IP Routes as a Graphical Database

Tidewater Big Data Enthusiasts
Chuck Cartledge
Developer

June 28, 2016 at 8:14pm

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1 Introduction

We interact with graphs all the time. Every time we use the internet, we are sending packets of data using the internet protocol (IP) from one machine to another. Usually the sending machine is our own, and by convention, it has a special name: localhost. Other machines are hosts of a different color, and have different names. And to make things even more confusing, any machine can have multiple names.

In this little paper, we will map out some of the routes that IP packets can and have taken from our localhost to a collection of destination hosts. As a way to reduce the abstraction of the IP routing map, we'll present information discovered between our localhost and the destination in several different formats. We'll list them in a table. We'll draw them out like pearls on a string. We'll plot them on a geographic map. And finally, we'll bring all the discoveries together into one map.

2 Approach

There are three different parts to mapping the Internet. They are:

1. Getting a list of IP numbers between yourself (localhost) and the destination.
2. Matching those IP numbers to physical places.
3. Displaying the results in a meaningful manner.

Each of these has its own set of interesting challenges.

2.1 Getting an IP route

There are a number of tools available to get a list of IP numbers between localhost and the destination. The set of tools varies based on the operating system.

Under a Windows environment there is the `TRACERT` command. This is a sample of the `TRACERT -d support247webs.ca` command[a]:

```
1     1 ms    <1 ms    <1 ms  192.168.2.1
2    16 ms    15 ms    29 ms  10.11.1.17
3     17 ms    17 ms  10.178.206.20
4    16 ms    16 ms    16 ms  10.178.206.21
5    21 ms    17 ms    18 ms  64.230.110.32
6    21 ms    18 ms    18 ms  64.230.73.216
7    20 ms    18 ms    17 ms  64.230.50.13
8    17 ms    17 ms    17 ms  64.230.97.159
9    17 ms    17 ms    17 ms  63.243.172.25
10    28 ms    28 ms    28 ms  64.86.33.89
11    29 ms    29 ms    29 ms  66.198.96.61
12    28 ms    27 ms    28 ms  66.110.8.34
13    54 ms    35 ms    35 ms  216.187.114.197
14    37 ms    36 ms    36 ms  216.187.88.34
15    36 ms    36 ms    36 ms  209.15.202.79
```

[a] `https://support247webs.com/windows-traceroute/`

The Linux operating system (and its derivatives) have a wider collection of tools. Including: `tracepath`, `mtr`, `traceroute`

This is a sample of the `tracepath www.clc-ent.com` command:

```
 1?: [LOCALHOST]                                          pmtu 1500
 1:  192.168.2.1                                            0.578ms
 1:  192.168.2.1                                            0.532ms
 2:  10.10.208.1                                            9.623ms
 3:  100.127.40.184                                        12.869ms
 4:  172.22.51.66                                           8.173ms
 5:  port-channel201.car1.Richmond1.Level3.net            179.153ms
 6:  Verizon-level3-100G.Washington12.Level3.net           16.171ms asymm  8
 7:  no reply
 8:  odu-gw.customer.alter.net                             22.374ms asymm 10
 9:  no reply
10:  no reply
11:  no reply
12:  no reply
13:  no reply
```

This is a sample of the `mtr www.clc-ent.com` command:

```
HOST: office-computer             Loss%   Snt   Last   Avg  Best  Wrst StDev
  1.|-- 192.168.2.1                0.0%    10    0.3   0.3   0.3   0.4   0.0
  2.|-- 10.10.208.1                0.0%    10    6.9   7.8   6.2  11.2   1.3
  3.|-- 100.127.40.184             0.0%    10    8.1   8.1   6.8   9.4   0.5
  4.|-- 172.22.51.66                0.0%    10    8.1   7.6   7.0   8.1   0.0
  5.|-- port-channel201.car1.Rich   0.0%    10    9.0  18.7   9.0  97.8  27.8
  6.|-- Verizon-level3-100G.Washi   0.0%    10   15.6  15.4  14.0  16.8   0.7
  7.|-- ???                        100.0    10    0.0   0.0   0.0   0.0   0.0
  8.|-- odu-gw.customer.alter.net   0.0%    10   21.8  22.4  21.4  23.7   0.5
  9.|-- spacely.edifax.com          0.0%    10   32.8  31.7  24.7  41.4   6.3
```

This is a sample of the `traceroute www.clc-ent.com` command:

```
1  192.168.2.1 (192.168.2.1)  0.329 ms  0.321 ms  0.464 ms
 2  10.10.208.1 (10.10.208.1)  8.250 ms  8.249 ms  8.243 ms
 3  100.127.40.184 (100.127.40.184)  13.302 ms  13.412 ms  13.405 ms
 4  172.22.51.66 (172.22.51.66)  13.162 ms  13.157 ms  13.243 ms
 5  port-channel201.car1.Richmond1.Level3.net (4.26.64.145)  15.939 ms  15.931 ms  16
 6  4.68.62.134 (4.68.62.134)  22.019 ms Verizon-level3-100G.Washington12.Level3.net
 7  * * *
 8  odu-gw.customer.alter.net (152.179.89.90)  24.856 ms  24.398 ms  24.511 ms
 9  * * *
10  * * *
11  * * *
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  * * *
```

Both operating systems support the `ping` command, what when combined with a creative use of the time-to-live (TTL) argument will return a path.

The `mtr` command was used to collect data for this report.

2.2 Matching IP numbers to places

There appears to be commercial value to matching IP numbers to physical locations, hence there are lots of sites that will provide that information to you for a fee. For this exploration and proof of concept, we don't want to pay any money. So we looked for, and found enough data to show that our system works.

MaxMind[1] promotes itself as one of the leading GeoIP database and service providers. They have at least two levels of service GeoIP2 Precision and legacy. The GeoIP2 Precision service provides much more precise data than legacy. Legacy databases are free and available for download.[2]. We chose to use the legacy databases.

The database consists of two files, one indexed by IP numbers[3] that returns a location ID, and the other used location ID to give a latitude and longitude. It is worth noting that the latitude and longitude are the approximate centers of the cites where the companies are that have registered that IP number, and not the location of the device using that number. If the IP number is a "private" number then no location is really possible, and so 0 latitude and 0 longitude is assumed. Arguably, just about any position could be used (most recent, centroid of all positions, next location, etc.).

2.3 Displaying the results

The IP routing map is displayed in three different formats, because each shows something different. A simple table is presented that summarizes the path from the localhost to the destination, and each private IP number is annotated as such. A simple bubble chart showing the path from the localhost to the destination (much like you would draw by hand). A geographic map showing where the IP packets are routed across the world.

3 Hosts that we have explored

I sort of randomly selected a few destination hosts as a way to map the Internet from me to them (see Table 1). For each of these hosts, I collected the IP routes to get from my localhost and displayed the results in different ways. Based on putting together this report, there are a number of things that I "knew" but didn't really pay too much attention to. These include:

1. The route taken on one day may not be the route taken on another.
2. Parts of the route may be on the "public" IP world, and parts may be on the "private" world.
3. The geographic route may be completely wrong, because it is based on company locations, vice hardware locations.

When looking at the IP addresses that are discovered, we need to keep in mind the private IP addresses are defined and well known[1, 2]. Private IP addresses (see Table 2), must not

[1] `https://www.maxmind.com/en/home`

[2] `http://geolite.maxmind.com/download/geoip/database/GeoLiteCity_CSV/`

[3] The IP numbers are converted from the familiar dotted notation to unsigned long integers (216.9.89.29 becomes DB09591D becomes 3674822941).

be routed over the "public" internet. If we assume that the system administration personnel at each of the hosts follows this dictum, then the IP route from localhost to target goes in and out the public internet.

Table 1: Target hosts selected to map the internet.

Human name	**Host name**
CLC Enterprises	www.clc-ent.com
Google	www.google.com
Louvre Museum	www.louvre.fr
National Library of Australia	www.nla.gov.au
National Library of Brazil	www.bn.br
National Library of India	www.nationallibrary.gov.in
National Library of Pakistan	www.nlp.gov.pk
National Library of South Africa	www.nlsa.ac.za
National University of Singapore	www.nus.edu.sg
Old Dominion Computer Science ssh server	fast.cs.odu.edu
The British Library	www.bl.uk

Table 2: Private IP addresses.

Start Address	**End Address**	**Number of hosts**
10.0.0.0	10.255.255.255	16,772,216.000
172.16.0.0	172.31.255.255	1,048,576.000
192.168.0.0	192.168.255.255	65,536.000

3.1 fast.cs.odu.edu

The route to get from localhost to fast.cs.odu.edu was discovered (see Table 3). This route can be displayed as a simple bubble diagram (see Figure 1), or as a geographic route (see Figure 2).

Table 3: Route from localhost to fast.cs.odu.edu. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		**IP Address**	**Hostname**	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.88	100.127.40.88	
4	D	172.22.51.91	172.22.51.91	Private IP
5	E	172.21.249.122	172.21.249.122	Private IP
6	F	174.77.88.22	wsip-174-77-88-22.hr.hr.cox.net	
7	G	128.82.4.31	odu	

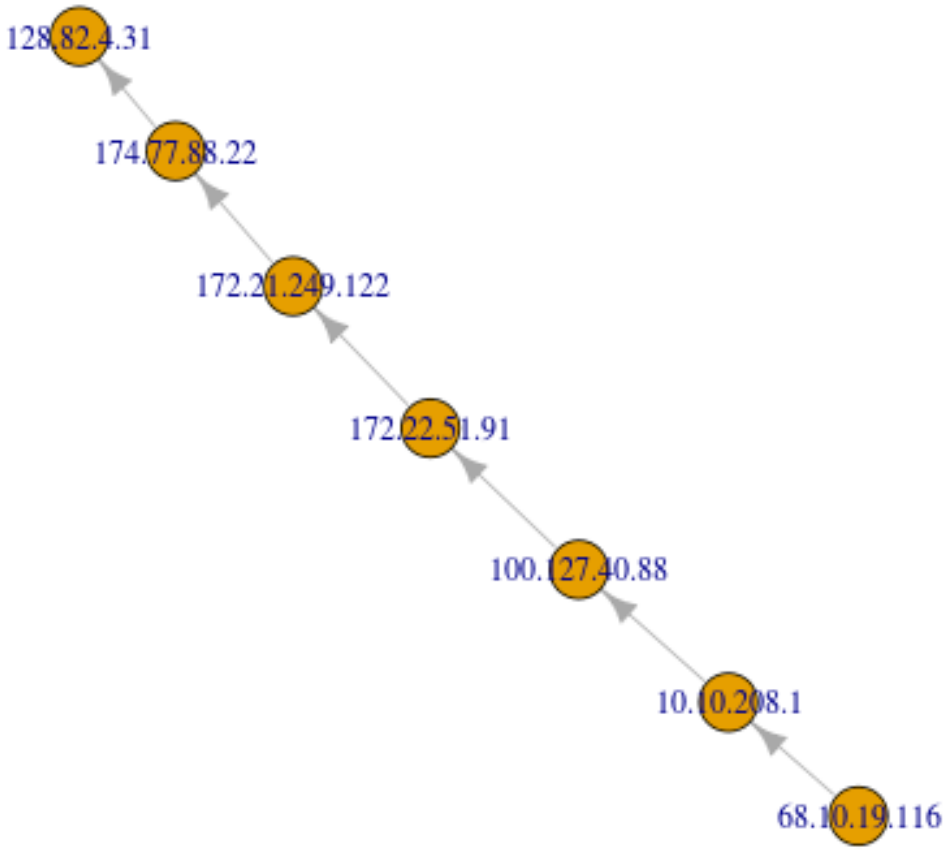

Figure 1: Route from local host to fast.cs.odu.edu.

