

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



Autonomous
System (AS)

Tubes across
organizational
boundaries



Transit

Customer



Provider

Peering

Peer



Peer

Modeling of Internet Economics

Internet



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Autonomous
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Transit

Customer

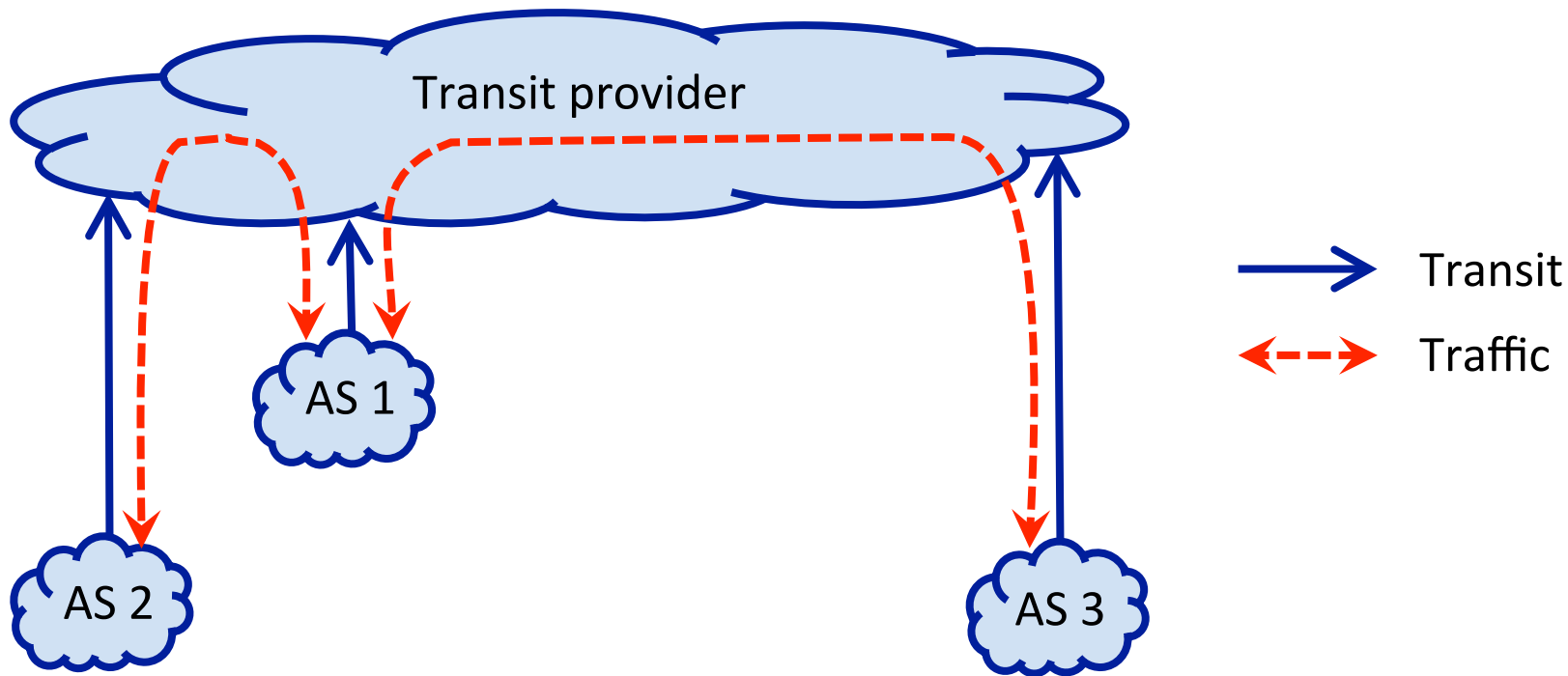
Provider

Peering

Peer

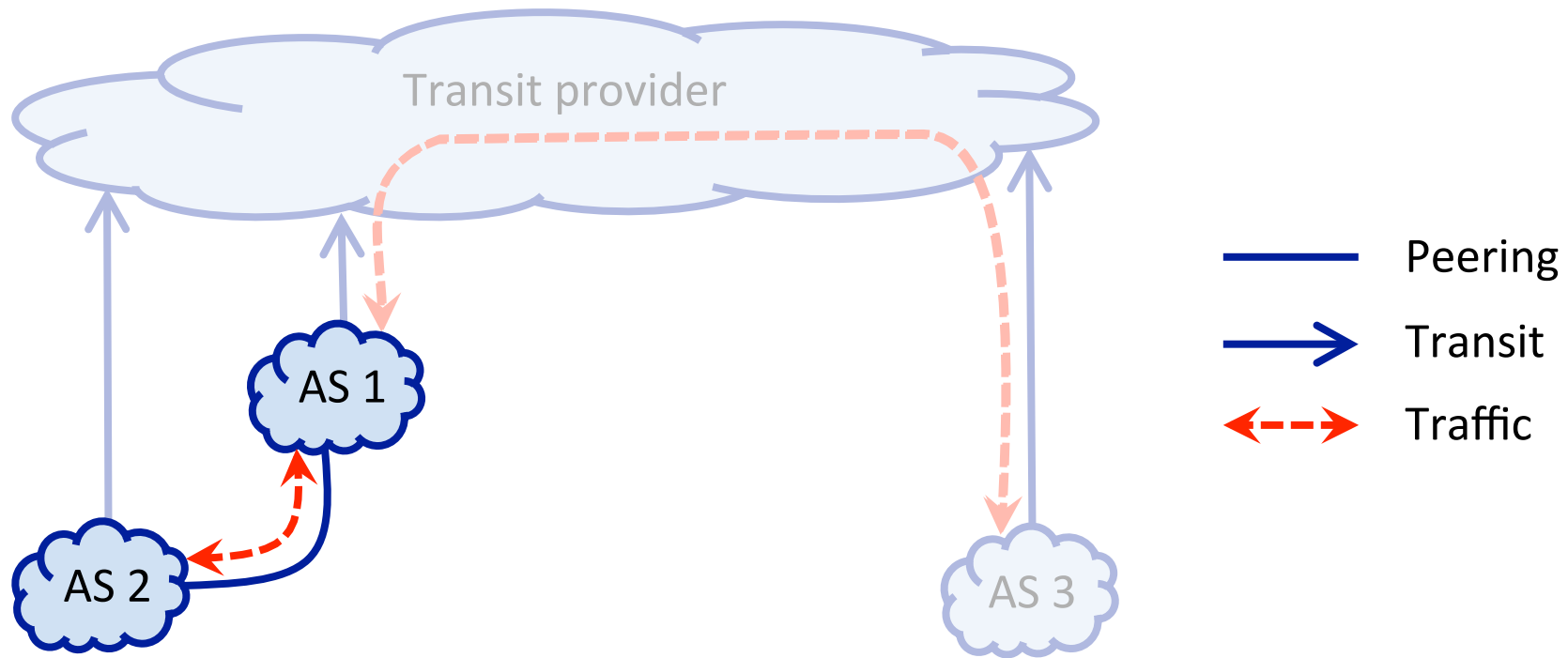
Peer

Mostly Transit in the Early Internet



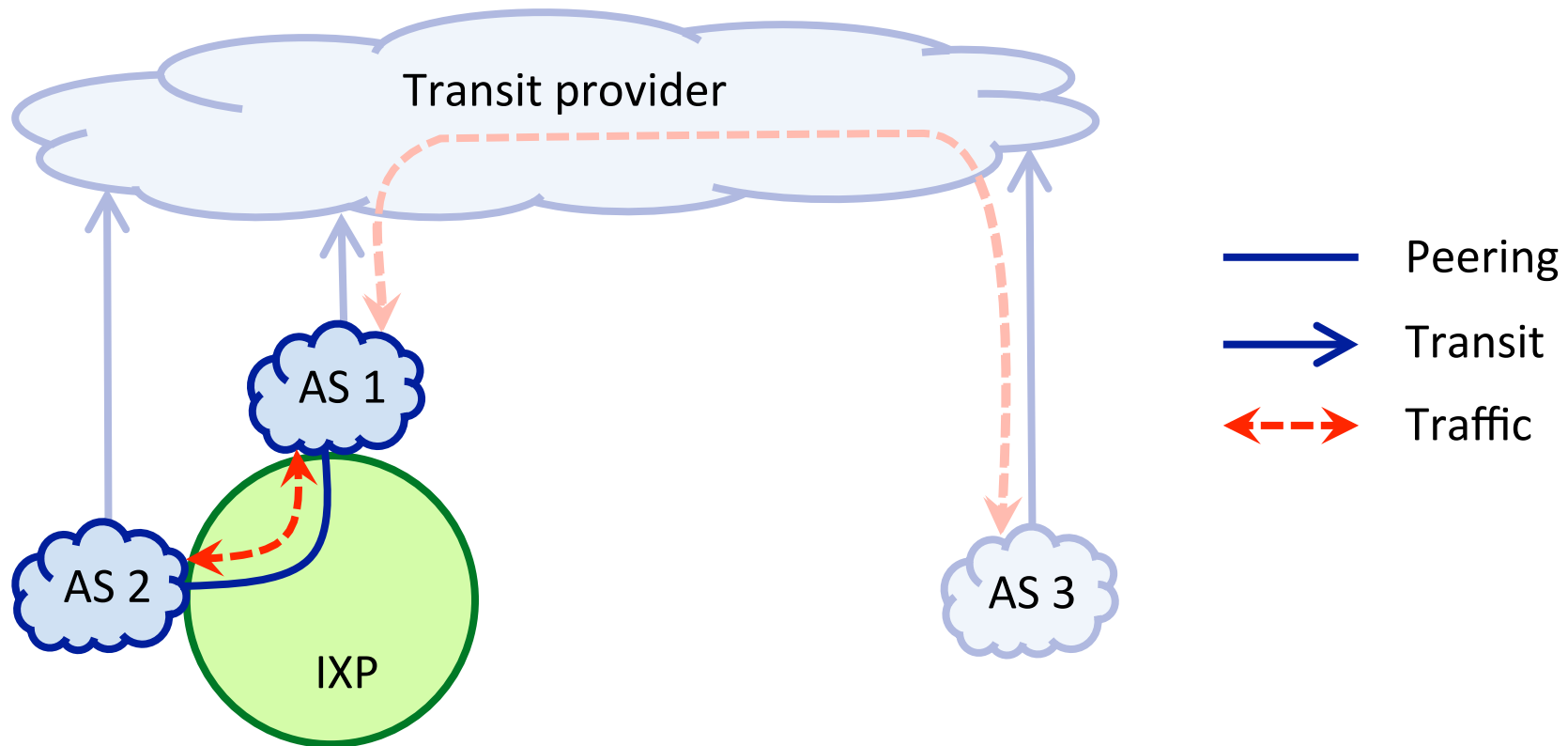
- Customer pays provider for bidirectional traffic
- Peering is an alternative for colocated customers
 - Both peers reduce their transit costs

