Remote Peering: More Peering without Internet Flattening

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“The Internet is a series of tubes”

Who operates the tubes?

How are they connected?

Where does the traffic flow?

Economics is crucial for Internet operation
Modeling of Internet Economics

Internet → Layer-3 model

Tubes of the same organization

Tubes across organizational boundaries

Autonomous System (AS)

Transit

Customer → Provider

Peering

Peer → Peer
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Peer → Peer
Mostly Transit in the Early Internet

- Customer pays provider for bidirectional traffic
- Peering is an alternative for colocated customers
  - Both peers reduce their transit costs
Layer-3 Structural Evolution

- Increased peering of colocated ASes
- Internet flattening
  - Fewer ASes on end-to-end paths
IXPs as Promoters of Peering

• Internet eXchange Point (IXP)
  – Layer-2 infrastructure for cost-effective peering
  – Geographical constraint of AS colocation with IXP
Remote-Peering Providers

- New type of layer-2 intermediaries
- More peering without Internet flattening
Modeling implication

Internet economic structure needs to be modeled on both layers 2 and 3
Remote Peering as a Service

• Service components
  – Layer-2 connectivity of the AS to the IXP
  – Peering equipment at the IXP

• Costs
  – Trade-off between transit and peering
Usage of Remote Peering

- Reaching a distant IXP
- Connecting two IXPs
- Reducing costs over short distances
- Trial peering

- African AS
- AMS-IX Hong Kong
- AMS-IX
- Dutch AS
- Dutch AS

Remote peering
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Remote peering

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Trial peering

Remote peering

Peering
Our Contributions

• Measurement-based studies
  – Spread of remote peering
  – Impact of remote peering on Internet traffic

• Modeling of economic viability
  – Remote peering vs. transit and direct peering
Estimating the Spread

• Studied questions
  – How many IXPs have remote peering?
  – How many IXP members are remote peers?

• Approach
  – Conservative estimate
  – RTT (Round-Trip Time) as a metric of peer remoteness
  – 22 IXPs with colocated Looking Glass servers
Classification of Peers as Remote

- IP address from PCH, PeeringDB, and IXPs’ websites
- Ping reply within one IP hop if its TTL = maximum TTL
- 4 months and 6 filters to get minimum RTT reliably

If RTT > threshold, classify the peer as remote

empirical threshold of 10 ms
Validation

- Public IXP information on remote peers
- Ground truth from TorIX
  - RTT measurements
  - Remotely peering ASes
Spread across IXPs

91% of the IXPs have remote peering
Around 20% of AMS-IX peers are remote
Our Contributions

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  – Spread of remote peering
  – Impact of remote peering on Internet traffic

• Modeling of economic viability
  – Remote peering vs. transit and direct peering
Estimating the Offload Potential

• Studied questions
  – How can an AS benefit from remote peering?
  – How much traffic can the AS offload from its transit-provider links?

• Evaluated AS
  – RedIRIS, the Spanish national academic network
  – 1 month of NetFlow traffic data
  – Routing tables
Transit-Provider Traffic of RedIRIS

- 2 transit providers
- 29,570 ASes contribute traffic
  - origins of inbound traffic or
  - destinations of outbound traffic
• Up to 65 IXPs from Euro-IX
• Up to 12,238 reached ASes
  – including 2,192 IXP members
Choice of Peers for RedIRIS

Peering policies from PeeringDB

1. all open, lower bound
2. all open and top 10 selective,
3. all open and selective,
4. all policies upper bound
Top 30 among Offload Contributors

Top peers include major content providers and CDNs (Content Delivery Networks)
Offload Potential at a Single IXP

Big European trio
AMS-IX, LINX, DE-CIX

Terremark

South American hub in Miami
SFINX, Netnod, CoreSite, TIE, NL-ix, PITT
Which IXP to Reach Next?

Overlap in IXP memberships affects next IXP choice.
Gain from Reaching a Second IXP

![Bar chart showing offload potential at IXP (Gbps) for different IXPs and policies.]

- **AMS-IX**
  - Full
  - Remaining after peering at AMS-IX
  - Remaining after peering at LIX
  - Remaining after peering at DE-CIX
  - Remaining after peering at Terremark

(all policies)
How Much Traffic can RedIRIS Offload?

Between 8% and 25% of reduction in transit traffic
Utility of Reaching an Additional IXP

Reaching only 5 IXPs realizes most of the offload potential
Is the RedIRIS Case Representative?

Decreasing marginal utility of reaching an additional IXP is a general property
Conclusions

• Remote peering, a new common interconnection
  – AS reaches and peers at IXP via a layer-2 provider

• Potential impact on Internet traffic is substantial
  – Reaching only 5 IXPs realizes most of the potential

• Internet economic structure needs refined models
  – Layer-2 entities need to be represented