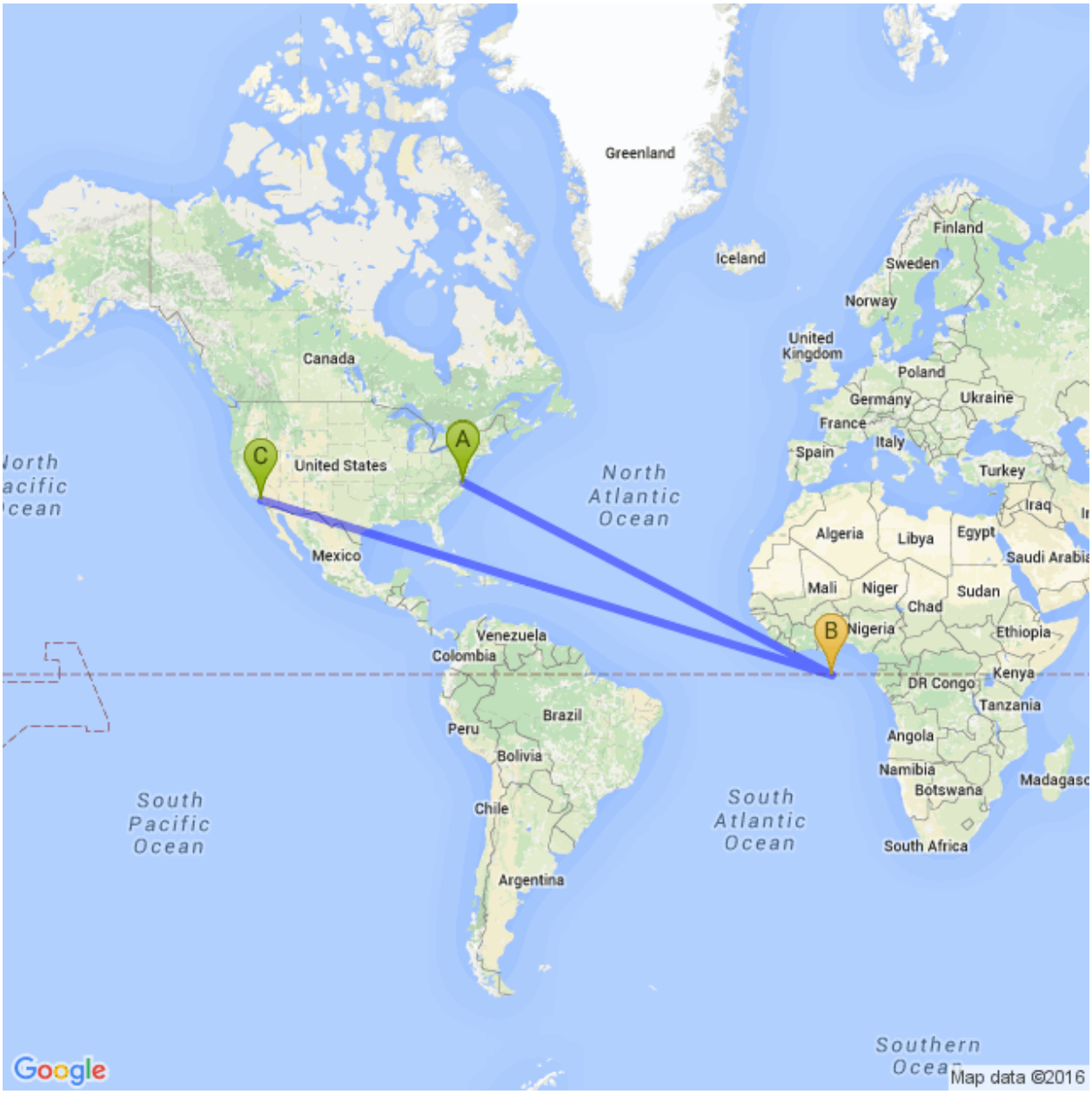

Figure 2: Geographic route from local host to fast.cs.odu.edu. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.2 www.bl.uk

The route to get from localhost to www.bl.uk was discovered (see Table 4). This route can be displayed as a simple bubble diagram (see Figure 3), or as a geographic route (see Figure 4).

Table 4: Route from localhost to www.bl.uk. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.184	100.127.40.184	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	4.26.64.145	port-channel201.car1.Richmond1.Level3.net	
6	F	4.69.142.254	ae-11-11.car2.Richmond1.Level3.net	
7	G	212.187.173.54	212.187.173.54	
8	H	146.97.33.14	ae27.erdiss-sbr1.ja.net	
9	I	146.97.33.42	ae29.manckh-sbr1.ja.net	
10	J	146.97.36.222	ae26.leedlu-rbr1.ja.net	
11	K	146.97.40.34	british-library.ja.net	

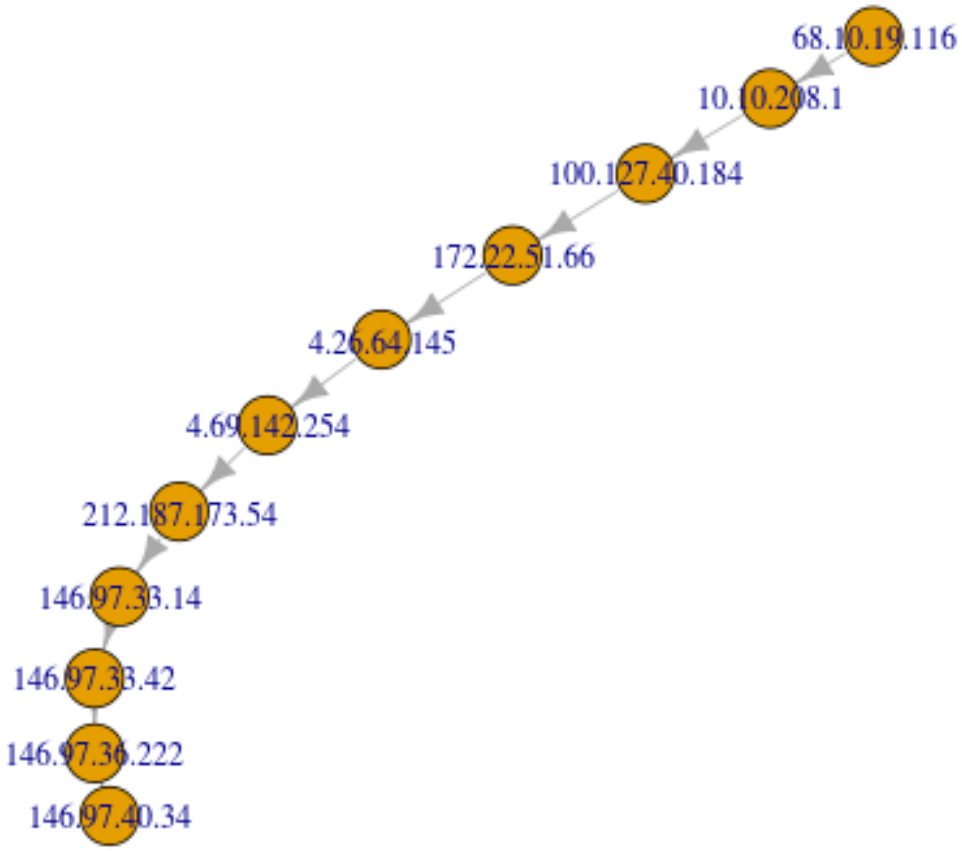

Figure 3: Route from local host to www.bl.uk.

Figure 4: Geographic route from local host to www.bl.uk. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.3 www.bn.br

The route to get from localhost to www.bn.br was discovered (see Table 5). This route can be displayed as a simple bubble diagram (see Figure 5), or as a geographic route (see Figure 6).

Table 5: Route from localhost to www.bn.br. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.88	100.127.40.88	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	4.26.64.145	port-channel201.car1.Richmond1.Level3.net	
6	F	4.69.149.82	ae-2-70.edge3.Washington4.Level3.net	
7	G	208.51.134.81	po5-503-60G.ar2.DCA3.gblx.net	
8	H	64.214.61.250	level-3-brasil.xe-0-3-1.ar2.gig1.gblx.net	
9	I	200.20.96.5	200.20.96.5	
10	J	200.20.96.7	200.20.96.7	
11	K	200.20.96.9	200.20.96.9	
12	L	200.20.96.27	200.20.96.27	
13	M	200.20.98.106	200.20.98.106	

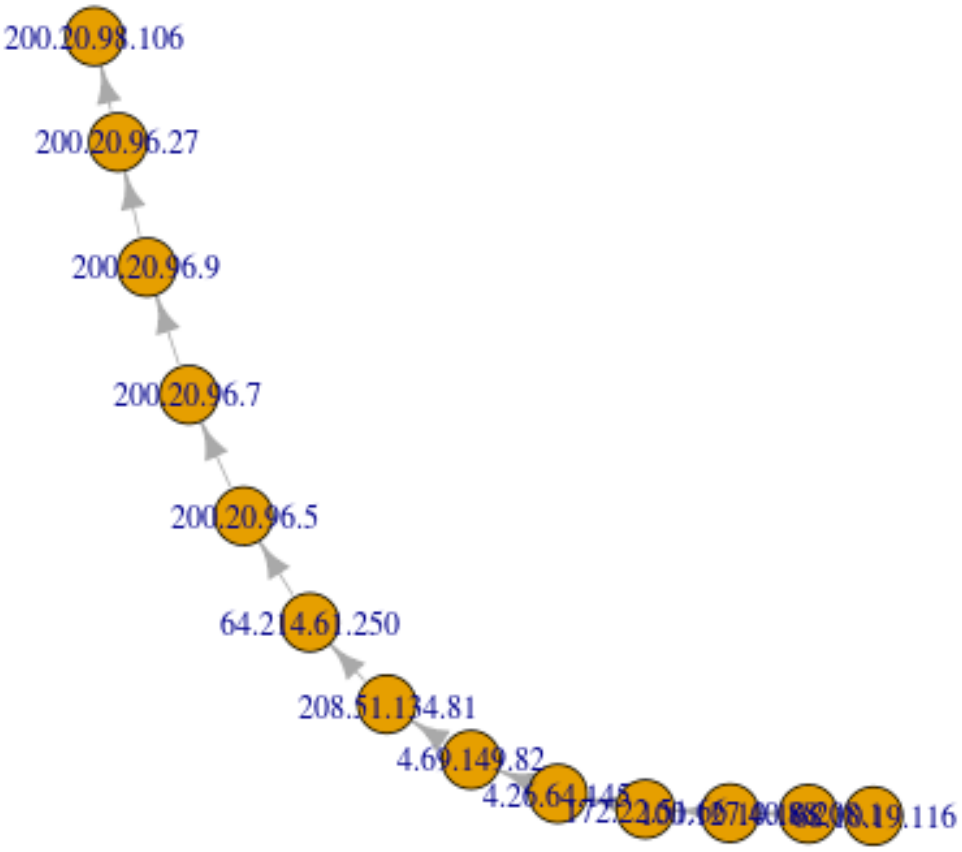

Figure 5: Route from local host to www.bn.br.

Figure 6: Geographic route from local host to www.bn.br. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.4 www.clc-ent.com

The route to get from localhost to www.clc-ent.com was discovered (see Table 6). This route can be displayed as a simple bubble diagram (see Figure 7), or as a geographic route (see Figure 8).

