Kirtus G. Leyba,
Benjamin Edwards,
Cynthia Freeman,
Jedidiah R. Crandall, and
Stephanie Forrest

IETF 106 in Singapore

November 19th, 2019

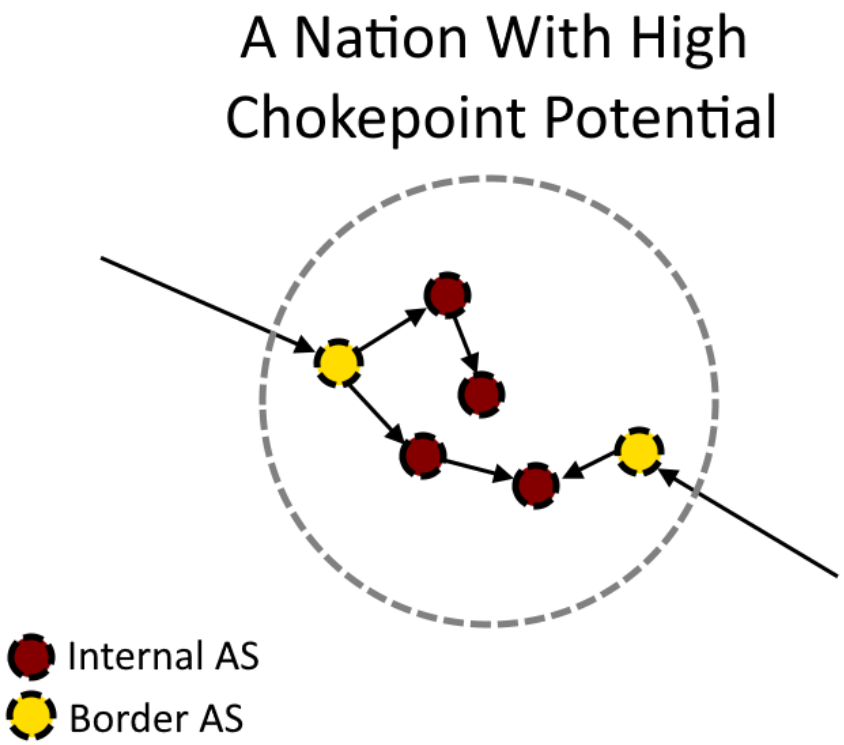
Borders and Gateways: Measuring and Analyzing National AS Chokepoints

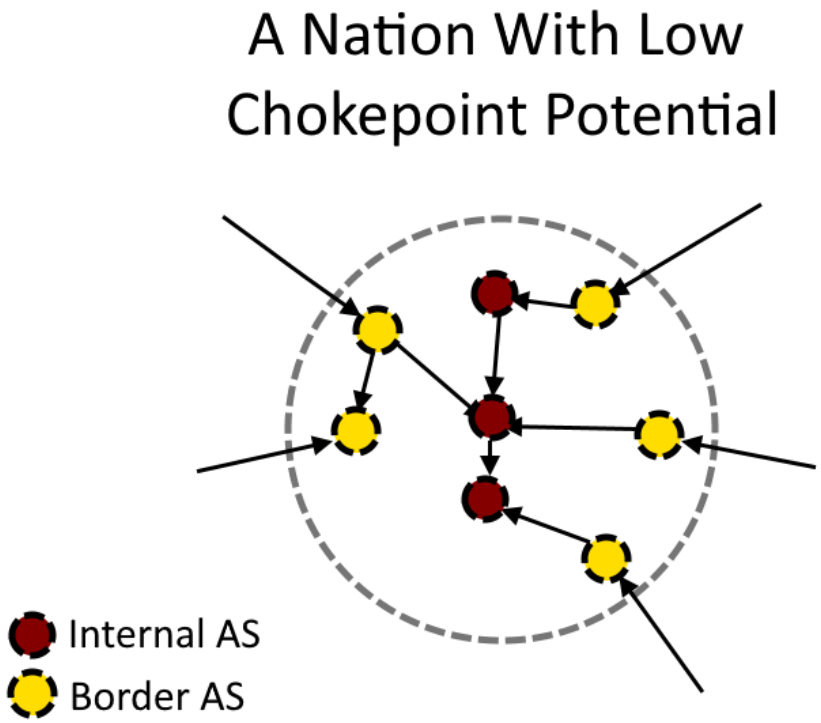
ACM COMPASS 2019

What am I doing in ASU's Biodesign Center for Biocomputation, Security and Society?

(The last time I took a biology class was in high school).

Evolution of what?





https://techtribes.org/cameroon-shuts-down-the-internet-for-240-days/

We Are Our Work Blog Resources LMS Login

Cameroon shuts down the internet for 240 days.

August 29, 2018 Categories

Access Now, 2017

Author: Thijmen Calis

https://www.rferl.org/a/iran-internet-disruptions-election/25028696.html
iran internet slowdown

IRAN

June 26, 2013 12:59 GMT

By Golnaz Esfandiari

Iran Admits Throttling Internet To 'Preserve Calm' During Election

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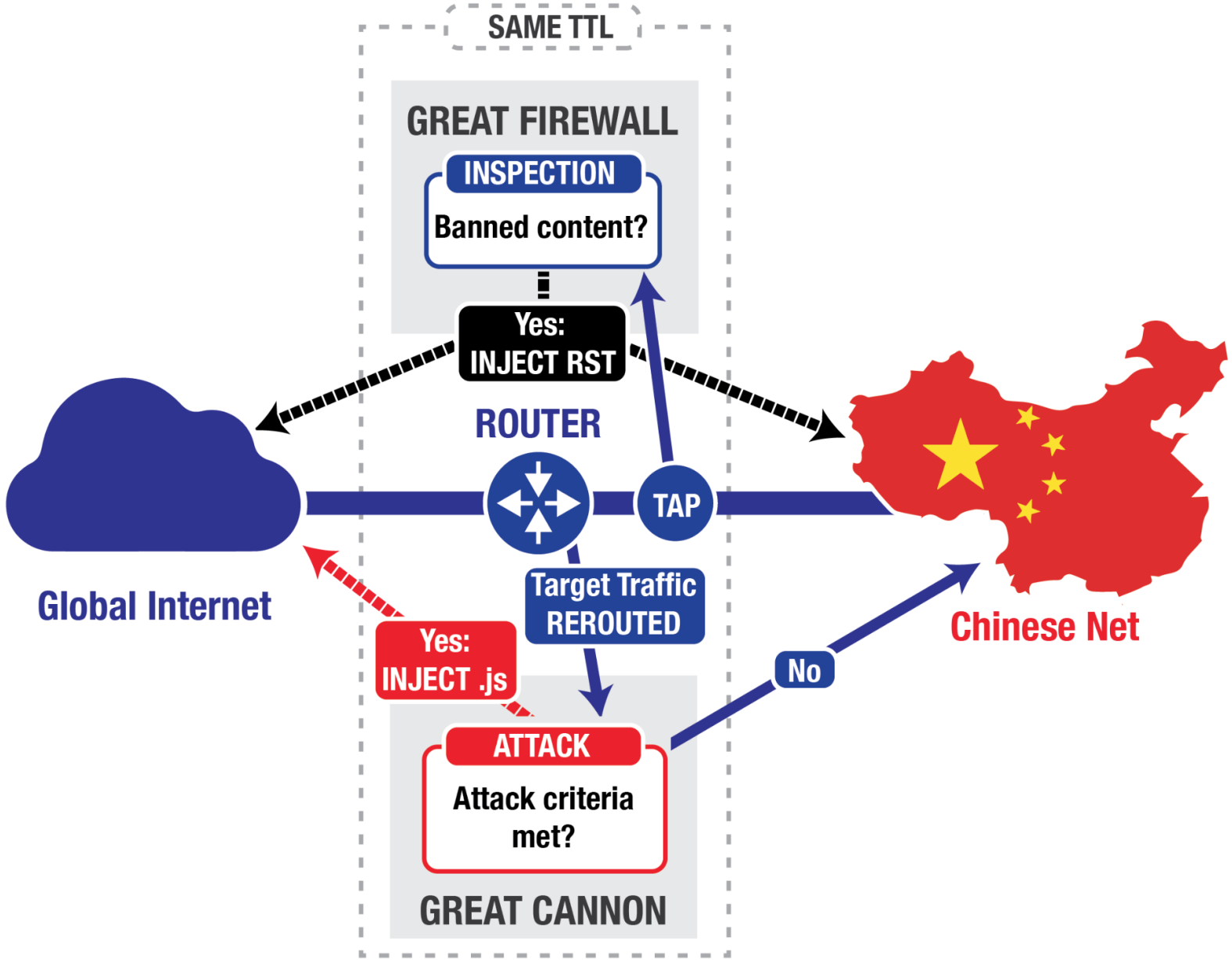

Source: https://citizenlab.ca/2015/04/chinas-great-cannon/

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KIM ZETTER SECURITY 04.22.15 12:40 PM

How to Detect Sneaky NSA 'Quantum Insert' Attacks

BAD TRAFFIC

Sandvine's PacketLogic Devices Used to Deploy Government Spyware in Turkey and Redirect Egyptian Users to Affiliate Ads?

By Bill Marczak, Jakub Dalek, Sarah McKune, Adam Senft, John Scott-Railton, and Ron Deibert

March 9, 2018 أزمة مرورية (Arabic translation), KÖTÜ TRAFİK (Turkish translation)

This report describes our investigation into the apparent use of Sandvine/Procera Networks Deep Packet Inspection (DPI) devices to deliver nation-state malware in Turkey and indirectly into Syria, and to covertly raise money through affiliate ads and cryptocurrency mining in Egypt.

