A Framework for Provable Avoidance

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Consider this traceroute

```
trace from 5a0-us.dpx to 202.28.17.129 TH 500
 1 216.66.49.85        0.8         US                                    e0-29.switch1.atl1.he.net US-1ms
 2 *
 3 *
 4 *
 5 184.104.197.110  45.4          US                              port-channel4.core3.lax2.he.net US-1ms
 6 184.105.64.126   182.8         HK                                100ge0-62.core2.hkg1.he.net HK-1ms
 7 65.49.108.78     183.1 cisco   HK cat-telecom-public-company-ltd.10gigabitethernet7-2.core1.hkg1.he.net HK-1ms
 8 61.19.9.229      244.4 cisco                                                       SG-31ms
 9 61.19.7.206      241.5 cisco                                                       TH-5ms
10 122.155.225.6    241.9 cisco                                                       TH-4ms
11 *
12 202.28.213.222   243.1 cisco                                                       TH-5ms
13 *
```
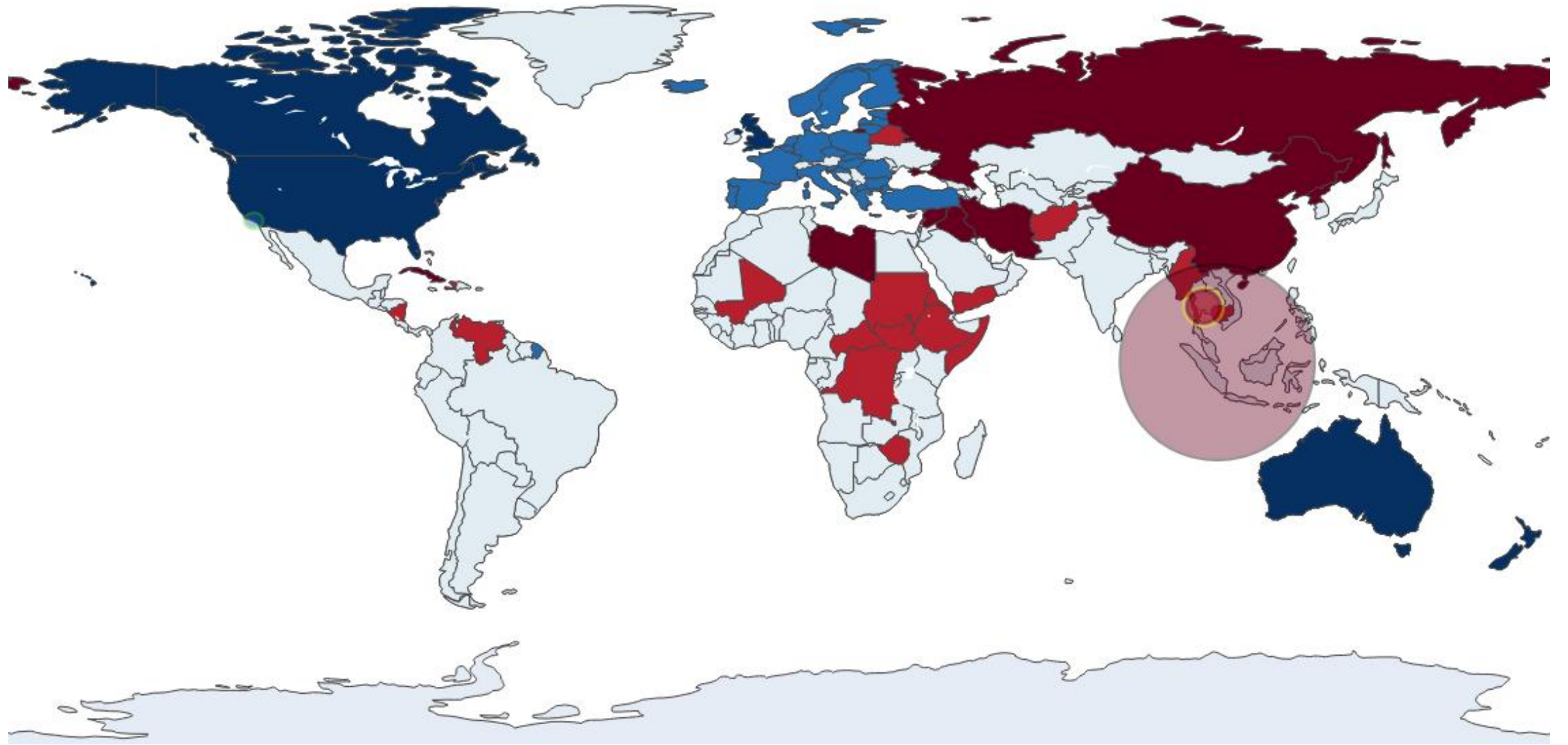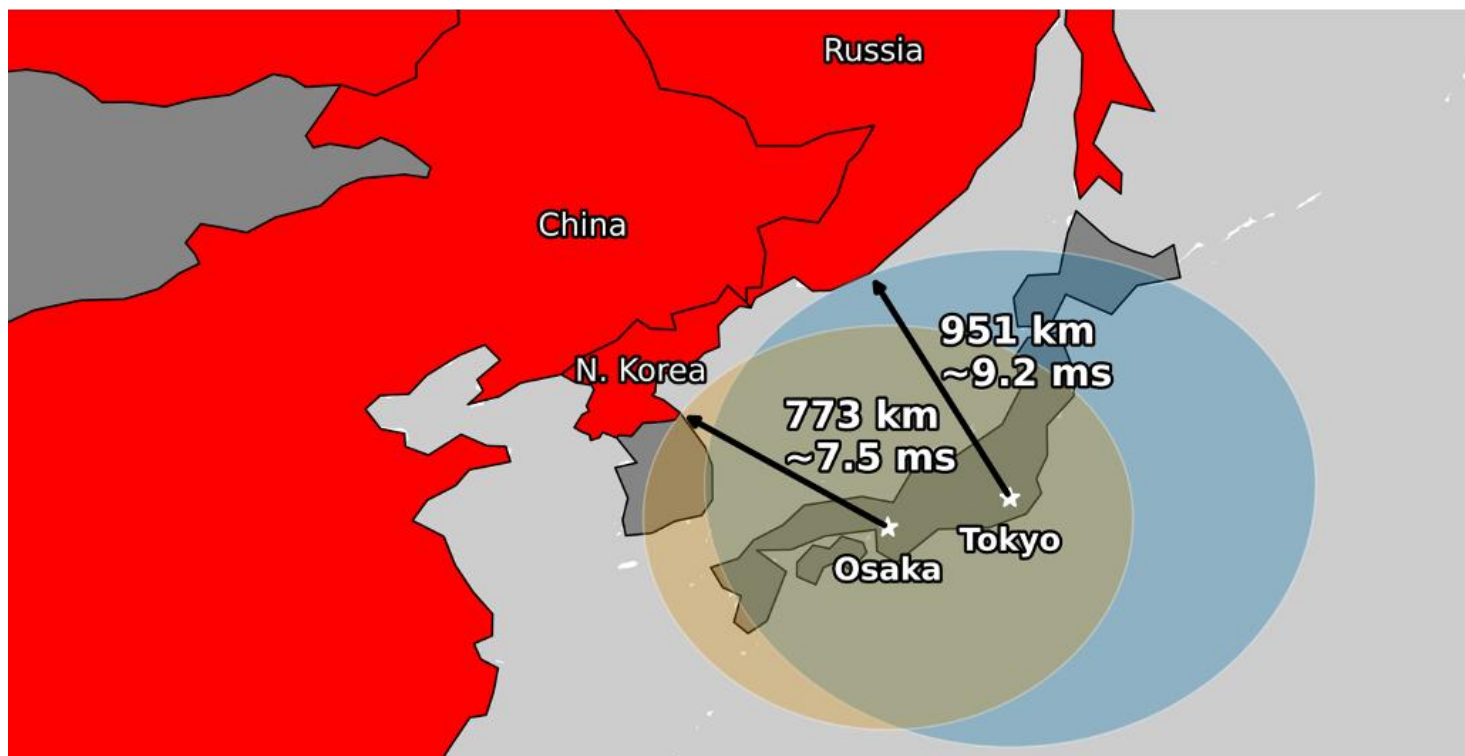
