Poster: Multi-Dimensional Observation of Splinternet

Edwin D. Sutherland
Loughborough University
Loughborough, United Kingdom
e.sutherland@lboro.ac.uk

Iain Phillips
Loughborough University
Loughborough, United Kingdom
i.w.phillips@lboro.ac.uk

CCS CONCEPTS

• **Networks** → **Network measurement**; • **General and reference** → *Measurement*.

KEYWORDS

Internet, censorship, cyber sovereignty, Internet fragmentation

ACM Reference Format:
Edwin D. Sutherland and Iain Phillips. 2021. Poster: Multi-Dimensional Observation of Splinternet. In *Proceedings of ACM Internet Measurement Conference 2021 (AMC IMC '21).* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

The unprecedented growth of the Internet over the last decade saw a parallel development in nation states' pursuit in shaping the Internet to the needs and expectations of their citizens. In concert, the monopolistic dominance of a few big Internet companies, have also contributed to building islands of cyberspace that entrap Internet users into closed eco-systems of services and content. Once envisaged to be open and untethered, the global Internet is now under intense pressure and likely to fracture into fragments of bordered networks [4]. Some nations have trialled a national Internet model where Internet services and content are exclusively delivered within their borders with no dependency on the global Internet. Others have taken approaches such as censorship, data localisation and data protection laws and directives to carve out parts of the Internet they see fit. This phenomenon of splintering the Internet into multiple apparent Internet instances where the experience, services and content accessible differ wildly based on a user's location has come to be known as Internet fragmentation. Much work has debated fragmentation, however, little technical work has been undertaken to measure and understand its benefits and limitations.

Fragmentation can be caused by commercial and government actors as well as the technical forces that underpin the architecture of the Internet [1]. Examples of these are walled gardens, Internet shutdowns, IPv4 to IPv6 migration and the introduction of Secure BGP solutions. Motivations for fragmentation often centre around cyber sovereignty on the governmental front and corporate expansion and innovation strategies on the commercial front. Methods for inducing fragmentation vary widely, leveraging one or multiple layers of the TCP/IP suite.

Without a quantifiable analysis of fragmentation, technical inefficiency maybe introduced into the operation of the Internet through the use of circumvention tools to evade fragmentation enforcement and as well as suboptimal techniques used for its implementation. The lack of comprehensive fragmentation measurement is significant because without it the influence of fragmentation in creating either a thriving or receding cyberspace becomes more difficult to comprehend and act on. Importantly, the implications of fragmentation call for a wider assessment on issues such as Internet governance, economics and politics.

2 MEASURING FRAGMENTATION

Internet Fragmentation is a topic that intermingles politics, Internet governance, commercial aims and technology. This research delves into the technology aspect focusing on measuring diversity of fragmentation types, methods and frequency to assess current and potential future impact on Internet architecture. This work will identify side effects and inefficient uses of technology and, where appropriate, propose alternative solutions.

Measuring Internet fragmentation requires assembling of new and existing Internet measurement systems to capture the multi-dimensional nature of fragmentation. Web and App censorship, Internet shutdowns, packet filtering are the most pervasive causes of fragmentation on the Internet. There is also a growing list of interesting data sources to survey and account for as many fragmentation types as possible. Some of these include data localisation policies, Freedom House's Freedom On The Net(FOTN) ranking, Internet user population, and National Chokepoint Potential(NCP); which determines the likelihood of fragmentation practices due to optimal positioning of filtering systems facilitated by AS topology arrangement in a country [2].

Albeit there are exiting systems to capture the common fragmentation incidents, few tools out there provide an aggregated view of these data sources to observe fragmentation. Current Internet measurement systems such as CensoredPlanet, Internet Outage Detection and Analysis(IODA), Open Observatory of Network Interference(OONI), AccessNow Shutdown Tracker Optimization Project(STOP) and more were originally developed to measure specific observations aligned to performance, censorship and service availability. Individually these systems do not provide the scope and breadth to measure fragmentation holistically.

AccessNow Shutdown Tracker Optimization Project (STOP) uses qualitative and quantitative data to account for shutdown events globally on an annual basis. It collects data from news and media outlets plus technical measurements from systems such as IODA, OONI and more. The STOP system is purposely built to track Internet shutdown issues.

AMC IMC '21, November 02–04, 2021, Virtual Event

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM…$15.00
https://doi.org/10.1145/nnnnnnn.nnnnnnn

CensoredPlanet is a longitudinal censorship measurement platform using remote measurement techniques to monitor the Internet for censorship activities. It employs four measurement systems: Augur (TCP/IP side channels to measure reachability between two Internet endpoints); Satellite (DNS manipulation), Quack (keyword filtering by DPI blockers), and HyperQuack (interference with HTTP and HTTPS flows). Fragmentation issues such as app store censorship, NCP and Internet shutdowns are unaccounted for.

