Research Synopsis

COLLECTION OF AUTONOMOUS SYSTEM LEVEL TOPOLOGY USING LOOKING GLASS SERVERS

BY

Rana Faraz Ahmed

**MASTER OF PHILOSOPHY
IN
COMPUTER SCIENCE**

September, 2017.

NCBA & E
RYK Campus
MPhil CS

Certificate of Synopsis Submission

Dated: ________________

IT IS CERTIFIED THAT MR.

RANA FARAZ AHMED

S/O

RANA NAVEED AHMED

WHO IS A REGULAR STUDENT OF M.PHIL (COMPUTER SCIENCE), UNDER REGISTRATION NUMBER ____________, AT **NCBA&E**, IS CONDUCTING RESEARCH UNDER MY SUPERVISION.

Supervisor: ________________

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

Degree Sought: Master of Philosophy

Department: Computer Science

Candidate's Name: Rana Faraz Ahmed

Qualification: BS(CS)

E-Mail: ranafarazahmed@gmail.com

Supervisor: Dr. Akmal Khan

Contents

1 Introduction **5**
1.1 Motivation 5
1.2 Problem Statement 6
1.3 Research Questions 6
1.4 State of Art 6
1.5 Scope of this Research 7

2 Background **7**
2.1 Autonomous Systems 9
2.2 Border Gateway Protocol (BGP) 10
2.3 Internet Topology Measurement 11
2.4 Looking Glass Servers 11

3 Proposed Methodology **12**

4 Available Topologies **13**
4.1 Ark 14
4.2 iPlane 14
4.3 IRL 14
4.4 IRR 14

5 Literature Review **14**
5.1 Comparative Research on Features of ASes [20] 14
5.2 Modeling of AS Topology [18] 15
5.3 Internet is an inter-connected ASes [19] 15

6 Conclusion **17**

Abstract

With the advent of emerging technologies like Internet of Things and Social Media, the usage of Internet has dramatically accelerated, over the past decade. Billions of smart devices, granting access to the Internet, are portraying enormous challenges to the Network and Internet Service Providers. Eternal need to access Internet by ever increasing numbers of Internet users, the speed, durability, efficiency and absolute performance of Internet has become inevitable. To meet these challenges, significant and accurate designing of inter-connected ASes, is a task of high intensity. As Internet is not owned by any standard body, therefore, the topology through which Autonomous Systems around the world, interacts, varies on the basis of socio-political circumstances. In this document, we propose research work that aims to collect efficient Autonomous System Level Topology using Looking Glass Servers.

1 Introduction

Internet is a heterogeneous network of inter-connected devices. It can be referred as Autonomous Systems connected with each other that uses border gateway protocols for the exchange of information. In this divergent network, each Autonomous System is a node and a BGP connection among those node are known as links. The importance of AS level topology construction is highlighted through many studies. This research work intents to design an Autonomous System level topology using Looking Glass Server.

1.1 Motivation

Because of the regularly expanding client-base of web, its ecosystem is persistently advancing to address the challenges. Extraordinary changes in the customary framework of Web has enhanced its execution, capacity and has enabled a world of new services. For Network Providers and Internet Service Providers (ISPs), meeting and encountering the rapidly emerging activity request, has been a technological, practical and political challenge.

The Internet was never developed with the vision of what it is today and the way it is growing. Accordingly, these change factors has promoted a system of tremendous complexities that was not an output of well-founded design principle. Yet the researchers community is long way from accomplishing a satisfactory level of understanding the Internet's dynamic structure. A huge factor for this complexity lies in the Internets scale and infrastructure.

According to the Regional Internet Registries Statistic, billions of IPv4 and IPv6 have been assigned to 82, 136 Autonomous Systems worldwide, as of Mon, Sep, 18, 2017 [8], which are inter-connected by billions of intelligent and physical links. Despite the continuous efforts of the scientific and enterprise communities to model the Internet, understanding its structure remains a hard challenge. But despite all odds and hardships, precise and complete modeling of the Internet at AS Level is an assignment of great significance for future protocol outlines, execution assessment, examination and reenactment.

