

Measuring IXP Interconnectivity

*A Study on Canadian Network
Interconnection*

NLnet
10000110001
111010110001
100110101000
011000011000
001111000100
000101101001
000101101011
Labs

Willem Toorop

Who is Who



a non-profit research institute seeking to improve the quality, robustness, and accessibility of the Internet.

supporting operations and analysis in the areas of

- Internet traffic exchange,
- routing economics,
- global network development.

... known for Peering Survey reports

Who is Who

cira



the non-profit domain name registry that operates the Internet country code top-level domain (ccTLD) for Canada: **.ca**

**NLnet
Labs**

a non-profit foundation with the objective to develop Open Source software and open standards for the benefit of the Internet.

- We are well known for our DNS and DNSSEC work
- Early users of RIPE ATLAS

Genesis

- CIRA asked PCH for a follow up of the 2011 research on IXP interconnectivity
- Strengthen the survey results with hard measurements.
- PCH approached Emile Aben to include RIPE ATLAS measurements
- Emile forwarded PCH to NLnet Labs

Methodology

- Analyse traceroutes from Canadian sources to Canadian destinations.

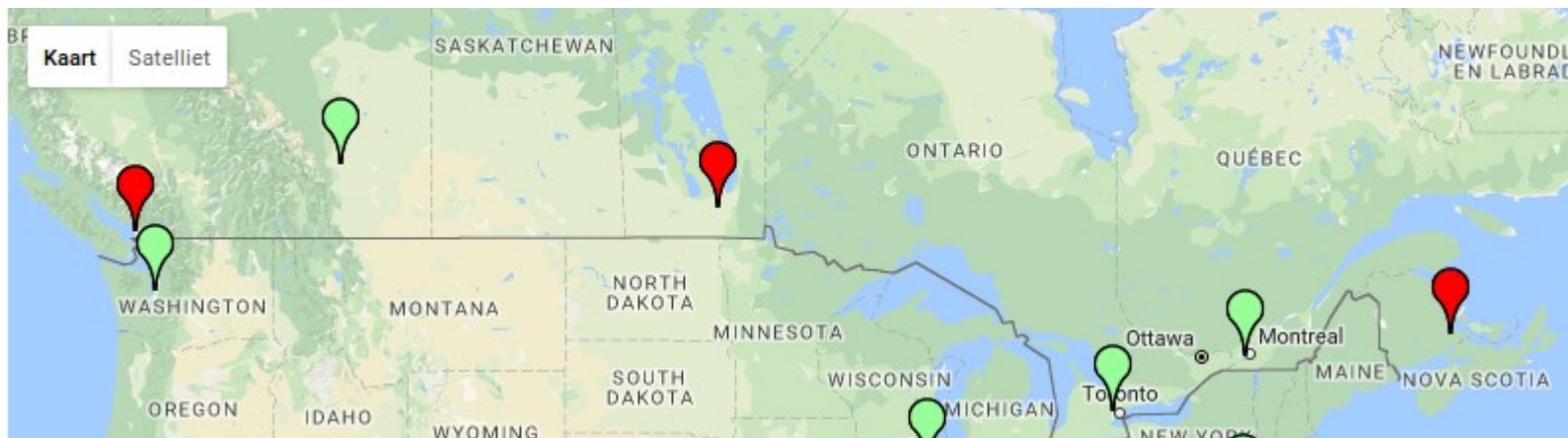
Source	# traceroutes
Already within RIPE Atlas 2013-07-26 ... 2016-09-20	333,896
Actively scheduled with RIPE Atlas 2013-09-23 ... 2016-10-15	68,520
From M-LAB 2014-08-28 ... 2016-09-22	873,326
total	1,275,742

Who is Who

MLAB

M-Lab is a consortium of research, industry and public-interest partners dedicated to:

- Provide an open, verifiable measurement platform for global network performance



Methodology

- Analyse traceroutes from Canadian sources to Canadian destinations.