Layer-3 Structural Evolution



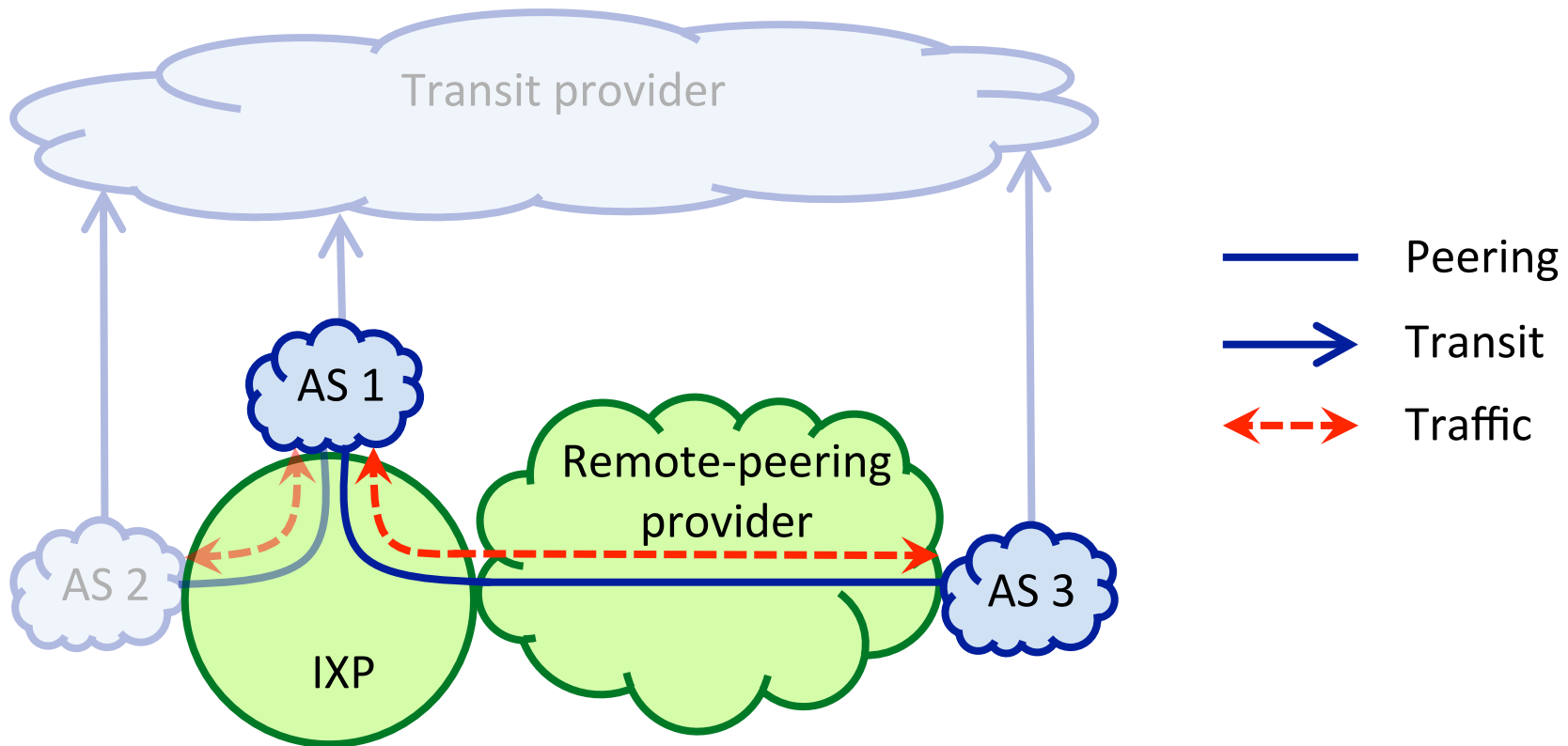
- Increased peering of colocated ASes
- Internet flattening
 - Fewer ASes on end-to-end paths

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



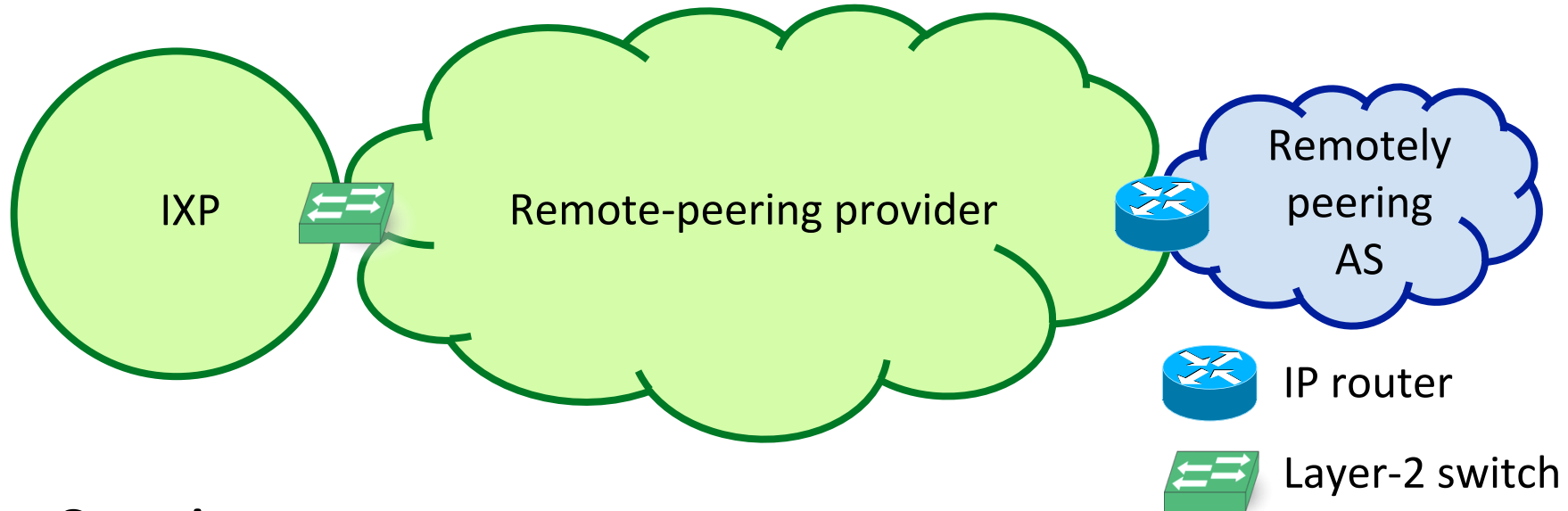
- New type of layer-2 intermediaries
- More peering without Internet flattening

Modeling implication

A large iceberg floats in a blue ocean under a clear sky. The visible tip of the iceberg is on the right side of the frame. The much larger, submerged part of the iceberg extends across the bottom half of the image, illustrating the concept of hidden or underlying implications.

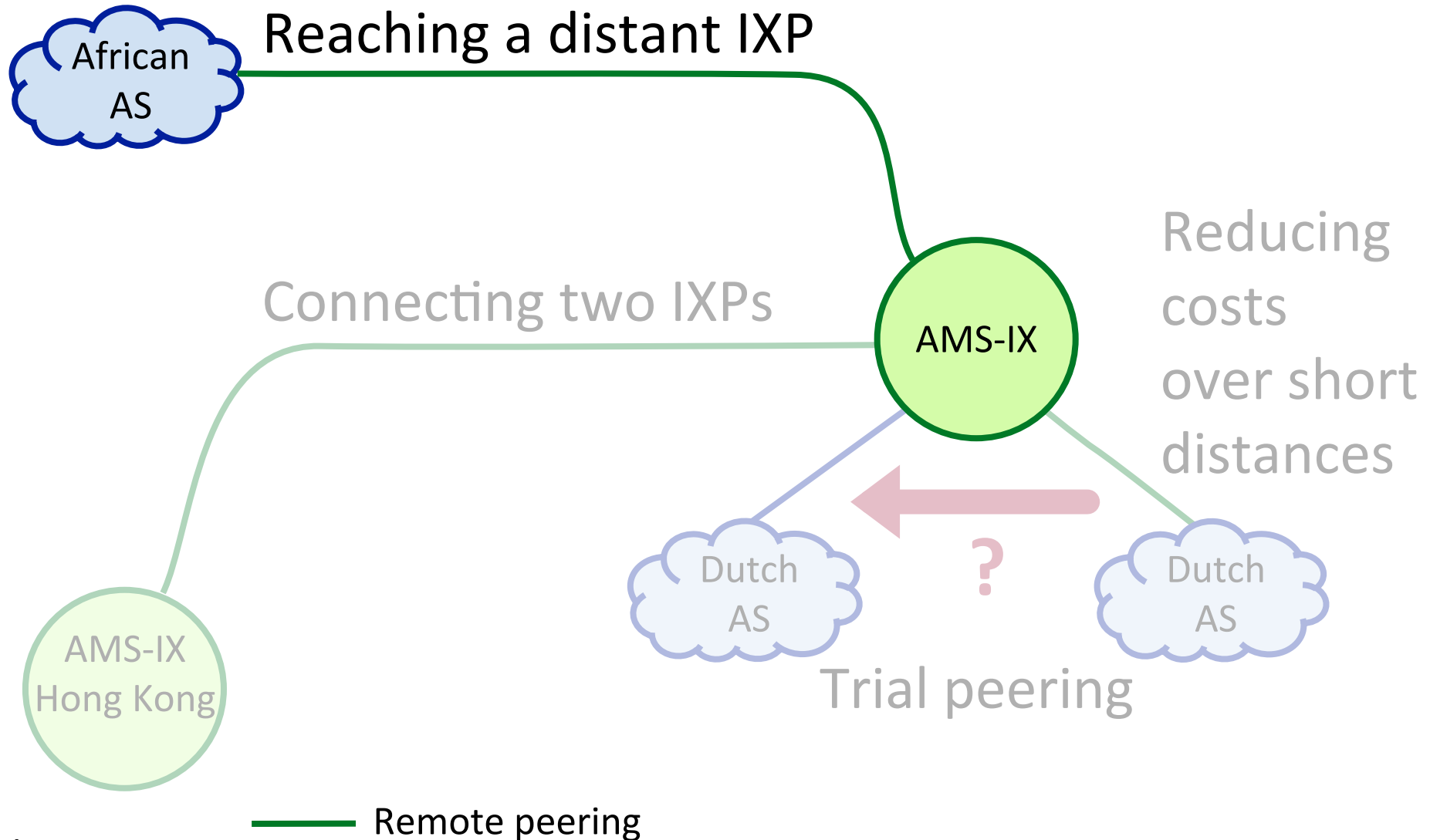
Internet economic structure
needs to be modeled
on both layers 2 and 3