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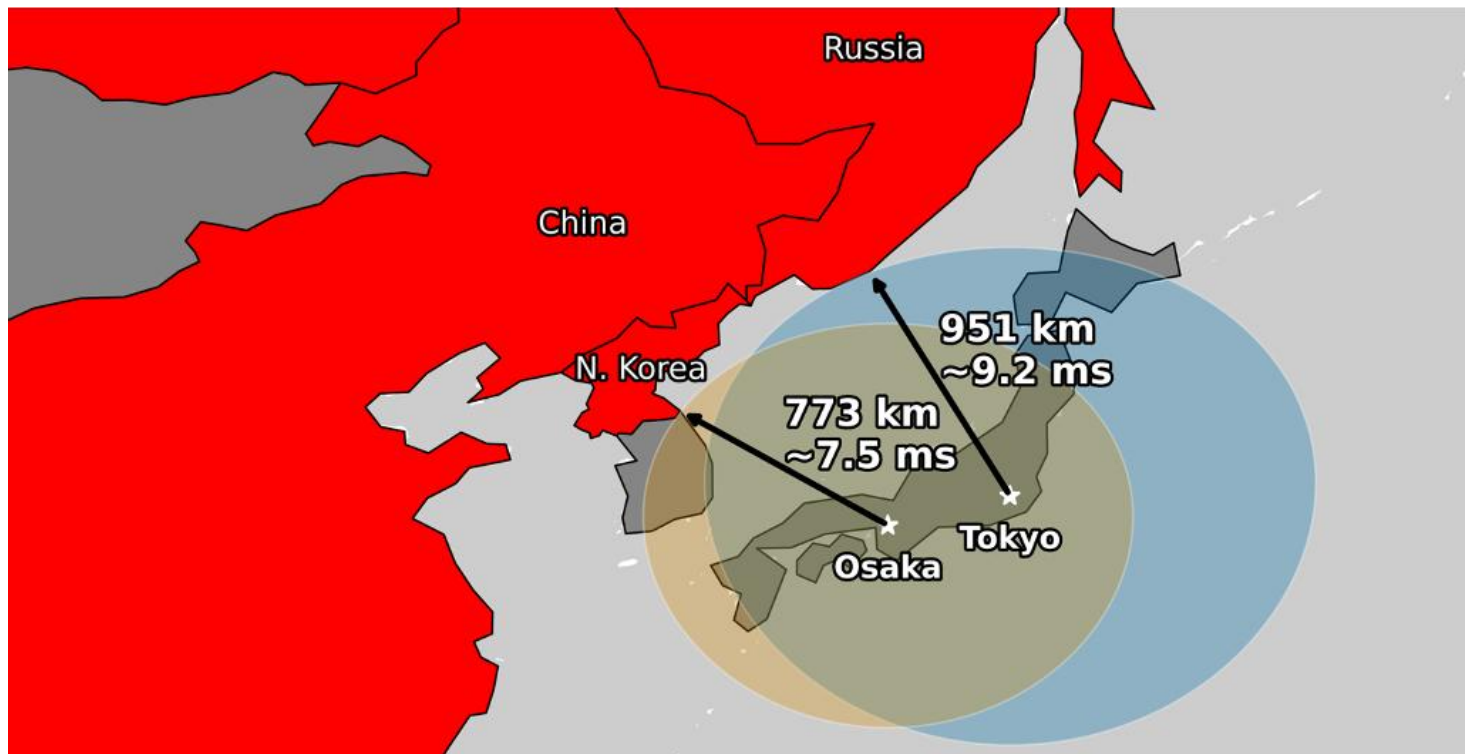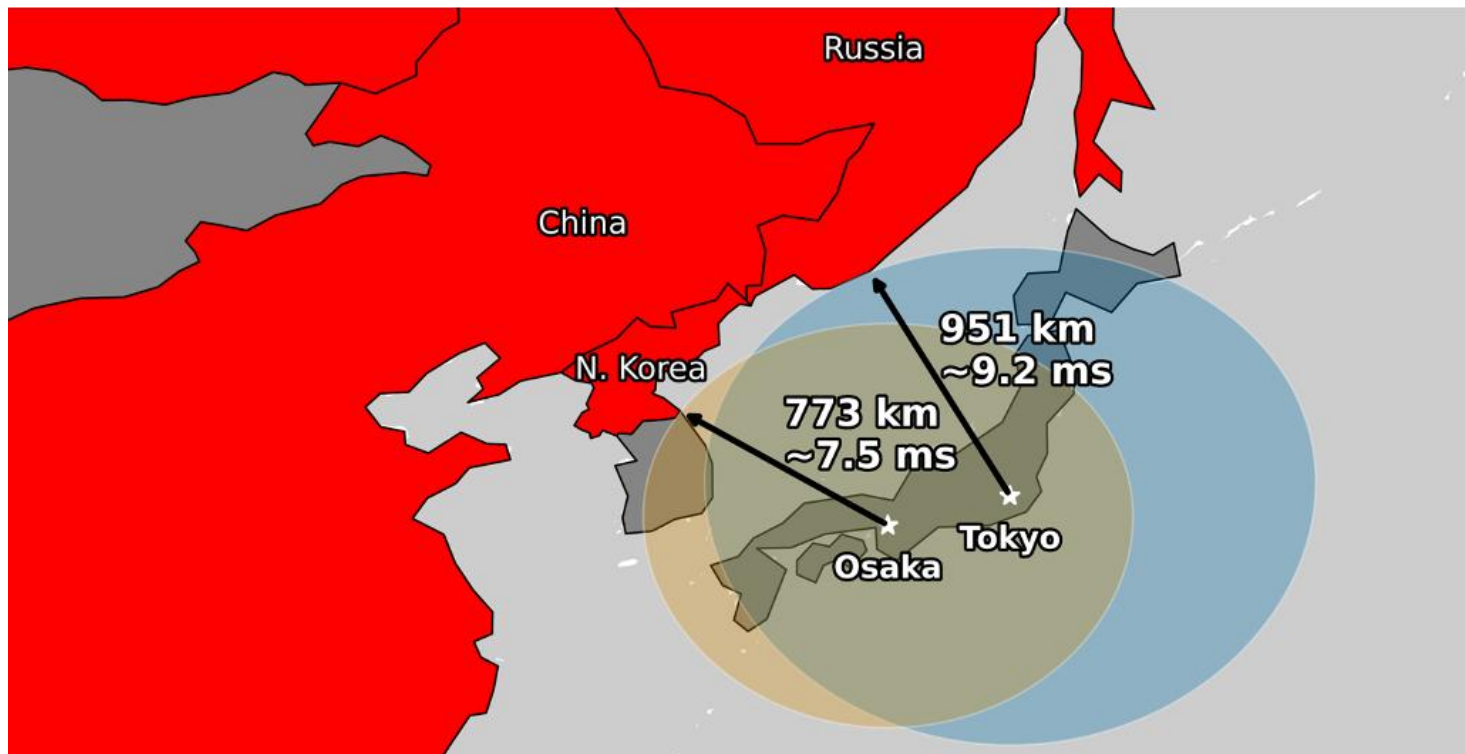
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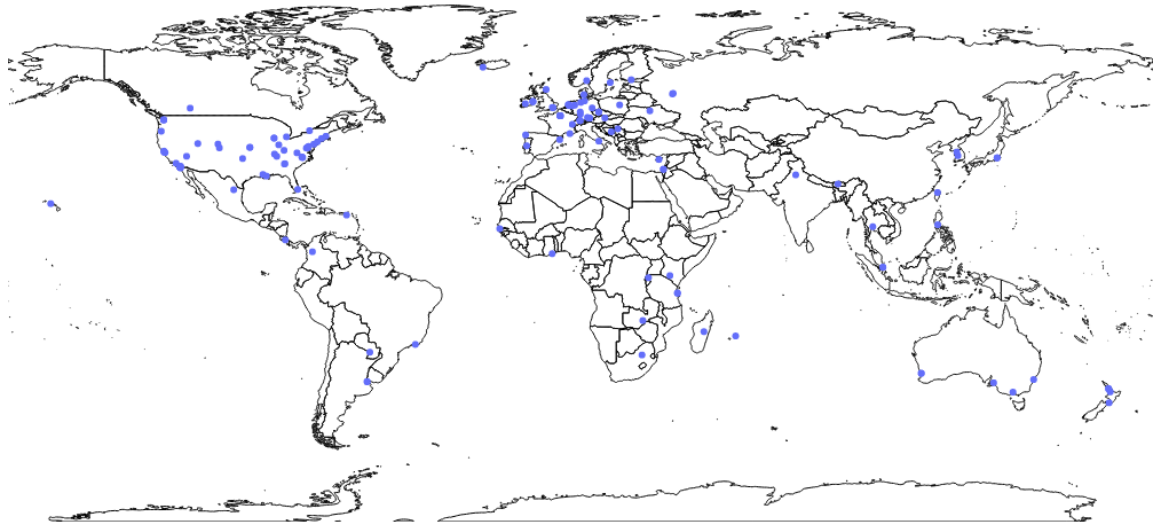
- Determine which countries a router cannot be in