Source	# unique source IPs	# unique dest. IPs	# unique traceroutes
Atlas (passive)	1,400	746	23,980
Atlas (active)	310	601	20,350
M-Lab	6	51,731	71,904
total	1500	52953	113442

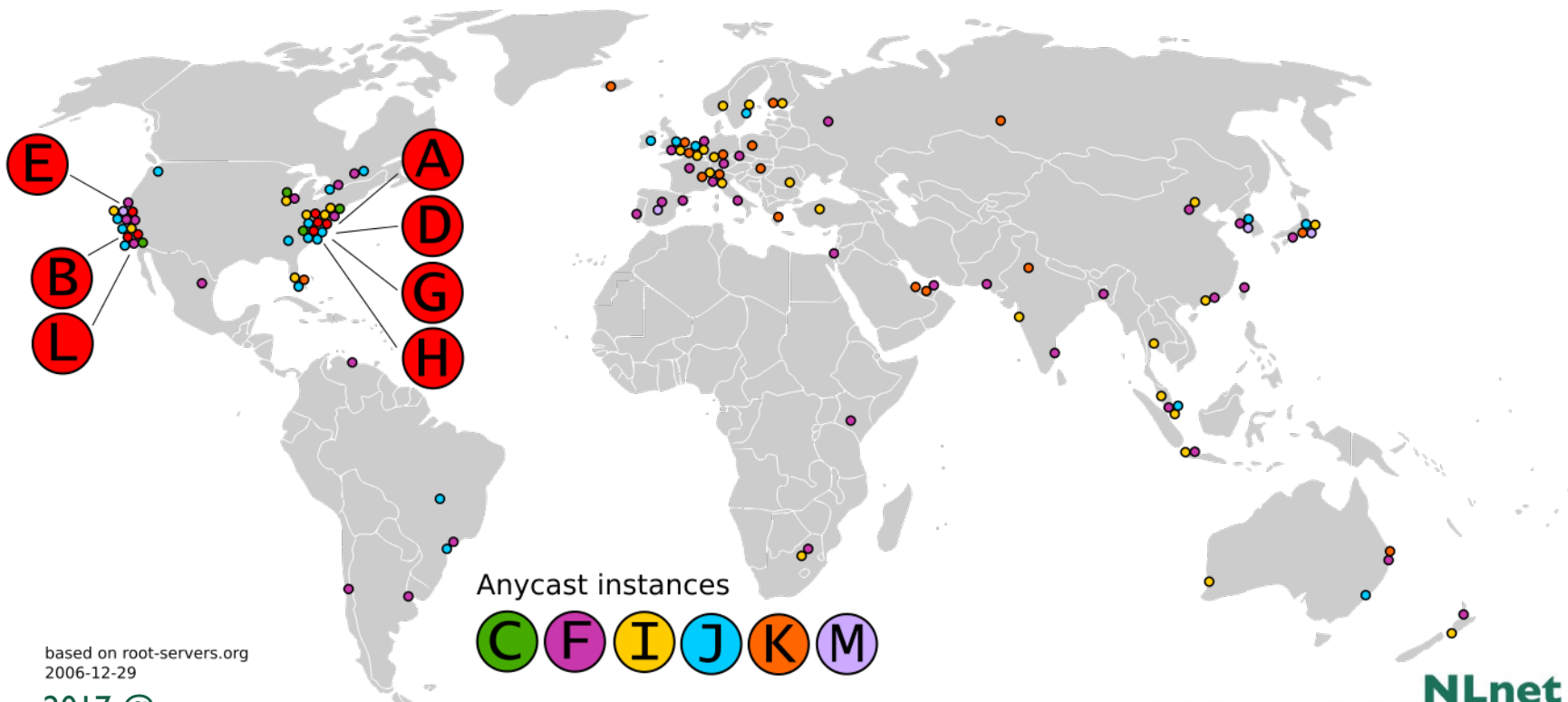
Methodology

- Active scheduled Atlas measurements:
 - DNS root DNS servers
 - **.ca** DNS servers