Remote Peering as a Service

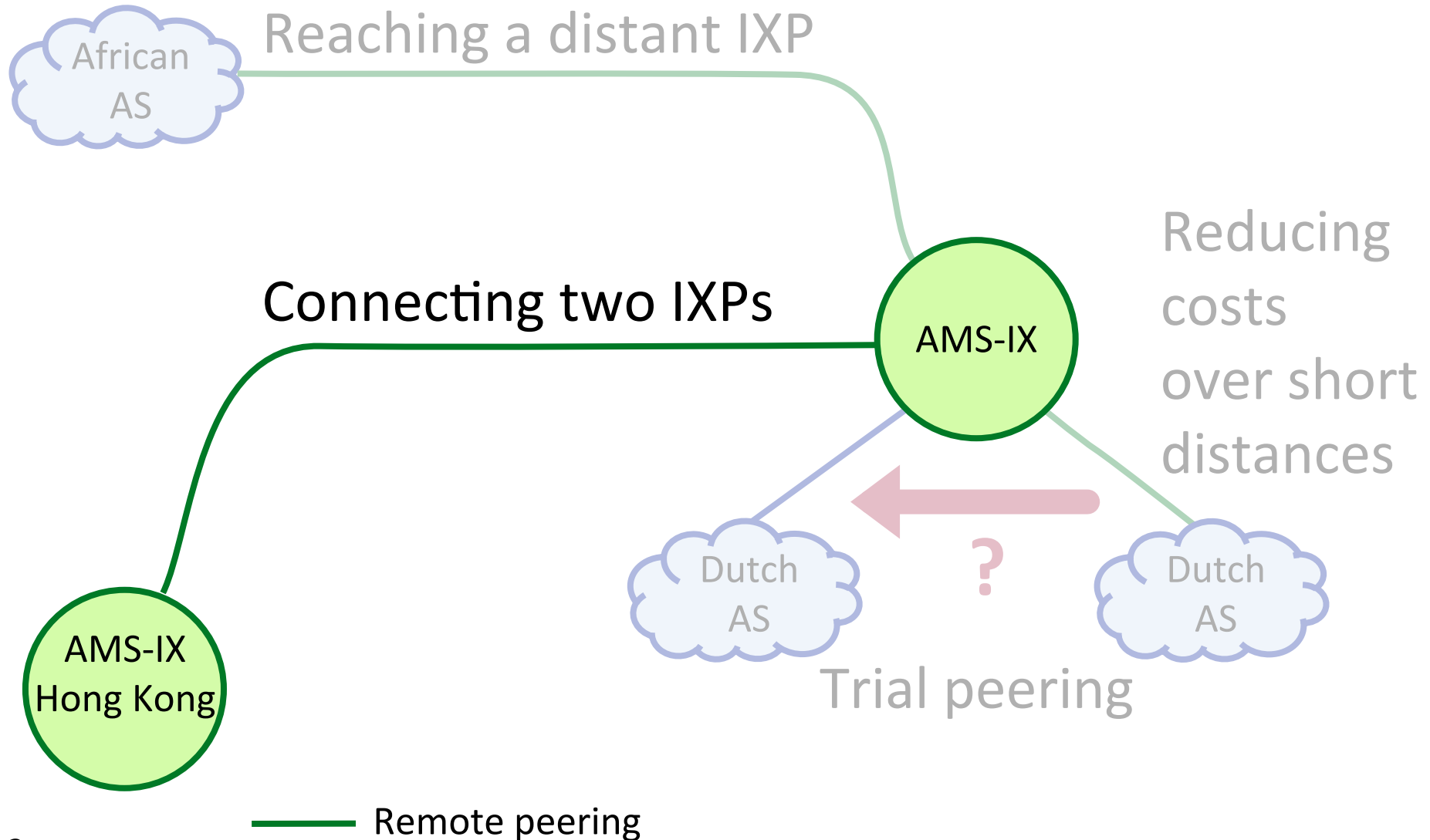


- Service components
 - Layer-2 connectivity of the AS to the IXP
 - Peering equipment at the IXP
- Costs
 - Trade-off between transit and peering