Commanding Heights of the Internet?

Can be, *e.g.*, a company or a physical point of presence.

IP layer censorship is often a prerequisite for higher layer censorship.

Geography and virtualization come into play.

BGP

Could have also considered traceroutes, traceroutes + BGP, physical maps, *etc.*

BGP is a good level of abstraction to capture the salient trends.

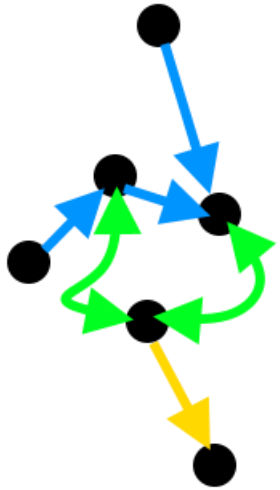
Research Questions

How are Internet borders evolving?

Is there a relationship between Internet freedom and topology?

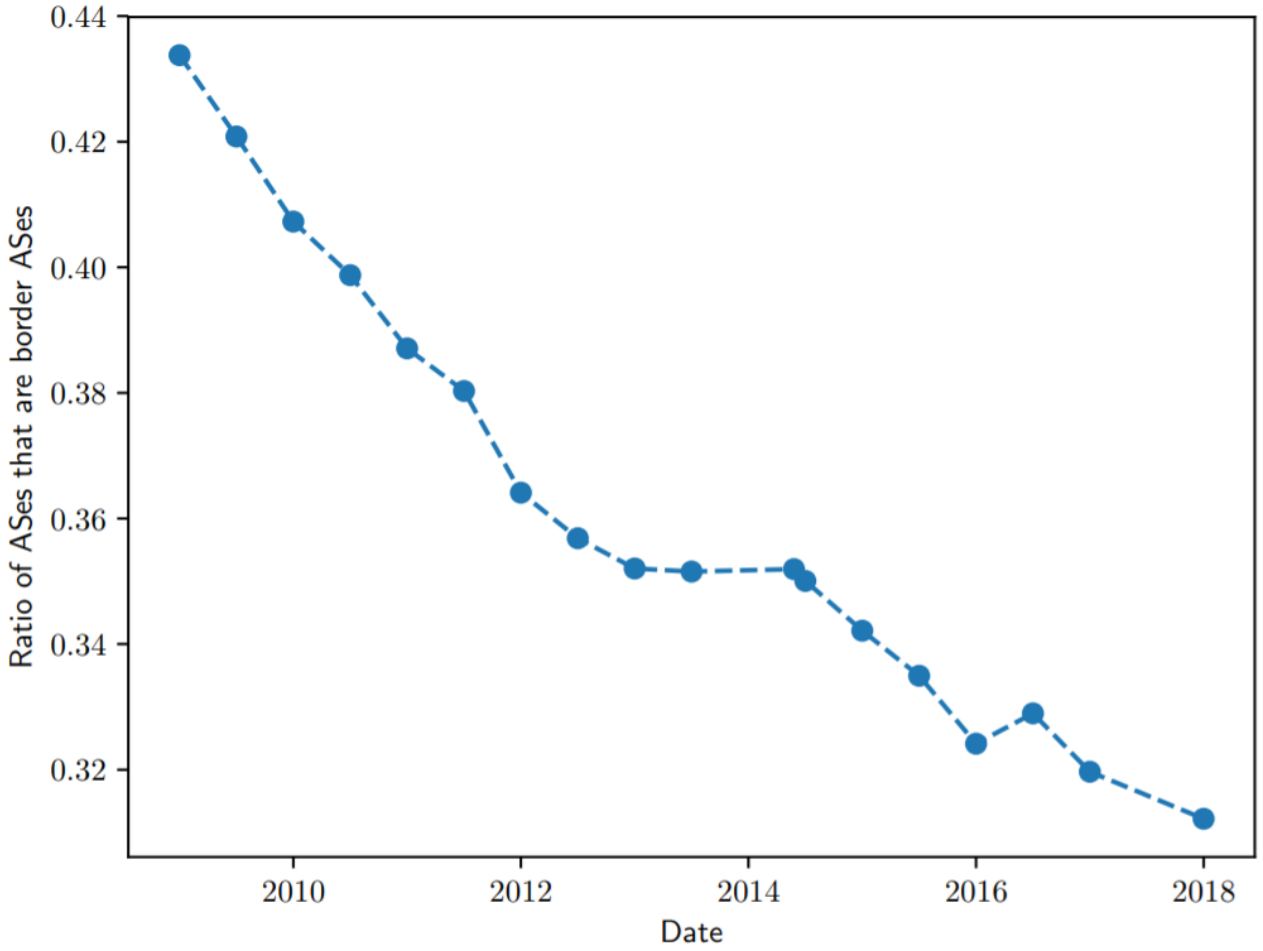
Internet Topology

CAIDA AS Relationship Dataset



- Publicly available inferred AS relationships every month

Team Cymru WHOIS service to determine nation to node mapping



Are Internet Borders becoming stronger?

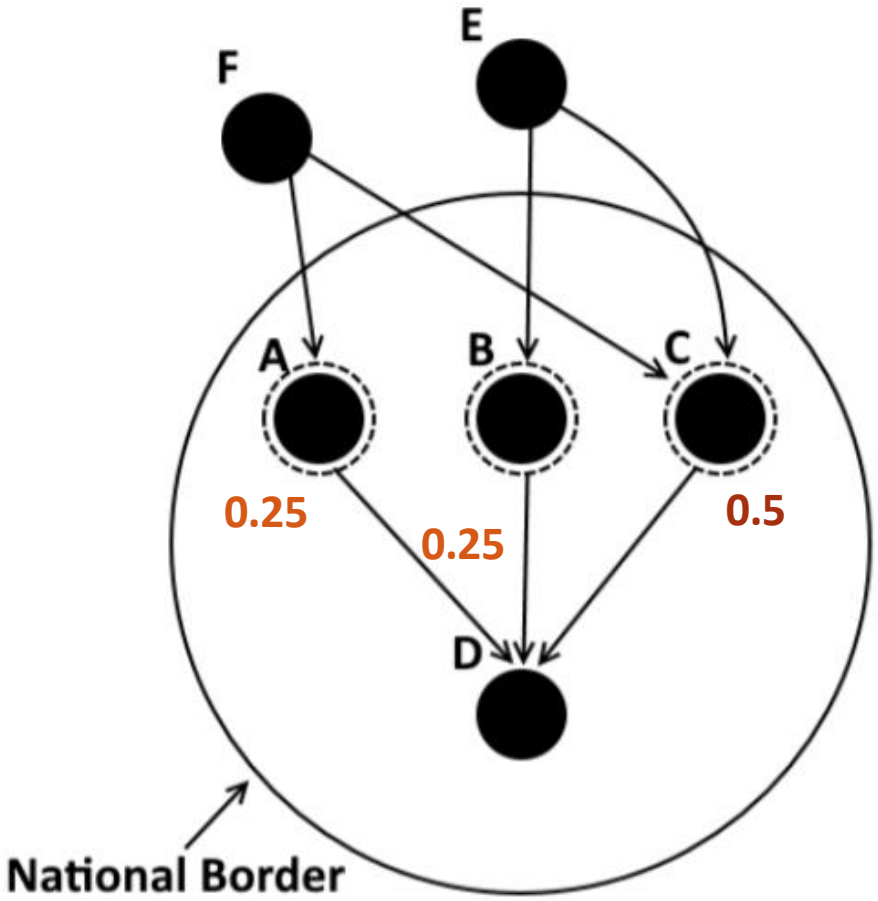
Chokepoint Potential

Chokepoint Potential

- A measure of the ratio of international Internet paths intercepted by a **border AS.**
  - **Border AS:** An AS connected to at least one other AS from a different nation than its own.

$$cp(a) = \frac{|\{p : p \in P \text{ and } a \in p\}|}{|P|}$$

Where P is the set of paths crossing a nation's border.



National Chokepoint Potential

- Aggregate form of chokepoint potential for an entire nation.
- Defined as a function of the number of border ASes required to intercept a percentage f of border crossing paths.

$$CP(c, f) = \frac{1}{j}$$

Where j is the smallest j such that $\sum_{i=1}^{j} cp(a_i) > f$

Results

CNNIC
中国互联网络信息中心
CHINA INTERNET NETWORK INFORMATION CENTER

中国互联网络连接带宽图
Internet Connection Map of China

监制单位：工业和信息化部电信管理局
Supervised by: Telecommunications Administration Bureau, MIIT
数据统计截止日期：2011年12月31日

