Timelapse of AS-Level Topology Graphs Using BGP Advertisements

Sourabh Gawande, TSRK Prasad, Amrita Suresh, Neena Goveas and Bharat Deshpande,
Department of Computer Science & Information Systems
BITS Pilani - K K Birla Goa Campus, Goa, India - 403726

Abstract

The objective is to **create timelapse of AS-level topology graphs** using the BGP data archived by Route Views Project of University of Oregon. Such timelapses can be used as a **visualization aid to understand the dynamic nature of the Internet topology** over a period of time.

Introduction

An AS-level topology estimate can be derived from BGP routing tables. Each entry in a BGP routing table shows AS connectivity information.

```
TIME: 12/12/13 12:00:00
TYPE: TABLE_DUMP_V2/IPV4_UNICAST
PREFIX: 1.0.6.0/24
SEQUENCE: 3
FROM: 208.51.134.246 AS3549
ORIGINATED: 12/05/13 06:31:50
ORIGIN: IGP
ASPATH: 6939 4826 38803 56203
NEXT_HOP: 208.51.134.246
MULTI_EXIT_DISC: 13899
```

Fig. 1: A typical BGP path advertisement; ASPATH attribute is highlighted. The sequence of numbers shown are AS numbers.

With respect to Figure 1, an IP packet destined for 1.0.6.0/24 network shall traverse 6939 4826 38803 56203 ASes. Thus **ASPATH attribute implicitly lists AS connectivity information between adjacent ASes** mentioned in ASPATH. We use ASPATH attribute to generate the AS-level topology graph.

Graph Generation

We generate the AS-level topology graph by using the following BGP path transformations.

1. **Each AS number is treated as a node.**
2. **Any two adjacent nodes are connected by an undirected edge.**

A few problems arise because of *route leakages and path padding*.

- Route leakages occur when private AS numbers are seen in some path advertisements. **We eliminate private AS numbers and edges leading to these eliminated nodes**.
- AS_SET attribute summarizes AS paths.
- If advertised AS_PATH is 300 {200 100}, then undirected edges (300,200) and (300,100) are added to the AS-level topology graph. **We expand AS_PATH sets to separate AS paths**.

Graph Layout

A polar plot of AS-topology layout has been made by arranging all the AS nodes in concentric circles. The exact position of a node is described by ***(r, θ)***.

1. **Radius (r) of an AS is determined By**

$$r = 1 - \log\left(\frac{out-degree+1}{max\ out-degree+1}\right)$$

2. **Angle is obtained in one of two ways**.

(i) If **WHOIS databases of Regional Internet Registry (RIRs)** contain the physical address of AS, we map the address to the corresponding longitude coordinates. **OR**

(ii) Else we obtain the **longitude coordinates of IP prefixes owned by the AS** using Maxmind geolocation database and use their mean as representative location for AS.

The size of a node is a function of its out-degree. **The thickness of an edge is a function of degree of two nodes connected by that edge**. The small ISPs are connected in a tree-like topology with the large ISPs. Edges connecting to the access ISP nodes are thin as an indication of their relatively small node degree.