Challenges

- Anycasted IPs cannot be geolocated
- Solution: **look at second last hop** for:
 - DNS root DNS servers
 - **.ca** DNS servers



based on root-servers.org
2006-12-29

Methodology

- Active scheduled Atlas measurements:



gc.ca

Government of Canada
2nd lvl domain registry

Canada



Alexa

The Web Information Company

Top 250 websites most
popular in Canada

Challenges

- Geolocated DNS targets
 - Return IPs close to the requester
- Solution: **Resolve on probe**
Resolve on Canadian
NLnog RING nodes



Coordinated 'shell access'
exchange deal between
network operators

Challenges

A



Non responding hops (72.89% of all traces)



Non routable prefixes



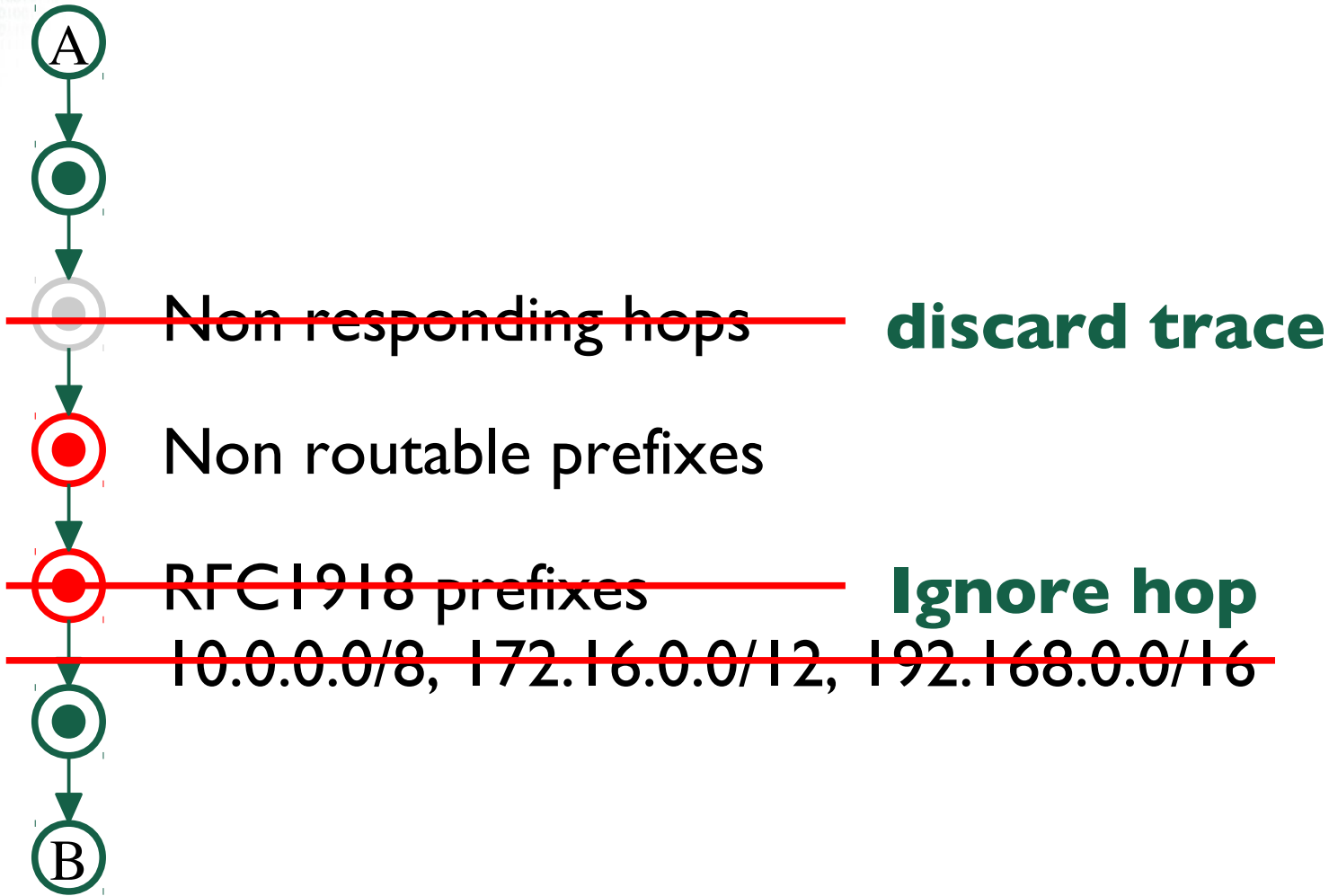
RFC1918 prefixes (26.04% of all traces)