1.2 Problem Statement

Absolute and precise modeling of Internet Topology at Independent Level is a task of high priority for defining future set of rules, assessment of execution, analysis and implementation. Till today it is a challenge for researchers to design complete modeling of the Internet Topology due to enormous constraints.

1.3 Research Questions

- What are the hindrances to construct an absolute Internet Topology design?
- What does Internet looks like at AS Level?
- How many AS are there in the world?
- How does AS interacts with each other?
- Does the modeling of Internet at AS level is necessary?
- How this research work will help in regards of better modeling of Internet Topology?
- Why other data sets ignores Autonomous System links collected by Looking Glass Servers?
- Why Looking Glass Servers do not discover AS Links found in other datasets?
- How this research work would be different from other previously done or ongoing researches?

1.4 State of Art

There are three main approaches to develop Autonomous System level topology:

1. Collection of Border Gateway Protocol's routing tables [12] and updated by filtering routing policies. These measurements are referred as passive measurements.
2. Another available dataset is IRR - Internet routing registry [3] but it is said to have deprecated information and they might be contradicting towards RIPE. [16].

3. Third approach is the measurements using traceroute and it is active type of measurement [1]. But it contains anomalies and outdated data because of the issues in the Internet Protocol to Autonomous System Mapping.

1.5 Scope of this Research

Analyzing and modeling the Internet topology is a unique, active and evergreen research domain of Networks. Modeling topology of Internet on AS level is of great significance as there is no absolute solution available, to this problem. It is because of the ever-growing ecosystem of the Internet.

Analyzing and modeling of Autonomous System level topology is essential for defining future set of rules, assessment of execution, analysis & betterment in regards of services. This research work will encapsulate the designing of Internet Topology at Autonomous Level using web-based portals referred as Looking Glass Servers. Will also highlight the present challenges to construct an absolute topological design.

2 Background

The Internet is a heterogeneous network of all networks around the globe. Inde-pendent administrative elements, organize and own these networks and they are known as Autonomous Systems. We can state that an AS is a cluster of IP net-works operated by one or more network operators whose external routing policy is solitary and well defined. To exchange routing information between Autonomous Systems, Exterior Routing Protocols are used.

The Internet is complex and difficult to model because it exists along with enormous socio-political and geographical problems. As autonomous systems are widely effected by geographical and socio-political hindrances, therefore they differ in regards of inter-domain routing policies. The intension is better deliverance, durability, bandwidth and consistency.

Autonomous System are uniquely identified as carriers that are independent institutes, with their own inter-domain routing policies. These Autonomous Systems can be Internet Service Providers, they can be Internet Exchange Points or may be Content Delivery Networks. Universities can also be referred as ASes.

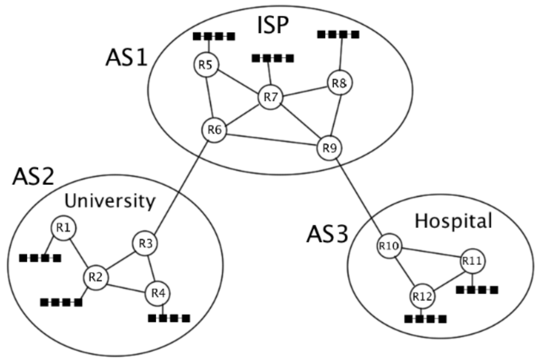

Figure 1: Autonomous Systems represent a collection of networks administrated by a single entity. The Internet consists of interconnected ASes [13].

All these autonomous systems are interconnected and exchange data in regards of some commercial agreements. These are not public and usually researchers are unaware that upon what terms and conditions, data is being exchanged. Also the protocols by which the data is transmitted are not revealed.

Autonomous System are being added to the ecosystem of Internet day by day. Therefore, the construction of Autonomous System Level Topology is an influence task. The significance of AS level topology has been enlightened through various studies such as collection of autonomous system level topology using looking glass servers [17], Ranking of Autonomous Systems depending upon topological characteristics [20], modeling of Internet at AS level [18], the Internet is a system of interconnected ASes [19] and modeling structure and resilience of dark network [14].

Acknowledging the greatness of the subject matter in multiple dimensions of networks, many researchers have contributed in it. But till today it is a confrontation to design a standard topology. In this document, I propose a technique, as my research project, for the collection of Autonomous System Topology by querying Looking Glass Servers.

