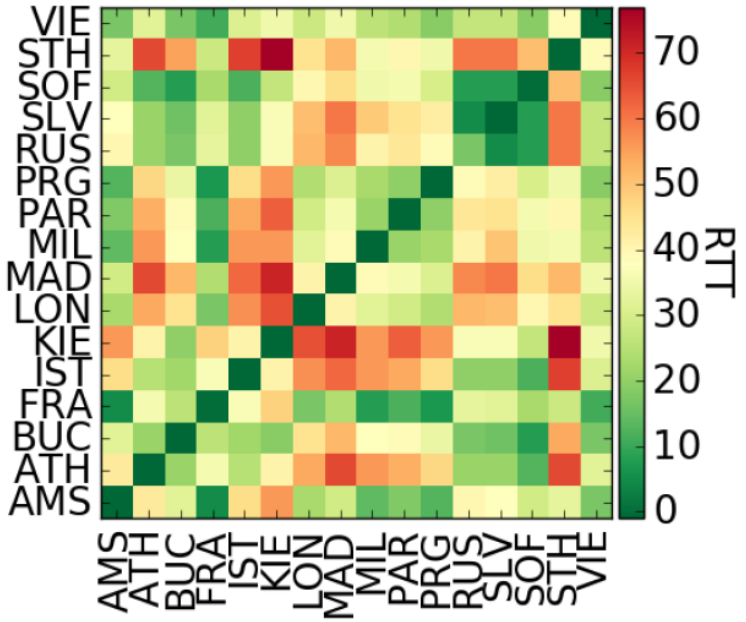
Castro, Ignacio, et al. "Remote peering: More peering without internet flattening." ACM CoNEXT 2014.

What Validation Dataset Says:

- **Regional IXPs:** **40%** of remote peers have **< 10ms** RTT
- **18%** of remote peers have < 1ms RTT



- **Wide-area IXPs:** **87%** of facility pairs have **>10ms** median RTT (NET-IX)
- **~14%** of IXPs are wide-area