10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16



B

Challenges



Challenges

A



B



PeeringDB

facilitates the exchange of information related to Peering

Non routable prefixes

Or else ignore hop,
but record the owner of the prefix (WHOIS)

(prominent non-routable prefixes
BELLCANADA & TELUS)

Challenges

- Reliable Geolocating IPs?



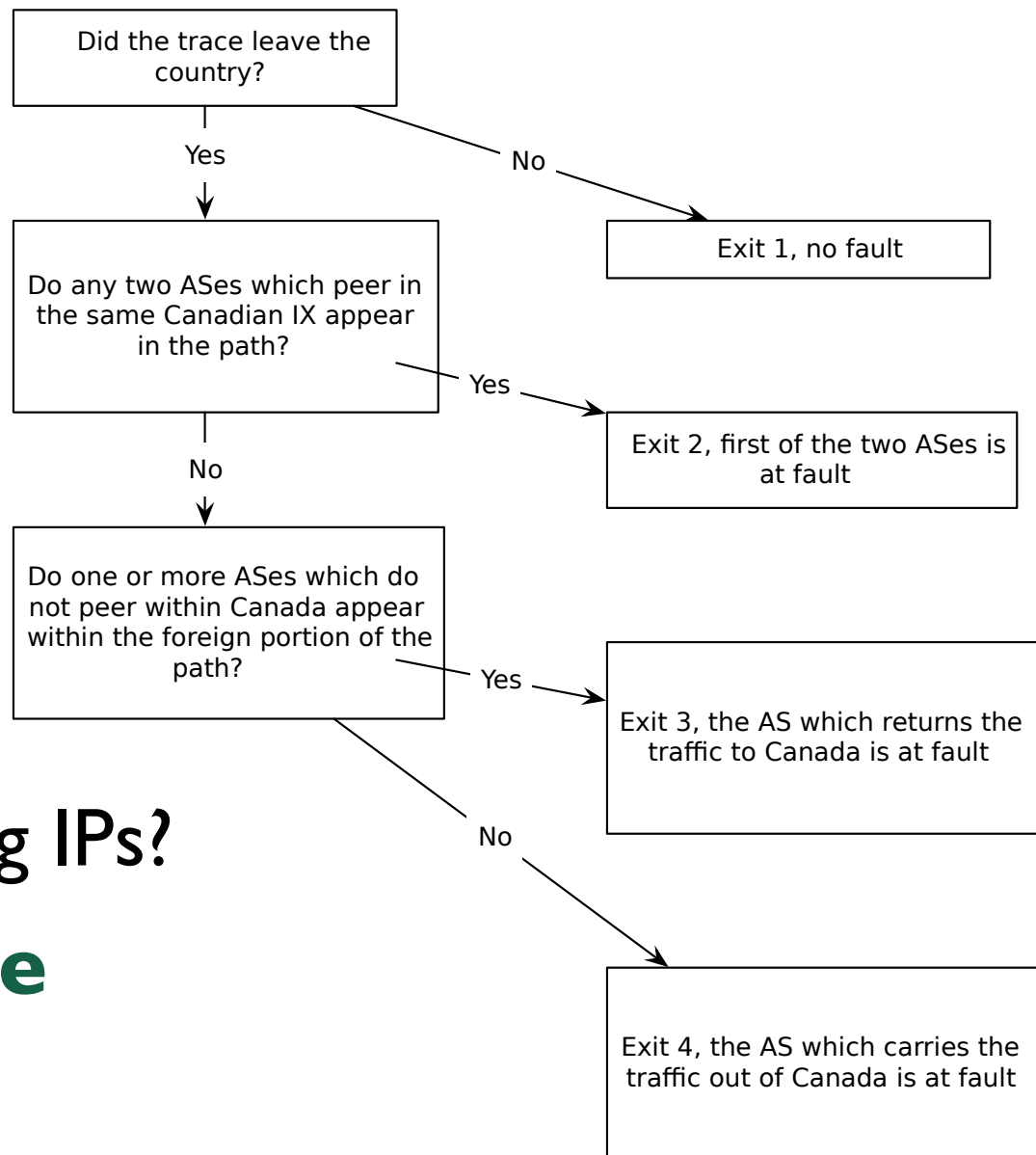
GeoLite2 databases are free IP geolocation databases comparable to, but less accurate than, MaxMind's GeoIP2 databases

