Impactful Routing Research with **PEERING**

Combining intradomain emulation with *real* BGP connectivity

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AIMS
February 2015
With **Peering**, experiments can exchange **BGP routes** and **traffic** at locations around the world.
**PEERING: The BGP Testbed**

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![Diagram of PEERING: The BGP Testbed with HE and Microsoft logos, connected to Amsterdam IX (AMS-IX) server.](image)

**Amsterdam IX (AMS-IX)**
PEERING: The BGP Testbed

With PEERING, experiments can exchange

BGP routes and traffic at locations around the world

Amsterdam IX (AMS-IX)

Experimentor
Allocated: 184.164.224.0/23
**PEERING: The BGP Testbed**

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**Amsterdam IX (AMS-IX)**

**Experimentor**

Allocated: 184.164.224.0/23
PEERING provides unprecedented control

Route monitors / traceroutes only measure *existing* routes
Simulations and emulations lack realism
**PEERING** provides unprecedented control

**Route monitors / traceroutes** only measure *existing* routes
**Simulations and emulations** lack realism

With **PEERING**, experiments can **make changes**…
- route poisoning to check how other networks react
- announce / withdraw routes at different PoPs / for different peers
- select their outgoing routes
Route Origin Authorizations (ROA)
- specifies which networks are allowed to announce a prefix

Existing studies have focused on the adoption of ROAs
- do prefixes have ROAs and do they match the observed routes?
- but ROAs are only effective if they are used in routing decisions
Measuring ROA Filter Adoption with PEERING

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With PEERING, we're measuring how / if ROAs are used in decisions
- coordinate BGP announcements, ROA manipulations
- observe how ASes react (traceroutes, BGP collectors)
Announce Anchor Prefix (184.164.224.0/24)

Announce **anchor prefix** prefix originated from two ASNs

AS61574's announcement is propagated to a transit provider

AS61575's announcement is propagated directly to peer

**Expected path for HE to prefix**
HE -> PEERING -> **AS61575** (shortest path)
Check Behavior for Test Prefix (184.164.225.0/24)

Add ROA for test prefix
AS61574 is valid origin

Announce test prefix
originated from same ASNs
propagated to same peers

If HE's filters account for ROAs
will reject route from 61575
prefer longer route from 61574

184.164.225.0
Measuring Path Performance with **Peering**

Large content and cloud providers have many paths to destination
- result of lots of peering at IXPs and backbones between PoPs

**What's the value of this rich interdomain connectivity?**
- can it help improve end-user experience? (bypass congestion?)
- what's the relative value of different IXP connections?
Large content and cloud providers have many paths to destination
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With **Peering**, we can:
- direct traffic across different paths and measure performance
- build and evaluate systems that leverage this rich connectivity
Research Supported by **Peering**

- LIFEGUARD: route around failures
- PECAN: joint content & network routing
- PoiRoot: locate root cause of path changes
- ARROW: deployable fix to routing problems
- SDX: software-defined Internet exchange
- Measuring Internet routing policies
- Sprite: SDN-based inbound traffic engineering
- RAPTOR: Routing attacks on TOR

**SIGCOMM 12**
**SIGMETRICS 13**
**SIGCOMM 13**
**SIGCOMM 14**
**IMC 15**
**SOSR 15**
**USENIX Security 15**

(bold = Peering required)
Updates on PEERING Testbed
More Points of Presence, More IXP Connectivity

Now control 8 ASNs, multiple IPv4 and v6 prefixes
- Officially transferred our primary ASN (47065) from GENI

Peering projected to have 17 points of presence by mid-year
- adding 10 or 40G connectivity at CloudLab sites (3 sites)

Highest priority = Internet Exchange Points (7 sites)
- Seattle Internet Exchange (connected)
- Amsterdam Internet Exchange (connected)
- Phoenix Internet Exchange (connected)
- Equinix facilities in Dallas and Asburn (equipment at facilities)
- Brazil Internet Exchange in São Paulo (shipping soon)
- One Wilshire in Los Angeles (planning)
Measurements as a Service

Beacon service continuously issues announcements
- cycles any unallocated prefixes through announcement loop

Experiments can control beacon service
- request announcement through web interface UI
- lower overhead than setting up infrastructure locally (VPNs, BIRD)
- investigating programmatic interface (hackathon feedback)

Regular measurements and announcement
- regular traceroutes from RIPE Atlas towards all /24s (every 20 min)
- announcements archived in BGPMon
Colocating Experiments at PoPs

Today, clients establish VPN connections to **Peering** PoPs:
- control and data-plane traffic is relayed to their system
- sufficient for almost any control-plane experiment
- difficult to run services, conduct performance measurements
Remove backhauling by **installing user VMs at PoPs**
- supports non-resource intensive experiments
- enables hosting of Anycast content / services
- enables performance / routing experiments
Virtualized Layer-2 Backbone Connecting Sites

Connecting all PoPs via virtualized layer-2 interconnection
- use R&E network infrastructure
- provides performance guarantees, control over routing
Experimenting with Large Cloud Networks

Cloud datacenters
(compute, 10/40G)

Connecting L2 network
(virtualized via R&E Networks)

Points of Presence
(interdomain connectivity, 10/40G at some sites)
Experimenting with Large Cloud Networks

Qualitative representation of cloud / content provider's network
- control of intra and interdomain routing, including R&E routes
- services can be hosted for performance / route measurements
- new routing schemes can be evaluated
Improving Experiment Setup Process

New website interface for users
- experiment setup was previously manual, error-prone process
- automated majority of the steps, including allocations
- adding more visibility to website, including looking glass

Rewrote setup scripts to make them easier to use
- decide which peers at an IX receive an announcement
- decide how egress traffic is routed among available paths
- changed from Quagga to BIRD to support added functionality
- successfully supported multiple clients during hackathon
**Summary**

**PEERING is built for the community's research:**
- we've tackled the challenge of setting up this infrastructure
- deployed routers and established peerings around the world
- manage filters, traffic restrictions, peering sessions, servers

**Working to expand PEERING to meet the community's needs:**
- colocated experiments, backbone connectivity, CloudLab
- supporting a number of new security experiments

**Contact us:**
- team@peering.usc.edu