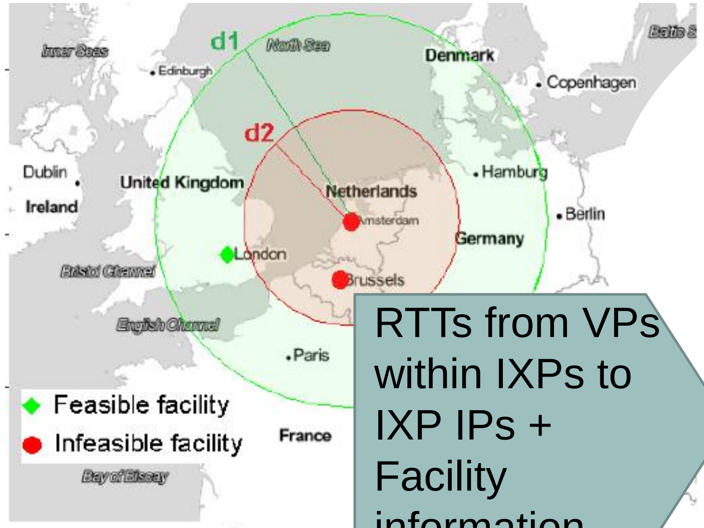


Our Methodology - How it works

- We propose a 'first-principles' approach to infer remote and local peers

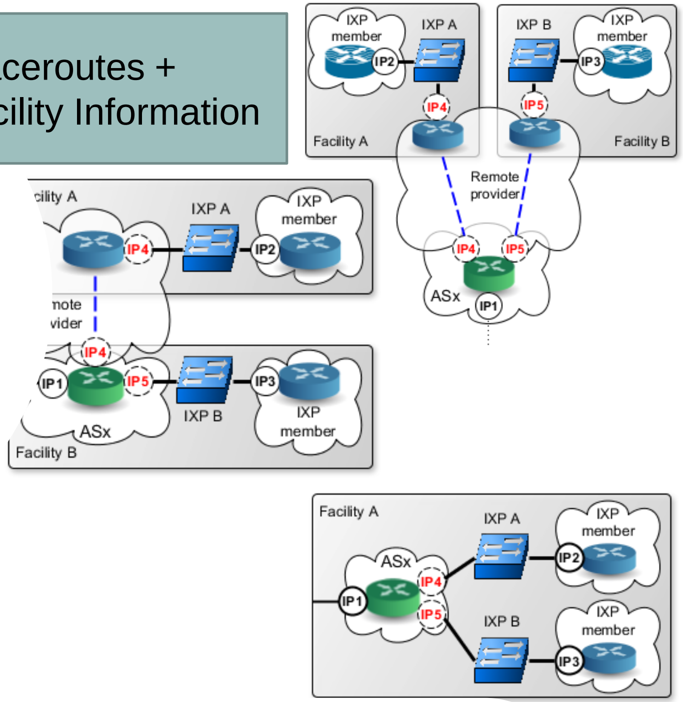
- Design aspects:
  1. Port Capacity
     - Low port capacities indicate that networks peer remotely at an IXP
  2. Ping RTT Measurements
     - RTT values provide evidence for how far (from the IXP) a peer is located
  3. Colocation Facilities
     - An AS can be a local peer of an IXP if they are colocated in the same facility (no reseller involved)
  4. Multi-IXP Routers