2.1 Autonomous Systems

An autonomous system (AS) is a union of numerous switches and systems work-ing under a solitary regulatory specialist or space. A case of an AS could be an organization, a college, or an ISP. They interface with each other through private connections. Be that as it may, because of the expanding multifaceted nature of the Web, steering is performed by two conventions. Intra-area steering, which is steering inside the AS utilizing an Interior Gateway Protocol (IGP), and between area steering, which is directing among ASes utilizing an Exterior Gateway Protocol (EGP).

ASes self-rulingly decide their own particular inward correspondence approaches, and Interior Gateway Protocol IGP. The most broadly utilized IGP conventions are Open Shortest Path First (OSPF), Directing Information Protocol (RIP), and Intermediate System to Intermediate Framework (IS-IS). Despite what might be expected, ASes must utilize the same EGP, which right now is the Border Gateway Protocol (BGP) variant 4 portrayed in RFC 4271. The difference amongst BGP and some other IGP is that BGP needs to consider the Figure: **??**, delineates a basic portrayal of the ASes and their network. We demonstrate three ASes: an ISP, a college and a doctor's facility. Each AS comprises of switches (portrayed by circles) and has (delineated by squares). In this case, switches R3, R6, R9, and R10 will utilize BGP while the rest of the switches will utilize their own IGP.

The BGP convention is mindful of interfacing the ASes, giving the consistent structure of the Internet. BGP switches recognize each AS by a one of a kind ID number called self-governing framework number (ASN), which is given by RIRs at the snapshot of enrollment. Furthermore, BGP switches utilized the tactless between area steering documentation (CIDR), which is a smaller portrayal of a piece of IP address space indicated in RFC 4632. At the point when a BGP switch first joins the Internet, it builds up an association with the straightforwardly associated BGP switches and downloads their whole directing tables, which will be for all time kept up in its memory. Every section in the directing tables contains the IP prefix, the following bounce, and the whole AS way to achieve that IP prefix. With those tables, it executes a calculation to deliver its own directing table thinking about the particular approaches and cost for each course and in addition another table that will be utilized to send to other BGP switches. From that point forward, the main messages traded between ASes are refreshes for either a pull back or another favored course. For the situation those updates contain new data the directing determination calculation will be executed once more.

Choosing what courses to forward or share depends in the financial advantages also, the arrangements between the ASes. The business strategies among ASes could be amazingly assorted and complex, however it is conceivable to improve the part of an AS in the financial connections in three kinds. An AS is a supplier on the off chance that it gets paid by another AS to travel information. An AS is a client in the event that it pays another AS to travel information. At last, an AS is an associate on the off chance that it travel information with another AS without charge.

2.2 Border Gateway Protocol (BGP)

BGP (Border Gateway Protocol) is protocol that manages how packets are routed across the internet through the exchange of routing and reachability information between edge routers. BGP directs packets between autonomous systems (AS) – networks managed by a single enterprise or service provider. While IPs are utilized to accommodate the particular recognizable proof of gadgets over the Internet, BGP is basic for correspondence in the system all in all, as it is the main convention that gives reachability and way data over the entire Internet.

Border Gateway Protocol (BGP) is the convention utilized for executing the interconnection between ASes on the Internet by giving systems to the trading of directing data (AS ways) between ASes. BGP additionally permits ASes to implement peering concurrences with neighboring ASes, deciding the best possible stream of movement amongst them, and subsequently executing the total structure of the Internet.

Internet BGP (iBGP) convention trades directing data inside an AS, while external BGP (eBGP) conventions accommodate the trades of directing data between neighboring ASes. The switches that exist at the edge between ASes must run both eBGP and iBGP, and are known as the border routers. Each outskirt switch has an immediate connect to another fringe switch in a neighboring AS. At the point when new reachability data is found inside an AS, or when promotions for new ways are gotten from neighboring ASes, this data is annexed to a table inside the switch (BGP tapble), and is engendered to neighboring ASes. Along these lines, ways for access to all parts of the Internet are shared over the system.