December 2008

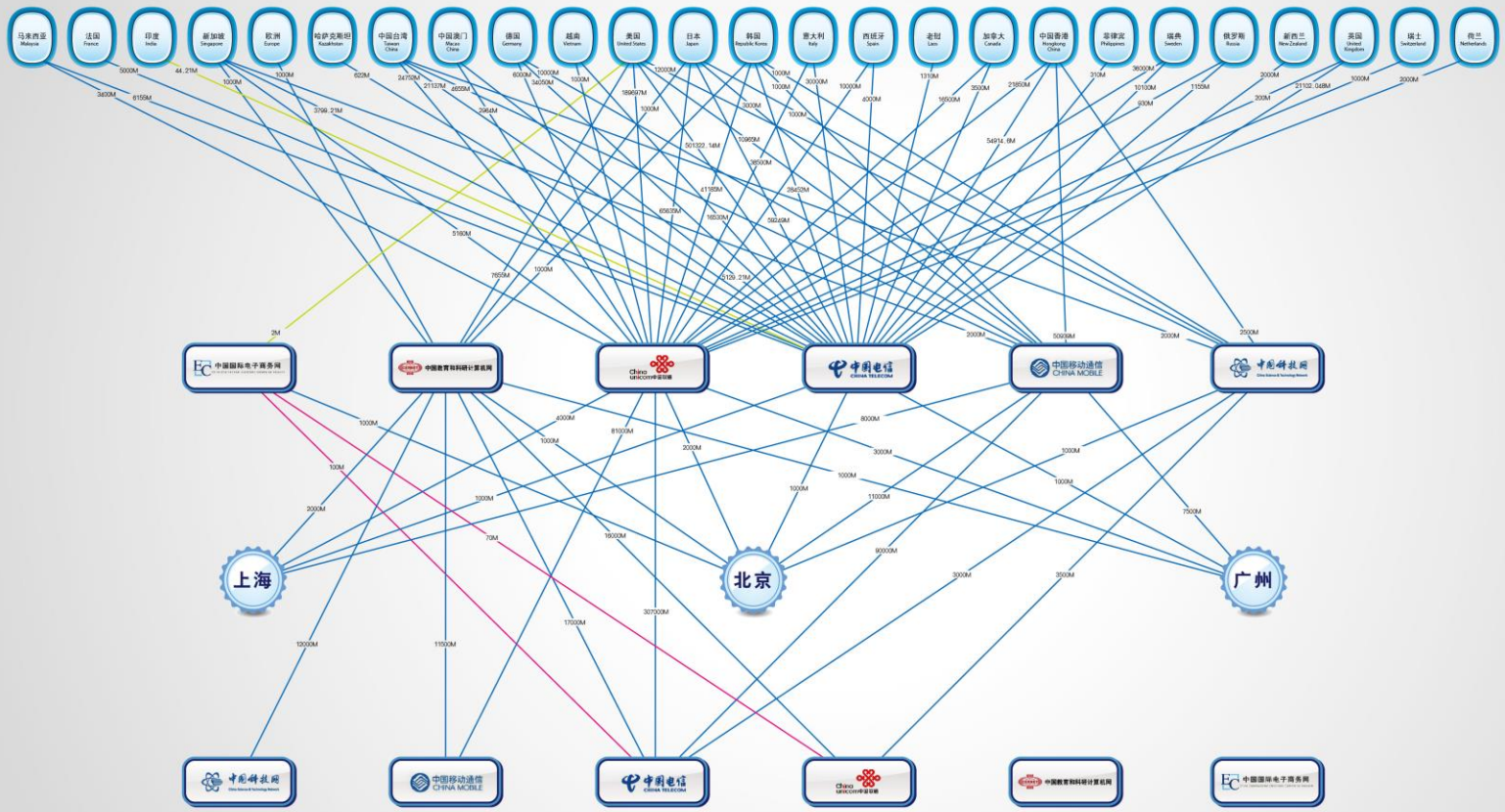


图 例
LEGEND

国家及地区
Country/Region

骨干网运营商
Backbone Network Operator

交换中心
IX

<45M

45M≤X<155M

≥155M

注释：
本服务为中国互联网络信息中心（CNNIC）提供的免费服务。

Note:
The survey service is provided by China Internet Network Information Center (CNNIC), and such service is free of charge.

Tel: 86-10-58813030
E-mail: info-serv@cnnic.cn
Website: WWW.CNNIC.CN

ConceptDoppler: A Weather Tracker for Internet Censorship

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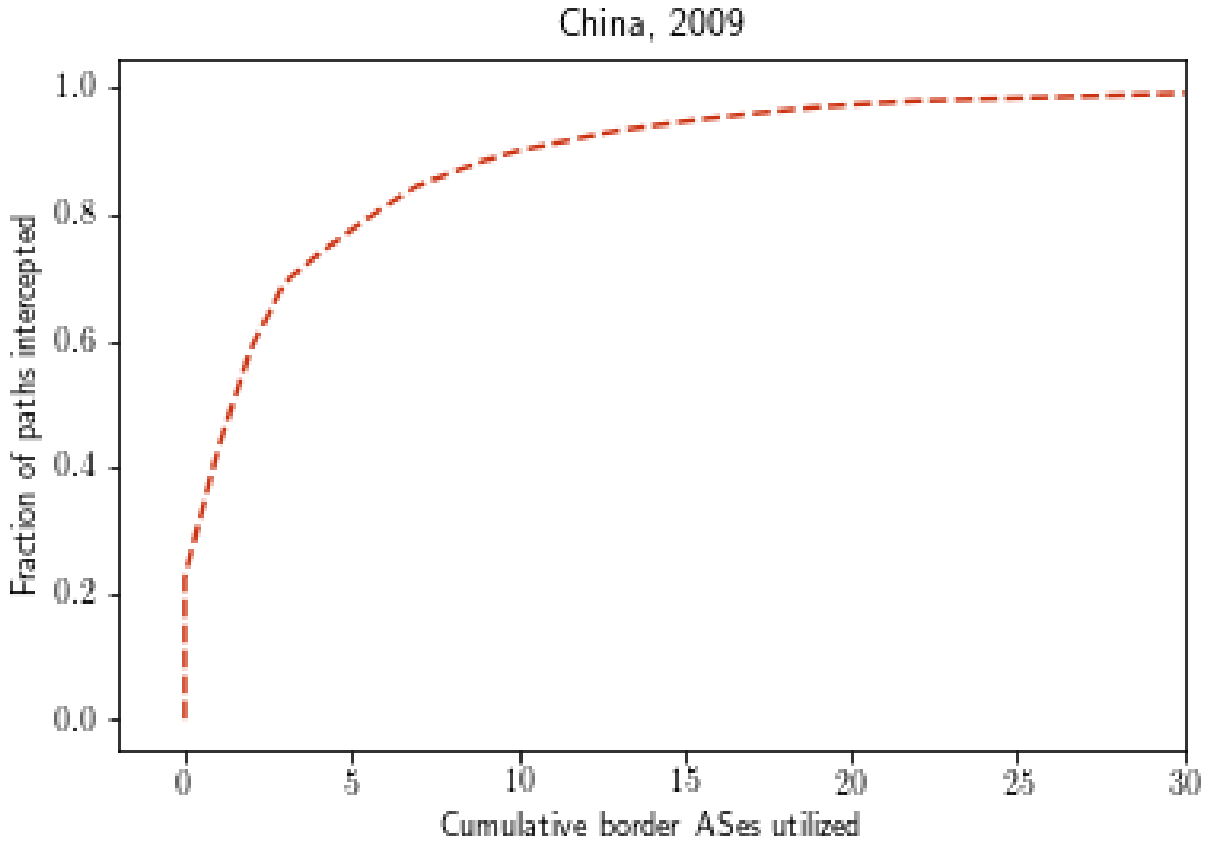
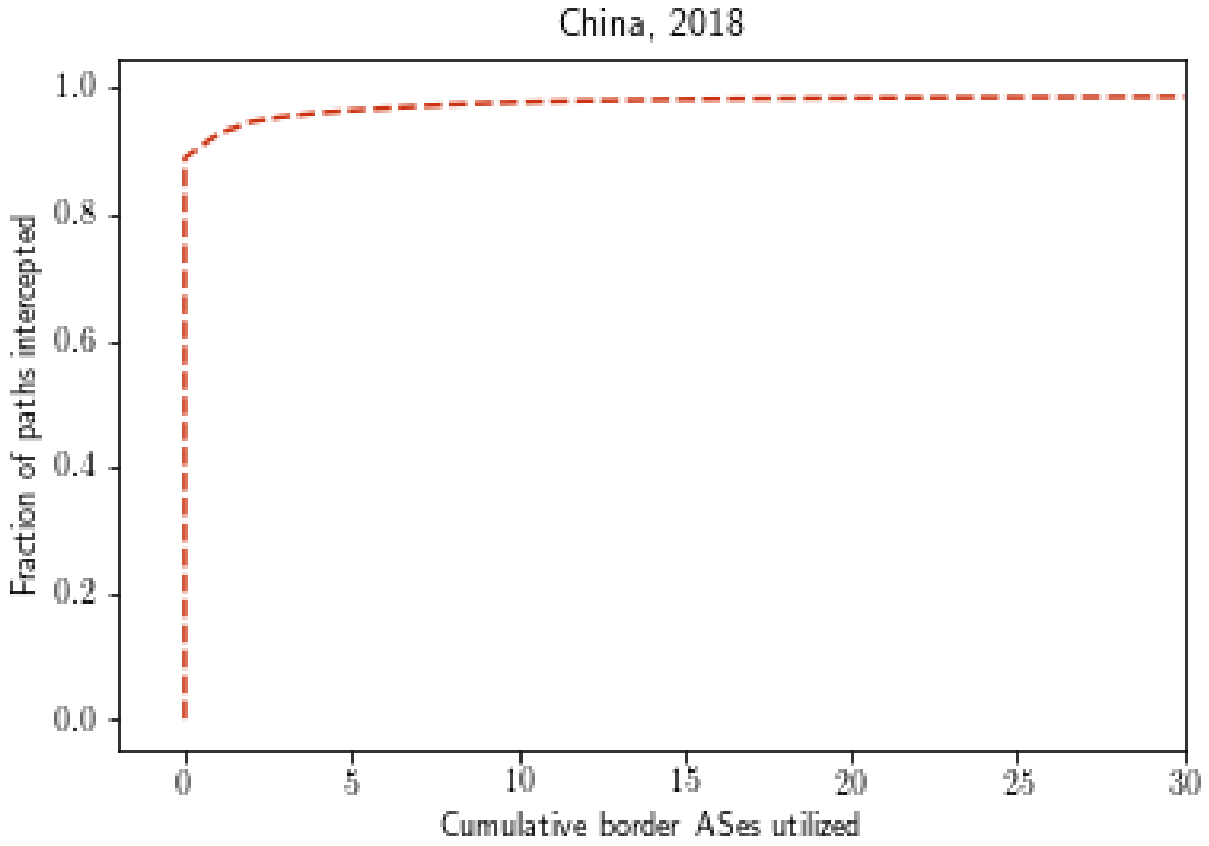
In 2007 we said, "Approximately 28.3% of the Chinese hosts we sent probes to were reachable along paths that were not filtered at all." (More recent studies show these kinds of failures to be more like 1% now.)