Negative Geolocation

- Use RTT from known vantage points to prove where a router *cannot* be

- Determine which countries a router cannot be in

- Only consider paths not starting or ending in a country

Data

- CAIDA ITDK (Feb 2024)
  - Traceroutes over two weeks
  - RTT measurements
  - Hoiho geolocation
  - AS2Org

- Additional geolocation for destination from the MaxMind GeoLite Country database

- Natural Earth data for country borders

Limited by MPLS

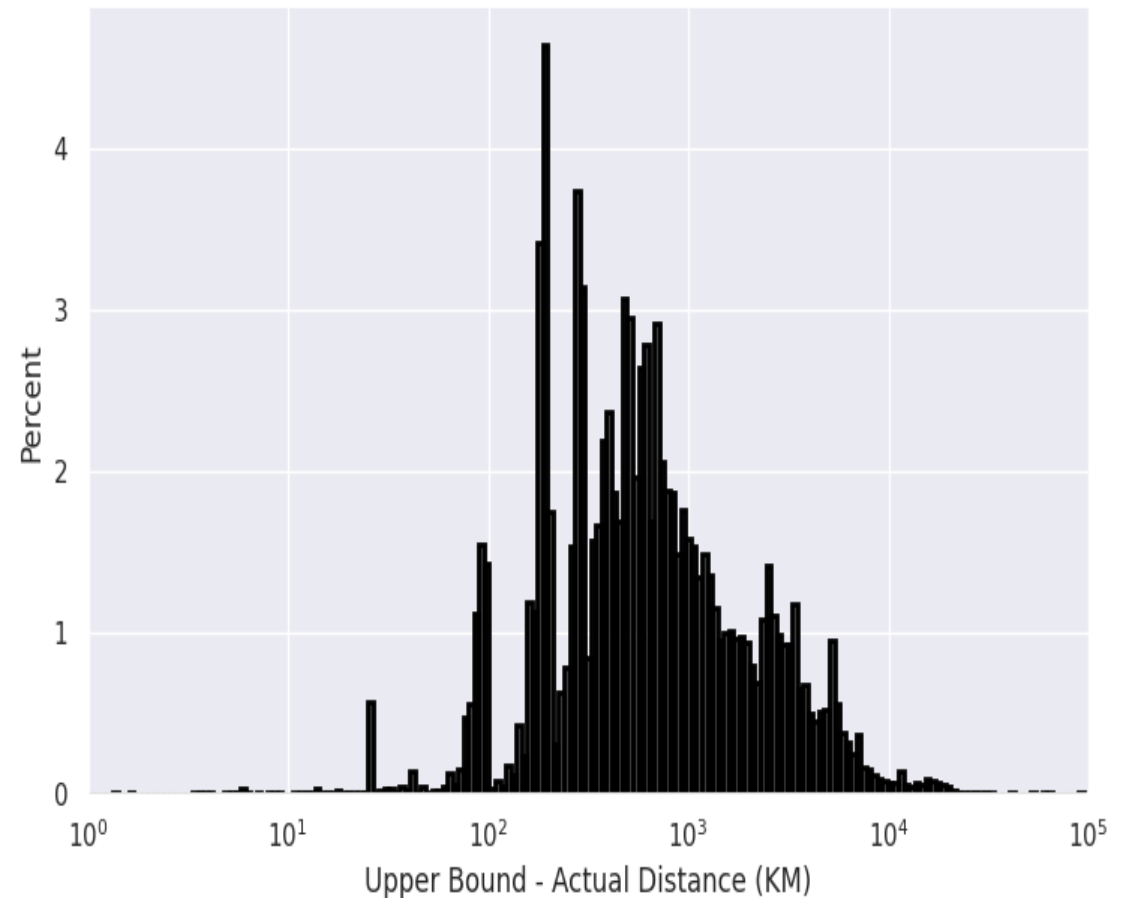- MPLS tunnels may hide routers

Limited by MPLS, Vantage Points

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- Distribution of vantage points creates bias
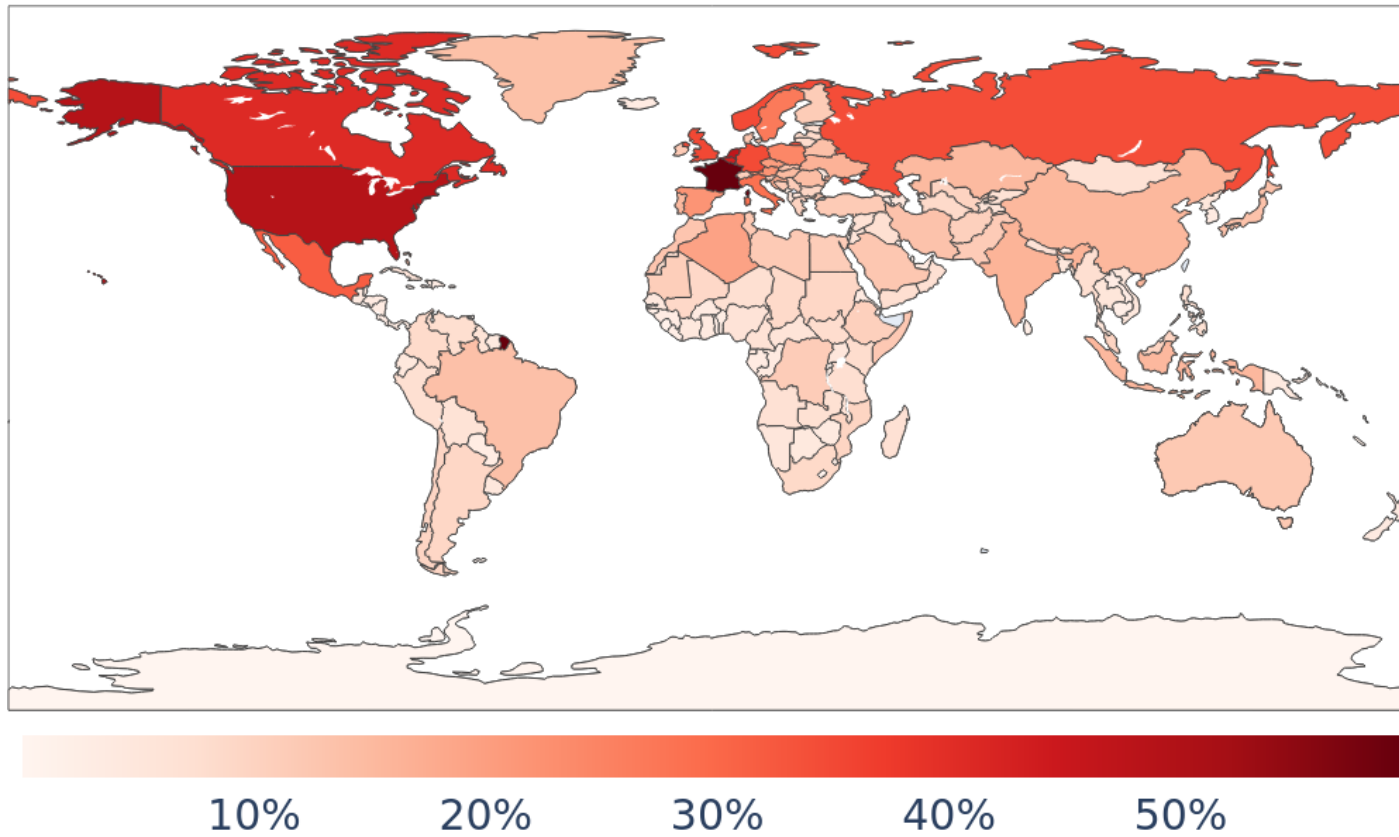
Limited by MPLS, Vantage Points, & RTTs

- MPLS tunnels may hide routers

- Distribution of vantage points creates bias

- High RTT measurements weaken estimates

The US and Europe are hardest to avoid

A map of how many paths do not provably avoid a country

Censorship states are easier to avoid

Rank*	Country
1	China
2	Myanmar
3	Iran
4	Cuba
5	Russia

*As reported by Freedom House's internet freedom scores

Censorship states are easier to avoid

Rank*	Country	Paths Excluded
1	China	9.84%
2	Myanmar	0.01%
3	Iran	0.35%
4	Cuba	0.01%
5	Russia	2.79%

*As reported by Freedom House's internet censorship scores

Censorship states are easier to avoid

Rank*	Country	Paths Excluded	% Provably Avoiding this Country
1	China	9.84%	80.12%
2	Myanmar	0.01%	92.42%
3	Iran	0.35%	86.49%
4	Cuba	0.01%	94.46%
5	Russia	2.79%	65.47%

*As reported by Freedom House's internet censorship scores

Important Geopolitical Coalitions

Name	% Provably Avoiding Coalition
BRICS	54.41%
Five Eyes	19.19%
NATO	11.59%
Russia, China, & Iran	66.16%

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Name	% Provably Avoiding Coalition	Paths Excluded
BRICS	54.41%	20.43%
Five Eyes	19.19%	68.33%
NATO	11.59%	82.59%
Russia, China, & Iran	66.16%	12.84%