2.3 Internet Topology Measurement

Web topology estimations are produced careful either passive or active implies. Passive measurements are performed by estimating a system without creating any extra movement. Uninvolved estimation procedures maintain a strategic dis-tance from the likelihood of modifying activity information by not producing extra parcels on the deliberate organize. For instance, the Routeviews Project gathers information from BGP steering tables, which characterize how ASes are intercon-nected. Derivations can be made about the attributes and topology of a system by means of aloof estimations. Different strategies for detached estimation incorpo-rate apparatuses that use bundle sniffing strategies to catch organize information.

Passive Measurement techniques are utilized to assemble data by infusing testing movement into the objective system. Utilizing test parcels It is conceivable to get data about a system, for example, the quantity of hubs and edges it contains, the jump separate amongst hubs, and how hubs are between associated. It is additionally conceivable to discover attributes of examined gadgets, for example, have OS write, connect data transmission, what's more, their network.

2.4 Looking Glass Servers

A Looking Glass is a web-based portal running on a web server that allows ex-ternal users to get a look at routing and network behavior as it originates from the remote network. A looking glass accesses a remote router and performs ei-ther a ping, trace, or one of several show commands allowing a view of the IP and BGP route tables.The information is then returned as a web page. Looking Glasses are most commonly used for verifying routing between providers, and for verifying that routes are propagating correctly across the Internet. They are used to remotely access & view the information of routing or to look into the routing tables of Border Gateway Protocols. Therefore, we can say that Looking Glass (LG) servers are a real-time source of routing and BGP related information for network administrators. Looking Glass servers are deployed in different parts of the Internet and allow on-line checking of prefixes, collected from the BGP speaking routers. LGs make network administrators more effective during trou-bleshooting, helping them see their prefixes from the outside. In the second case, LG helps Internet users to understand how the BGP speaking routers interconnect Autonomous Systems (AS).

The importance of LG servers for AS topology construction has been highlighted in Collection of AS Level Topology using Looking Glass Servers [17]. In this research work, an application has been developed to automate the process of requesting/querying the LG servers, sequentially. Many LG servers do not entertain automated scripts/applications unless it is authorized by the relevant authorities like PCH (Figure 2.1). So to takeover such hindrances, we implemented different techniques that are mentioned in Methodology Chapter.

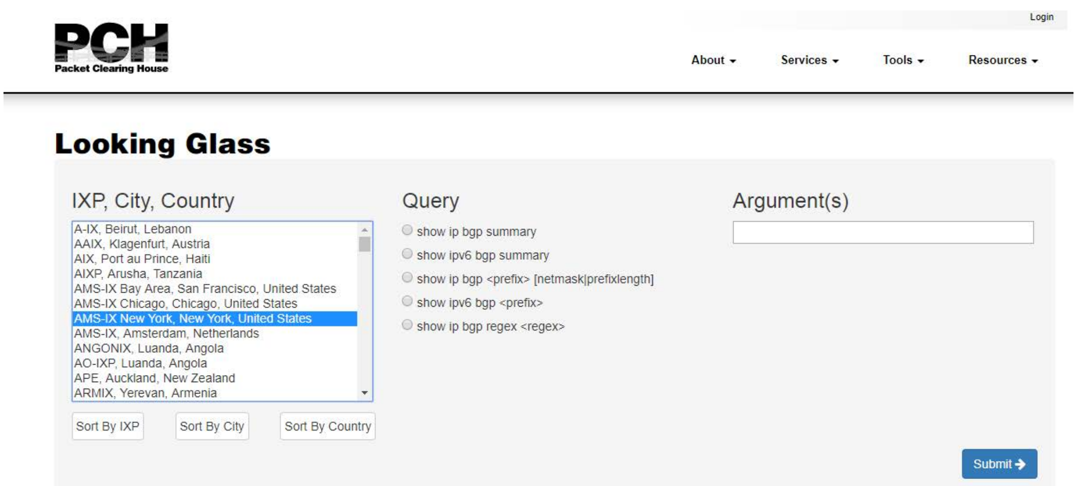

Figure 2.1: PCH Looking Glass Server

3 Proposed Methodology

In this research work, Looking Glass Servers would be used, managed by ISPs for the development of Autonomous System level topology for the collection of AS level topology.