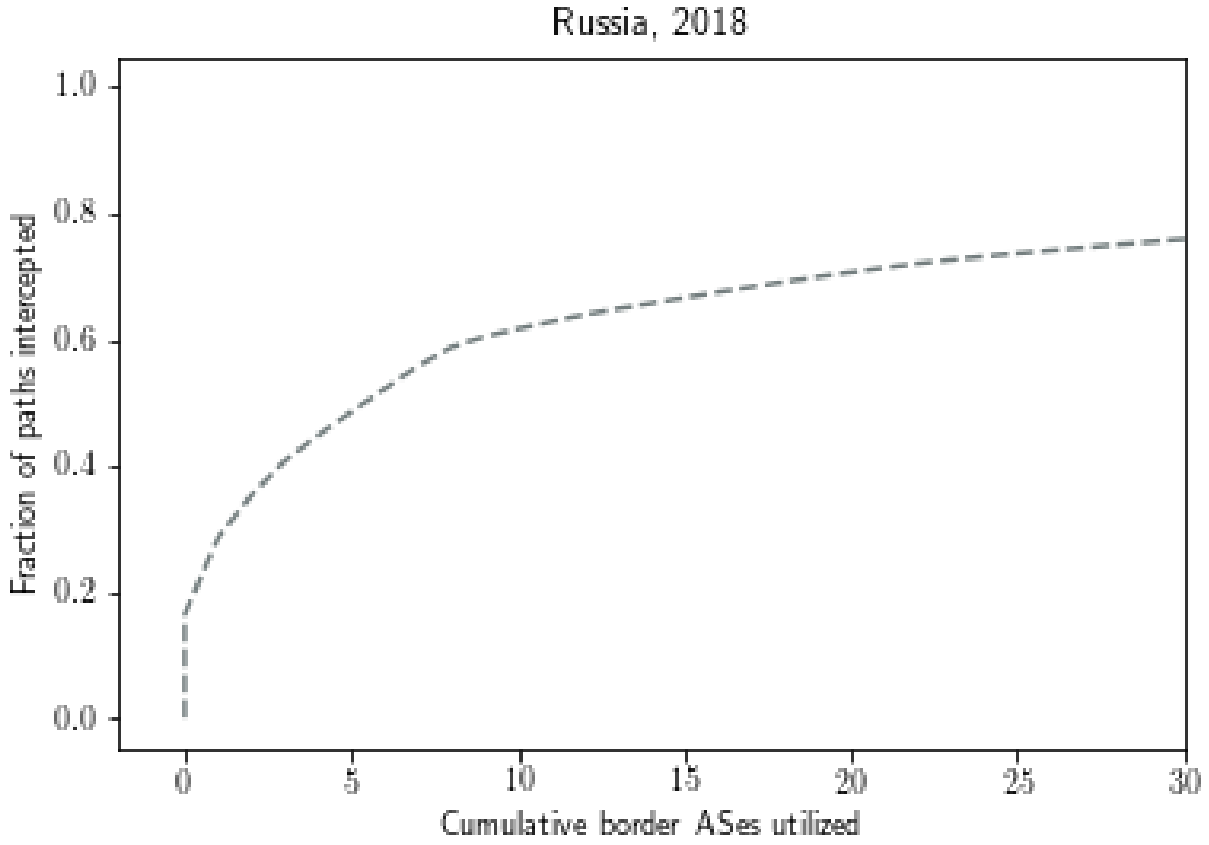
China in 2009



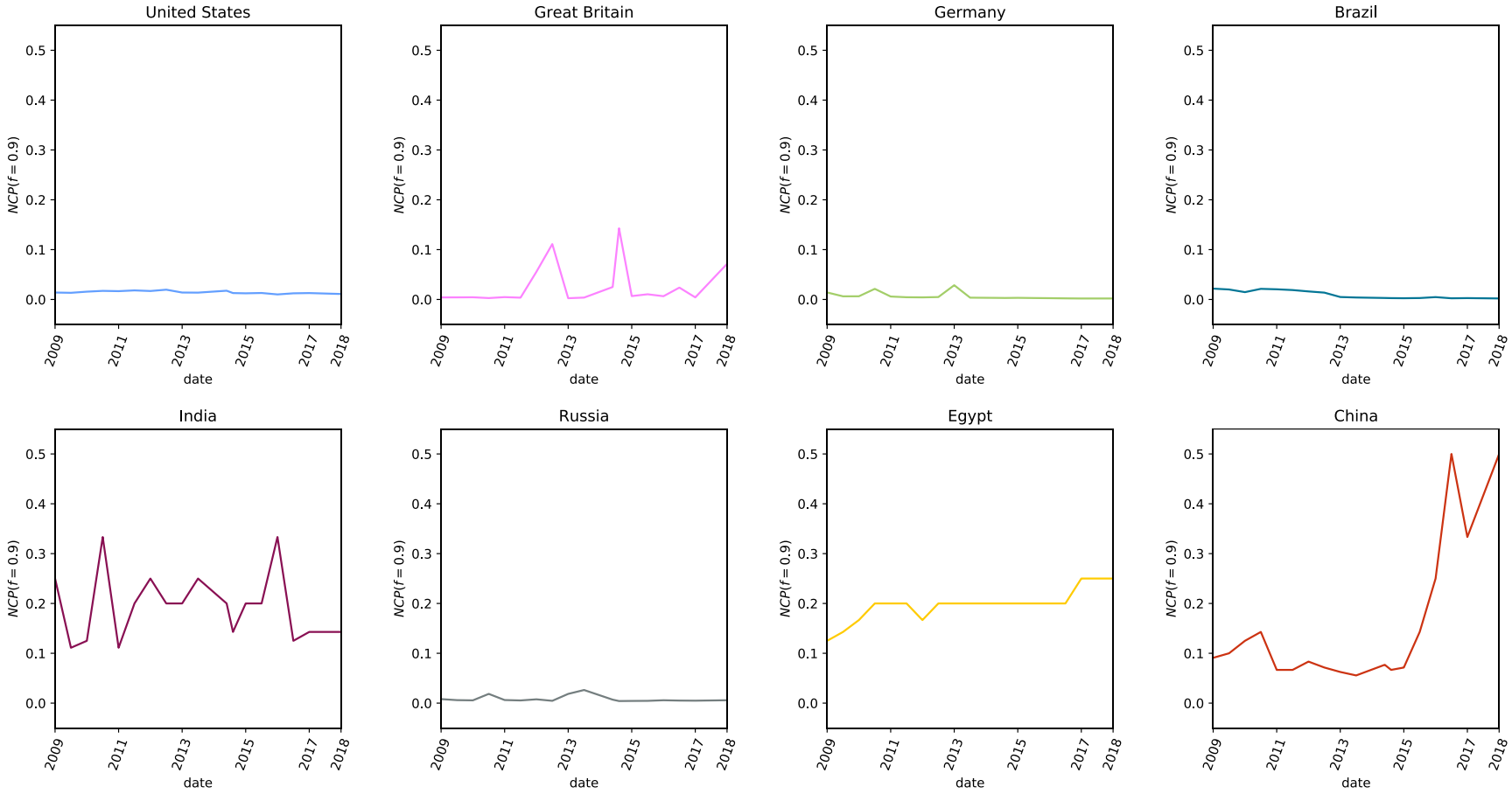
China in 2018



Russia in 2018

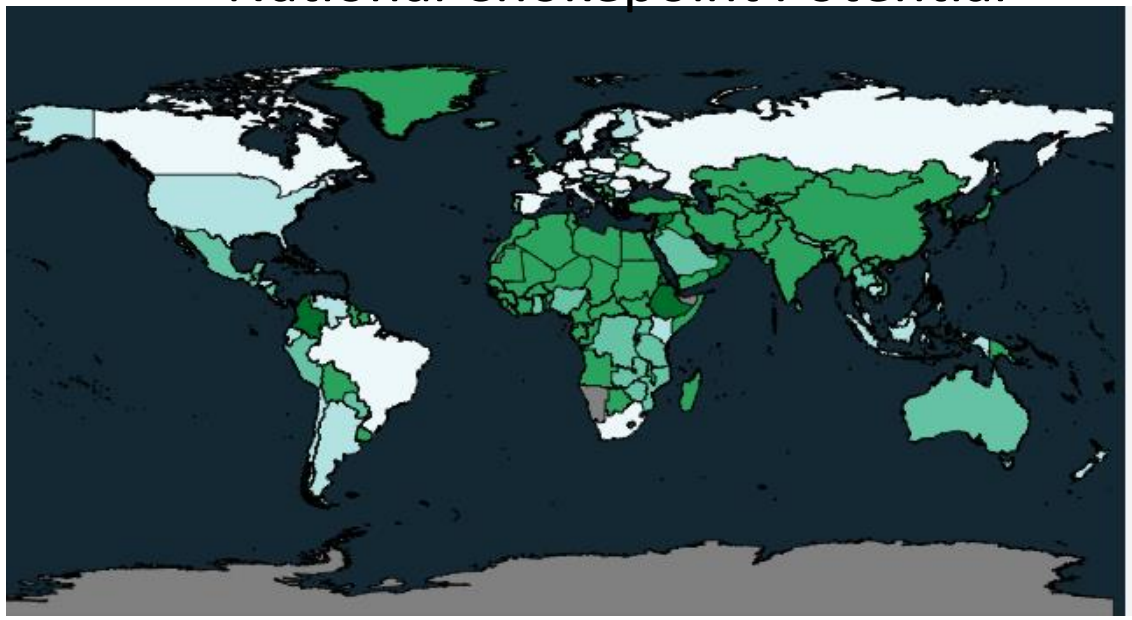


The Evolution of Internet Borders

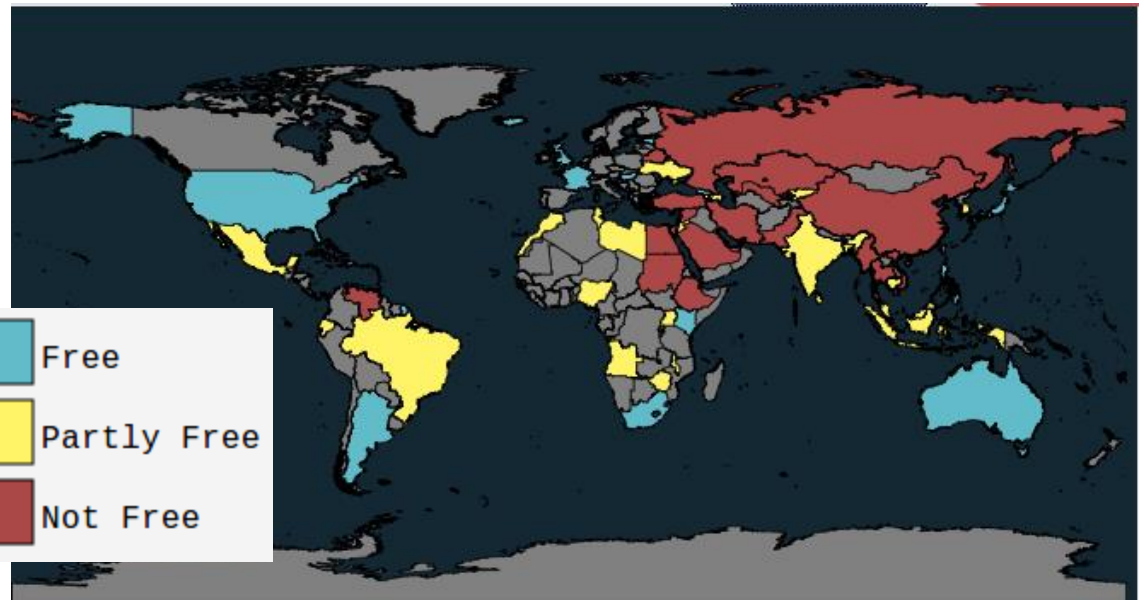


An Application: Internet and Press Freedom

National Chokepoint Potential



Internet Freedom



Decentralized Control: A Case Study of Russia

Reethika Ramesh*, Ram Sundara Raman*, Matthew Bernhard*, Victor Ongkowijaya*,
Leonid Evdokimov†, Anne Edmundson†, Steven Sprecher*, Muhammad Ikram‡, Roya Ensafi*
*University of Michigan, {reethika, ramaks, matber, victorwj, swsprec, ensafi}@umich.edu
‡ Macquarie University, †Independent, leon@darkk.net.ru

***Abstract*—Although past censorship research has largely focused on blocking in highly centralized networks such as China's, censorship in decentralized networks is on the rise. It was long thought that large-scale censorship on decentralized networks with thousands of ISPs was prohibitively difficult. Our in-depth investigation of the mechanisms underlying decentralized information control in Russia shows that such large-scale censorship can be achieved in decentralized networks through inexpensive commodity equipment. This new form of information control presents a host of problems for censorship measurement, including difficulty identifying censored content, requiring measurements from diverse perspectives, and variegated censorship mechanisms that require significant effort to identify in a robust manner.