     - An AS may connect to multiple IXPs through the same border router
  5. Private Connectivity over Facilities
     - Private interconnections can be established within the same IXP-hosting facility

Algorithm Overview – 4 Modules



RTTs from VPs within IXPs to IXP IPs + Facility information

Traceroutes + Facility Information



Does it work?

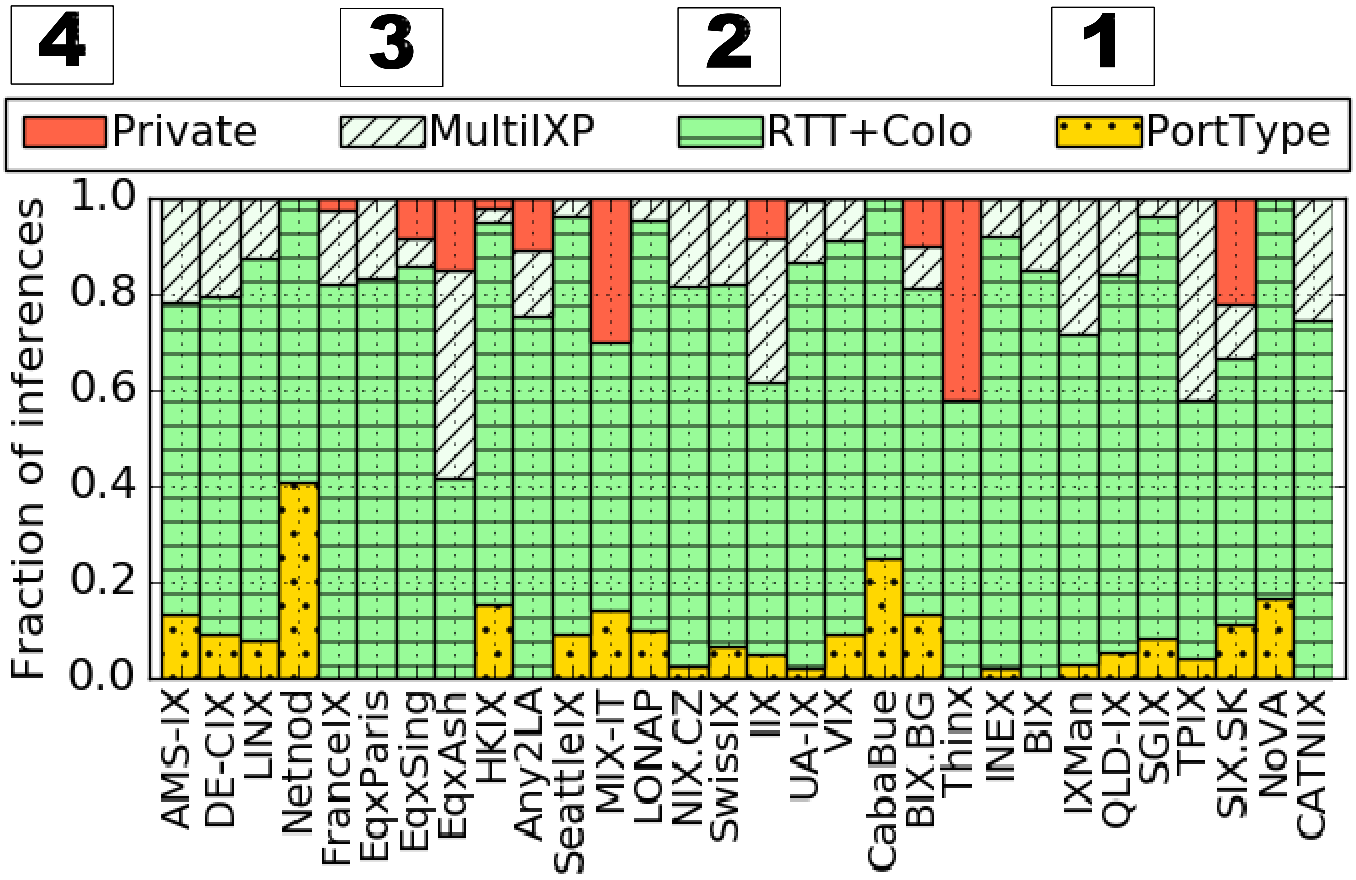
Inference Module	**Coverage**	**Precision**	**Accuracy**
1) Port Capacity	11%	96%	
2) RTT (*min*) + Colocation Info	76%	99.6%	94%
3) Multi-IXP	53%	97.5%	93%
4) Private Links	49%	95%	85%
Combined	93%	95%	94.5%