ASes contribute little to avoidability
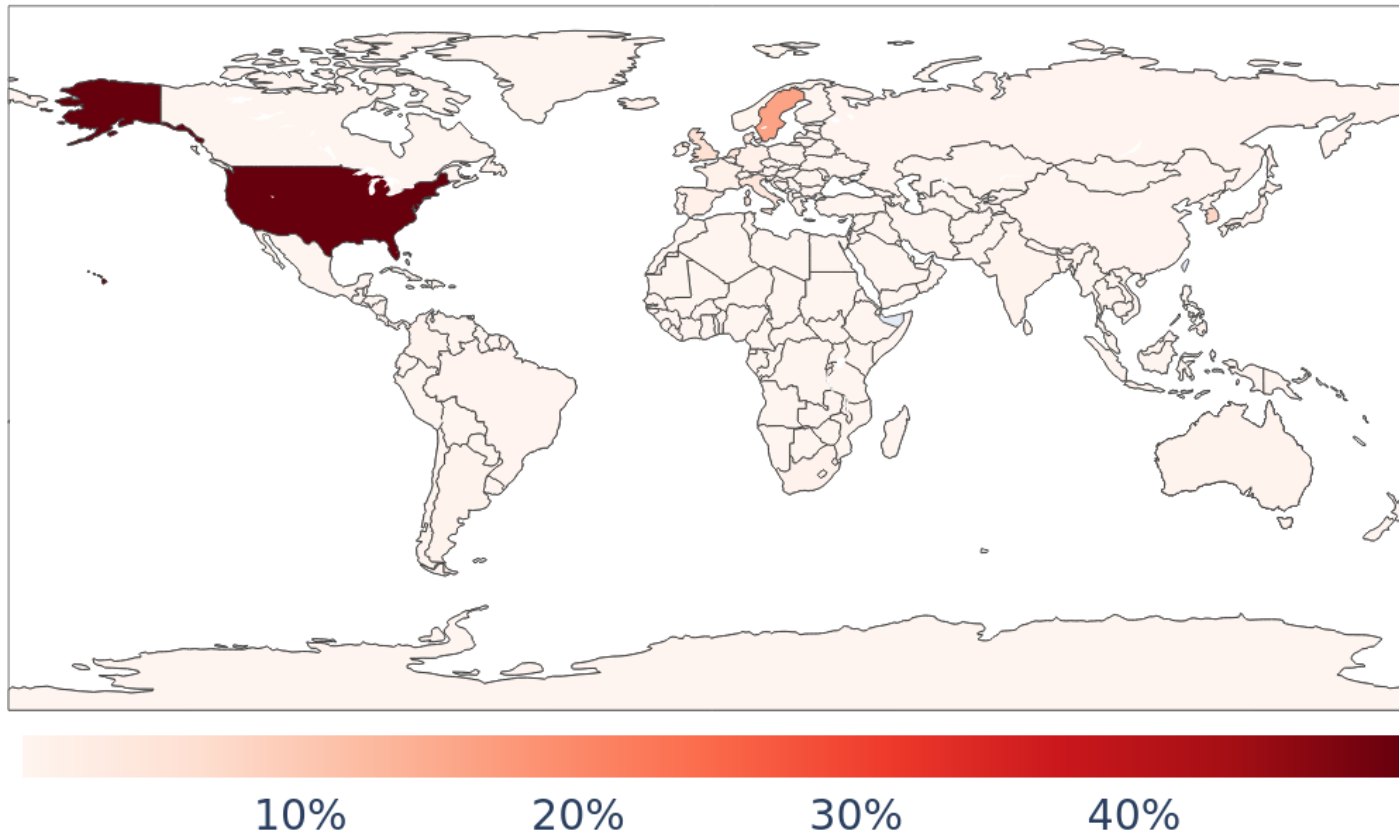
Future Work

- Incorporate techniques to handle MPLS

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- Integrate real time system with an overlay

Conclusions

- The US and Europe are the most difficult regions to provably avoid

- Current censorship countries are slightly easier to avoid

- Coalitions of countries can significantly increase difficulty to avoid
  - With fewer paths to prove this

- Ases do not have a significant influence on most countries