Studying Transnational Routing Detours

Annie Edmundson, Roya Ensaﬁ, Nick Feamster, Jennifer Rexford
Princeton University
Characterizing and Avoiding Routing Detours

**Characterizing detours**

- Which countries are Internet paths to popular destinations currently traversing?
- Does local traffic leave the country? To where?

**Avoiding detours**

- Can end-users avoid certain countries to popular destinations?
- Can end-users keep more local traffic local?
Current State of Surveillance

Surveillance States
Reactions against Surveillance
Studied Countries
Characterizing and Avoiding Routing Detours

**Characterizing detours**

- Which countries are Internet paths to popular destinations currently traversing?
- Does local traffic leave the country? To where?

The most common destination and transit country among all five countries studied is the United States.

**Avoiding detours**

- Can end-users avoid certain countries to popular destinations?
- Can end-users keep more local traffic local?
Measurement Study: Experiment

1. Connect to VPNs and `curl`

2. Extract 3rd party domains

3. DNS queries

4. Collect DNS responses

5. Traceroute to all IPs

Alexa Top 100 Domains → VPNs → Domains & 3rd Party Domains → RIPE Atlas → Domain: IPs → RIPE Atlas → Traceroutes
### Where are popular domains hosted?

<table>
<thead>
<tr>
<th>Terminating in Country</th>
<th>Brazil</th>
<th>Netherlands</th>
<th>India</th>
<th>Kenya</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>.169</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Canada</td>
<td>.001</td>
<td>.007</td>
<td>.015</td>
<td>.006</td>
<td>-</td>
</tr>
<tr>
<td>United States</td>
<td>.774</td>
<td>.454</td>
<td>.629</td>
<td>.443</td>
<td>.969</td>
</tr>
<tr>
<td>France</td>
<td>.001</td>
<td>.022</td>
<td>.009</td>
<td>.023</td>
<td>.001</td>
</tr>
<tr>
<td>Germany</td>
<td>.002</td>
<td>.013</td>
<td>.014</td>
<td>.028</td>
<td>.001</td>
</tr>
<tr>
<td>Great Britain</td>
<td>-</td>
<td>.019</td>
<td>.021</td>
<td>.032</td>
<td>.002</td>
</tr>
<tr>
<td>Ireland</td>
<td>.016</td>
<td>.064</td>
<td>.027</td>
<td>.108</td>
<td>.001</td>
</tr>
<tr>
<td>Netherlands</td>
<td>.013</td>
<td>.392</td>
<td>.101</td>
<td>.200</td>
<td>.024</td>
</tr>
<tr>
<td>Spain</td>
<td>.001</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kenya</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.022</td>
<td>-</td>
</tr>
<tr>
<td>Mauritius</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.004</td>
<td>-</td>
</tr>
<tr>
<td>South Africa</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.021</td>
<td>-</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.011</td>
<td>-</td>
</tr>
<tr>
<td>India</td>
<td>-</td>
<td>-</td>
<td>.053</td>
<td>.002</td>
<td>-</td>
</tr>
<tr>
<td>Singapore</td>
<td>-</td>
<td>.002</td>
<td>.103</td>
<td>.027</td>
<td>-</td>
</tr>
</tbody>
</table>

77.4% of paths that start in Brazil terminate in the United States.
Which countries are on the path to popular domains?

<table>
<thead>
<tr>
<th>Transiting Country</th>
<th>Brazil</th>
<th>Netherlands</th>
<th>India</th>
<th>Kenya</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Canada</td>
<td>.013</td>
<td>.007</td>
<td>.016</td>
<td>.008</td>
<td>.081</td>
</tr>
<tr>
<td>United States</td>
<td>.844</td>
<td>.583</td>
<td>.715</td>
<td>.616</td>
<td>1.00</td>
</tr>
<tr>
<td>France</td>
<td>.059</td>
<td>.102</td>
<td>.104</td>
<td>.221</td>
<td>.104</td>
</tr>
<tr>
<td>Germany</td>
<td>.005</td>
<td>.050</td>
<td>.032</td>
<td>.048</td>
<td>.008</td>
</tr>
<tr>
<td>Great Britain</td>
<td>.024</td>
<td>.140</td>
<td>.204</td>
<td>.500</td>
<td>.006</td>
</tr>
<tr>
<td>Ireland</td>
<td>.028</td>
<td>.106</td>
<td>.031</td>
<td>.133</td>
<td>.006</td>
</tr>
<tr>
<td>Netherlands</td>
<td>.019</td>
<td>1.00</td>
<td>.121</td>
<td>.253</td>
<td>.031</td>
</tr>
<tr>
<td>Spain</td>
<td>.176</td>
<td>.004</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kenya</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>Mauritius</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.322</td>
<td>-</td>
</tr>
<tr>
<td>South Africa</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.334</td>
<td>-</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.152</td>
<td>-</td>
</tr>
<tr>
<td>India</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>.058</td>
<td>-</td>
</tr>
<tr>
<td>Singapore</td>
<td>-</td>
<td>.002</td>
<td>.270</td>
<td>.040</td>
<td>.003</td>
</tr>
</tbody>
</table>
Characterizing and Avoiding Routing Detours