Table 6: Route from localhost to www.clc-ent.com. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.184	100.127.40.184	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	4.26.64.145	port-channel201.car1.Richmond1.Level3.net	
6	F	4.68.62.138	Verizon-level3-100G.Washington12.Level3.net	
7	G	152.179.89.90	odu-gw.customer.alter.net	
8	H	216.9.89.29	spacely.edifax.com	

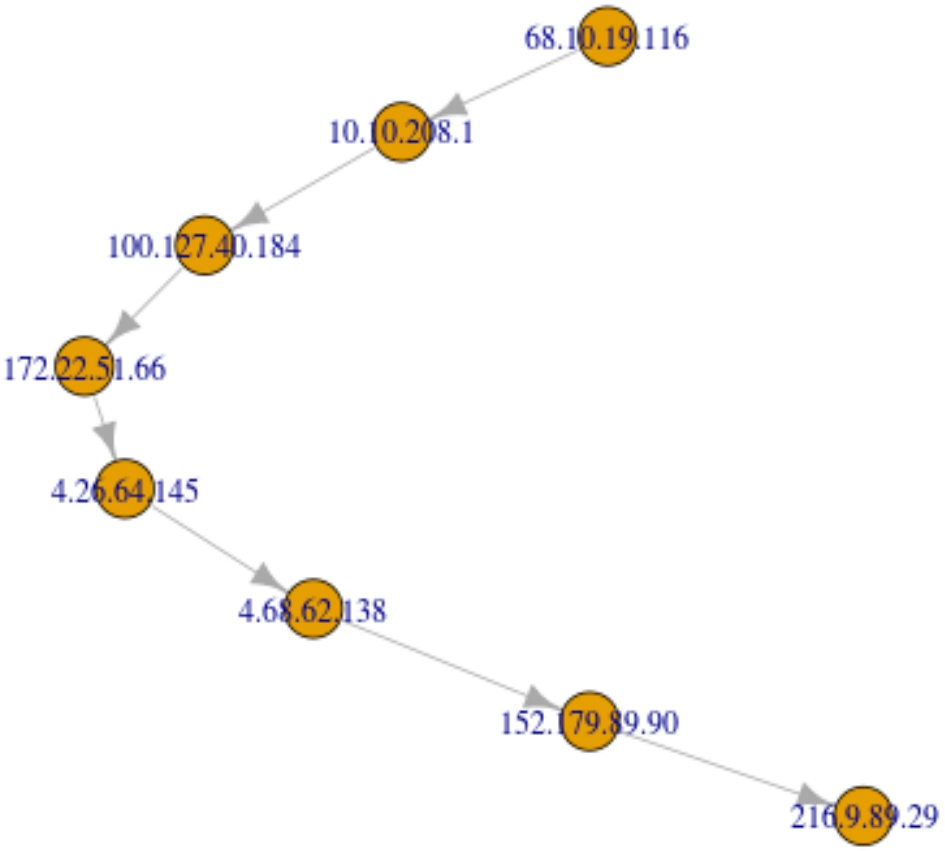

Figure 7: Route from local host to www.clc-ent.com.

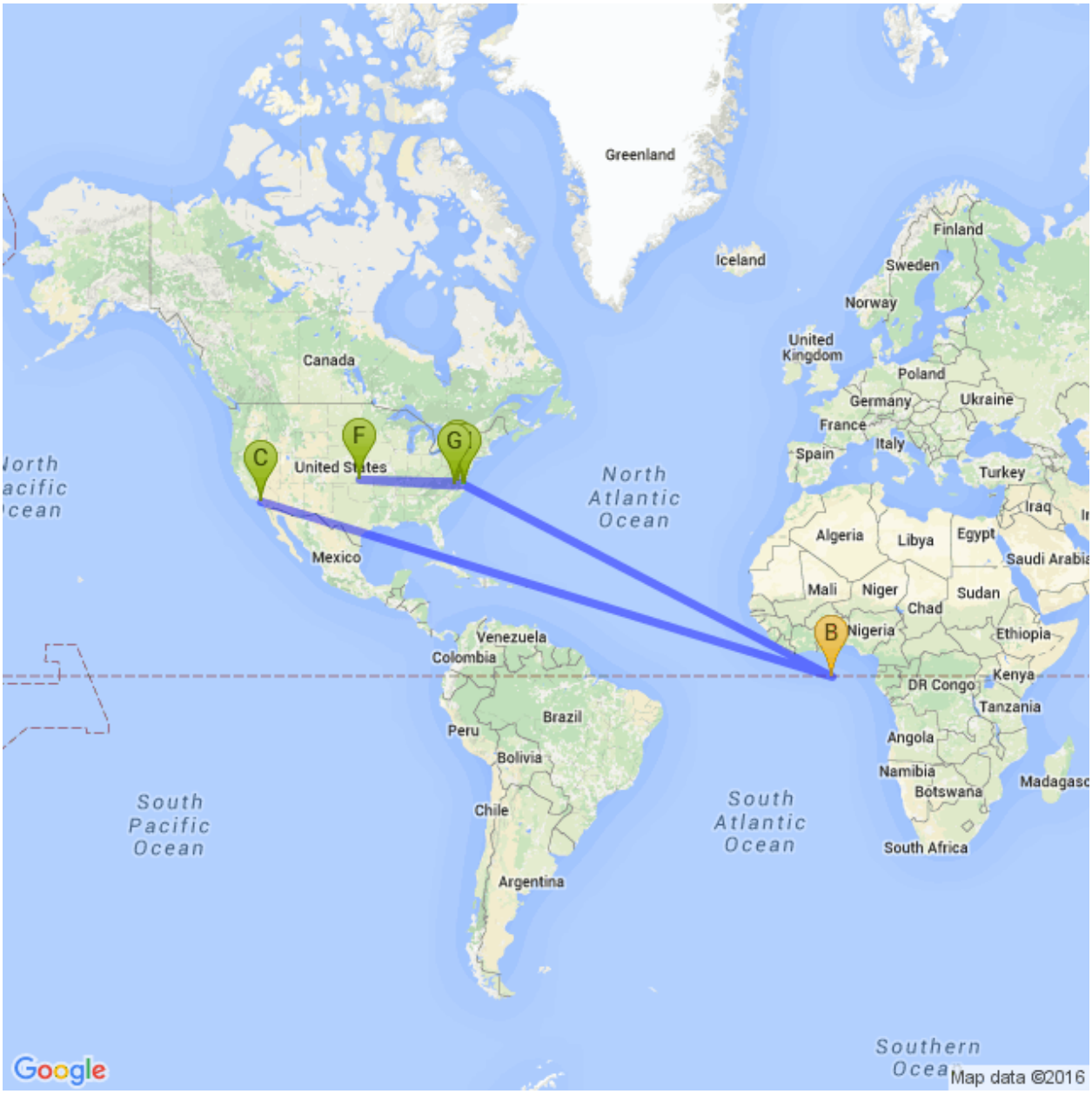

Figure 8: Geographic route from local host to www.clc-ent.com. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.5 www.example.com

The route to get from localhost to www.example.com was discovered (see Table 7). This route can be displayed as a simple bubble diagram (see Figure 9), or as a geographic route (see Figure 10).

Table 7: Route from localhost to www.example.com. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.41.120	100.127.41.120	
4	D	172.22.51.96	172.22.51.96	Private IP
5	E	68.1.4.139	ashbbprj02-ae2.0.rd.as.cox.net	
6	F	72.21.83.157	edgecastcdn.net	
7	G	198.7.25.18	198-7-25-18.edgecastcdn.net	
8	H	93.184.216.34	93.184.216.34	

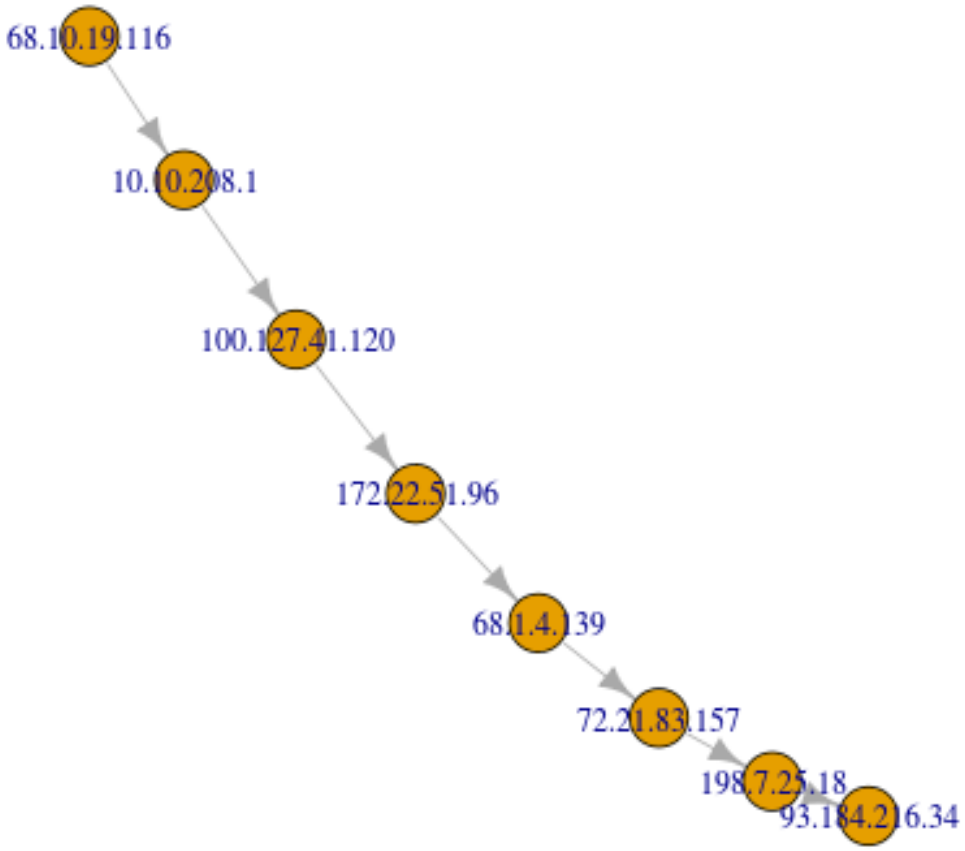

Figure 9: Route from local host to www.example.com.

Figure 10: Geographic route from local host to www.example.com. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.6 www.facebook.com

The route to get from localhost to www.facebook.com was discovered (see Table 8). This route can be displayed as a simple bubble diagram (see Figure 11), or as a geographic route (see Figure 12).

Table 8: Route from localhost to www.facebook.com. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.88	100.127.40.88	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	68.1.0.242	ashbbprj01-ae2.rd.as.cox.net	
6	F	68.105.30.90	68.105.30.90	
7	G	204.15.23.143	psw01d.iad3.tfbnw.net	
8	H	173.252.65.123	msw1as.01.iad3.tfbnw.net	
9	I	31.13.69.228	edge-star-mini-shv-01-iad3.facebook.com	

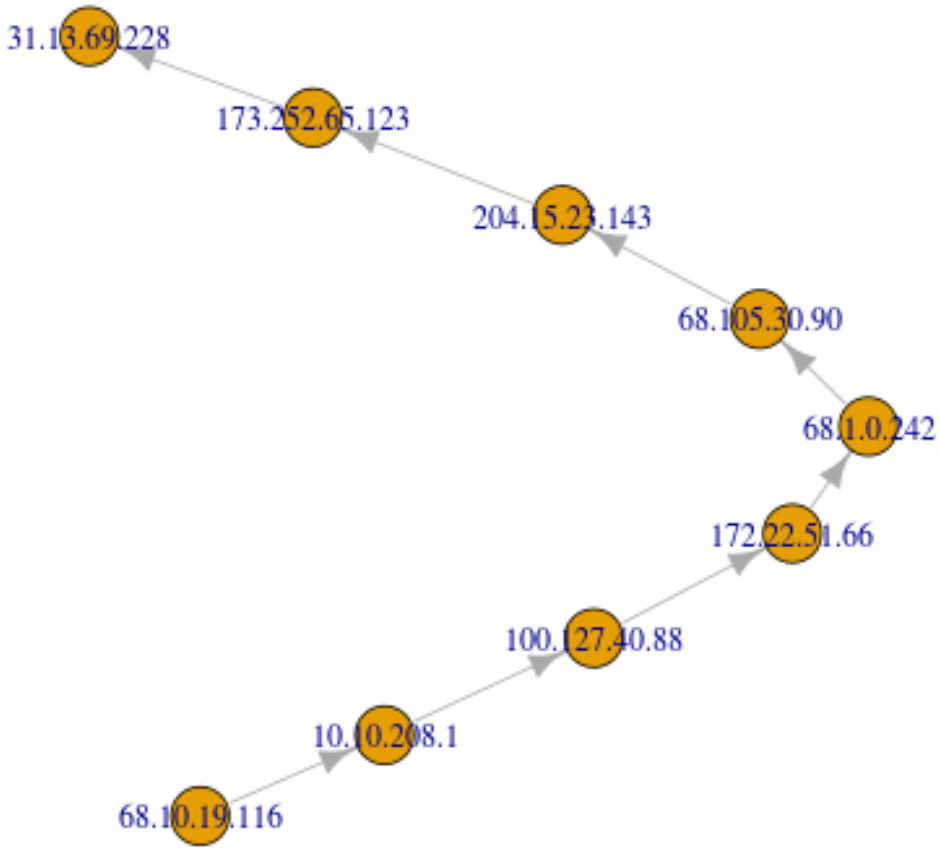

Figure 11: Route from local host to www.facebook.com.