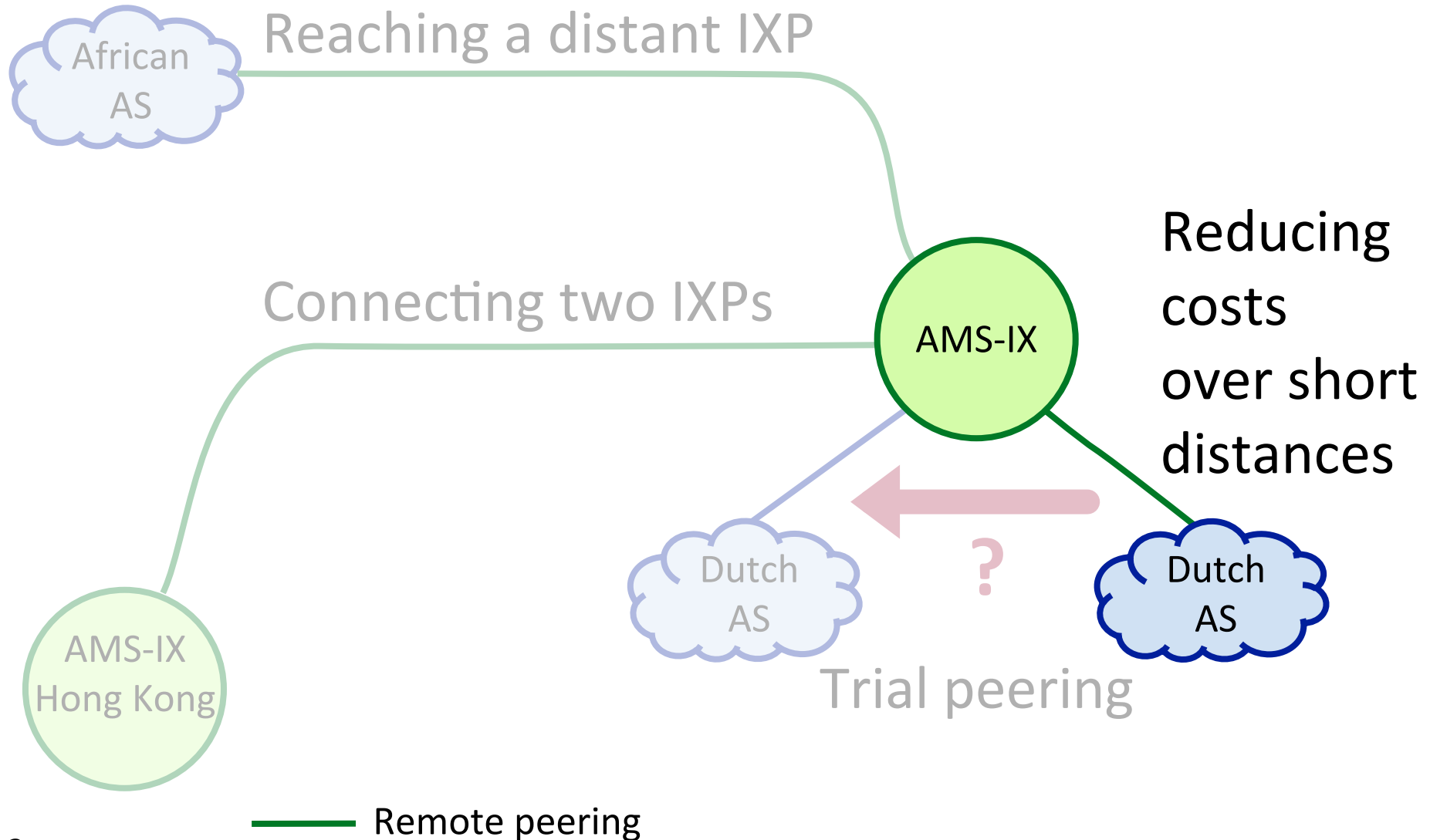
Usage of Remote Peering



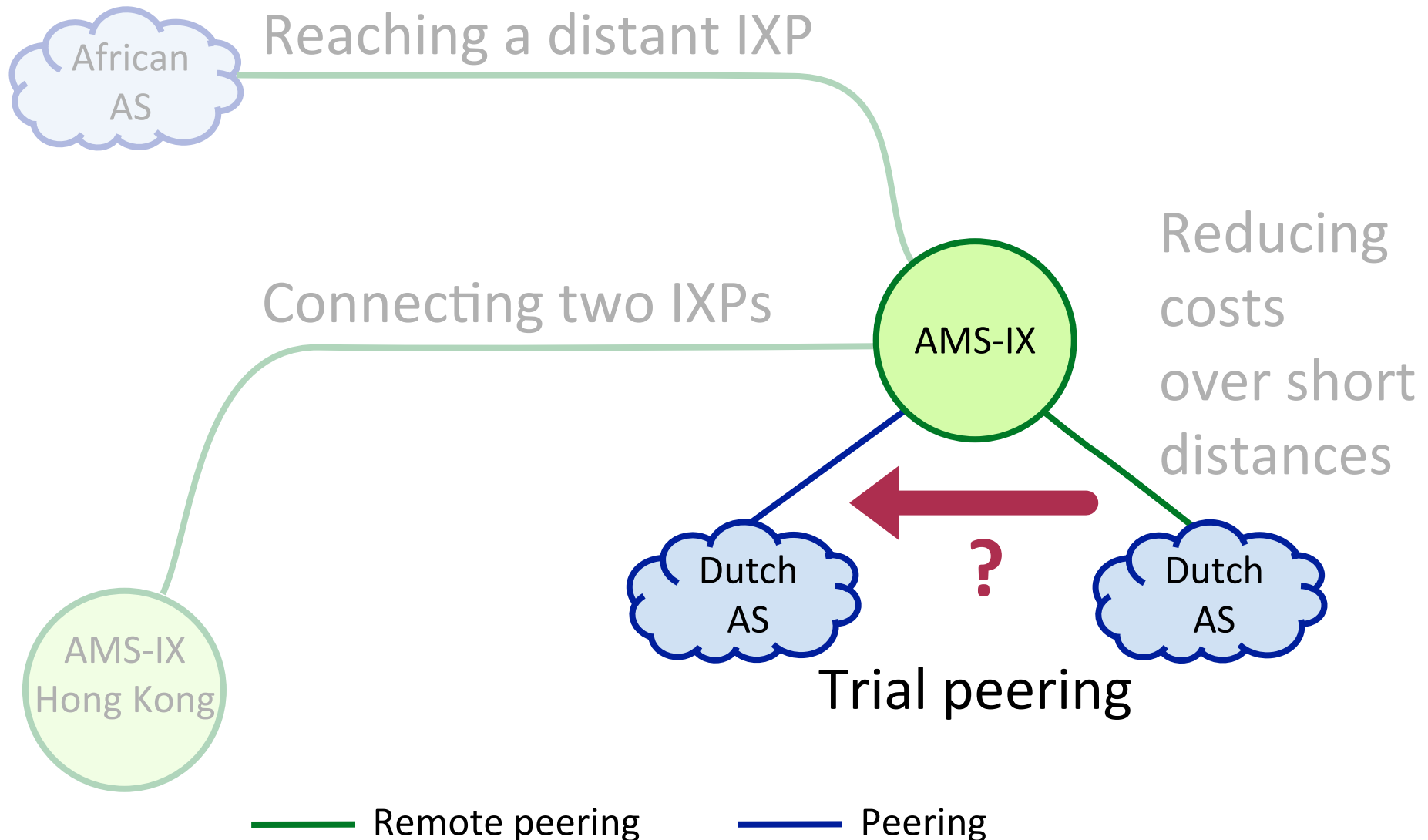
Usage of Remote Peering



Usage of Remote Reering



Usage of Remote Peering



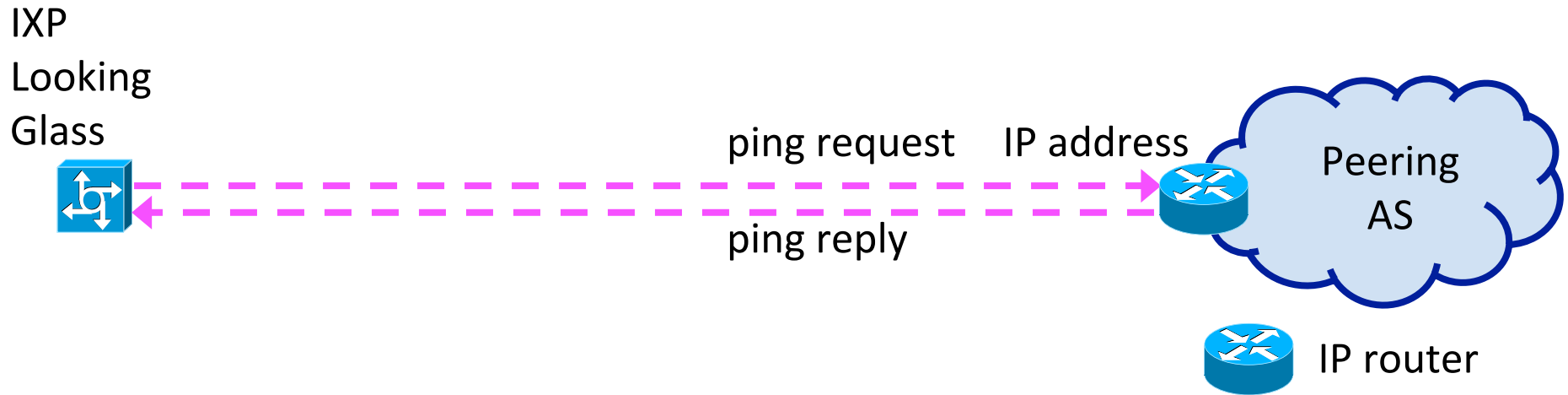
Our Contributions

- **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

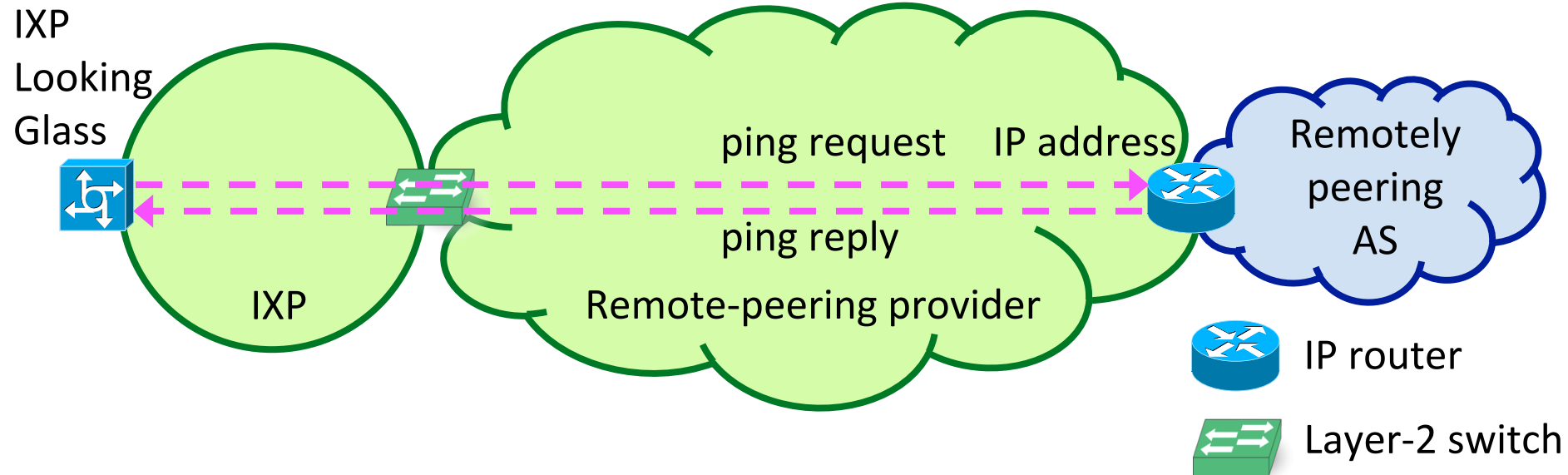


- IP address from PCH, PeeringDB, and IXPs' websites
- Ping reply within one IP hop if its TTL = maximum TTL
- 4 months and 6 filters to get minimum RTT reliably