Remote Peering in the Wild

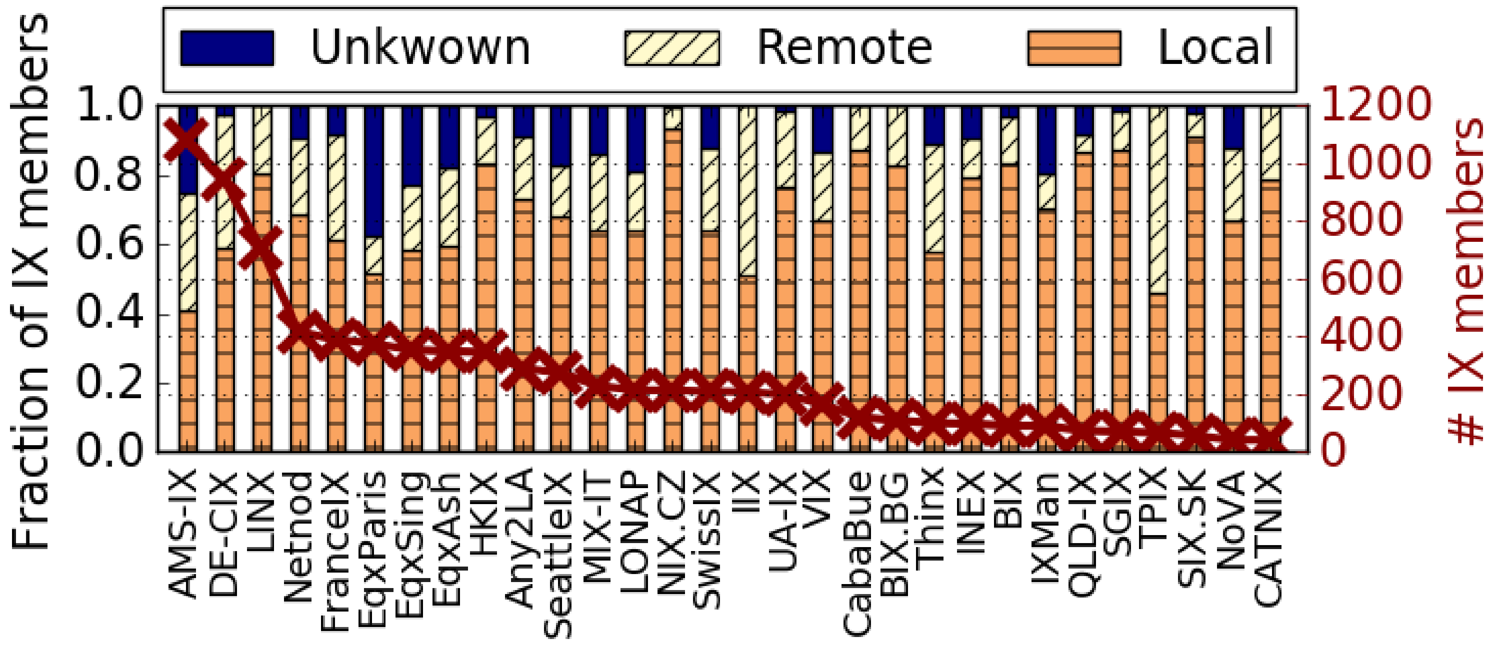
Contribution per Inference Module

For the ***top-30*** IXPs (7-9 April, 2018):

- ✓ **10%** of the inferences can be made using only port capacity information
- ✓ **RTT+Colo** and **MultiIXP** modules account for the majority of the inferences
- ✓ **25%** of the multi-IXP routers connect to more than 10 IXPs



Inference Results



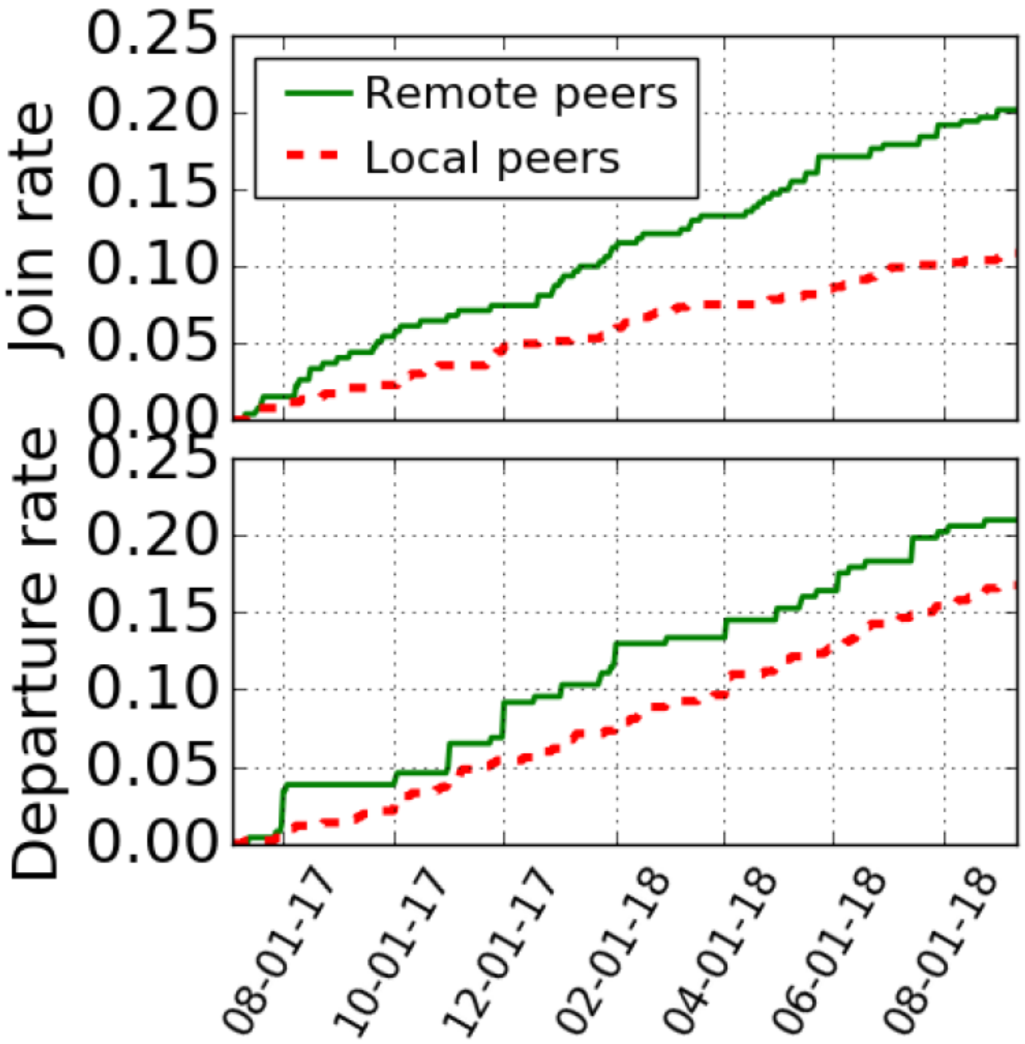
We also found:

- ✓ **1 / 3** of members peers remotely with the IXP
- ✓ **90%** of IXPs have at least **10%** of their peers as remote
- ✓ Large IXPs (*e.g.* AMS-IX, DE-CIX, France-IX) have **~40%** of their peers as remote

Growth Rate

1. **5** IXPs between **2017/07 – 2018/10**
   - LINX, LONAP, HKIX, THINX, UAIX
2. Also confirmed from annual reports of AMS-IX, DE-CIX, France-IX

- Remote peers grow ***twice*** as much compared with local peers
- Remote peers exhibit higher join (x2) and departure (x1.25) rates
- 18 remote peers switched to local

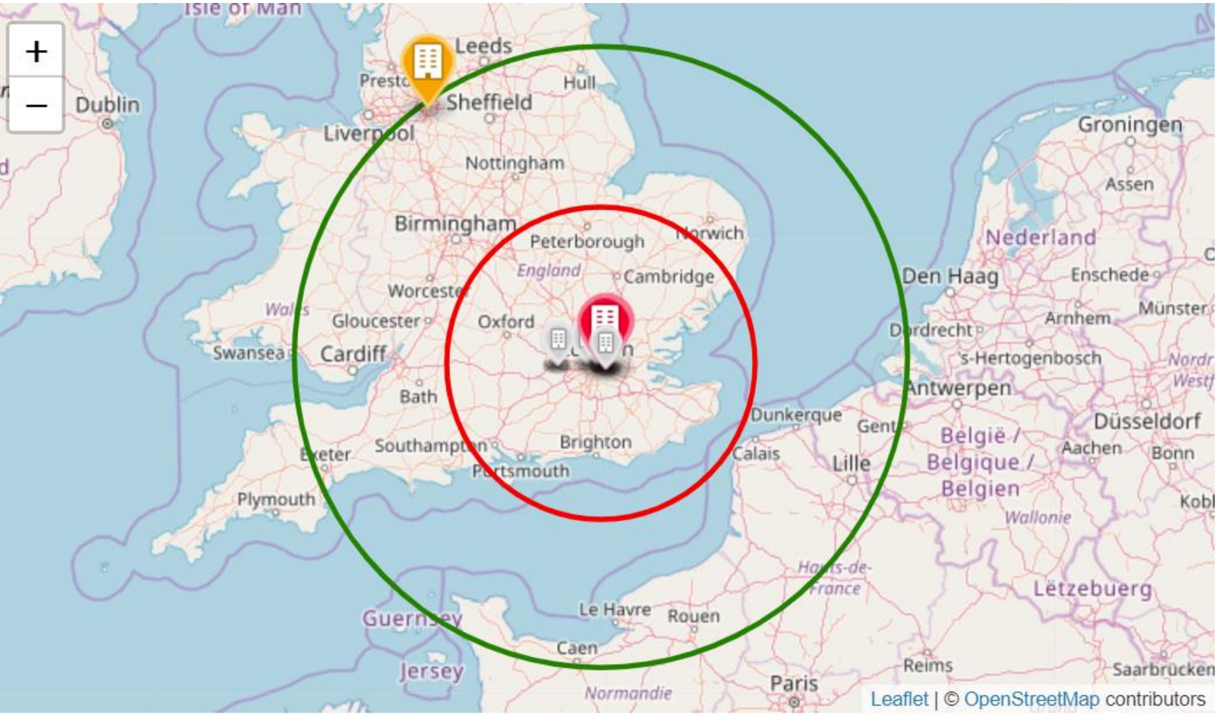


RP Routing Implications

- Interested in circuitous paths between ASes with >1 common IXP
- Traceroutes from remote peers (381 members) to any other IXP member (781 in total) in DE-CIX Frankfurt
- **66%** of the cases include the closest IXP to the remote peer
- **34%** of the cases do not comply with an expected *hot potato* exit strategy