Daylight Fragmentation Measurement [3] is one of the early efforts to provide a multi-dimensional fragmentation measurement. The daylight team measured four dimensions and analysed collated data for comparison between countries. These four dimensions cover data localisation and data protection laws, site locality, DNS and TCP manipulation and IPv6 adoption. Though it sheds light on a number of fragmentation issues, it is not sufficiently comprehensive to account for various fragmentation issues such as shutdowns, app store censorship and NCP.

Internet Outage Detection and Analysis is a system to identify apparent Internet outages impacting edge networks or country-wide. IODA uses: Global Internet Routing(BGP) (RouteViews and RIPE RIS projects), Internet Background Radiation (UCSD Network Telescope system), and active probing of IP address space. IODA is geared towards Internet outage detection and is often leveraged for post-event investigation and analysis. IODA's output is useful as supporting evidence for Internet shutdown and service disruption incidents.

Open Observatory of Network Interference(OONI) probe software measures blocking of websites, messaging apps (WhatsApp, Facebook Messenger and Telegram), censorship circumvention tools, network speed and performance and detection of middleboxes that might be culpable for censorship and/or surveillance. OONI is leveraged by other systems to infer fragmentation issues such as Internet outages and service throttling. Though OONI can serve as part of a multi-faceted dataset in analysing fragmentation in isolation it lacks a broader observation of fragmentation issues such as examination of NCP changes. It also does not incorporate external data sources to provide insight and correlation to fragmentation observations.

3 COMBINING THE MEASUREMENTS

This research proposes a multi-dimensional Internet fragmentation analysis system that incorporates the rich data sources available. The data collected will be processed in daily batches through an ETL data pipeline to remove incomplete and unnecessary data to provide clean and cumulative data for longitudinal analysis. Curated observation dashboards and data querying tools to generate new insights will be key components of this system. It is purposely designed this way to extend the use of the fragmentation measurement system beyond this research and to a broader audience to further research. The analysis system will employ cloud-native principles and architectures and open-source software stack where possible. Figure 1 depicts a high-level design.

The compiled dataset offers users the ability to interrogate for insights regarding fragmentation. For example:

Global Fragmentation Trend A line graph to depict the annual sum of fragmentation incidents over recent time. This is to show clear trends in the direction of fragmentation incidents over the defined timescale. A mock-up is in figure 2.

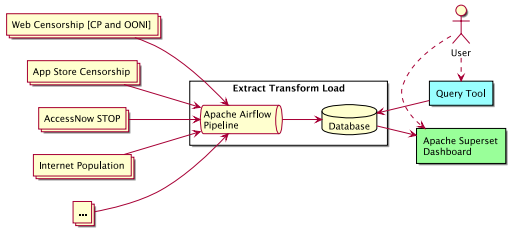

Figure 1: System high level design

Most Used Fragmentation Type A bar chart to show the rates at which different measured fragmentation types (or combinations) are employed. This provides a focal point to further investigate implications and solutions.

Per Country Fragmentation Breakdown A map chart estimating per-country, Internet user population impacted by fragmentation. This view will contextualise the scale of user impact and a foundation for correlating non-technology related data such as GDP and FOTN ranking.

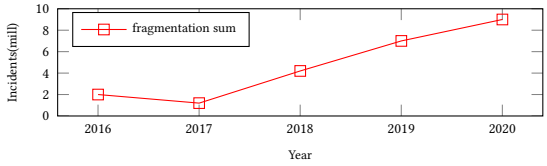

Figure 2: Global fragmentation trending plot

4 OUTLOOK

The outcome of this research will ensure the current and future Internet utilization in the context of fragmentation is better understood. The proposed system will provide rich aggregated data and tooling for academics and the Internet technical community to carry out independent investigations on fragmentation. The system will also present example analysis in the form of dashboards exploiting all the possibilities offered by the aggregated data. It is hoped the result of this research will give impetus for the Internet technical community to further research on Internet fragmentation.

REFERENCES

[1] William J. Drake, Vinton G. Cerf, and Wolfgang Kleinwachter. 2016. Internet Fragmentation: An Overview. *Future of the Internet Initiative White Paper* (2016).
[2] Kirtus G. Leyba, Benjamin Edwards, Cynthia Freeman, Jedidiah R. Crandall, and Stephanie Forrest. 2019. Borders and gateways: Measuring and analyzing national as chokepoints. In *COMPASS 2019 - Proceedings of the 2019 Conference on Computing and Sustainable Societies*. Association for Computing Machinery, Inc, 184–194. https://doi.org/10.1145/3314344.3332502
[3] Nick Merrill. 2019. Internet Fragmentation: Beyond "free" and "closed". https://medium.com/cltc-bulletin/internet-fragmentation-beyond-free-and-closed-cb8b1dfcd16a
[4] Hugo Zylberberg. 2016. We Should Not Fear a Fragmented Internet. https://www.cfr.org/blog/we-should-not-fear-fragmented-internet