Modelling the interactions between the Internet backbone and the BGP network

Ivana Bachmann
NIC Labs, Universidad de Chile, Chile
ivana@niclabs.cl

Felipe Espinoza
NIC Labs, Universidad de Chile, Chile
fdns@niclabs.cl

Abstract

Given the importance of the Internet network in our society, it is relevant to understand its behaviour under adverse scenarios. The Internet can be studied through different angles: by studying the Border Gateway Protocol (BGP) network, the Internet Backbone, the complete physical network, etc. However, these networks do not exist in isolation, but rather interact with one another (see figure 1). Furthermore, the robustness behaviour of interacting networks is different compared to their single network counterpart. In particular, it has been shown that networks can be more fragile when coupled [BPP+10]. Indeed, the single network approach to study the Internet's behaviour has been criticized in the past by Willinger et al. [WR13] as it does not capture the whole behaviour of it. Thus, to properly study the Internet we should model it as an interdependent network system.

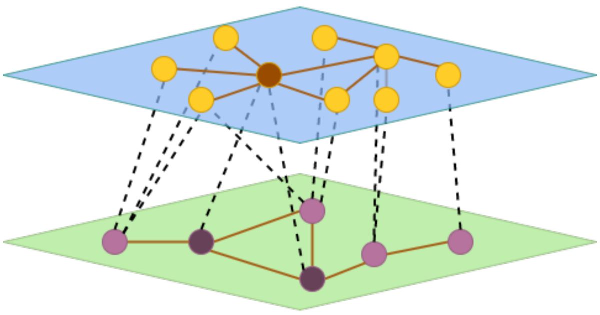

Figure 1: Interdependent networks example. Dotted lines represent interactions nodes of both networks.

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1 The Internet as an interdependent network system

An interesting approach, is to pair together the Internet Backbone and the BGP network, in order to analyze a physical-logical network pair. However, to the best of our knowledge, the articles applying interdependent networks models to study the Internet robustness, have not paired these two networks together [ZPC11, ATG16, ZZWY16, WKVM16]. Thus, the purpose of this ongoing study is to model the Internet as an interdependent network system composed by the Internet Backbone and the BGP network coupled together, and measure the Internet behaviour and robustness under adverse scenarios, such as failures, or attacks.

2 Initial approach

We have previously presented an initial model [BBJ17]. Here, we modelled the Internet Backbone using a modified version of the relative neighborhood model [WKVM16], and the BGP network was modelled using a Scale-Free network with an appropriate λ value [FFF99] as it has been widely used to model BGP networks. In our modified version of the relative neighborhood model, each node is allocated into a 2-dimensional space, and any two nodes, u and v, get to be connected if there is no other node in the intersection area of the circles centered at u and v, each of radius $d(u, v)$, where $d(u, v)$ is the euclidean distance between node u and v. This can be interpreted as follows: two nodes will get to be connected if there is no other node closer to them in-between them.

However, in this model the interconnections between both networks are established at random, and thus do not represent the actual network pairing nature of the Internet. In order to further develop this model, the relation between Internet Backbone nodes, and BGP nodes must be studied. Here, the hypothesis is that the number of Internet Backbone nodes interacting with a BGP node is proportional to the degree of such BGP node. To test this hypothesis, data has been collected to determine whether high degree nodes on the BGP network are coupled to a proportional number of nodes on the Internet backbone or not. As an initial approximation of the Internet Backbone, the localization of BGP nodes per country has been established. Thus, for the present work the hypothesis is that the number of countries in which BGP nodes have counterparts, is proportional to the degree of such node.

3 Data extraction

The information to determine the country localization of BGP nodes was obtained from the Routing Information Service (RIS) project from RIPE NCC [rip], and GeoLite2 geolocalization database [geo]. Here, the fAS prefixes obtained from the BGP routing tables were used to determine their geographical localization using GeoLite2. The router geolocalization obtained from this kind of database has been demonstrated to be precise enough to perform localization analysis [GSH+17].

To obtain the degrees for BGP nodes, we used BGP routes obtained from RIS project and Traceroutes from RIPE Atlas.

We used the data obtained in this stage was to get a first approximation about the relation of the BGP nodes degrees and the amount of physical counterparts of these nodes.

4 Results

From the data obtained we can observe that there is no correlation between the amount of countries in which a BGP node has physical counterparts, and the degree of said node. Indeed, the Pearson correlation coefficient of this data was of 0.23, showing the lack of correlation between the parameters studied. This can be further appreciated in figure 2.