**

practicing censorship at centralized network choke points for decades, receiving significant global and academic attention as a result. [4], [31], [45], [83]. As more citizens of the world begin to use the Internet and social media, and political tensions begin to run high, countries with less centralized networks have also started finding tools to exert control over the Internet. Recent years have seen many unsophisticated attempts to wrestle with decentralized networks, such as Internet shutdowns which, due to their relative ease of execution, have become the *de facto* censorship method of choice in some countries [14], [37], [82]. While some preliminary studies investigating information control in decentralized networks have examined India [88], Thailand [27], Portugal [61], [62], and other countries, there has

Data Processing

Data Techniques

Started with AS relationship dataset from CAIDA

Used a modified BFS algorithm and Gao-Rexford routing model to identify paths between AS pairs.

Generated routing trees for each destination AS.

Calculated chokepoint potential for each border AS using the large routing tree dataset

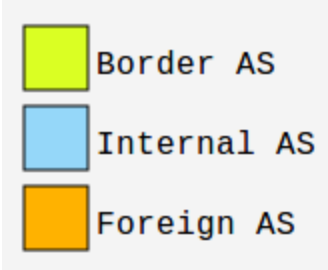
Tools and Data

- All these tools are bundled as BGP-Simulation Analysis and Storage (BGP-SAS)
- The data for 10 years of BGP routing trees is over 200GB compressed (2+ TB uncompressed)

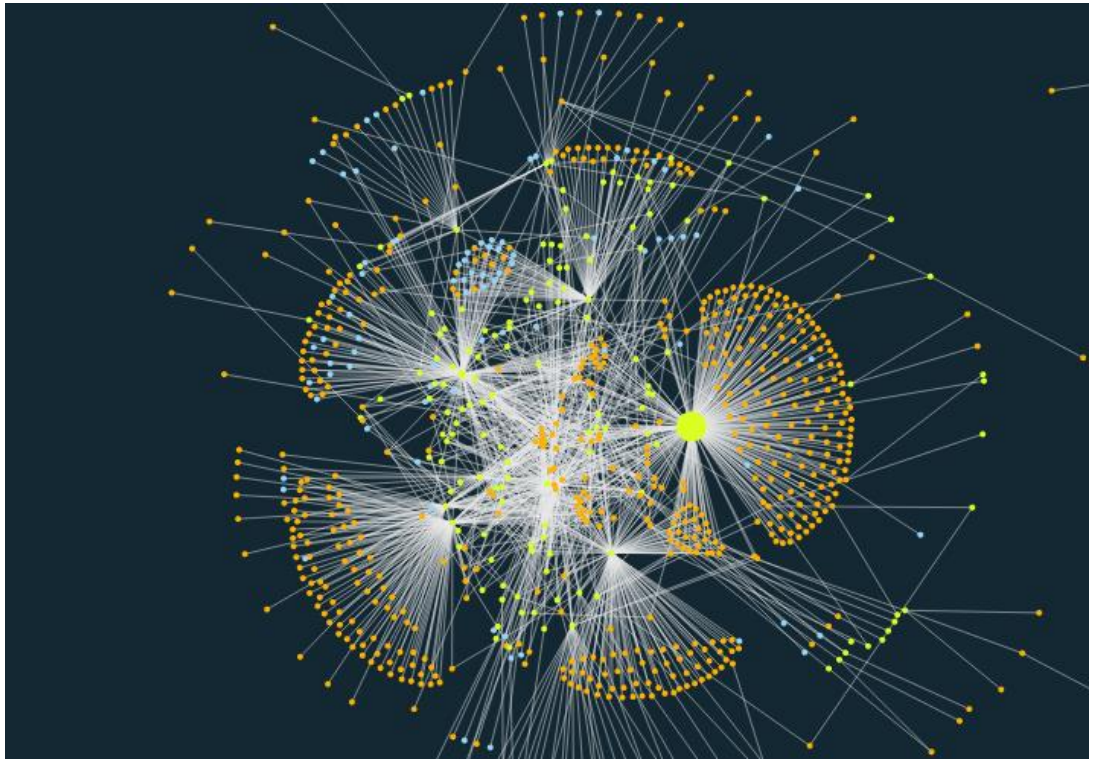
Links!

- http://www.cs.unm.edu/~crandall/irtfbordersandgateways.pdf
  - Where I plan to put these slides (Google my name and you'll find it).
- https://kirtusleyba.github.io/routingtrees.html
  - In case you don't have a supercomputer handy.
- https://kirtusleyba.github.io/iwm.html
  - What I'm about to show you...