DEMO: http://remote-ixp-peering.net

IXP's Facilities



IXP members ▾

IXP Facilities

Telehouse - London (Docklands North) **Outside range**

Telehouse - London (Docklands East) **Not present**

Digital Realty London (Sovereign House) **Not present**

Digital Realty London

AS47622 is remote. Minimum RTT: 4 ms. Possible remote PoPs: Equinix Manchester Williams/Kilburn (MA1) - GB

AS15169 is local. Minimum RTT: 1 ms

Portal

- Remote/Local peering visualization
- Filtering remote/local peers in the IXP and Facility level
- REST API
- Publicly available soon

Conclusions

- New methodology to accurately infer peers connected to IXPs through remote peering
  - Increase transparency of peering ecosystem
  - Illuminate peering trends and practices
- Remote Peering becomes popular practice and is almost ubiquitous
  - Saturation of local markets pushes IXPs to expand to new markets
- A publicly accessible web portal with:
  - Monthly snapshots with remote and local peering inferences
  - Visualization of geographical footprints of IXPs and their members

Future Work:

- An extensive analysis including more IXPs back in time
- Interpretation of traffic levels of remote and local IXP peering interconnections

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ABSTRACT

Internet eXchange Points (IXPs) are Internet hubs that mainly provide the switching infrastructure to interconnect networks and exchange traffic. While the initial goal of IXPs was to bring together networks residing in the same city or country, and thus keep *local traffic local*, this model is gradually shifting. Many networks connect to IXPs without having physical presence at their switching infrastructure. This practice, called *Remote Peering*, is changing the Internet topology and economy, and has become the subject of a contentious debate within the network operators' community. However, despite the increasing attention it attracts, the understanding of the characteristics and impact of remote peering is limited. In this work, we introduce and validate a heuristic methodology for discovering remote peers at IXPs. We (i) identify critical remote peering inference challenges, (ii) infer remote peers with high accuracy (>95%) and coverage (93%) per IXP, and (iii) characterize different aspects of the remote peering ecosystem by applying our methodology to 30 large IXPs. We observe that remote peering is a significantly common practice in all the studied IXPs; for the largest IXPs, remote peers account for 40% of their member base. We also show that today, IXP growth is mainly driven by remote peering, which contributes two times more than local peering.

CCS CONCEPTS

• **Networks** → **Network measurement**; **Network architectures**; **Network properties**;

Remote Peering Interconnections at IXPs. In *2018 Internet Measurement Conference (IMC '18), October 31-November 2, 2018, Boston, MA, USA.* ACM, New York, NY, USA, 14 pages. https://doi.org/10.1145/3278532.3278556

1 INTRODUCTION

Internet eXchange Points (IXPs) are crucial components of today's Internet ecosystem [25, 29, 37, 38], that provide infrastructure for the direct interconnection (*peering*) of Autonomous Systems (ASes). Currently, there exist more than 700 IXPs around the world, with more than 11K member networks (i.e., *peers*); these correspond to approximately 20% of the total number of ASes [11, 15, 16]. The largest IXPs host more than 800 networks each [1, 7], and handle aggregate traffic that peaks at or exceeds 6 Tbps [3, 8].

IXPs were originally created to locally interconnect ASes at layer-2 (L2), and *keep local traffic local* [39]. Under this model, networks peer at IXPs to *directly connect* with each other and avoid connections through third parties, and thus reduce costs, improve performance (*e.g.*, lower latency), and better control the exchanged traffic [26, 67]. However, the ever-increasing traffic flowing at the edge of the Internet, creates pressure for denser and more diverse peering that challenges the traditional IXP model. As a result, the IXP ecosystem is undergoing a fundamental shift in peering practices to respond to these requirements: networks may establish peering connections at IXPs from *remote* locations, to broaden the set of networks they reach within one AS-hop [41, 69], either over a (owned or rented) "long cable" or over *resellers* that provide ports on the IXP and L2 access through their own network [13, 18]. This