If $RTT > \text{threshold}$, classify the peer as remote

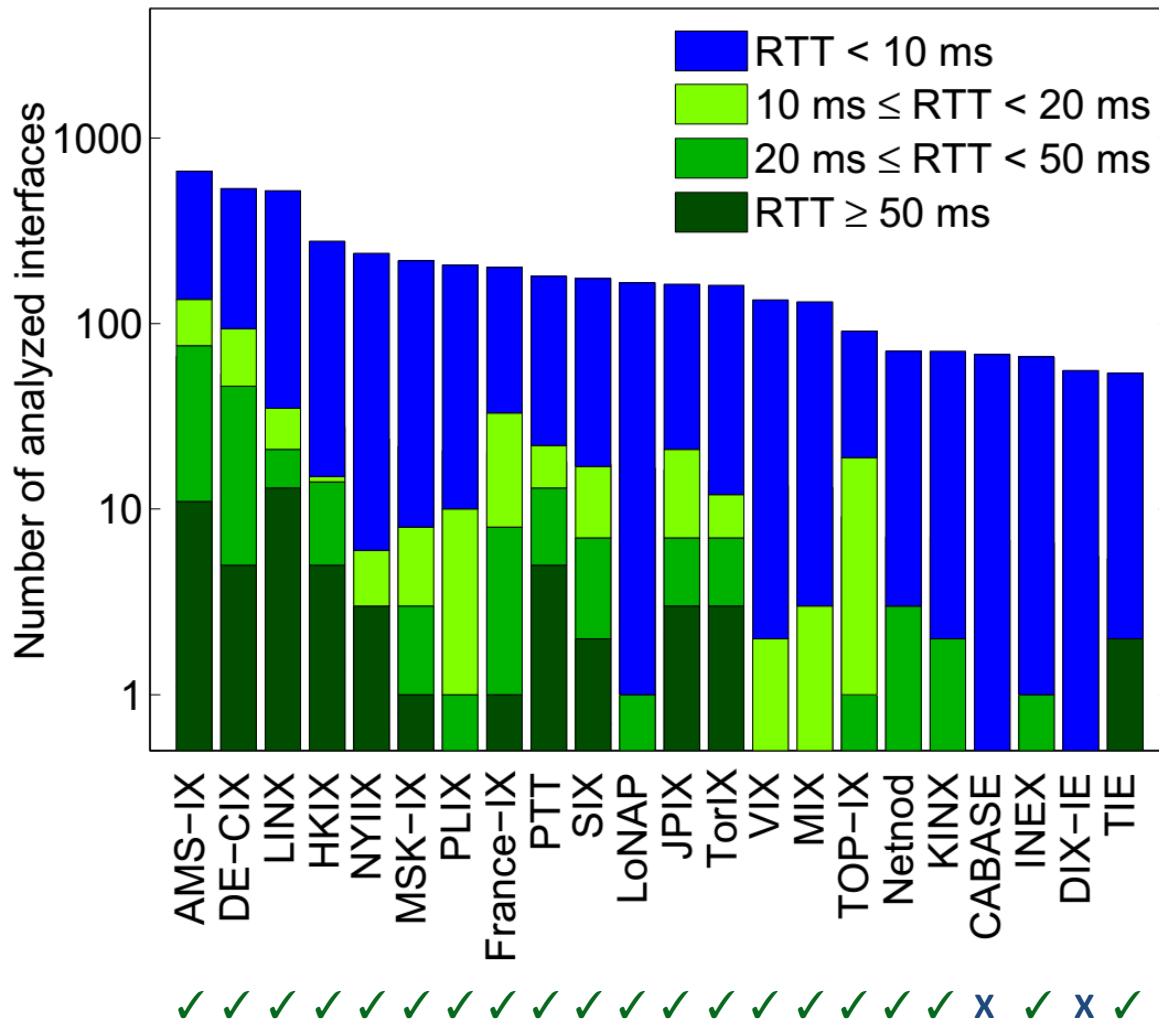
empirical threshold of 10 ms

Validation



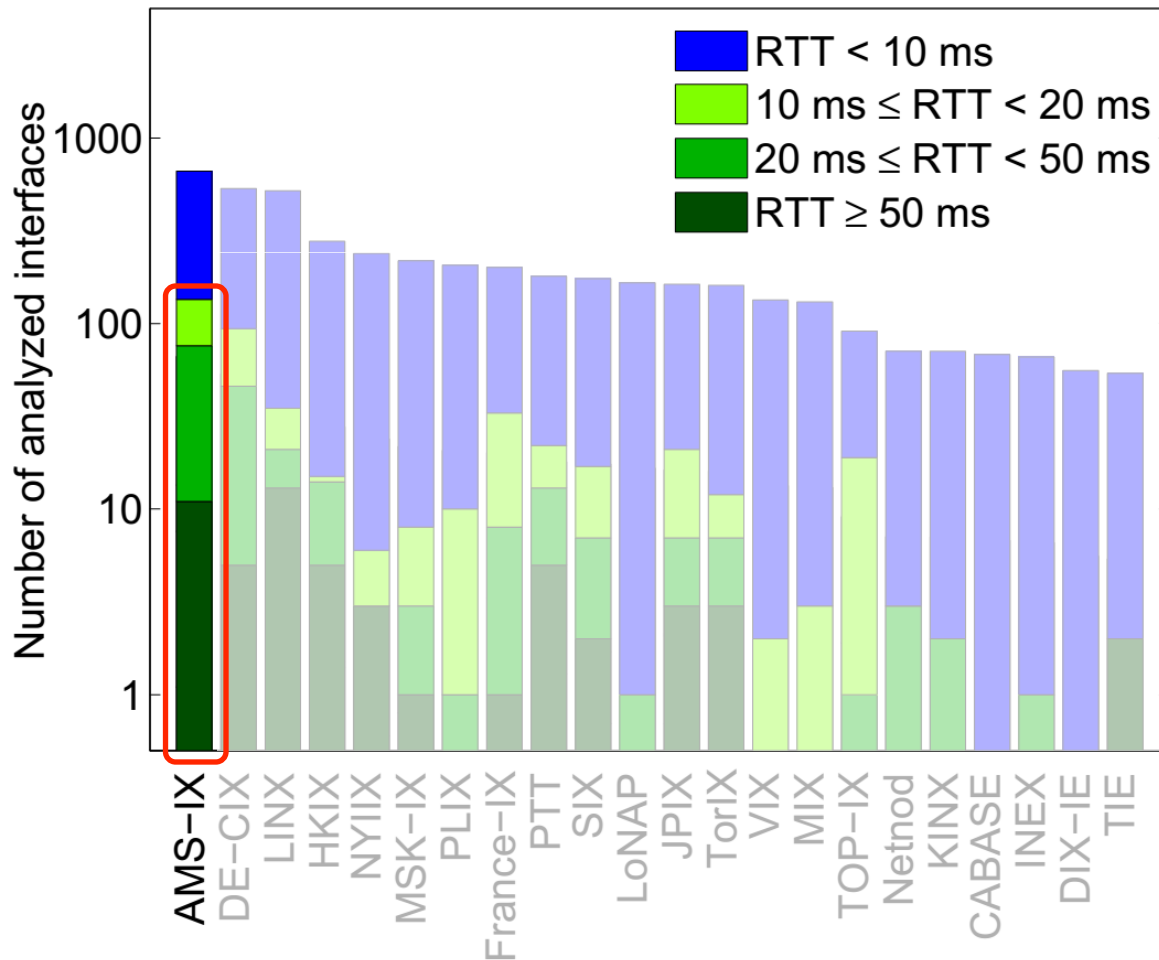
- Public IXP information on remote peers
- Ground truth from TorIX
 - RTT measurements
 - Remotely peering ASes

Spread across IXPs



91% of the IXPs have remote peering

Spread within IXPs



Around 20% of AMS-IX peers are remote

Our Contributions

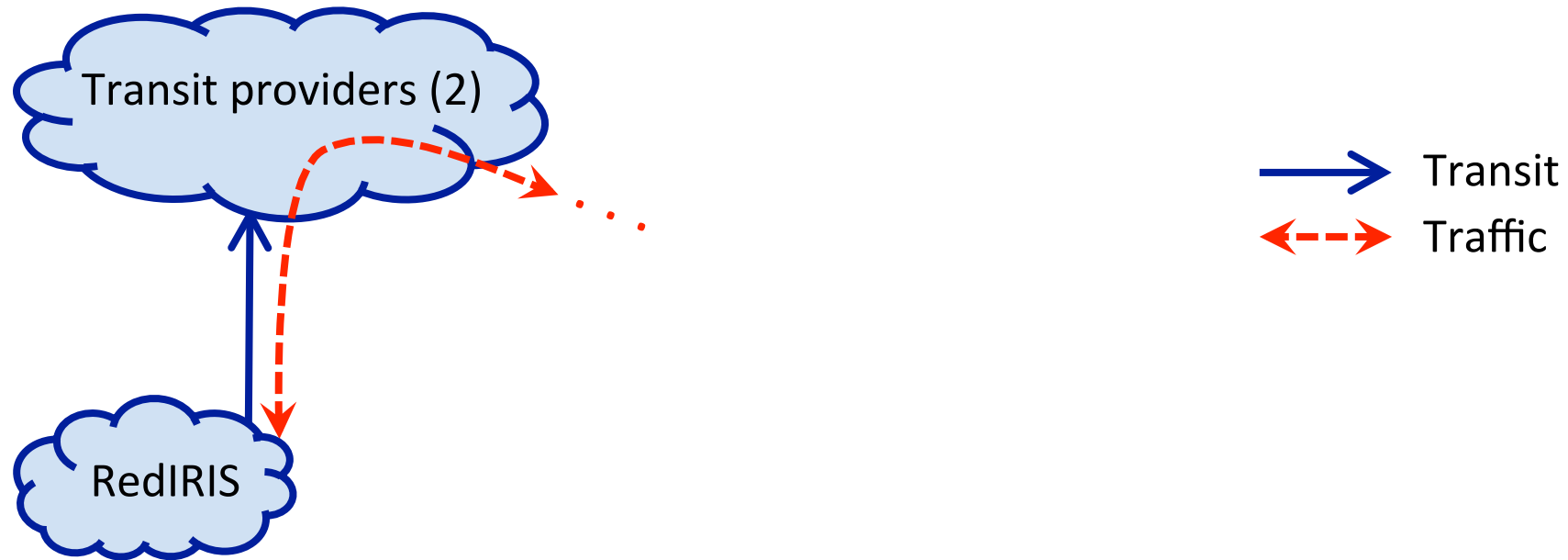
- **Measurement-based studies**
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 - **Impact of remote peering on Internet traffic**
- **Modeling of economic viability**
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Estimating the Offload Potential