Characterizing detours

• Which countries are Internet paths to popular destinations currently traversing?
• Does local traffic leave the country? To where?

Despite having large IXPs, Brazil and Netherlands paths often trombones to the United States.

Avoiding detours

• Can end-users avoid certain countries to popular destinations?
• Can end-users keep more local traffic local?
Netherlands: Where is local traffic going?

Fraction of Paths

- United States
- Great Britain
- France
- Sweden
- Germany
- Italy
- Austria
- Spain
- Norway
- Switzerland
- Ireland

“Five Eyes”
Brazil: Where is local traffic going?

Brazil begins laying its own Internet cables to avoid U.S. surveillance

Brazil looks to break from US-centric Internet

Brazil Is Keeping Its Promise to Avoid the U.S. Internet

Fraction of Paths

Great Britain France China Mexico New Zealand Ireland
Kenya: Where is local traffic going?

“Five Eyes”
Characterizing Routing Detours: Summary

• Routing detours often transit surveillance states – especially the United States

• Local traffic doesn’t always stay local

• Is it possible to avoid certain countries by tunneling traffic through relays?
Characterizing and Avoiding Routing Detours

Characterizing detours

• Which countries are Internet paths to popular destinations currently traversing?
• Does local traffic leave the country? To where?

Avoiding detours

• Can end-users avoid certain countries to popular destinations?
• Can end-users keep more local traffic local?

Yes, but it’s more difficult to avoid the United States than it is to avoid any other country.
Country Avoidance

- \textit{Country Avoidance} = fraction of paths that do not pass through Country X
Avoidance Study: Experiment

Client to Relay Path:
1. Connect to VPNs
2. Traceroute to relay IPs

Relay to Server Path:
1. ssh to relays
2. Traceroute to all IPs
Can clients avoid countries more often?

Yes – many countries are almost completely avoidable for the top 100 domains

<table>
<thead>
<tr>
<th>Country to Avoid</th>
<th>Brazil</th>
<th>Netherlands</th>
<th>India</th>
<th>Kenya</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Canada</td>
<td>.98</td>
<td>.99</td>
<td>.98</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>United States</td>
<td>.15</td>
<td>.41</td>
<td>.28</td>
<td>.38</td>
<td>.40</td>
</tr>
</tbody>
</table>
Characterizing and Avoiding Routing Detours

**Characterizing detours**

- Which countries are Internet paths to popular destinations currently traversing?
- Does local traffic leave the country? To where?

**Avoiding detours**

- Can end-users avoid certain countries to popular destinations?
- Can end-users keep more local traffic local?

Tromboning Brazilian paths decreased from 13.2% to 9.7%.
Avoiding Routing Detours: Summary

- It is more difficult to avoid the United States than it is to avoid any other country.

- Tromboning Brazilian paths decreased from 13.2% to 9.7%.
Future Work

• Connectivity within a country

• Relationship between IXPs and nation state routing

• Country avoidance based on IPv4 vs. IPv6 connectivity
Conclusion

• Paths commonly traverse known surveillance states – 84% of paths from Brazil traverse the United States

• Relays can help prevent routing detours, but some of the more prominent surveillance states are the least avoidable

• Tromboning Brazilian paths decreased from 13.2% to 9.7% with relays.

Full write-up and more data at: ransom.cs.princeton.edu
Relays as Proxies

- Relays act as proxies
- Modify Proxy Auto-Configuration (PAC) file

```javascript
function FindProxyForURL(url, host) {
    if (dnsDomainIs(host, "www.google.com") ) {
        return "PROXY 4.5.6.7:8080";
    } else if (dnsDomainIs(host, "www.youtube.com") ) {
        return "PROXY 4.5.6.7:8080";
    } else if (dnsDomainIs(host, "www.twitter.com") ) {
        return "PROXY 7.8.9.10:8080";
    } else if (dnsDomainIs(host, "aws") ) {
        return "PROXY 1.2.3.4:8080";
    } else {
        return "DIRECT";
    }
}
```