Figure 12: Geographic route from local host to www.facebook.com. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.7 www.google.com

The route to get from localhost to www.google.com was discovered (see Table 9). This route can be displayed as a simple bubble diagram (see Figure 13), or as a geographic route (see Figure 14).

Table 9: Route from localhost to www.google.com. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.88	100.127.40.88	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	68.1.0.252	ashbbprj01-ae5.0.rd.as.cox.net	
6	F	68.105.30.118	68.105.30.118	
7	G	209.85.252.80	209.85.252.80	
8	H	72.14.236.152	72.14.236.152	
9	I	72.14.232.71	72.14.232.71	
10	J	209.85.247.10	209.85.247.10	
11	K	72.14.238.83	72.14.238.83	
12	L	216.239.40.8	216.239.40.8	
13	M	209.85.247.0	209.85.247.0	
14	N	209.85.142.93	209.85.142.93	
15	O	216.58.216.36	lax02s22-in-f4.1e100.net	

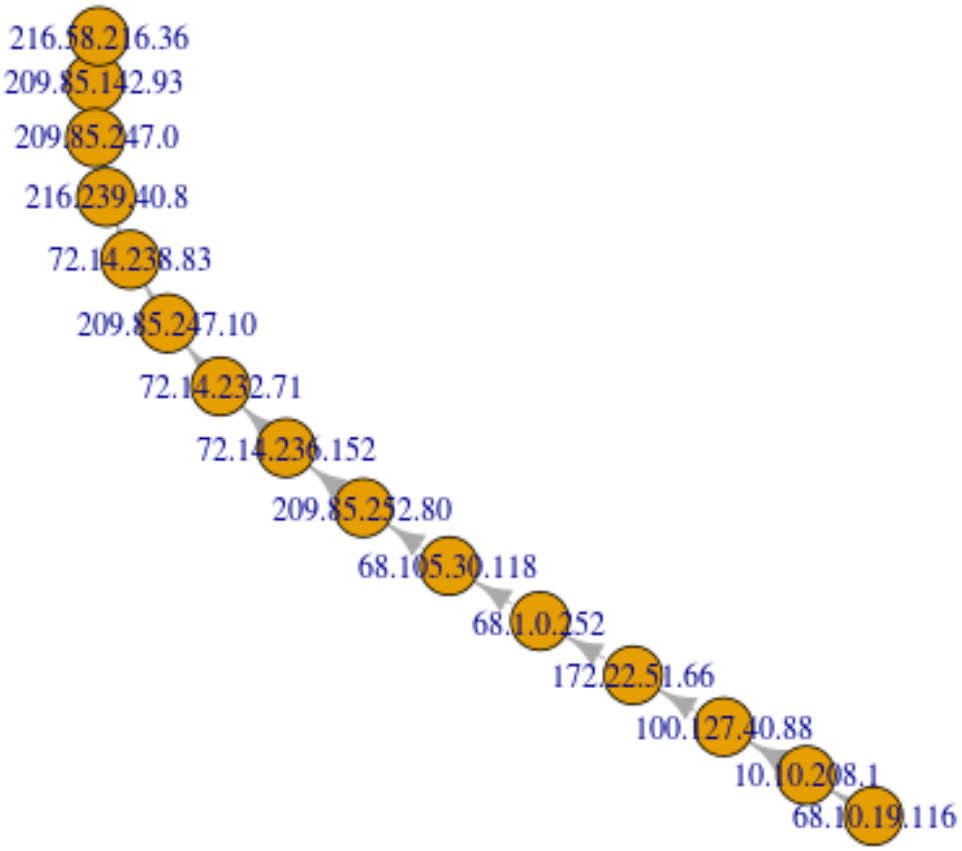

Figure 13: Route from local host to www.google.com.

Figure 14: Geographic route from local host to www.google.com. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.8 www.library.metro.tokyo.jp

The route to get from localhost to www.library.metro.tokyo.jp was discovered (see Table 10). This route can be displayed as a simple bubble diagram (see Figure 15), or as a geographic route (see Figure 16).

Table 10: Route from localhost to www.library.metro.tokyo.jp. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		**IP Address**	**Hostname**	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.88	100.127.40.88	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	68.1.4.139	ashbbprj02-ae2.0.rd.as.cox.net	
6	F	129.250.194.149	ae-26.r06.asbnva02.us.bb.gin.ntt.net	
7	G	129.250.2.120	ae-2.r22.asbnva02.us.bb.gin.ntt.net	
8	H	129.250.3.189	ae-5.r23.lsanca07.us.bb.gin.ntt.net	
9	I	129.250.3.192	ae-12.r31.tokyjp05.jp.bb.gin.ntt.net	
10	J	129.250.3.28	ae-3.r02.tokyjp05.jp.bb.gin.ntt.net	
11	K	120.88.53.18	120.88.53.18	
12	L	125.170.97.129	125.170.97.129	
13	M	125.170.97.74	125.170.97.74	
14	N	153.149.219.14	153.149.219.14	
15	O	153.149.219.38	153.149.219.38	
16	P	180.37.200.10	180.37.200.10	

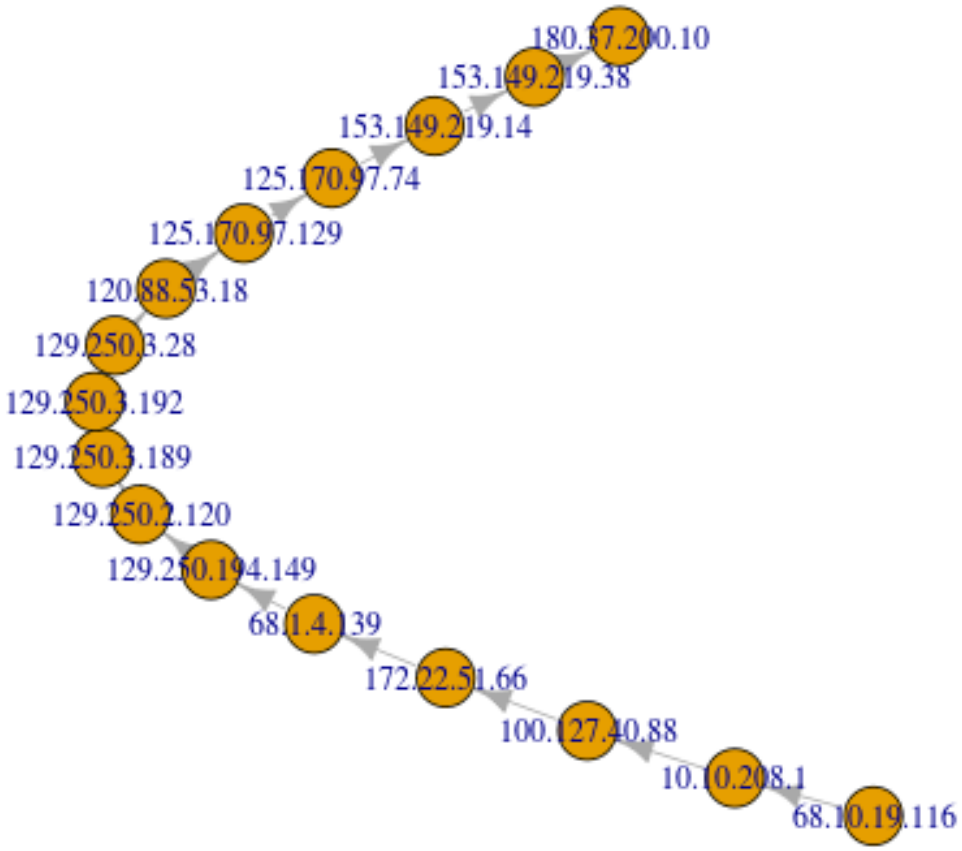

Figure 15: Route from local host to www.library.metro.tokyo.jp.

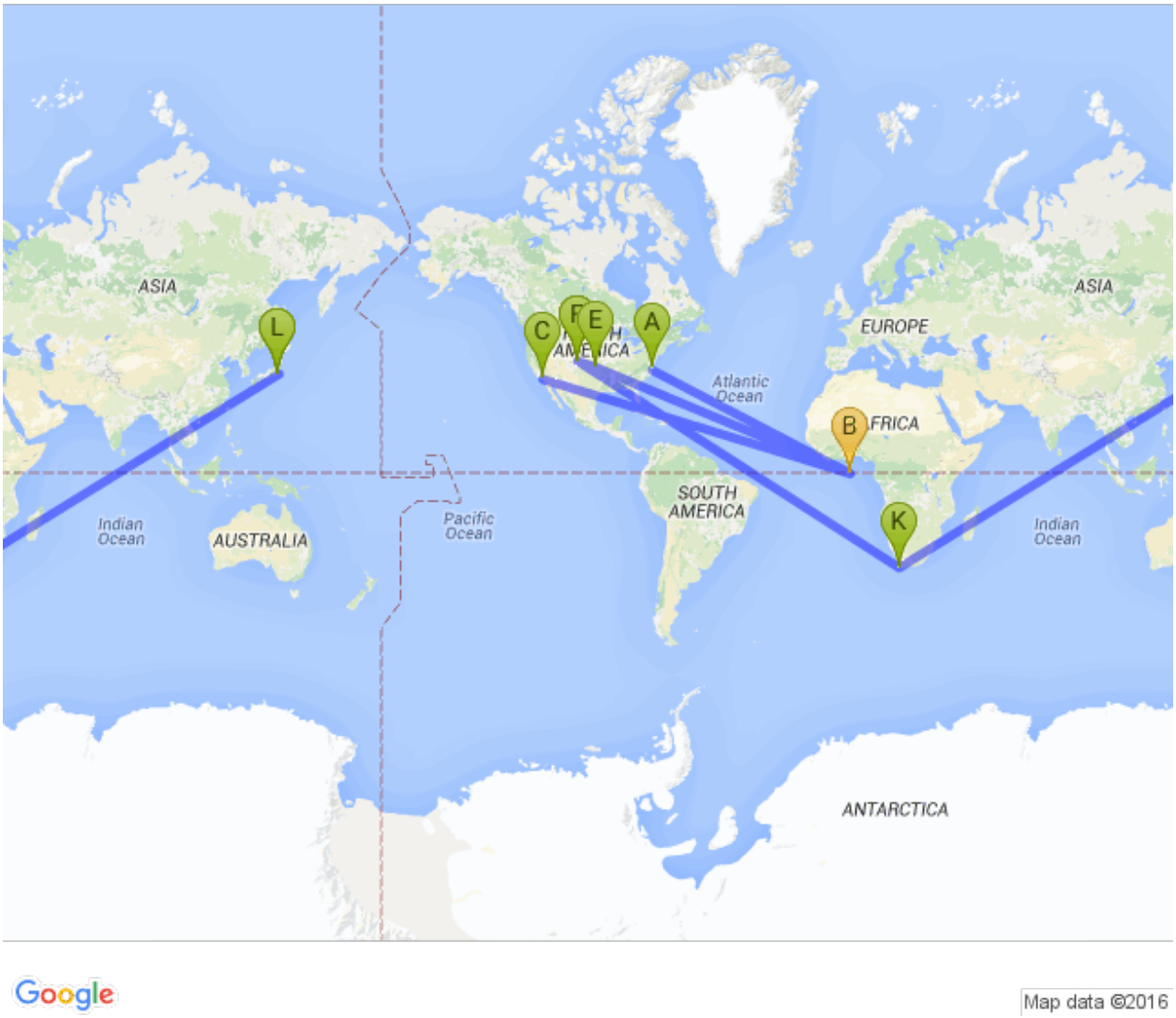

Figure 16: Geographic route from local host to www.library.metro.tokyo.jp. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.9 www.louvre.fr

The route to get from localhost to www.louvre.fr was discovered (see Table 11). This route can be displayed as a simple bubble diagram (see Figure 17), or as a geographic route (see Figure 18).

