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Improving Peering Interconnection Mapping from a Different Point of View

PhD Work Plan

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Porto Alegre
October 2018

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1 INTRODUCTION

Context. Peering infrastructures, such as colocation facilities and Internet Exchange Points (IXPs) are increasingly deployed all over the world, supporting a growing number of network members and peering interconnections (GIOTSAS et al., 2017). Colos are physical locations that provide essential infrastructure as power, space and supports interconnection of networks. IXPs are physical infrastructures and provide a shared switching fabric where participating networks can interconnect their routers. (GIOTSAS et al., 2015)

Brazil peering infrastructure maintains the largest set of public IXPs in a single country and is among the world's top ten IXPs in terms of traffic. (BRITO et al., 2016). Currently, there are 31 public IXPs deployed in all regions (IX. . . , 2018). Access to privileged data (i.e., flows samples and BGP information) of the major IXPs of the IX.br Project (e.g., IX-SP and IX-RS) leaves large room to explore measurement studies.

Investigate if leveraging IXPs as scalable vantage points, performing measurements campaigns from IXP to the outside Internet, and using available privileged data (i.e., flows samples and BGP information) can improve the interconnection mapping to facilities and create a broader, more accurate and scalable methodology which would be used to enhance network infrastructure and safety. Investigate if using IXPs as vantage points could improve the initial IXP/AS to facility mapping through measurements instead of relying on online resources (PeeringDB, IXPs/ASes websites). Looking Glass has some servers colocated with IXPs that can be used as vantage points. However, they are not scalable since they are not appropriate for scanning a large range of addresses due to probing limitations (GIOTSAS et al., 2015).

Motivation. Expand existing results would provide a more scalable and more accurate interconnection mapping which would help to pinpoint outages and attacks, troubleshoot network problems, track traffic flows and improve the resilience of interconnections more precisely.

Recent methodologies (GIOTSAS et al., 2015) provide accurate results but can not scale to large scenarios with several coloc, IXPs and ASes, given the large amount of active probing campaigns needed. The initial process of mapping networks, and IXPs to facilities is manual and time-consuming to be developed/updated. The work of (GIOTSAS et al., 2017) combines BGP communities with a colocation map to infer the location of outages. However, the map is done similarly as in (GIOTSAS et al., 2015). Besides, BGP communities have no standardized semantics and are only employed by half of the BGP paths announced on the Internet.

Expected contributions. We expect that leveraging IXPs as scalable vantage points, given their global role seeing traffic from a large fraction of the Internet (CHATZIS et al., 2013a), and using available privileged data (i.e., flows samples and BGP information) will enable higher visibility and knowledge about the geolocalization of peering interconnections, and will allow creating a broader and more accurate interconnection mapping to facilities.

Having a precise and scalable methodology to map peering interconnections to facilities could improve the understanding of interconnections efficiency (interconnection in different facilities in the same area could decrease the number of hops or latency) and level of peering interconnection redundancy.

Outline of the proposal. Chapter 2 provides background and terminology. Chapter 3 presents the state-of-the-art and the main related work. In Chapter 4, we present the proposal work. Chapter 5 provides the expected results and main contributions. In Chapter 6, we show the expected methodology, set of steps and schedule. Finally, in Chapter 7, we present the expected coursework of the Ph.D. course.

2 BACKGROUD

2.1 Peering Infrastructures

2.2 Colocations Facilities

(GIOTSAS et al., 2015; KOTRONIS et al., 2017)

2.3 Internet Exchange Points

(CHATZIS et al., 2013b; CHATZIS et al., 2015; INTERNET…, 2015)

3 RELATED WORK

Body of related work separeted in categories:

3.1 Peering infrastructures and operation

(AGER et al., 2012; RICHTER et al., 2014; CHATZIS et al., 2013a; BRITO et al., 2016)

3.2 Relationship between ASes

(GIOTSAS et al., 2014; GIOTSAS et al., 2015; LUCKIE et al., 2013)

3.3 Mapping of peering infrastructures

(AUGUSTIN; KRISHNAMURTHY; WILLINGER, 2009; NOMIKOS; DIMITROPOULOS, 2016)

3.4 Mapping interconnections to facilities

(GIOTSAS et al., 2015) propose an algorithm to infer the physical interconnection facility where an interconnection occurs among all possible candidates. Uses data from PeeringDB, PCH, IXP, ASes and Network Operating Centers (NOCs) sites and lists provided in regional consortia of IXPs to build an initial mapping between AS, IXP, and facilities. Measurements from RIPE Atlas, Looking Glass, iPlane and CAIDA Ark.