OpenIPMap
<https://marmot.ripe.net/openipmap/>

tries to improve Internet Infrastructure geolocation by crowdsourcing

Prefer OpenIPMap over GeoLite2

Challenges



- Reliable Geolocating IPs?

**Carefully analyse
border crossing**

Results

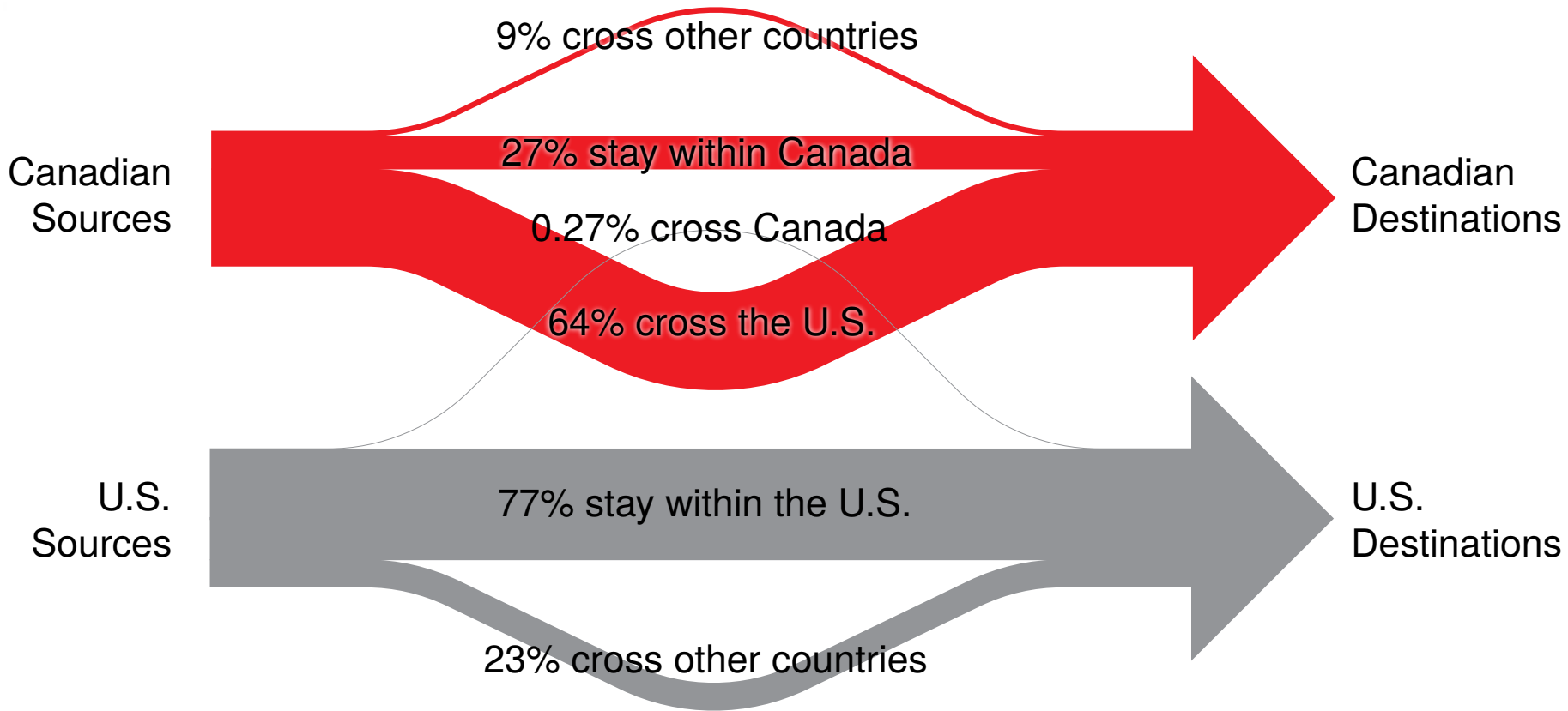


Methodology

- Analyse traceroutes from US sources to US destinations for comparisons:

<i>Source</i>	<i># traceroutes</i>
Already within RIPE Atlas 2016-06-10 ... 2016-09-28	703,170

Results



©2016 by Packet Clearing House



CC BY-NC-SA

Results

- Traceroutes that stayed within Canada had on average **9 hops**, and took **116ms**
- Traceroutes that crossed over to the US had on average **11 hops**, but took **84ms**

Canadian network operators upgrade international links in preference to domestic ones

Results

- Canadian governmental websites

961	Governmental websites
28.82%	Hosted in Canada
66.91%	Hosted in the United States
4.27%	Hosted in the Netherlands, UK and France

- Canadian governmental websites in Canada

45,291	traceroutes
52.86%	Crossed the United States
35.03%	Stayed entirely within Canada
12.11%	Crossed other countries

Results

- **Alexa Canadian top 250**

69.12%	Hotes in the United States
20.21%	Hosted in Canada
2.31%	Hosted in the Netherlands
7.06%	Hosted in other countries

- **Alexa Canadian top 250 in Canada**

9,364	traceroutes
52.86%	Crossed the United States
35.03%	Stayed entirely within Canada
12.11%	Crossed other countries

Results