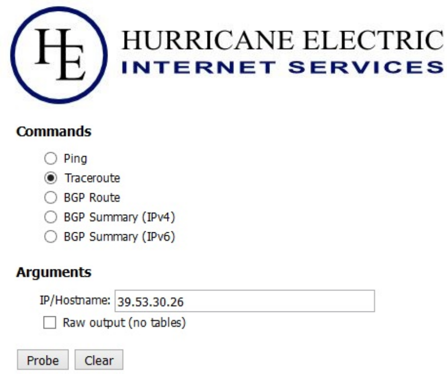

Figure 2.2: Example of LG Server: Hurricane Electric Looking Glass Server [2].

- Links between Autonomous Systems would be gathered using Looking Glass Servers that are running in various nations world-wide.
- Then, AS level topological-base will be designed using Looking Glass Servers.
- An application would be developed to mechanize the process of querying to multiple LG servers, simultaneously.
- The collected datasets using Looking Glass Servers would be analyzed in proportion of other datasets to enlighten the uniqueness and contributions of this research work.

4 Available Topologies/Datasets

There are many other Autonomous System level Topologies. Some of those are:

- Traceroute based Ark [1] iPlane [5]
- BGP based IRL [12]
- Internet Routing Registry based [3]

All the fore mentioned topologies collects there own datasets and construct topology on the basis of those. None of them uses the technique that is proposed in this document.

4.1 Ark

CAIDA Archipelago [1] portraits the topology of AS that is derived from traceroute based measurements.

4.2 iPlane

iPlane [5] service executes traceroutes from hundreds of PlanetLab locations daily to construct the topology of Internet.

4.3 IRL

UCLA IRL [12] extracts Autonomous System topology from the Border Gateway Protocol traces and regularly publishes it. These traces are shared by Internet2 [4], Packet Clearing House [7], RouteViews [9], RIPE-RIS [10].

4.4 IRR

It [3] is a system of distributed datasets and they contains IP Addresses and routing related information of Autonomous Systems.

5 Literature Review/Related Work

This section encapsulates the summary or review of the research papers that relates to the subject matter.

5.1 Comparative Research on Features of ASes [20]

In this study they thoroughly investigated six distinctive AS ranking schemes based on the topological features of the ASes:

- Degree of the Customer
- Degree of the Providers
- Degree of Peer
- Size of the Customer-Cone

- Centrality of Alpha
- Betweenness

They report fluctuating levels of agreement and contradictions among the positioning schemes and show that selecting multiple ranking schemes might be necessary to gain an assorted knowledge and diverse insight on the topology.

5.2 Modeling of AS Topology [18]

The aim of this paper is to build up a prediction model for Autonomous systems (ASes) Internet growth. The Border Gateway Protocol (BGP) is taken as signifi-cant source of data. RIBS that is raw data of BGP, collected from Project Archive of Route Views from Oregon Institute. Data from 2001 to 2009 are used in this study. Statistical methods are applied to analyze the collected data. A model is developed based on the outcome of the data analysis. It is found that the Internet growth follows Logistic Regression Model with a rate of growth equal 0.014. The link growth is also investigated and found to have followed an exponential pattern with a rate of growth equal 0.017.

In another research paper they examine the structure of Deep Web and explored that its structuring is genuinely inquisitive, depicted by non-homogeneous allotment of affiliation, scale free systems are there, very short path lengths and complex clustering, significantly small networks, and millions of greatly interconnected nodes are lacking. To again create such highlights, a design is proposed and a method is proposed to improve the security over the web, security of those topologies that are observed over the web. They discovered that its unconventional structure makes the deep web considerably much more versatile then the Internet.

5.3 Internet is an inter-connected ASes [19]

In this investigation, they initially portraits a scientific study of autonomous sys-tems (ASes) which is definite and compatible with the current AS-level structure of the Internet. At that time, they examine different classes of ASes to reveal in-sight on the complex structure of the Internet. They believe that their approach and findings will help telecom practitioners gain more insight into the structural and operational characteristics of the Internet and enhance their network infras-tructures.