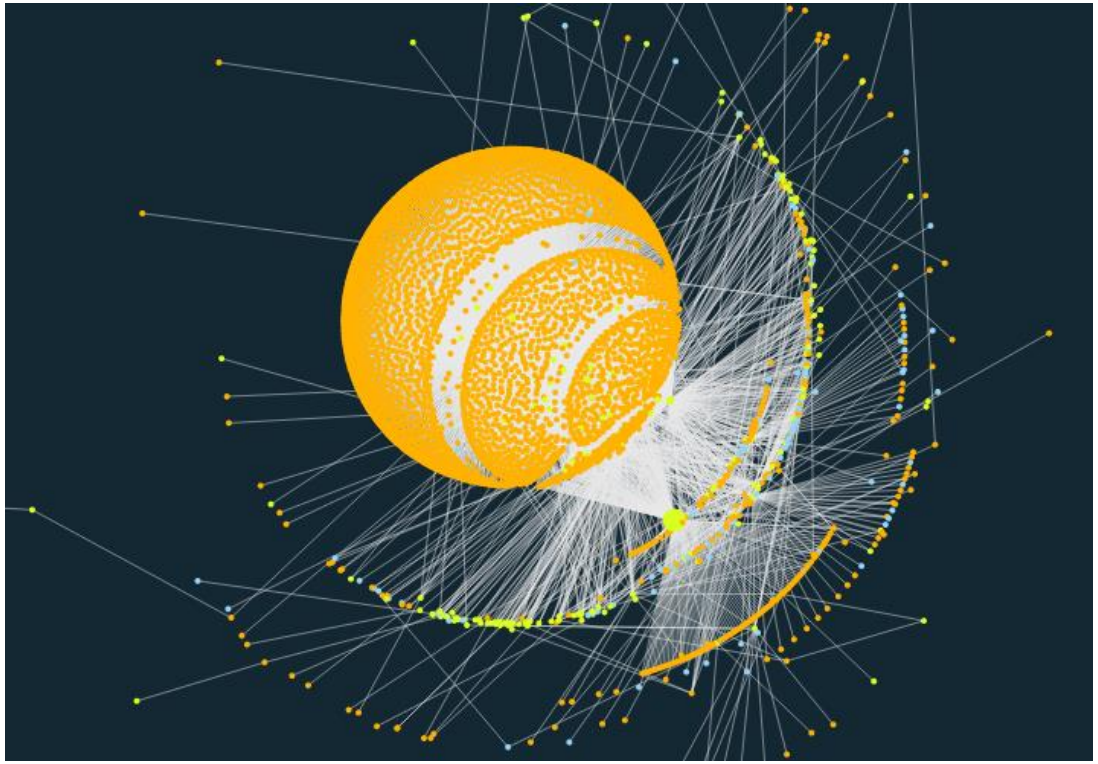
Singapore AS map



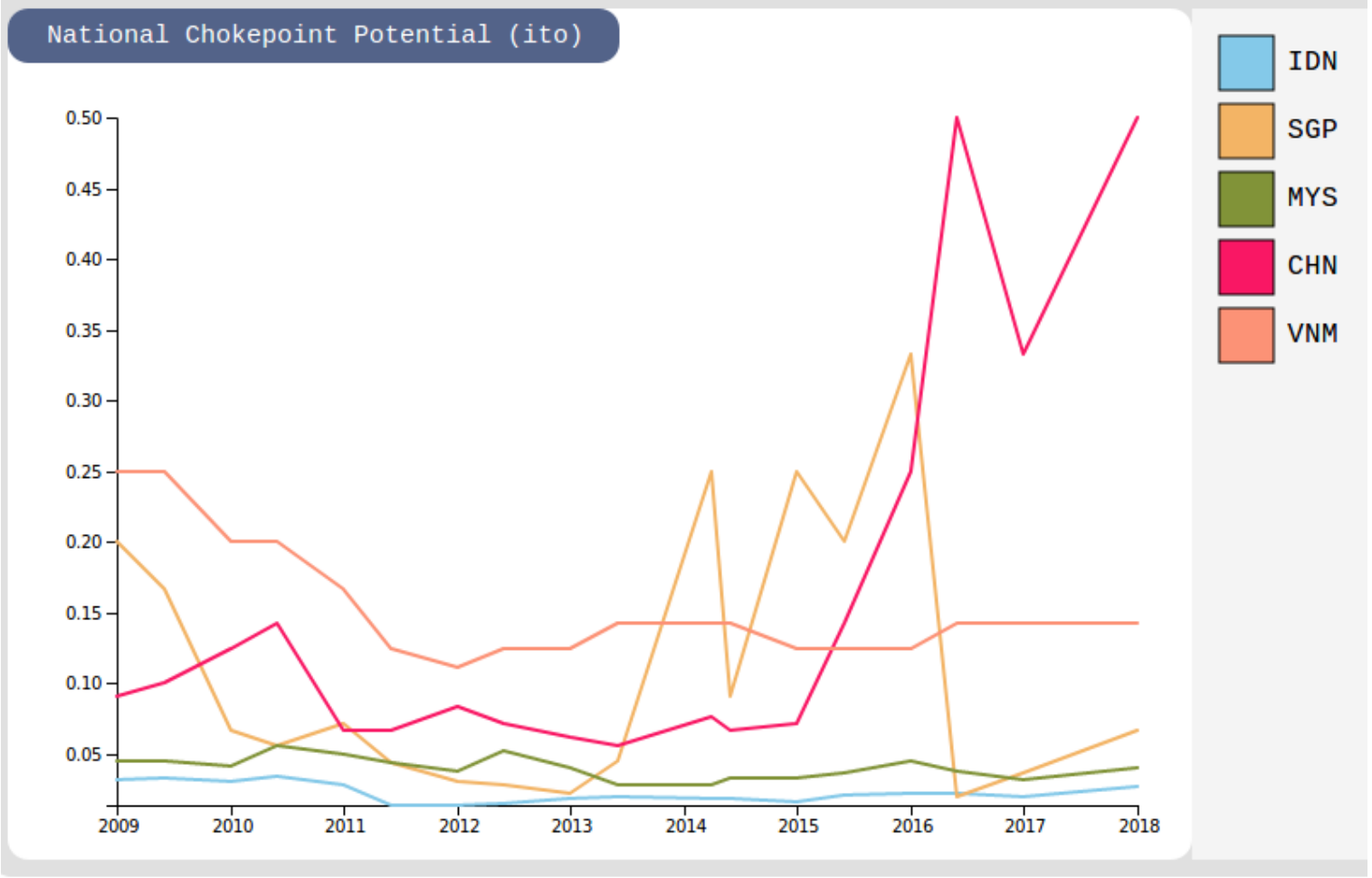
June 2015



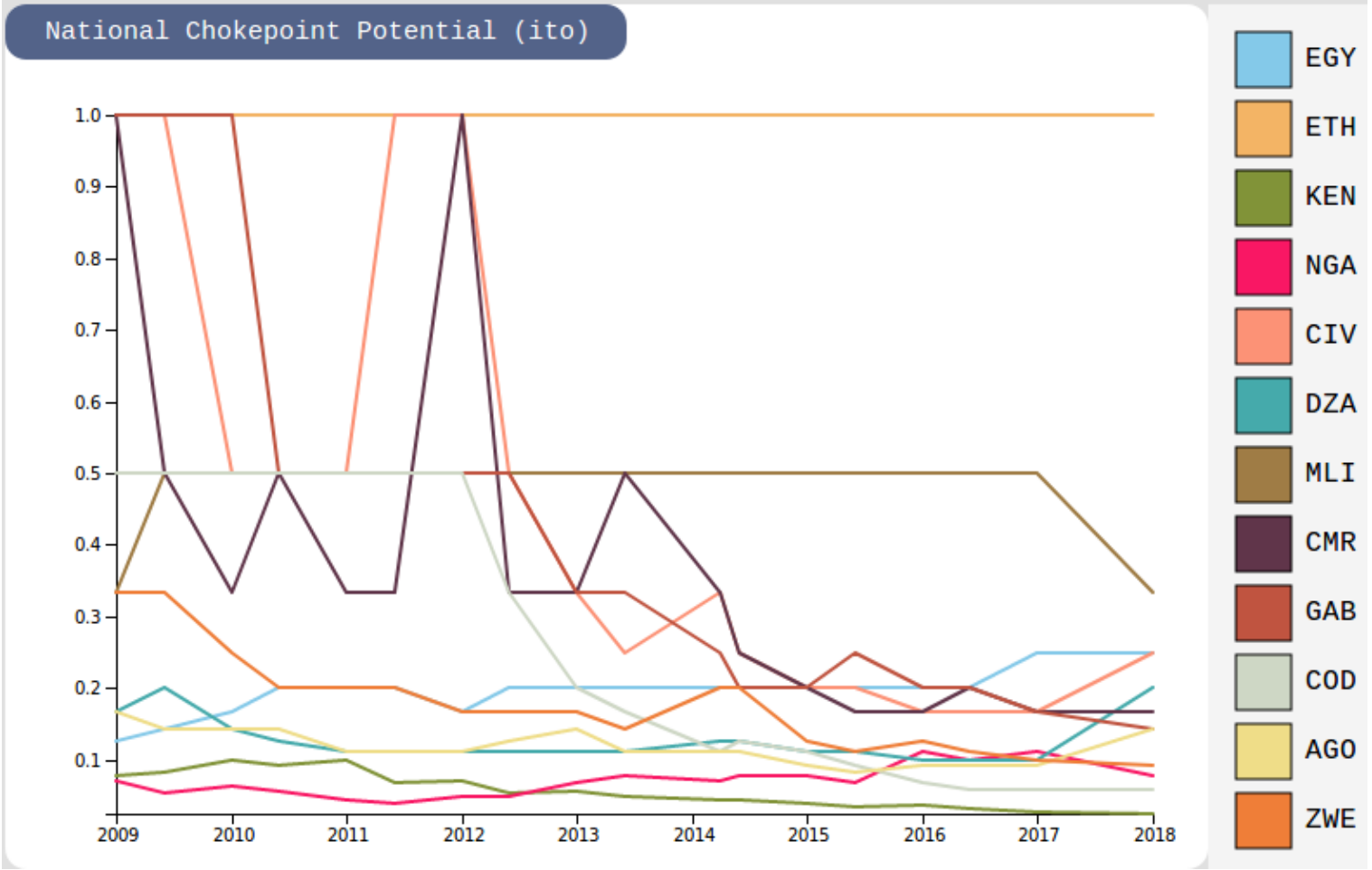
January 2018

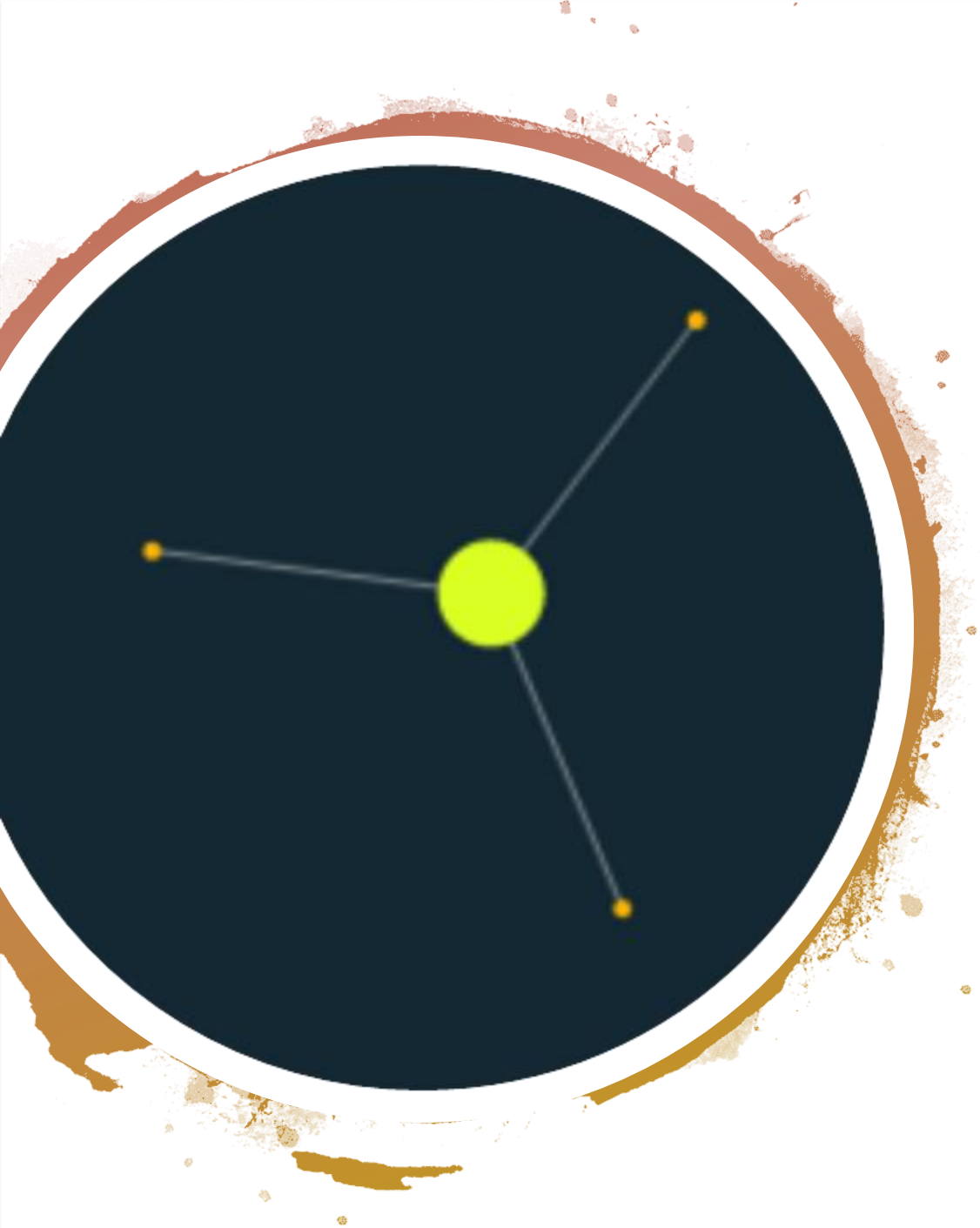


Singapore *vs.* surrounding countries...



African countries...





- Ethiopia's Internet

Conclusions and future work

- Take-away messages
  - National chokepoint potential can be a useful measure