Table 11: Route from localhost to www.louvre.fr. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.184	100.127.40.184	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	4.26.64.145	port-channel201.car1.Richmond1.Level3.net	
6	F	4.69.168.137	ae-3-80.edge6.Paris1.Level3.net	
7	G	213.242.120.70	213.242.120.70	
8	H	212.43.193.205	sd-mse1-te-0-0-0-7.router.fr.clara.net	
9	I	212.43.193.145	sd-ar11-te-0-0-2-0.router.fr.clara.net	
10	J	89.185.58.93	sr-louvre.router.fr.clara.net	
11	K	89.185.38.136	89.185.38.136	

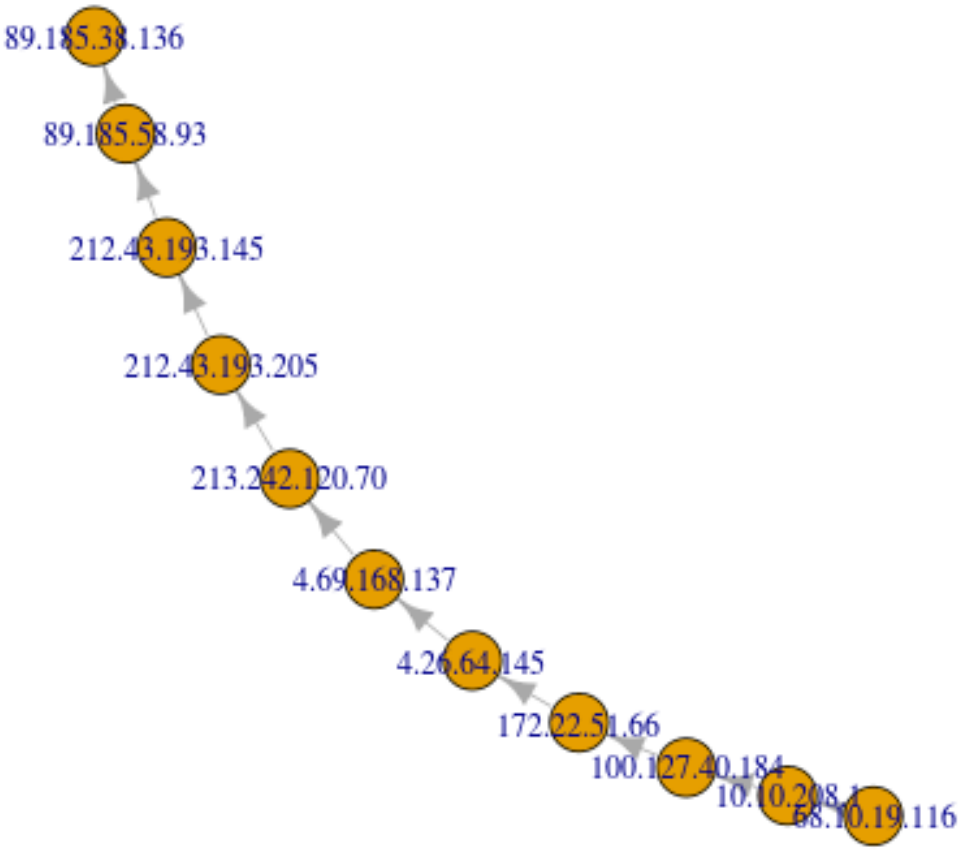

Figure 17: Route from local host to www.louvre.fr.

Figure 18: Geographic route from local host to www.louvre.fr. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.10 www.msn.com

The route to get from localhost to www.msn.com was discovered (see Table 12). This route can be displayed as a simple bubble diagram (see Figure 19), or as a geographic route (see Figure 20).

Table 12: Route from localhost to www.msn.com. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.88	100.127.40.88	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	68.1.0.242	ashbbprj01-ae2.rd.as.cox.net	
6	F	207.46.41.30	ae5-0.ash-96cbe-1a.ntwk.msn.net	
7	G	104.44.81.56	104.44.81.56	
8	H	204.79.197.203	a-0003.a-msedge.net	

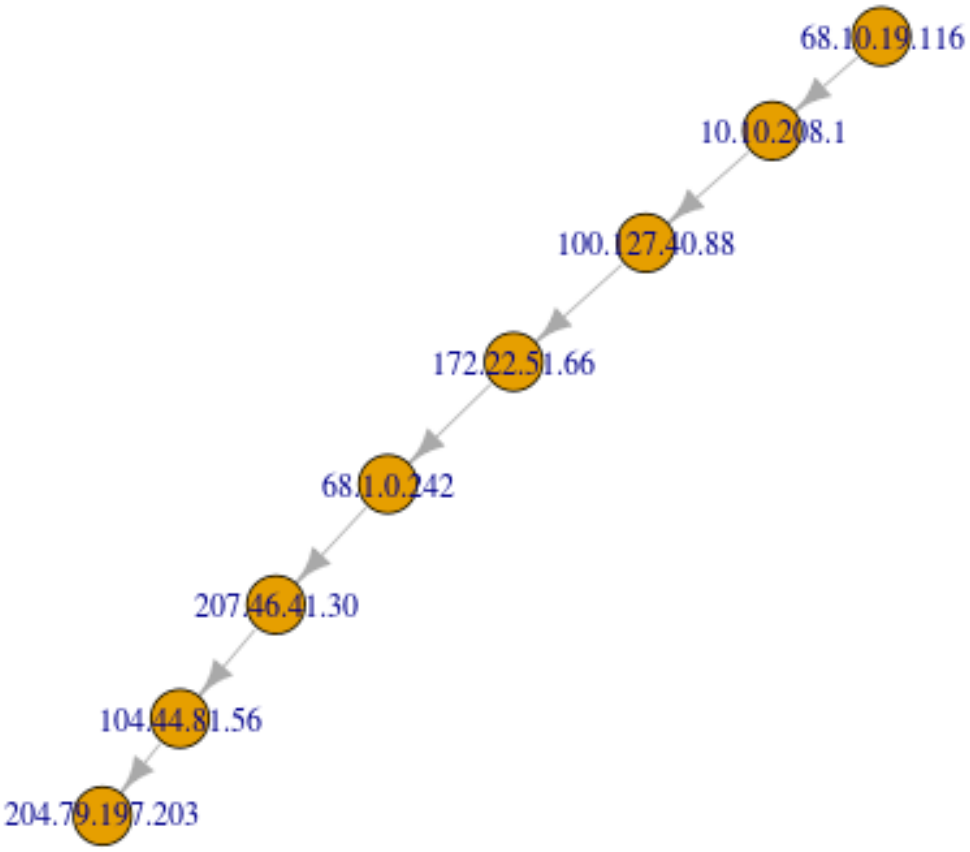

Figure 19: Route from local host to www.msn.com.

Figure 20: Geographic route from local host to www.msn.com. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.11 www.nationallibrary.gov.in

The route to get from localhost to www.nationallibrary.gov.in was discovered (see Table 13). This route can be displayed as a simple bubble diagram (see Figure 21), or as a geographic route (see Figure 22).

Table 13: Route from localhost to www.nationallibrary.gov.in. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.184	100.127.40.184	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	4.26.64.145	port-channel201.car1.Richmond1.Level3.net	
6	F	4.69.149.16	ae-1-60.edge2.Washington4.Level3.net	
7	G	216.6.87.65	ix-ae-21-0.tcore2.AEQ-Ashburn.as6453.net	
8	H	216.6.87.10	if-ae-3-2.thar2.NJY-Newark.as6453.net	
9	I	216.6.57.1	if-ae-1-3.thar1.NJY-Newark.as6453.net	
10	J	80.231.130.33	if-ae-4-2.tcore1.L78-London.as6453.net	
11	K	80.231.131.1	if-ae-2-2.tcore2.L78-London.as6453.net	
12	L	80.231.200.13	if-ae-9-2.tcore2.WYN-Marseille.as6453.net	
13	M	80.231.200.26	80.231.200.26	
14	N	14.140.113.30	14.140.113.30	

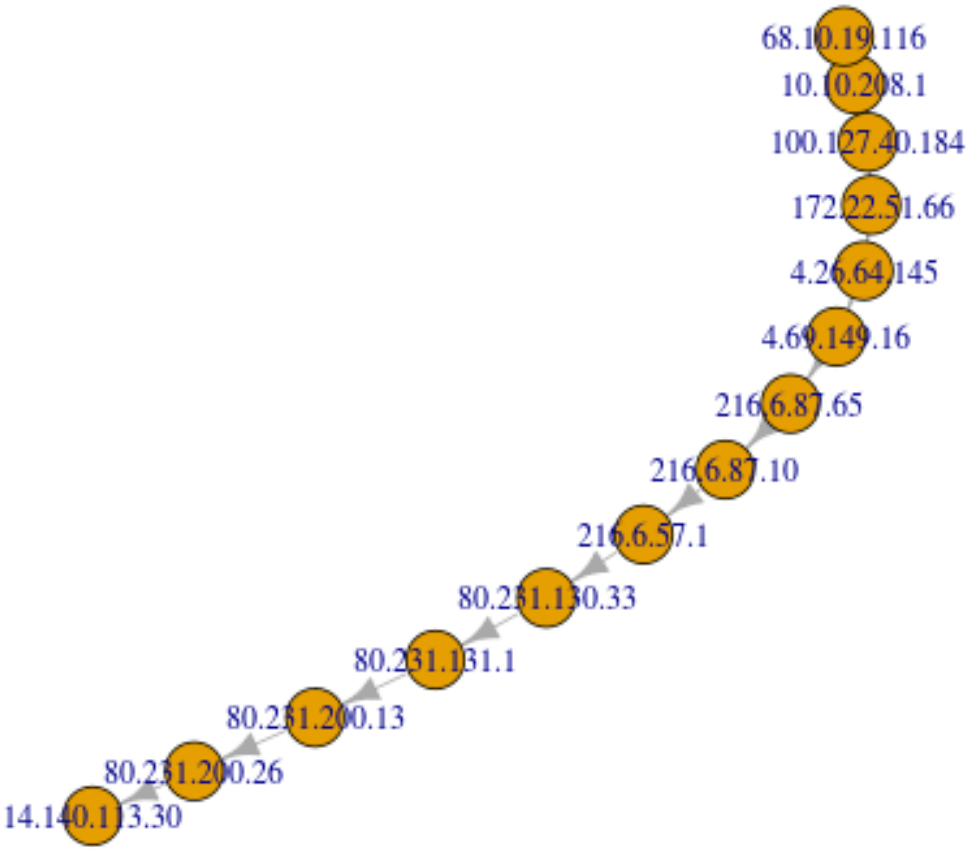

Figure 21: Route from local host to www.nationallibrary.gov.in.