They show a systematically tractable model of Internet development on Autonomous System level. This model is called as ”Multiclass Preferential Attachment” model (MPA). As its name is self explanatory, the model depends upon special connection. The greater part of its parameters are quantifiable from accessible Web topology information. Given the evaluated estimations of these parameters, our investigative outcomes foresee a definitive arrangement of measurements describing the AS topology structure. These measurements are not part of model detailing. The MPA show along these lines shuts the measure-model validate-foresee” circle, and gives additional proof that special connection is the fundamental main thrust behind evolution of the Internet.

In another work they contemplate the particular structure of the Internet router level chart in request to survey to what degree the Autonomous Systems fulfill a portion of the known ideas of group structure. They watch that a large portion of the traditional group identification techniques neglect to recognize the Autonomous Systems as groups, basically because of the particular structure of the Internet is considerably wealthier than what can be caught by enhancing a worldwide ASes got great structures, capabilities and regional occupation. Traditional strategies are extremely influenced by determination limits and by the complexity of the groups. They demonstrates that multi resolution strategies do discover the group structure of the Autonomous Systems. every one of them must be seen at the right determination level. Then they developed an algorithm that is used for modularity optimization in a scenario of low complexity multi resolution. Utilizing this strategy, they demonstrate that with a rare learning of the hub affiliations, multi resolution techniques can be changed in accordance to extract the AS. At last, they presented about formal work acknowledging the utilization of afore mentioned technique to find group topology in heterogeneous networks.

6 Conclusion

There are enormous other techniques for Internet Topology modeling, even on Autonomous System Level but they are said not to be absolute and we are confident that our proposed method of collecting Autonomous System level topology using Looking Glass Servers will prove to be effective, efficient, distinctive and will bring the expected useful results.

References

[1] Caida ark. [$http://www.caida.org/projects/ark$].

[2] Hurricane electric looking glass servers: [$https://lg.he.net/$].

[3] Internet routing registry [$http://www.irr.net/$].

[4] Internet2 [$https://www.internet2.edu/$].

[5] iplane: An information plane for distributed services. usenix nsdi, may, 2006.

[6] Looking glass servers: [$www.bgp4.as/looking-glasses$].

[7] Packet clearing house [$https://www.pch.net/$].

[8] Regional internet registries statistics: [$https://www-public.tem-tsp.eu/\ maigron/rir_stats/rir_delegations/world/asn-bynb.html$].

[9] Route views [$http://www.routeviews.org/$].

[10] Routing information service [$https://www.ripe.net/analyse/internet-measurements/routing-information-service-ris$].

[11] Sprint [$https://www.sprint.net/lg/$].

[12] Ucla irl, [$http://irl.cs.ucla.edu/topology$].

[13] Jose Carlos Acedo. Evolution of the internet topology from a regional perspective. 2015.

[14] Manlio De Domenico and Alex Arenas. Modeling structure and resilience of the dark network. *Physical Review E*, 95(2):022313, 2017.

[15] Enrico Gregori, Alessandro Improta, Luciano Lenzini, Lorenzo Rossi, and Luca Sani. On the incompleteness of the as-level graph: a novel methodology for bgp route collector placement. In *Proceedings of the 2012 ACM conference on Internet measurement conference*, pages 253–264. ACM, 2012.

[16] Akmal Khan, Hyun-chul Kim, Taekyoung Kwon, and Yanghee Choi. A comparative study on ip prefixes and their origin ases in bgp and the irr. *ACM SIGCOMM Computer Communication Review*, 43(3):16–24, 2013.

[17] Akmal Khan, Taekyoung Kwon, Hyun-chul Kim, and Yanghee Choi. As-level topology collection through looking glass servers. In *Proceedings of the 2013 conference on Internet measurement conference*, pages 235–242. ACM, 2013.

[18] Sami M Sharif and Hisham A Adam. Internet autonomous systems (ases) level topology modeling. *University Of Khartoum Engineering Journal*, 4(2), 2015.

[19] Mehmet Engin Tozal. The internet: a system of interconnected autonomous systems. In *Systems Conference (SysCon), 2016 Annual IEEE*, pages 1–8. IEEE, 2016.

[20] Mehmet Engin Tozal. Autonomous system ranking by topological characteristics: A comparative study. In *Systems Conference (SysCon), 2017 Annual IEEE International*, pages 1–8. IEEE, 2017.