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?

A Nation With High Chokepoint Potential

A Nation With Low Chokepoint Potential

- Internal AS
- Border AS
Cameroon shuts down the internet for 240 days.

Author: Thijmen Calis
Iran Admits Throttling Internet To 'Preserve Calm' During Election
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 Delbert
March 9, 2018

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
December 2008
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

- Free
- Partly Free
- Not Free
Decentralized Control: A Case Study of Russia

Leonid Evdokimov†, Anne Edmundson†, Steven Sprecher*, Muhammad Ikram‡, Roya Ensafi*

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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], [53]. 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!

  • Where I plan to put these slides (Google my name and you'll find it).

• [https://kirtusleyba.github.io/routingtrees.html](https://kirtusleyba.github.io/routingtrees.html)
  • In case you don't have a supercomputer handy.

• [https://kirtusleyba.github.io/iwm.html](https://kirtusleyba.github.io/iwm.html)
  • What I'm about to show you...
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
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Questions?
Backup slides...
The Evolution of Internet Borders
Layers of Abstraction

We’re working here!

Application Layer
Transport Layer
Internet Layer
Link Layer
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
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