- Root DNS anycast nodes in Canada

100.00%	Should have stayed within Canada
53.35%	Reached servers in Canada
42.88%	Reached servers in the United States
3.77%	Reached servers in Europe

- Of the subset that reached servers in Canada

61.45%	Crossed the United States
36.95%	Stayed entirely within Canada
1.60%	Crossed other countries

Results

- **.ca** DNS servers

100.00%	Should have stayed within Canada
44.92%	Reached servers in Canada
52.50%	Reached servers in the United States
2.58%	Reached servers in Europe

- Of the subset that reached servers in Canada

63.43%	Crossed the United States
32.63%	Stayed entirely within Canada
3.94%	Crossed other countries

Conclusion

- These measurements are hard
 - Geo-DNS
 - Anycasted destinations
 - non responding hops
 - Non-routable prefixes in the middle
(potentially reused on different locations)
 - Bad quality of Geo locating routable prefixes
(especially with infrastructure)
- A best effort affair
- Tried to minimize assumptions

Conclusion

- Combine many different public resources:
 - RIPE Atlas
 - M-LAB
 - NLnog RING
 - Root DNS zone
 - Alexa Canadian top 250
 - PeeringDB
 - WHOIS
 - University of Oregon Route views archive
- One not publicly available resource
 - gc.ca DNS zone

Thanks

- Measurements performed and processed September and October 2016
- Detailed analysis by PCH
- Official report:
<https://cira.ca/sites/default/files/public/Canadian%20Peering%202016.pdf>
- Me: Willem Toorop <willem@nlnetlabs.nl>