- 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

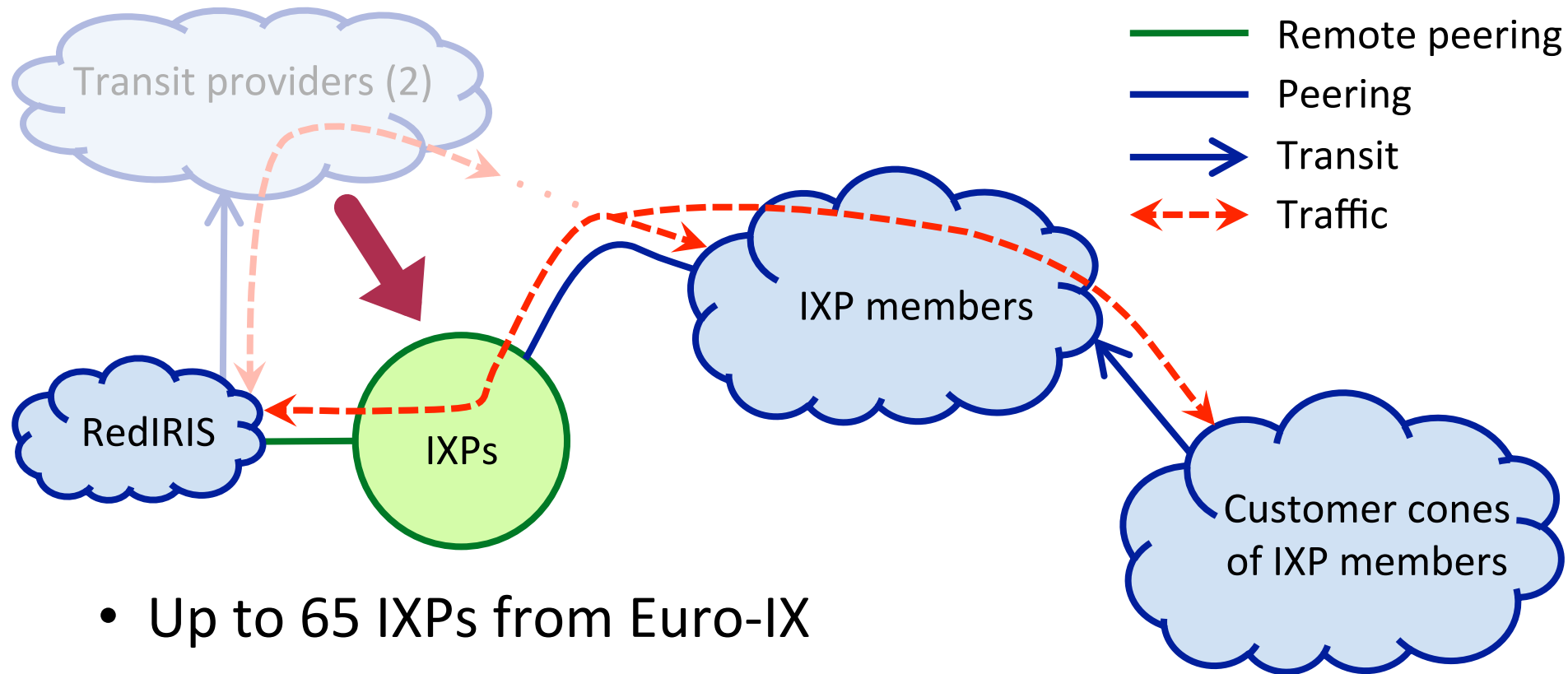


Transit-Provider Traffic of RedIRIS



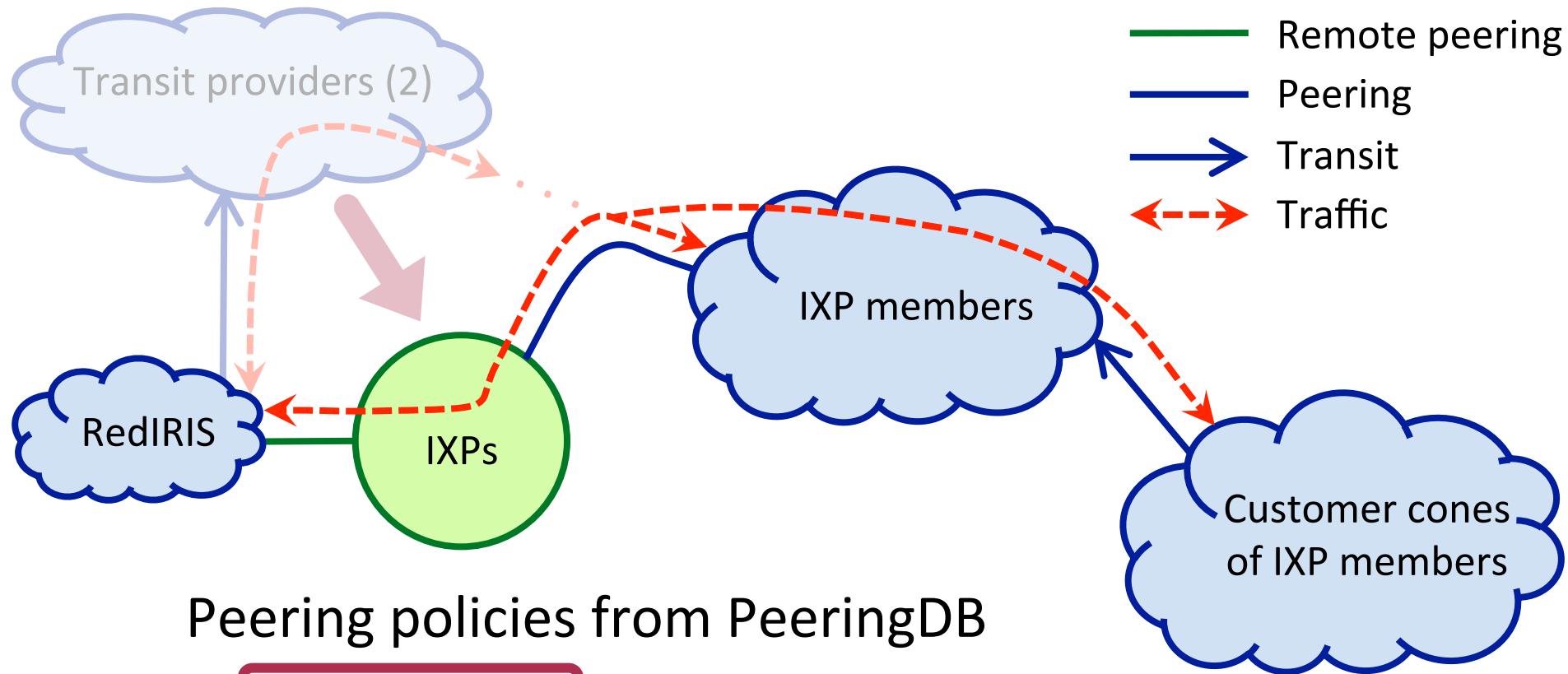
- 2 transit providers
- 29,570 ASes contribute traffic
 - origins of inbound traffic or
 - destinations of outbound traffic

Choice of Reached IXPs



- Up to 65 IXPs from Euro-IX
- Up to 12,238 reached ASes
 - including 2,192 IXP members

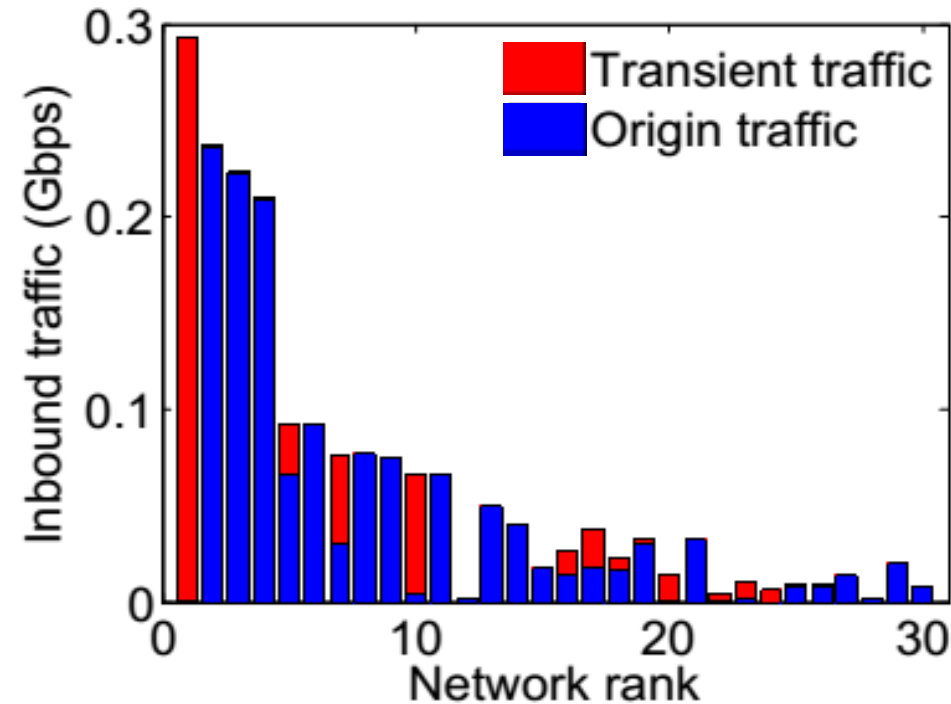
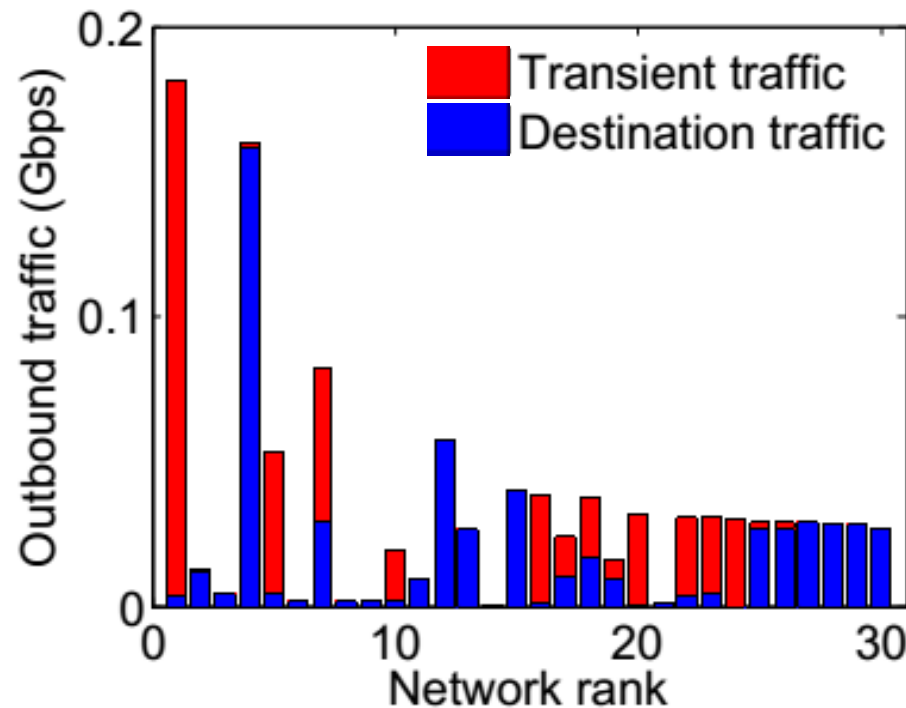
Choice of Peers for RedIRIS