Methodology provides accurate results for the interfaces that resolve to a facility in a low number of iterations. Key insight is that the type of peering for an interconnection sufficiently constrains the number of candidate facilities to identify the specific facility where a given interconnection occurs.

Unable to scale to large scenarios involving several colocation facilities, IXPs, and ASes, given a large amount of active probing campaigns needed. Initial process of mapping networks and IXPs to facilities, required by the methodology, is extremely manual and time-consuming to be developed/updated. Methodology is very sensitive to missing or incorrect information and could yield inaccurate results.

The work of (GIOTSAS et al., 2017) combines location-tagging BGP Communities with a colocation map to infer the location of outages. Map is done similarly as in (GIOTSAS et al., 2015). BGP communities have no standardized semantics and are only employed by half of the BGP paths announced on the Internet, which could lead to an incorrect and incomplete view of the infrastructure.

4 PROPOSED WORK

Investigate if leveraging IXPs as scalable vantage points, performing measurements campaigns from IXP to the outside Internet, and using available privileged data (i.e., flows samples and BGP information) can improve the interconnection mapping to facilities and create a broader, more accurate and scalable methodology which would be used to enhance network infrastructure and safety. Investigate if using IXPs as vantage points could improve the initial IXP/AS to facility mapping through measurements instead of relying on online resources (PeeringDB, IXPs/ASes websites).

Data to be used. We can use data sources as PeeringDB, PCH, DataCenterMap, Inflect Data Center and Peering Mapping (https://inflect.com), IXP, ASes, and Network Operating Centers (NOCs) websites and lists provided in regional consortia of IXPs, as well as active measurements using the IXP as a vantage point to build a mapping between AS, IXP, and facilities.

We can use other vantage points as RIPE Atlas, Looking Glass (Periscope (GIOTSAS; DHAMDHERE; CLAFFY, 2016)), iPlane and CAIDA Ark to augment our mapping or to validate the mapping obtained from the IXP point of view.

We can use datasets of BGP to leverage the BGP Communities attribute and acquire accurate location information for about half of all BGP IPv4 updates as (GIOTSAS et al., 2017). We can use flow sample datasets from IX.br to investigate how many IXPs a given flow is traversing, infer and "see" from where traffic arrives, leaves, where it comes from. Also to obtain the ground truth of this IXP's public peering fabric, map MAC addresses to router IP addresses and their respective AS numbers (AGER et al., 2012) and information about how two parties of an IXP peering use that link and for what purpose (RICHTER et al., 2014).

Data processing and implementation Assuming that we will be dealing with a significant amount of data, the processing in the IXP would generate a considerable overhead and it may not have the necessary resources. The ideal would be to process all data in a cloud (e.g., Azure).

Risks and limitations. IXPs could show as a bad vantage point to improve interconnection mapping. Using few numbers of IXPs as VPs could provide inaccurate results given that their visibility, individually, may not perfect. The privileged data that we expect to use to improve/validate our methodology could not be useful. IXPs could not see a clear advantage of being used as VPs, even though they could use this "role" to obtain better information about their networks, validation of colocs connections, search for new colocs to connect, improve infrastructure planning.

Set of metrics. Number of peering interfaces inferred. Fraction of resolved interfaces when dealing with less vantage points used. Fraction of unresolved interfaces with when removing facilities information. Fraction of ground truth locations that match inferred locations. (GIOTSAS et al., 2015). Number of peering interfaces inferred by one IXP. Error probability of inferred location.

Validation. We can validate our results both getting direct feedback from ASes, IXPs and network operators as using other information sources as BGP communities.

5 EXPECTED RESULTS

5.1 Main Contributions of the Thesis

The following contributions are expected with the development of the proposed work:

1. Analysis of the potential of Internet Exchange Points to be used as scalable vantage points and improve the mapping of peering interconnection to facilities, as well as its strengths and limitations;
2. Formalization of a methodology to improve the mapping of peering interconnections by exploiting the characteristics of the Internet Traffic Exchange Points, introducing new datasets and scalability;
3. Development of a prototype of the proposed methodology, allowing its applicability in practical situations and the development of new researches.