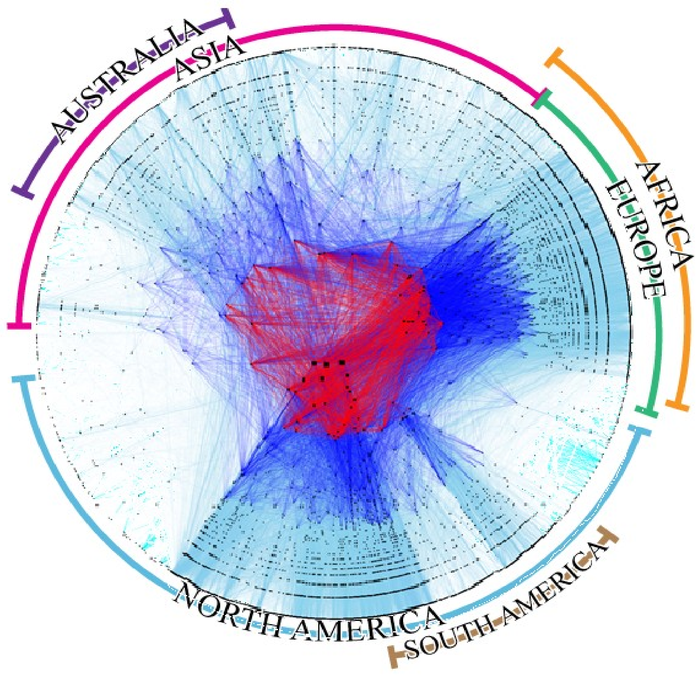

Fig. 2: AS-level topology generated using Route Views IPv4 BGP data snapshot taken at 01-January-2013 2:00AM.

Conclusions

- **Generation of CAIDA IPv4 AS core plot using only Route Views and Maxmind geoIP database**.
- **Dynamism in CAIDA IPv4 AS plot demonstrated using time lapse** of AS plot for the year 2013.
- **Created a database of ASN to geolocation mapping** using WHOIS database.
- **Proved densification of Ipv4 core (refer to Figures 3 and 4)**.

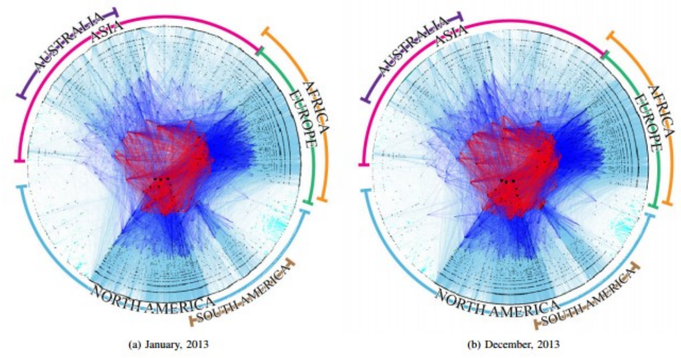

Fig. 3: AS-level topology graph generated using Route Views IPv4 BGP data dump taken at the beginning of two months in 2013. The connectivity among core ASes increased in December 2013 when compared with January, 2013. This change is reflected as increased density in the core of December 2013 graph.

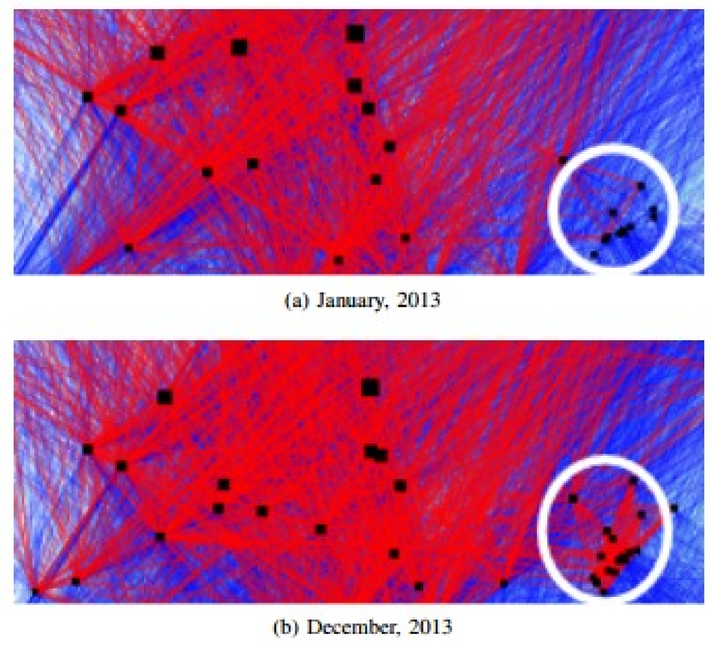

Fig. 4 : A slice of AS-level topology graphs 3. ASes in the encircled region show better connectivity in December 2013 when compared with January 2013.

Future Work

- **Reduce the time lapse generation time**
- **Reduce the granularity of time lapse from 2 hours to 15 minutes**
- **Create AS-level path trace for the Internet**

References

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