Figure 22: Geographic route from local host to www.nationallibrary.gov.in. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.12 www.nla.gov.au

The route to get from localhost to www.nla.gov.au was discovered (see Table 14). This route can be displayed as a simple bubble diagram (see Figure 23), or as a geographic route (see Figure 24).

Table 14: Route from localhost to www.nla.gov.au. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		**IP Address**	**Hostname**	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.184	100.127.40.184	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	68.1.5.184	sanjbprj01-ae0.0.rd.sj.cox.net	
6	F	68.105.31.53	PALTBBRJ01-GE030101.R2.pt.cox.net	
7	G	150.101.33.148	xe-0-1-0.br1.syd7.on.ii.net	
8	H	150.101.33.14	ae0.br1.syd4.on.ii.net	
9	I	150.101.33.23	ae2.cr2.cbr2.on.ii.net	
10	J	150.101.33.63	transact-cbr2-gw.on.ii.net	
11	K	202.55.144.40	static-144-40.transact.net.au	
12	L	202.55.146.118	static-146-118.transact.net.au	
13	M	202.6.91.108	Gigabitethernet0-0.nlasfw.nla.gov.au	
14	N	202.6.91.84	202.6.91.84	
15	O	202.6.91.84	202.6.91.84	
16	P	192.102.239.53	www-prod.nla.gov.au	

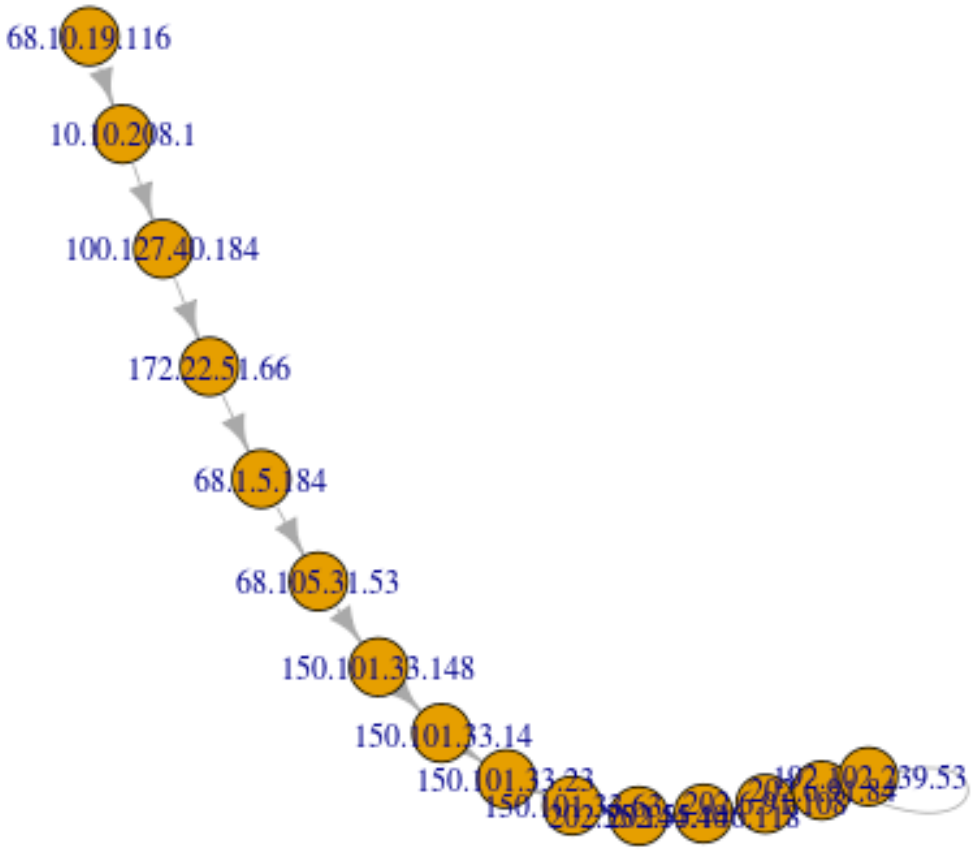

Figure 23: Route from local host to www.nla.gov.au.

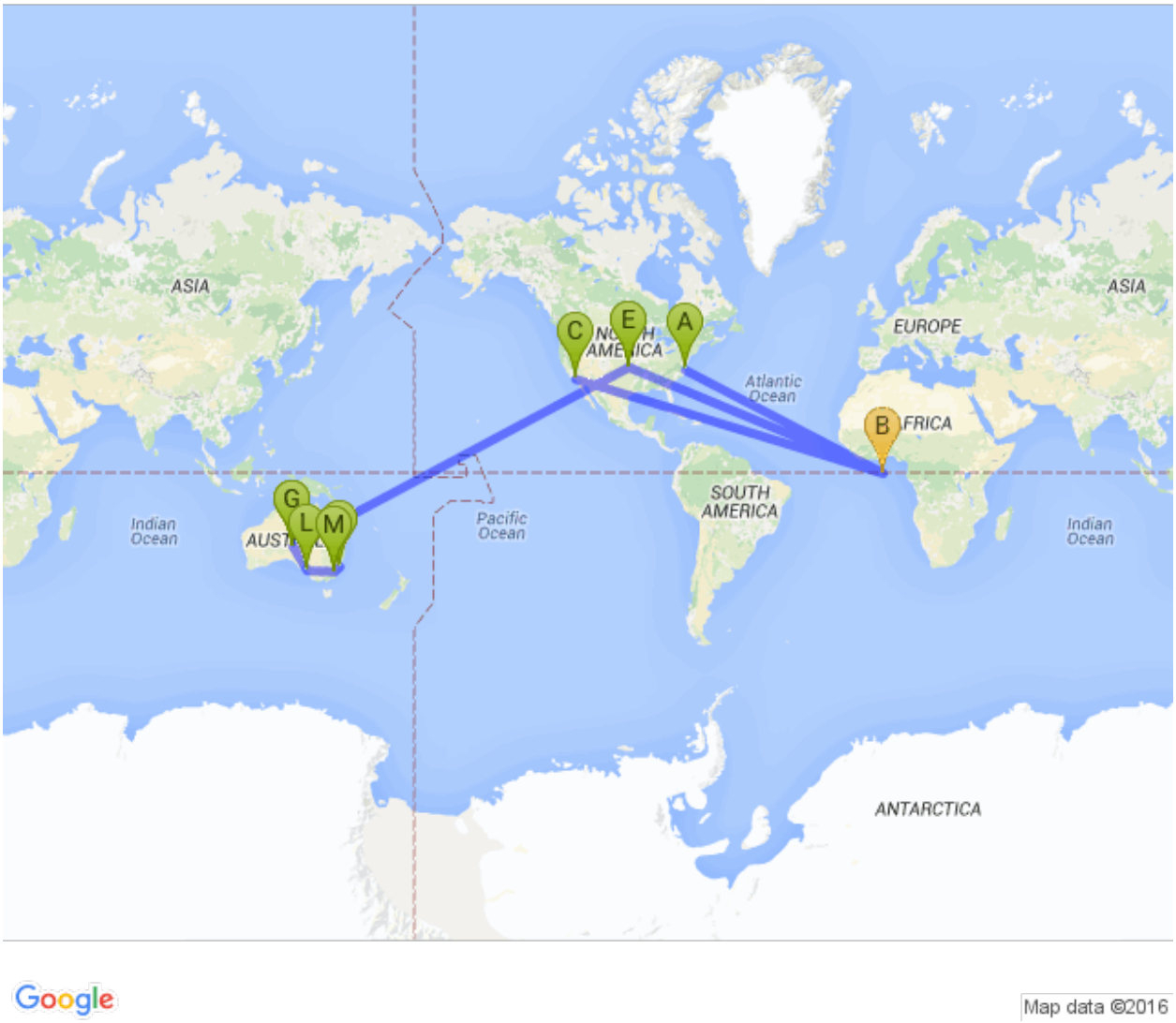

Figure 24: Geographic route from local host to www.nla.gov.au. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.13 www.nlp.gov.pk

The route to get from localhost to www.nlp.gov.pk was discovered (see Table 15). This route can be displayed as a simple bubble diagram (see Figure 25), or as a geographic route (see Figure 26).

Table 15: Route from localhost to www.nlp.gov.pk. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.88	100.127.40.88	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	4.26.64.145	port-channel201.car1.Richmond1.Level3.net	
6	F	4.53.56.190	ENDURANCE-I.bar2.Boston1.Level3.net	
7	G	171.144.96.66	171.144.96.66	

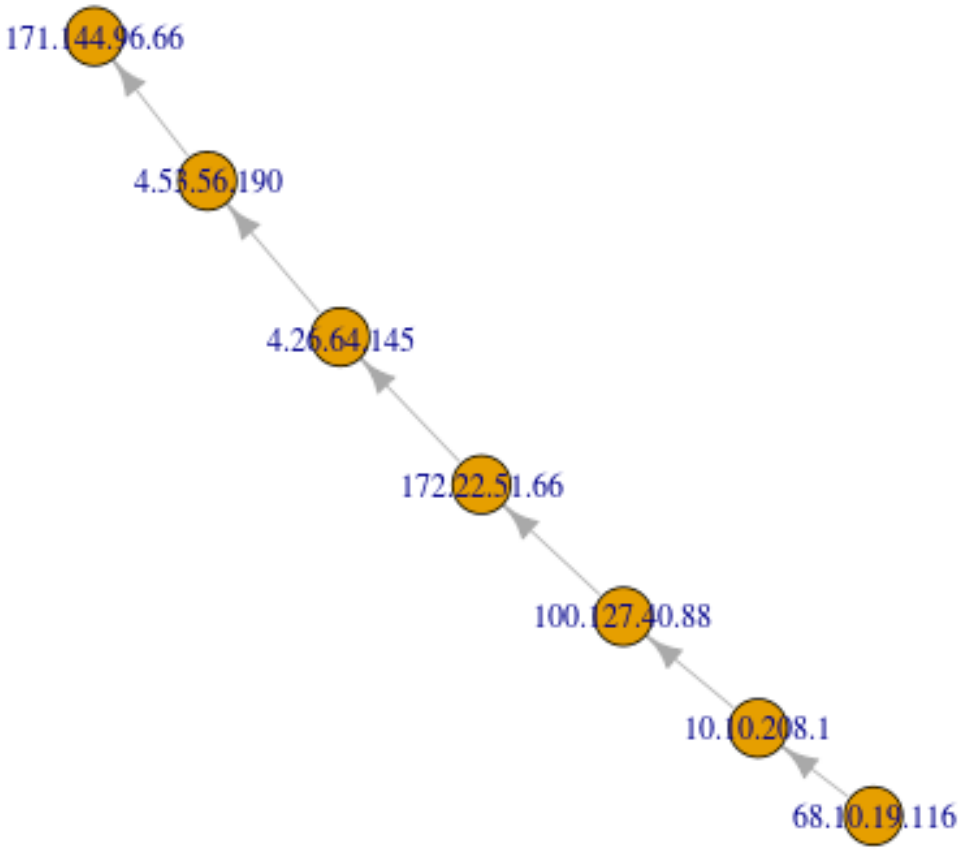

Figure 25: Route from local host to www.nlp.gov.pk.