5.2 Publications

Table 5.1: Journals related to PhD

Journal	**Impact Factor**	**Qualis**
ACM CCR		A1
Communications of the ACM		A1
IEEE/ACM Transactions on Networking		A1
Elsevier Computer Networks		A1

Table 5.2: Conferences related to PhD

Conference	Acceptance Rate	H-index	Qualis 2016
ACM Internet Measurements (IMC) Conference	24.7%		A1
Network Traffic Measurement and Analysis Conference (TMA)	39.2%		
Passive and Active Network Measurement Conference (PAM)	40.8%		A2
ACM Special Interest Group on Data Communication (SIGCOMM) Conference	18%		A1
ACM International Conference on emerging Networking EXperiments and Technologies (CoNEXT)	17.2%		A1
IEEE Conference on Computer Communications (INFOCOM)	20.9%		A1
USENIX Symposium on Networked Systems Design and Implementation (NSDI)	15.4%		A1

6 METHODOLOGY

6.1 Set of Steps

1. **Evaluation of state-of-the-art**: In-depth state-of-the-art study about Colocation Facilities, Internet Exchange Points, and the existing methodologies to map peering interconnections. Identify characteristics and limitations of each related work and understand better how IXPs can be leveraged as scalable vantage points to improve interconnection mapping to facilities;
2. **Preliminary modeling**: in this step, we will model a methodology capable of using IXPs as scalable vantage points and improve interconnection mapping to facilities;
3. **Preliminary evaluation**: preliminary evaluation of the previously proposed methodology, using small-scale measurements campaigns and a subset of the available data to obtain validation.;
4. **Prototype development**: in this step, a prototype of the proposed methodology will be developed to perform the experimental evaluation. The objective will be to create a scalable product to be used in IXPs environments;
5. **Experimental Evaluation**: final step of the study, including large-scale evaluation, composed of campaigns of measurements and data collection, to evaluate and validate the effectiveness of the developed methodology.

6.2 Schedule

1. In-depth state-of-the-art study about Colocation Facilities, Internet Exchange Points, and the existing methodologies to map peering interconnections;
2. Modeling of a methodology capable of using IXPs as vantage points and improve interconnection mapping to facilities;
3. Qualification Exam;
4. Examination of proficiency in a foreign language;
5. Preliminary evaluation of the previously proposed methodology, using small-scale measurements campaigns and a subset of the available data to obtain validation and identify main attributes and limitations;
6. Period reserved for doctorate sandwich;

7. Review and reassessment of the model in order to improve the initial modeling based on the results obtained in the performed evaluations;
8. Definition and design of the experimental evaluation;
9. Experimental evaluation of the proposed methodology;
10. Thesis Proposal Defense;
11. Improvement of the methodology considering the results obtained in previous activities, also considering contributions and recommendations of the evaluation committee of the thesis proposal;
12. Thesis writing;
13. Thesis defense;
14. Participation in conferences and symposia related to the theme of the thesis;
15. Writing and submitting articles for conferences and periodicals based on the results obtained during the studies and evaluations, related to the theme of this doctoral proposal.

Table 6.1: Schedule of activities during the doctoral period

Activities	2019/1	2019/2	2020/1	2020/2	2021/1	2021/2	2022/1	2022/2
1	■	■						
2		■	■					
3		■						
4		■						
5			■	■				
6			■	■				
7				■				
8				■	■			
9					■	■		
10						■		
11						■	■	
12				■	■	■	■	
13								■
14	■	■	■	■	■	■	■	■
15	■	■	■	■	■	■	■	■

6.3 Collaboration

joint work with UCSD. expands existing relationship. Second year of PhD expected to be located at CAIDA/UCSD. Funding to be determined.

7 COURSEWORK

This chapter presents the expected coursework to be taken in PhD course. Table 7.1 shows the courses and the number of credits that will be taken during the PhD. All courses sums a total of 20 credits, agreeing with the minimum required for the PhD.

Table 7.1: Courses to be taken in PhD

Code	**Period**	**Period**	**Credits**
CMP410	Teaching Practice I	2019/1	1
CMP230	Computer System Security	2019/1	4
CMP182	Computer Network	2019/1	4
CMP411	Teaching Practice II	2019/2	1
CMP267	Novel Internet Architectures and Paradigms	2019/2	4
CMP223	Computer System Performance Analysis	2019/2	4
CMP600	Qualification Exam	2019/2	2

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