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

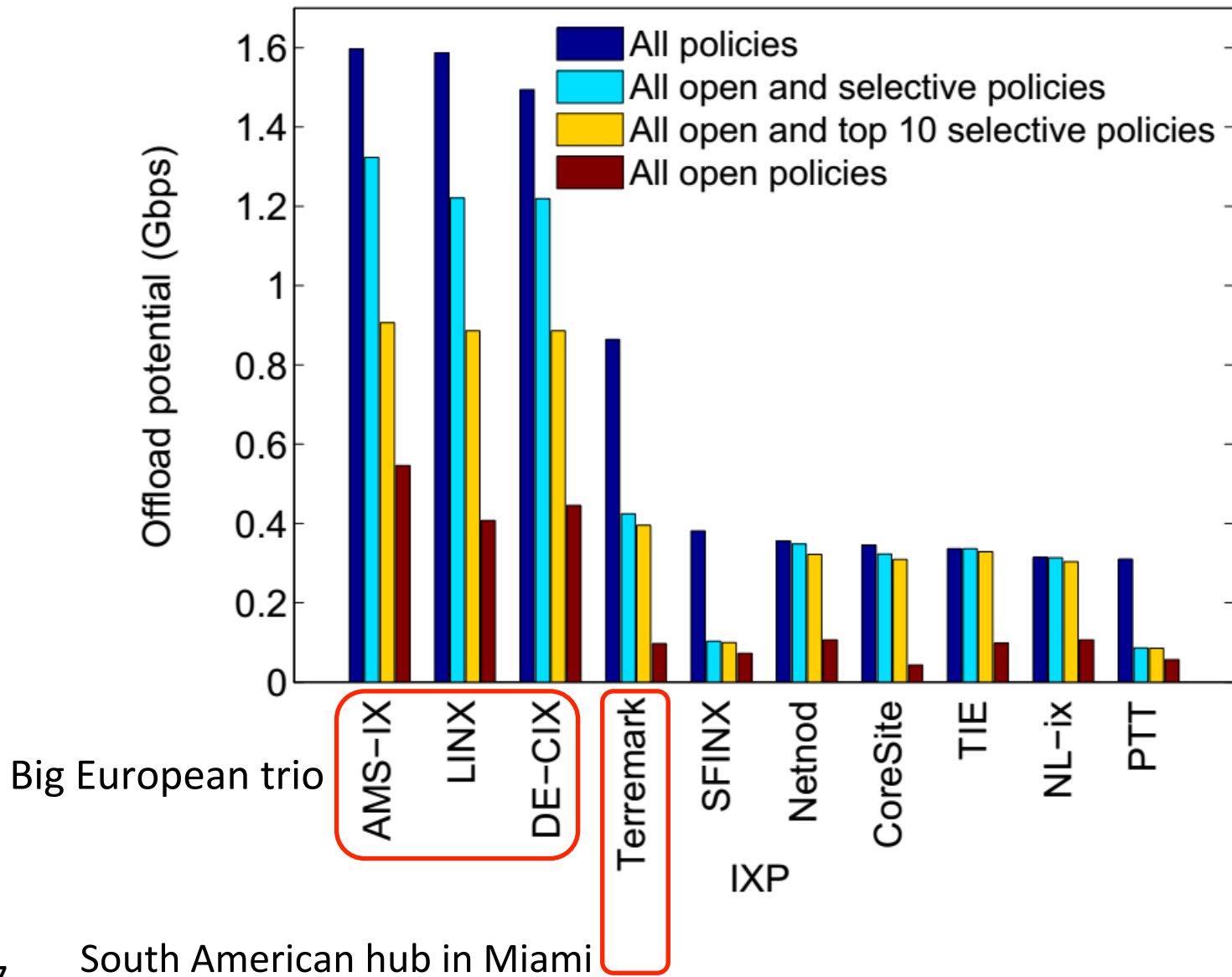
Top 30 among Offload Contributors



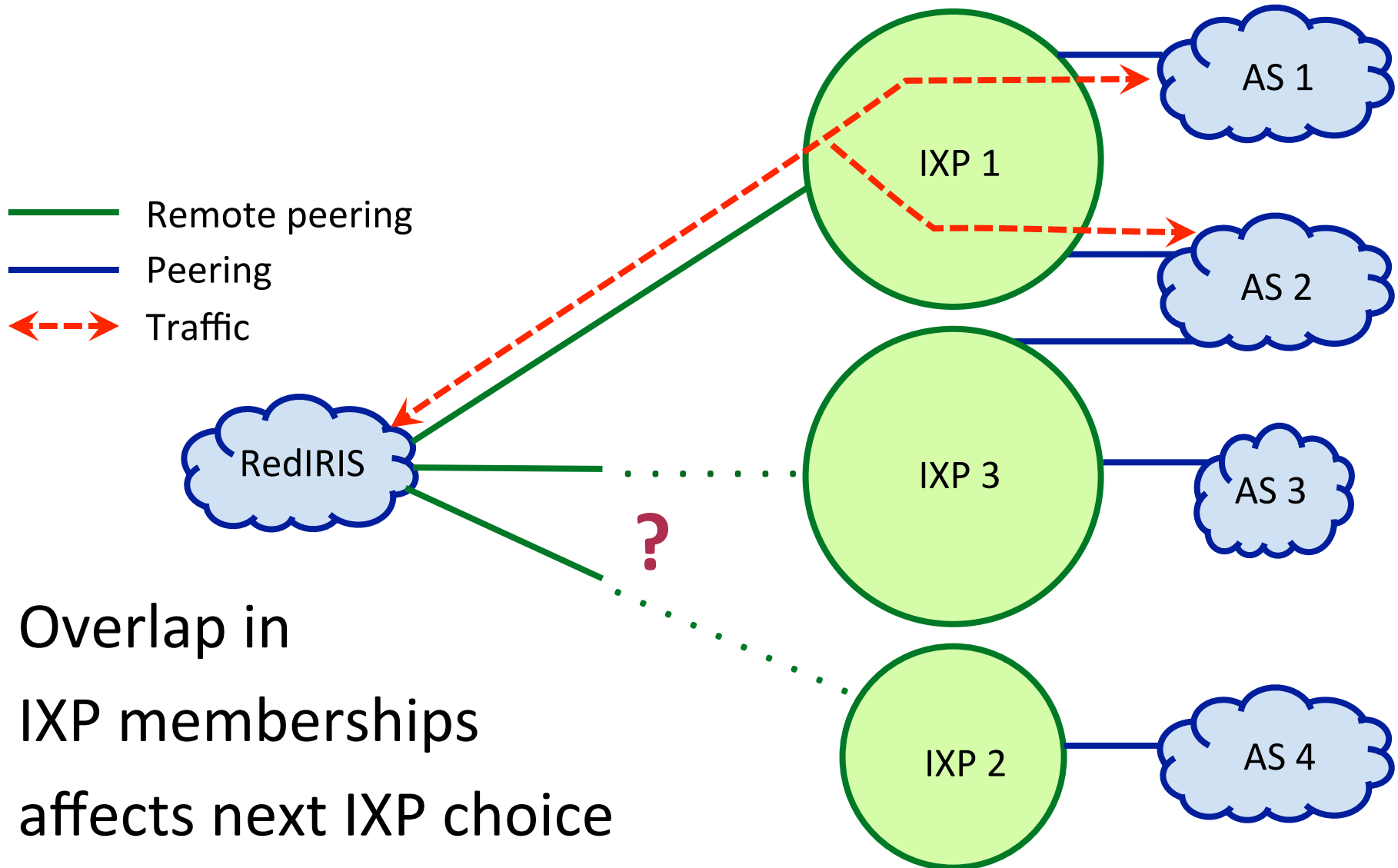
(all policies)

Top peers include major content providers and CDNs (Content Delivery Networks)

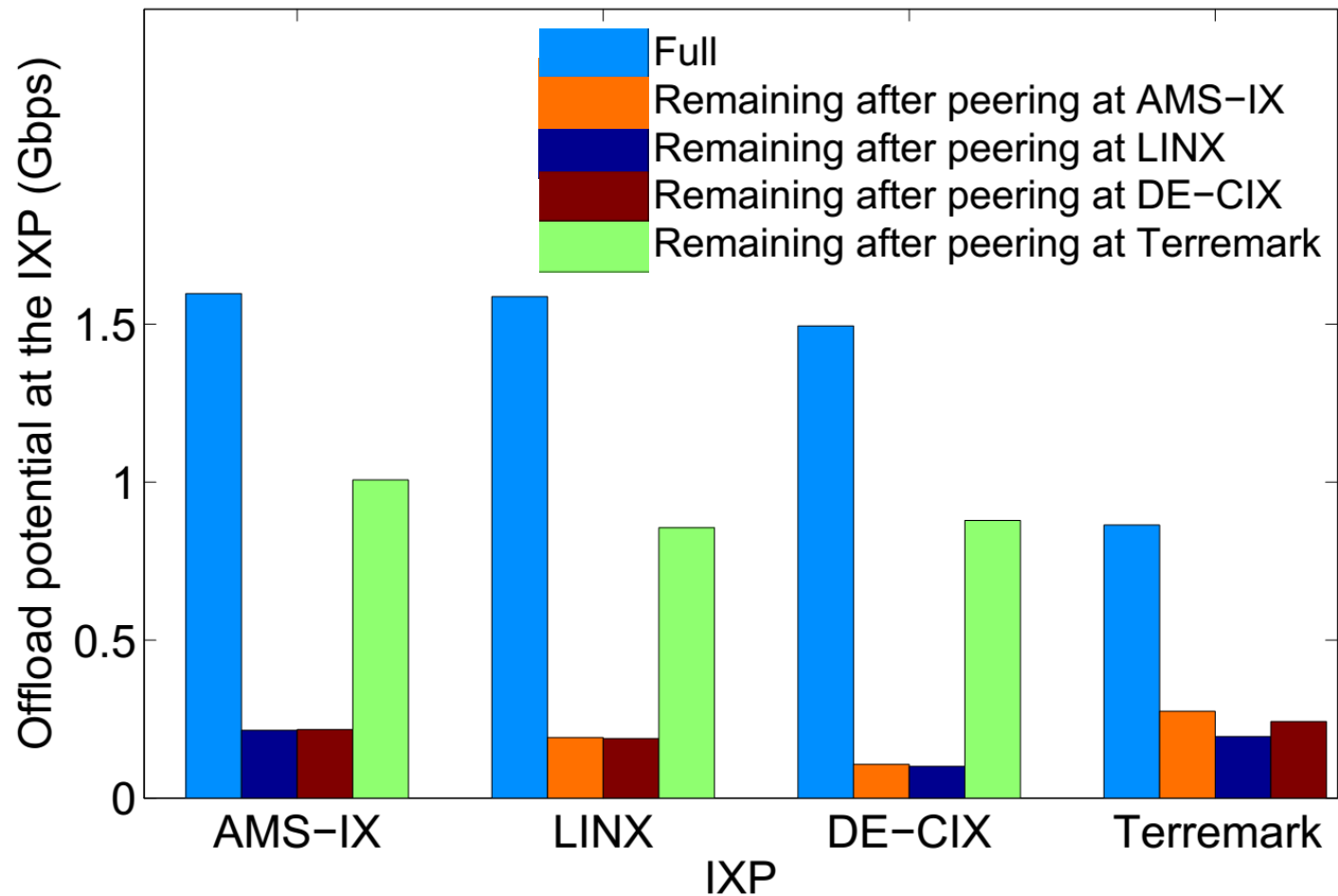
Offload Potential at a Single IXP



Which IXP to Reach Next?