Figure 26: Geographic route from local host to www.nlp.gov.pk. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.14 www.nlsa.ac.za

The route to get from localhost to www.nlsa.ac.za was discovered (see Table 16). This route can be displayed as a simple bubble diagram (see Figure 27), or as a geographic route (see Figure 28).

Table 16: Route from localhost to www.nlsa.ac.za. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.184	100.127.40.184	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	4.26.64.145	port-channel201.car1.Richmond1.Level3.net	
6	F	4.69.149.82	ae-2-70.edge3.Washington4.Level3.net	
7	G	4.68.63.174	COGENT-COMM.edge3.Washington4.Level3.net	
8	H	154.54.31.109	be2657.ccr42.dca01.atlas.cogentco.com	
9	I	154.54.40.109	be2807.ccr42.jfk02.atlas.cogentco.com	
10	J	154.54.42.86	be2490.ccr42.lon13.atlas.cogentco.com	
11	K	154.54.58.186	be2871.ccr21.lon01.atlas.cogentco.com	
12	L	154.54.56.238	be2866.rcr21.b015533-1.lon01.atlas.cogentco.com	
13	M	149.14.80.210	149.14.80.210	
14	N	196.32.209.50	xe-0-0-0.ams1.nl.ubuntunet.net	
15	O	196.32.209.117	xe0-0-2-2018-mtz1-pe1.tenet.ac.za	
16	P	155.232.6.86	xe0-0-2-700-dur1-pe2-n.tenet.ac.za	
17	Q	155.232.6.29	te0-12-0-2-pta1-p1-n.tenet.ac.za	
18	R	155.232.6.138	te9-4-pta1-pe1.tenet.ac.za	
19	S	196.21.43.12	196.21.43.12	

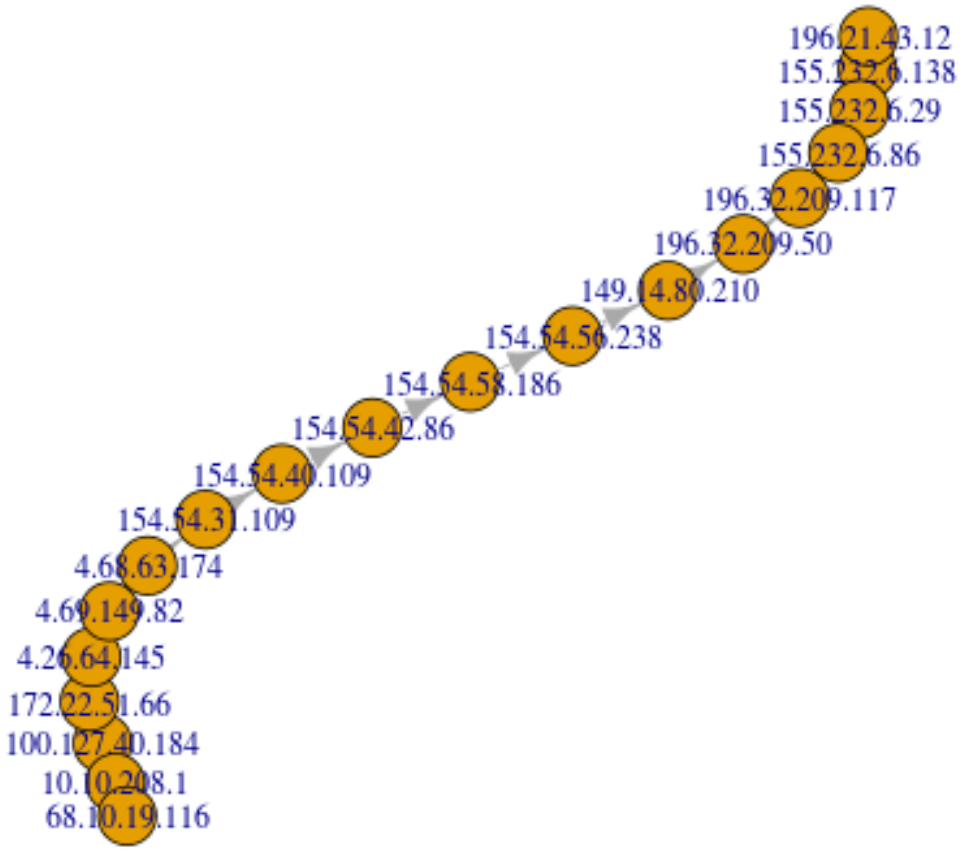

Figure 27: Route from local host to www.nlsa.ac.za.

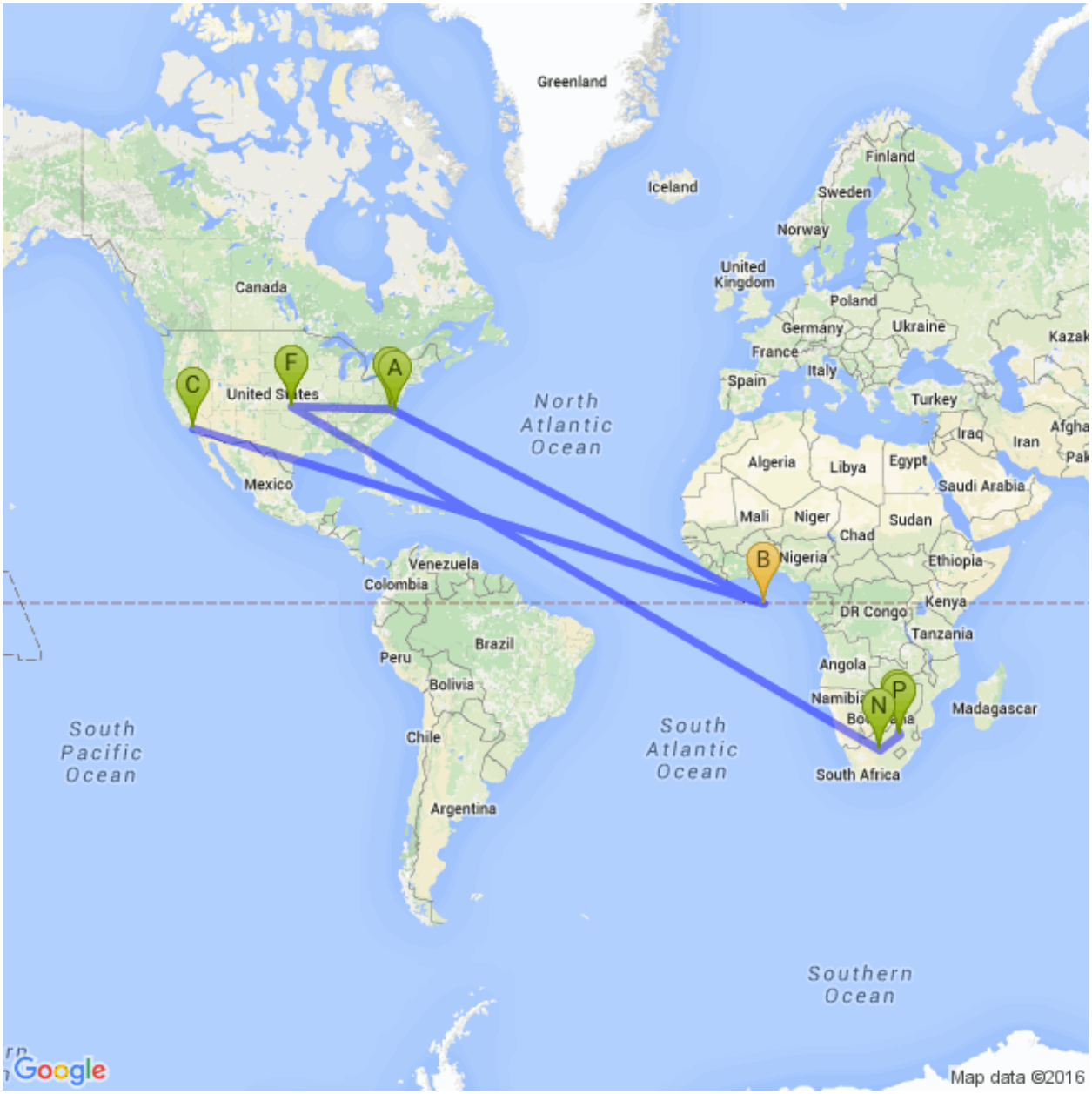

Figure 28: Geographic route from local host to www.nlsa.ac.za. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.15 www.nus.edu.sg

The route to get from localhost to www.nus.edu.sg was discovered (see Table 17). This route can be displayed as a simple bubble diagram (see Figure 29), or as a geographic route (see Figure 30).

Table 17: Route from localhost to www.nus.edu.sg. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.41.120	100.127.41.120	
4	D	172.22.51.96	172.22.51.96	Private IP
5	E	68.1.1.13	langbprj01-ae1.rd.la.cox.net	
6	F	206.223.123.82	Gi5-2.gw1.lax1.asianetcom.net	
7	G	61.14.157.210	te0-1-0-5.gw2.lax3.10026.telstraglobal.net	
8	H	61.14.157.209	te0-3-0-0.wr2.sin0.10026.telstraglobal.net	
9	I	61.14.158.43	gi12-0-0.gw5.sin1.10026.telstraglobal.net	
10	J	202.147.33.178	NUS-0020.GW2.SIN1.10026.telstraglobal.net	
11	K	202.51.240.81	202.51.240.81	
12	L	202.51.241.14	nus-gw1.gigapop.nus.edu.sg	

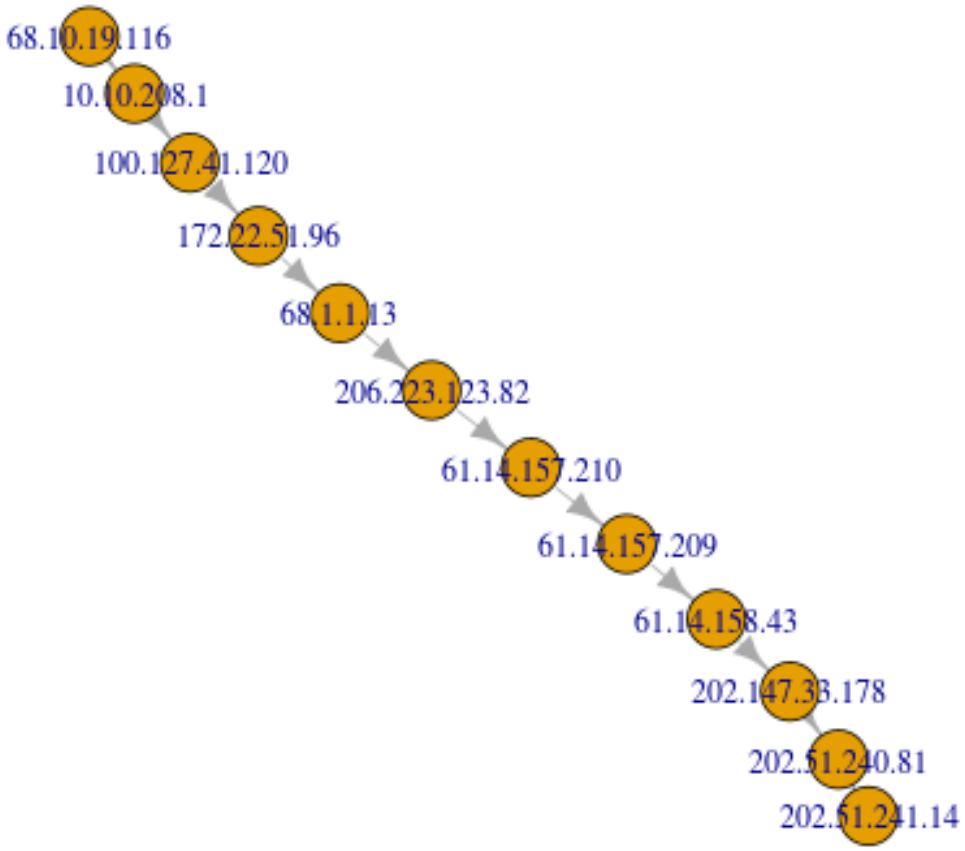

Figure 29: Route from local host to www.nus.edu.sg.