  - We have code and data if you want to explore it or make your own measure, plus routing trees if you don't have a supercomputer handy
- Future work
  - Missing links?
  - Measuring physical infrastructure
    - From a vantage point
    - From across the Internet (*e.g.*, off-path)
    - From inside a black hole
  - TCP/IP oddities
    - Initial Sequence Numbers, IPIDs, interactions with VPNs

Authors

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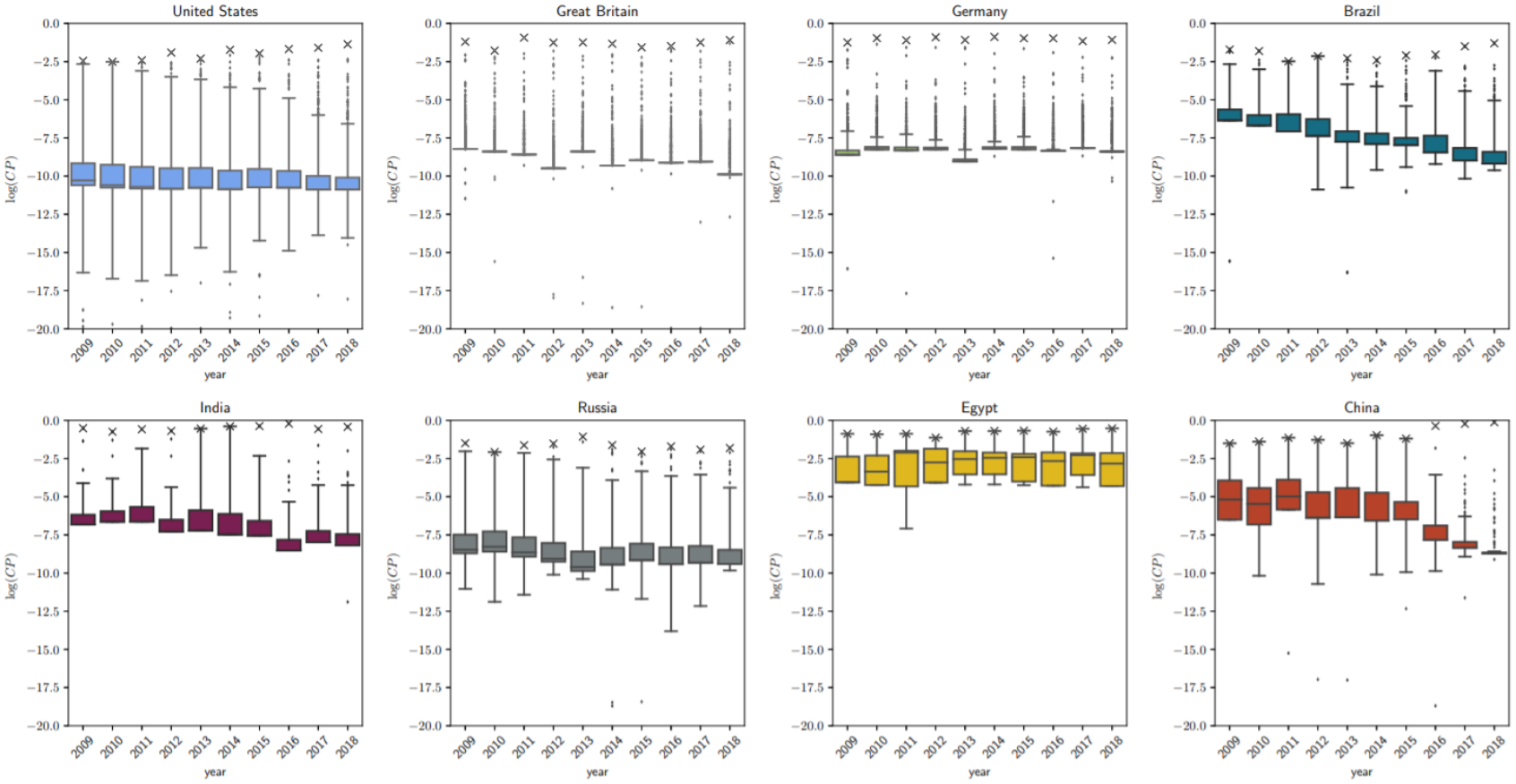
Questions?