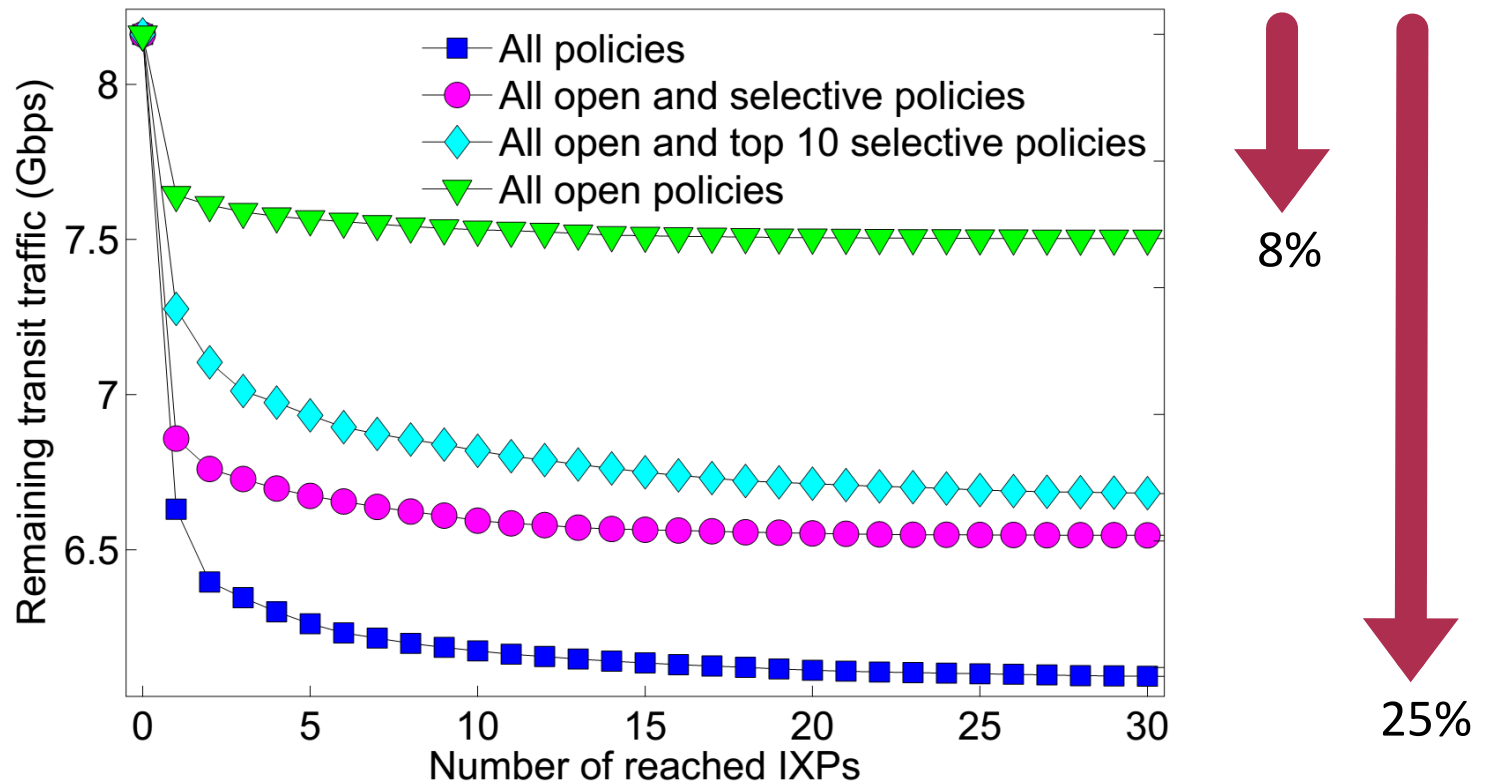


Gain from Reaching a Second IXP



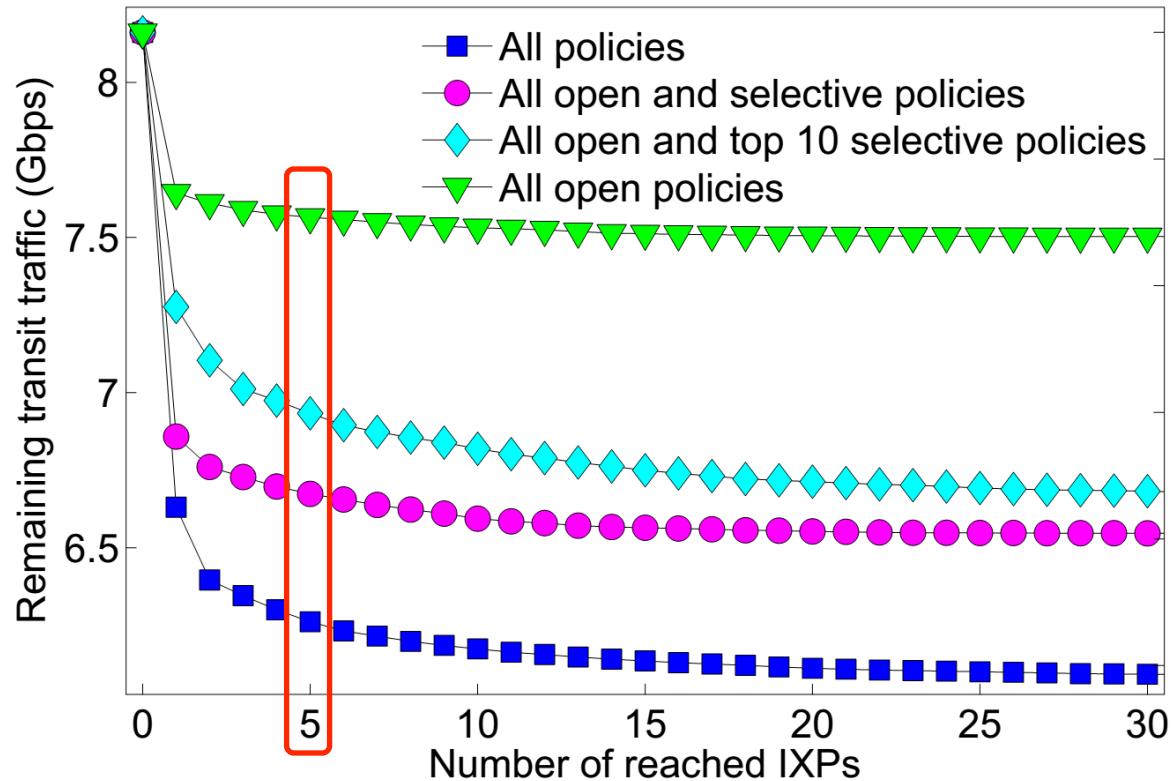
(all policies)

How Much Traffic can RedIRIS Offload?



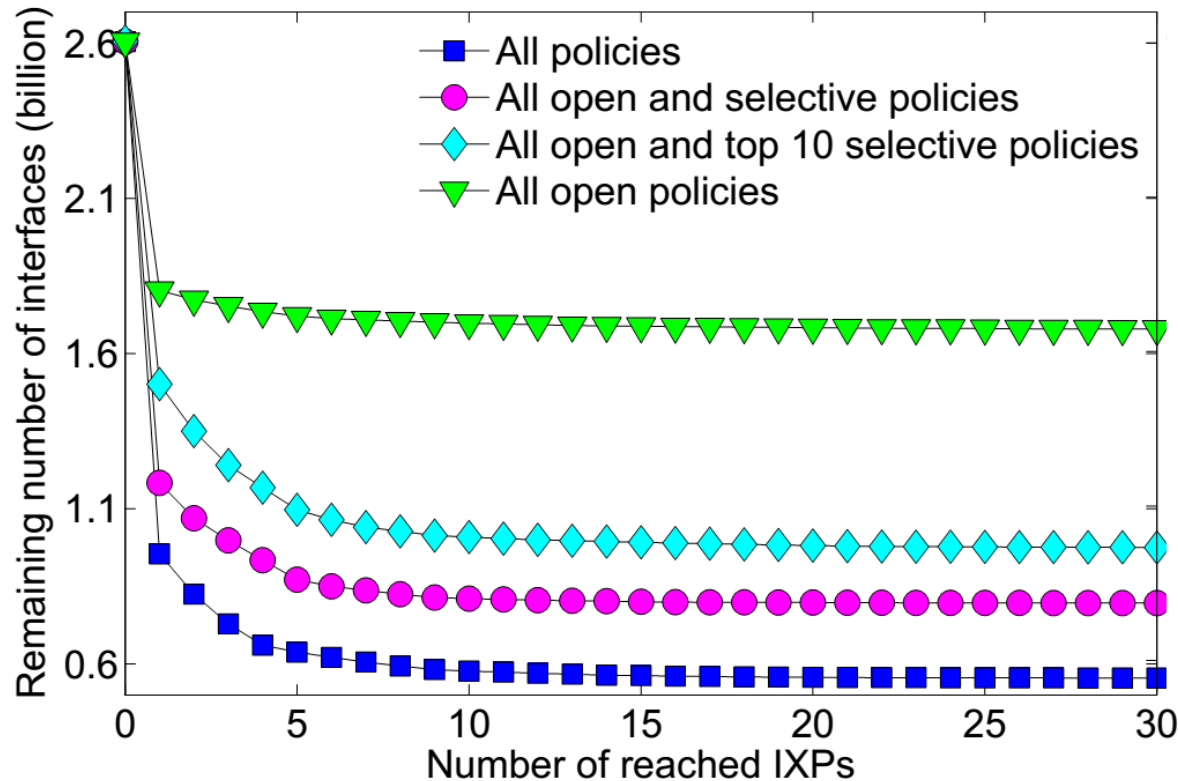
Between 8% and 25% of reduction in transit traffic

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