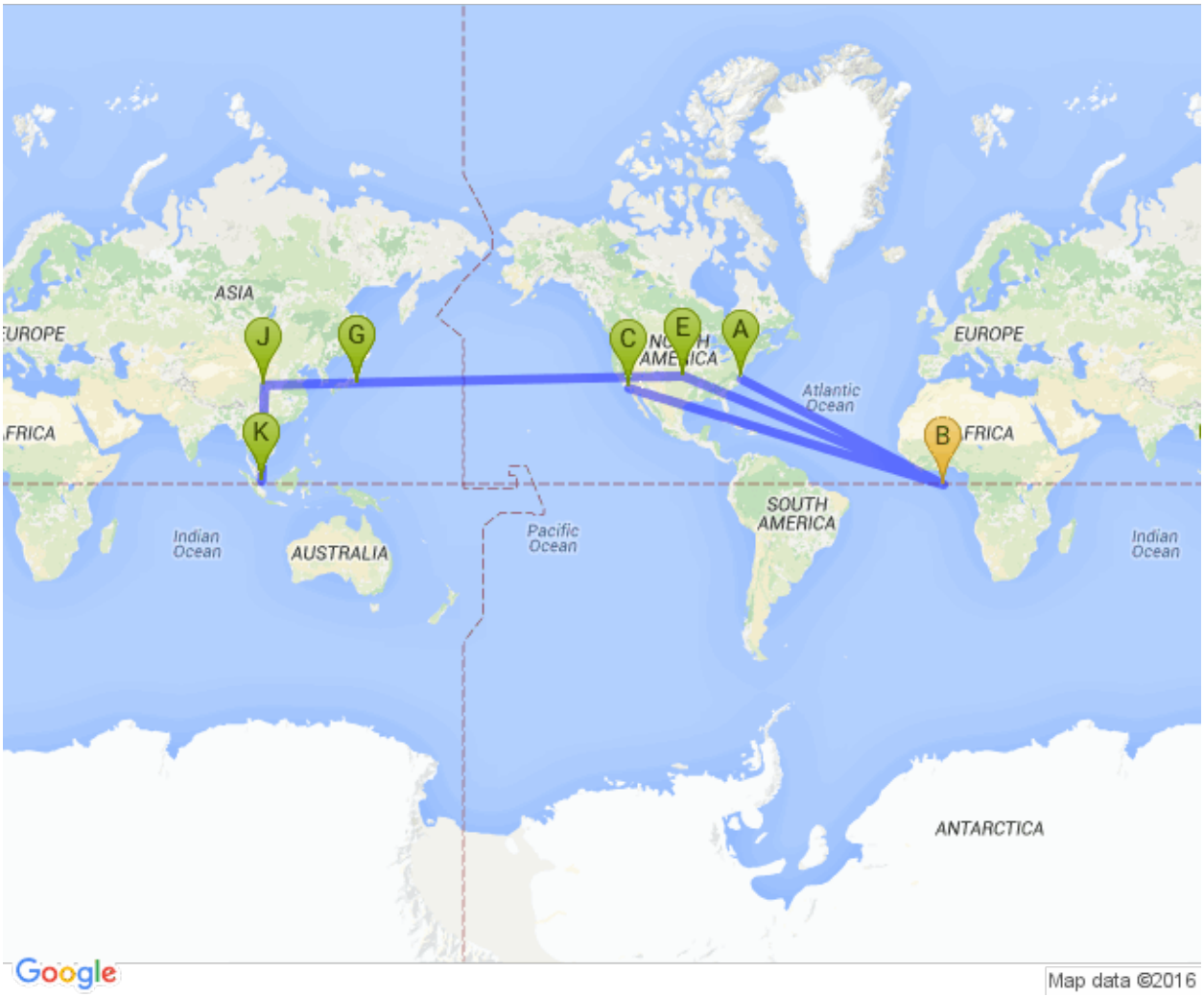

Figure 30: Geographic route from local host to www.nus.edu.sg. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

3.16 www.nytimes.com

The route to get from localhost to www.nytimes.com was discovered (see Table 18). This route can be displayed as a simple bubble diagram (see Figure 31), or as a geographic route (see Figure 32).

Table 18: Route from localhost to www.nytimes.com. Localhost is the first IP in the list. There may be more than one alias for the destination.

Hop		IP Address	Hostname	
1	A	68.10.19.116	68.10.19.116	
2	B	10.10.208.1	10.10.208.1	Private IP
3	C	100.127.40.88	100.127.40.88	
4	D	172.22.51.66	172.22.51.66	Private IP
5	E	68.1.4.139	ashbbprj02-ae2.0.rd.as.cox.net	
6	F	129.250.194.149	ae-26.r06.asbnva02.us.bb.gin.ntt.net	
7	G	165.254.191.118	be-30.r04.asbnva02.us.ce.gin.ntt.net	
8	H	209.200.144.192	unknown.prolexic.com	
9	I	209.200.144.197	unknown.prolexic.com	

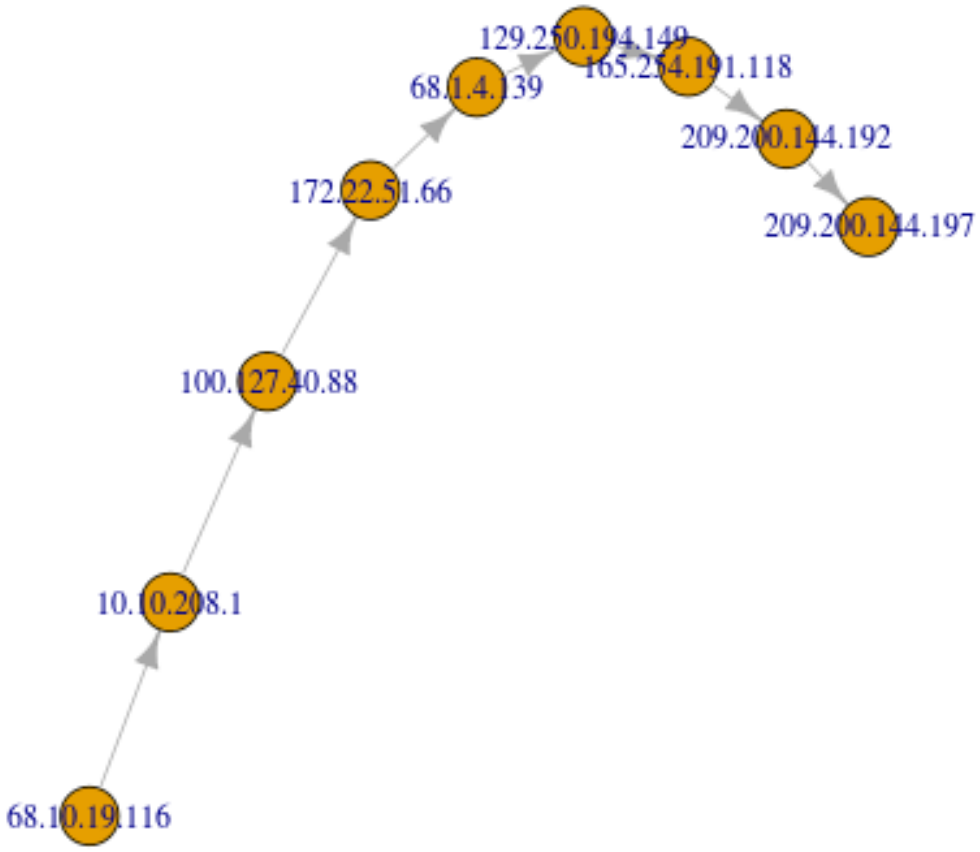

Figure 31: Route from local host to www.nytimes.com.

Figure 32: Geographic route from local host to www.nytimes.com. Public IP address locations are shown in green. Private IP addresses do not have a "known" location, so they are colored yellow and defaulted to 0 latitude and 0 longitude.

4 Conclusion

A number of things can be said about this investigation:

1. The IP route from a localhost to a destination host can involve many intermediaries.
2. The IP packets will traverse both public and private networks when going from localhost to the destination.
3. The IP route changes all the time.
4. IP routing maps do not remain fixed, nor are they guaranteed to be bi-directional.
5. IP routing maps make for interesting graphs (see Figure 33).
6. Displaying anything beyond relatively small graphs makes graphs that are too hard to read and understand.
7. Poking around the Internet can be fun.

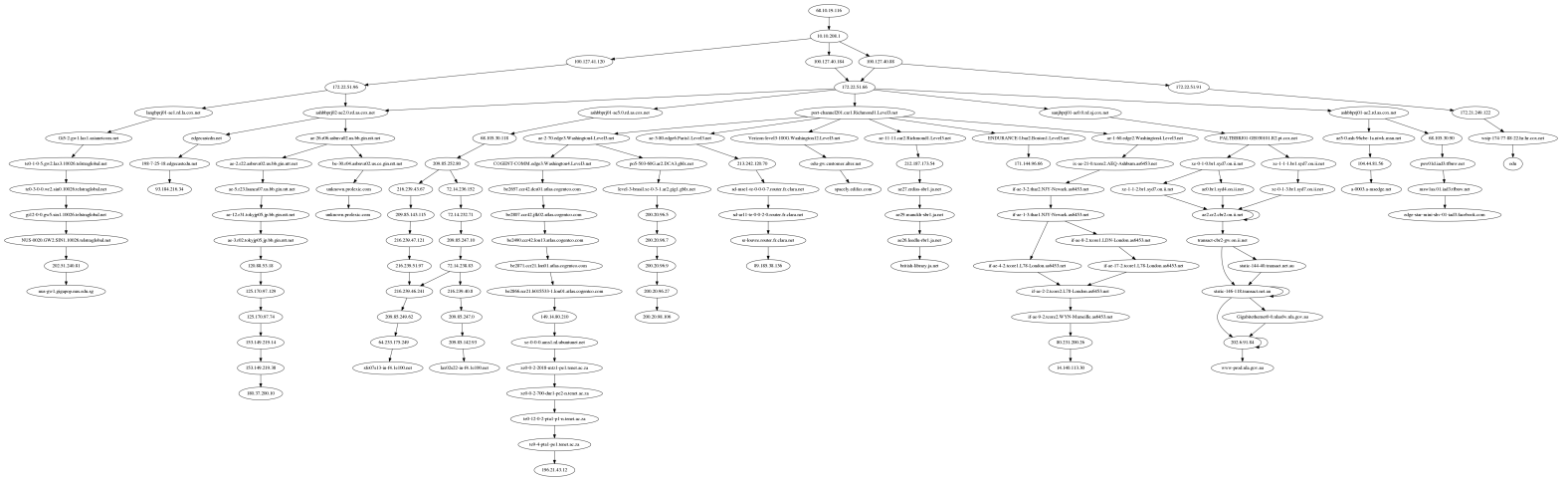

Figure 33: The discovered IP routing map. A link to the full image is provided (see Section A).

A Misc. files

The files used to create all the tables and figures are attached to this report. They are:

1. ipMap.R - an R program that explores and maps the IP path from the current local host to a collection of hosts.
2. overallNetwork.png - the full sized image from the conclusion.

B References

[1] Yakov Rekhter, *Address Allocation for Private Internets*, RFC (1996), no. 1918.

[2] Andrew S Tanenbaum, *Computer networks*, Prentice Hall, 2003.