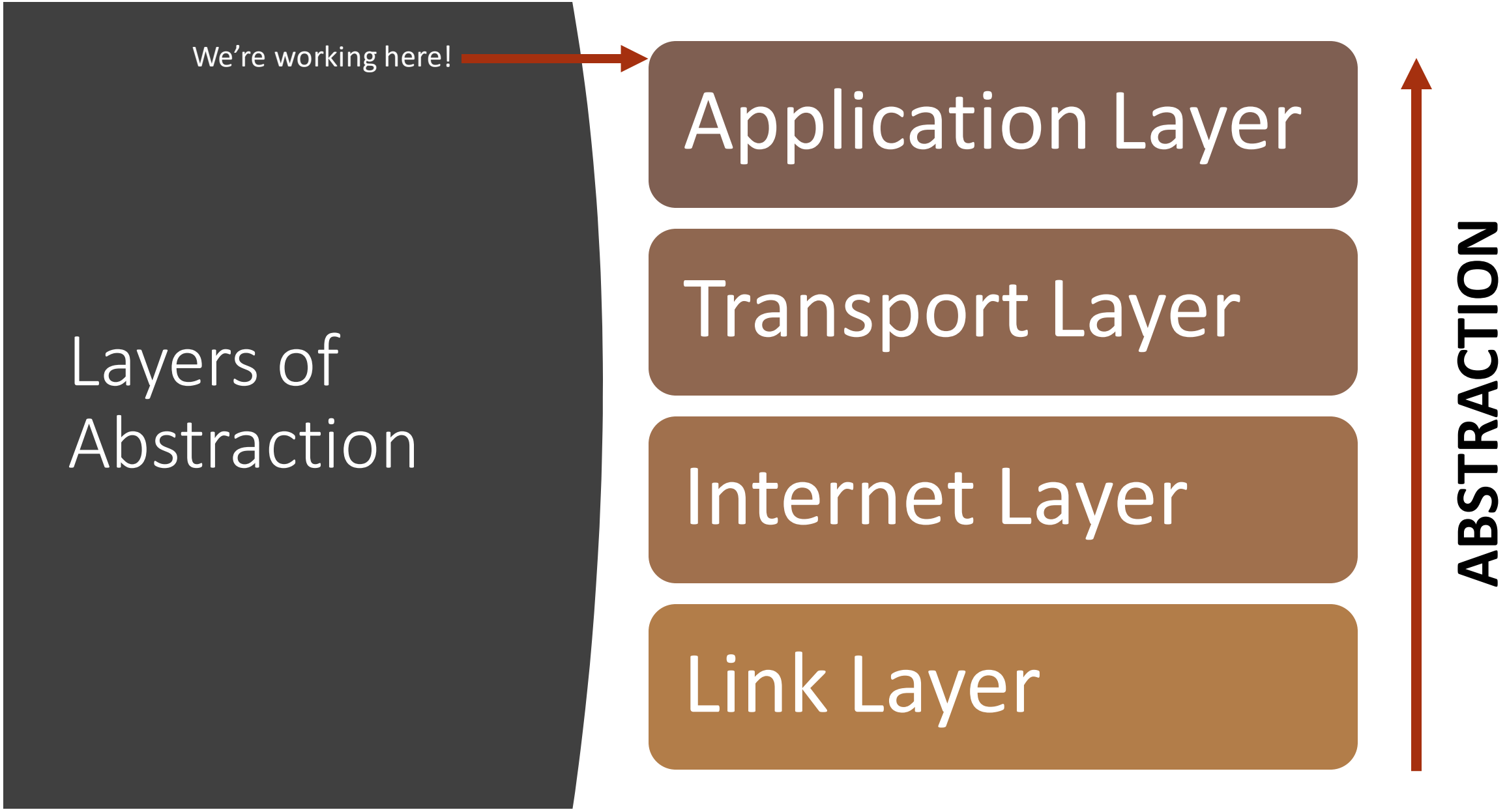
Backup slides…

The Evolution of Internet Borders



Layers of Abstraction

We're working here!



Border Gateway Protocol (BGP)

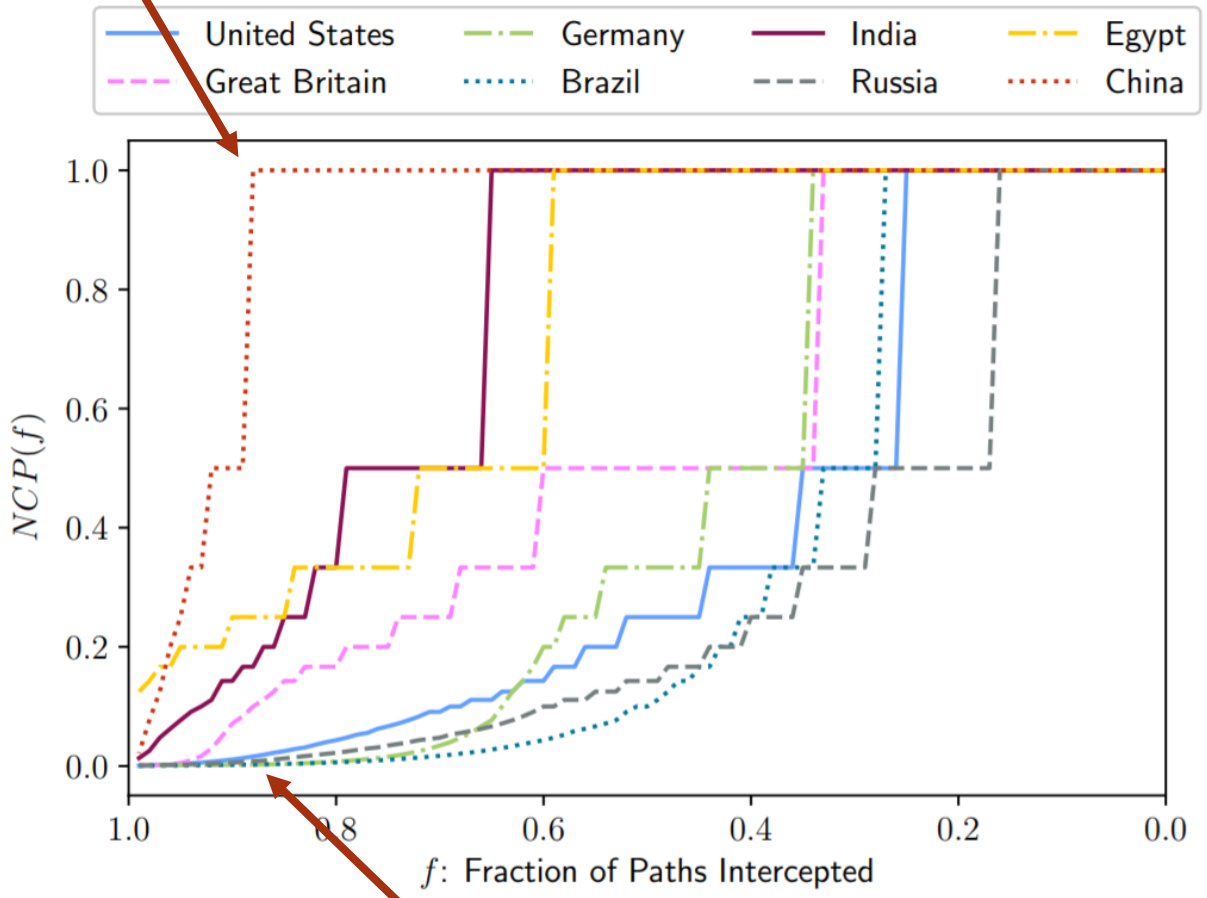
BGP is the routing protocol of the most abstract layer of Internet hierarchy.

BGP routes traffic between **Autonomous Systems (ASes)**

- ISPs
- University Networks
- Networks for Large Corporations
- Government Networks

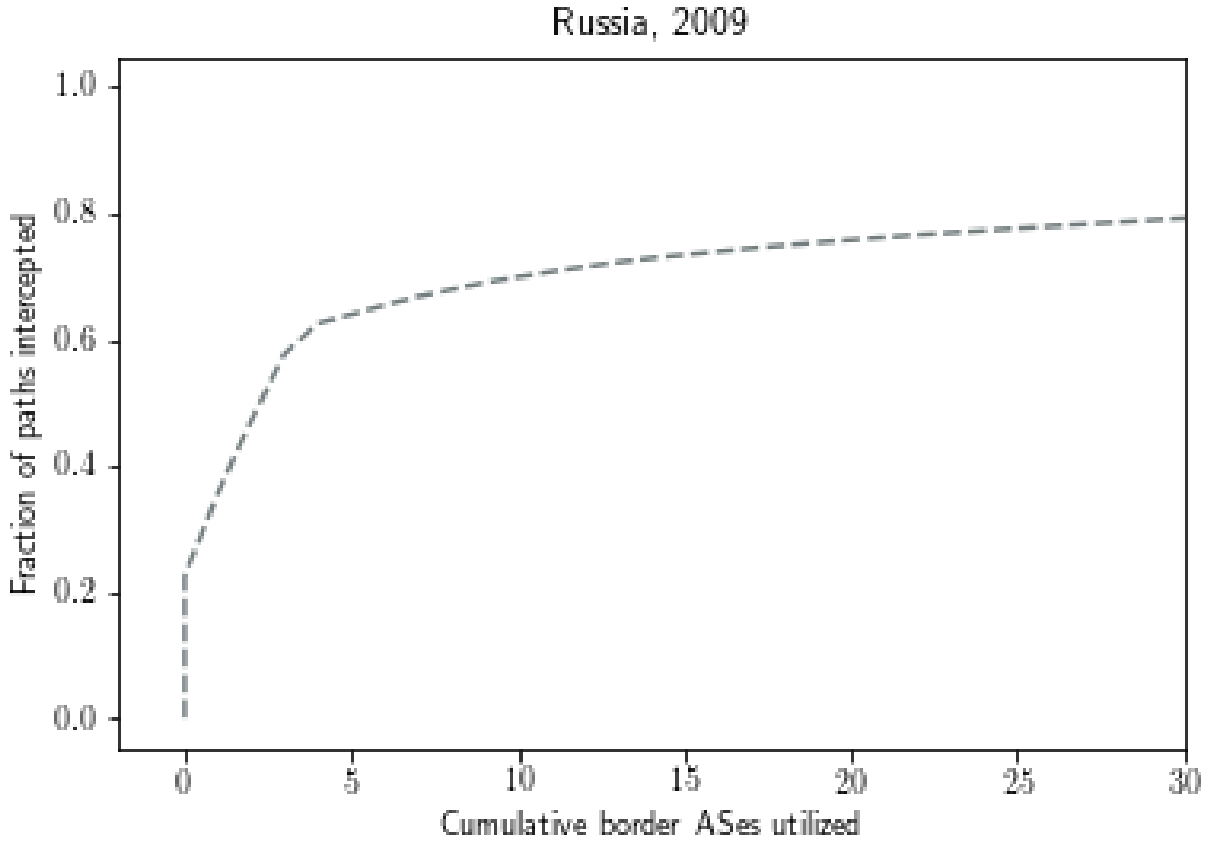
Measuring AS Chokepoints in different nations (2018)

China can intercept about 90% of its international routes with few ASes.



Russia needs more ASes to get there.

Russia in 2009



Acknowlegments and disclaimers…

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