These initial results show that in our initial model [BBJ17], the random coupling of both networks might be appropriate for modelling the Internet Backbone and the BGP network. However, we must note that the data used here to represent the Internet Backbone corresponds to an approximation using the number of countries in which a BGP node has physical counterparts, and therefore does not show the real amount of Backbone nodes coupled to each BGP node. Thus, to accurately determine the relation between the amount of Internet Backbone nodes interacting with a BGP node and the degree of said BGP node, we must determine the amount of Internet Backbone nodes associated to each BGP node within each country.

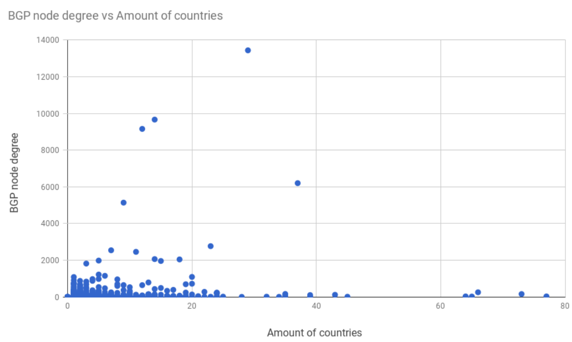

Figure 2: Each point represents a BGP node. For each node, we can see its degree versus the amount of countries in which that node has a physical counterpart.

5 Future work

As future work, we will study again the relation between the BGP node degree and the amount of Backbone nodes connected to said BGP node, this time looking for a non-linear relation. Also, further studies about the Internet Backbone, and the BGP network will be performed to continue the model development. In particular, this work will continue to research on data to determine a more precise approximation of Internet Backbone nodes. Once this work is completed, the possibility of adding other network infrastructures to the interdependent networks system model, that allow a better understanding of the Internet will be evaluated in order to improve the model.

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References

[ATG16] Abdulaziz Alashaikh, David Tipper, and Teresa Gomes. Supporting differentiated resilience classes in multilayer networks. In *2016 12th International Conference on the Design of Reliable Communication Networks (DRCN)*, pages 31–38. IEEE, 2016.

[BBJ17] Ivana Bachmann and Javier Bustos-Jiménez. Improving the chilean internet robustness: Increase the interdependencies or change the shape of the country? In *International Workshop on Complex Networks and their Applications*, pages 646–657. Springer, 2017.

[BPP+10] Sergey V Buldyrev, Roni Parshani, Gerald Paul, H Eugene Stanley, and Shlomo Havlin. Catastrophic cascade of failures in interdependent networks. *Nature*, 464(7291):1025–1028, 2010.

[FFF99] Michalis Faloutsos, Petros Faloutsos, and Christos Faloutsos. On power-law relationships of the internet topology. In *ACM SIGCOMM computer communication review*, volume 29, pages 251–262. ACM, 1999.

[geo] Geolite2 geolocalization database. `https://dev.maxmind.com/geoip/geoip2/geolite2/`. Accessed: 09-05-2018.

[GSH+17] Manaf Gharaibeh, Anant Shah, Bradley Huffaker, Han Zhang, Roya Ensafi, and Christos Papadopoulos. A look at router geolocation in public and commercial databases. In *Proceedings of the 2017 Internet Measurement Conference*, pages 463–469. ACM, 2017.

[rip] Ripe probes. `https://atlas.ripe.net/probes/`. Accessed: 09-05-2018.

[WKVM16] Xiangrong Wang, Robert E Kooij, and Piet Van Mieghem. Modeling region-based interconnection for interdependent networks. *Physical Review E*, 94(4):042315, 2016.

[WR13] Walter Willinger and Matthew Roughan. Internet topology research redux. *ACM SIGCOMM eBook: Recent Advances in Networking*, 2013.

[ZPC11] Xian Zhang, Chris Phillips, and Xiuzhong Chen. An overlay mapping model for achieving enhanced qos and resilience performance. In *Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT), 2011 3rd International Congress on*, pages 1–7. IEEE, 2011.

[ZZWY16] Qian Zhu, Zhiliang Zhu, Yifan Wang, and Hai Yu. Fuzzy-information-based robustness of interconnected networks against attacks and failures. *Physica A: Statistical Mechanics and its Applications*, 458:194–203, 2016.