

Internet Routing Policies Verification Method Based On AS Relationships

Zhai Peng

Department of Computer Science and Technology
University of Jining
Qufu, China
e-mail: sinomcse@hotmail.com

Qi Lu

Department of Computer Science and Technology
University of Jining
Qufu, China
e-mail: zbzx@jnxu.edu.cn

Zhang Liping

Department of Computer Science and Technology
Shandong Yankuang Technician Institute
ZouCheng, China
e-mail: 6232908@qq.com

Luo Feng

Department of Computer Science and Technology
University of Jining
Qufu, China
e-mail: luof@hotmail.com

Abstract—The type of business relationships between the Internet autonomous systems (AS) determines the BGP interdomain routing. Previous works on inferring AS relationships relied on the connectivity information between ASes. In this paper we thoroughly investigate the route policy between ASes, then present a method that can conduct new policies. On the basis of that, we also present a method of between AS policies verification based on AS relationships. Through this method we can find out the abnormal prefix advertise to verify the route policies. We accumulate BGP data from RouteViews, RIPE RIS and the public Route Servers in January 2013 and February 2014. Based on the routing policies extracted from data of the two BGP attributes, we obtain AS relationships for 41% links in our data, which include all links among the Tier-1 ASes and most links between Tier-1 and Tier-2 ASes. We took an experiment for our method between two ASs in AT&T, and the results are good.

Keywords—BGP; AS Relationship; Routing Policies; measurement; Policy Verification

INTRODUCTION

In the last two decades there has been a great effort in studying the Internet topology at the autonomous systems (AS) level. A number of topology datasets were collected, various topological properties were discovered and a number of network models were proposed [1], [2], [3], [4], [5].

The BGP (Border Gateway Protocol) protocol is widely used among ASs in the wide area network. A key characteristic of the BGP protocol allows AS to use different routing strategies to control the choice of the path and transmit the information of the path to other AS. The stability of Internet depends on to a large extent the stability of the BGP routing.

Internet research and engineering demand data and knowledge on both the AS topology and the AS

relationships. For business reasons, ASes do not want to disclose their relationships. In the last decade a number of algorithms have been proposed to infer AS relationships based on the AS topology data [6], [7], [8], [9]. Since the topology data only contain the connectivity information between ASes, these algorithms had to use various heuristics. The quality of their results have been questioned.

At present, the research of the BGP mainly concentrates on the BGP behavior analysis, the validation of the network protocol and the improvement of the router configuration. But few study the routing policy validation. Feamster analyzes configuration commands of router in the AS and verifies the Internet routing in the simulation method. This method has great limitation, and can't truly reflect the behavior among the AS. The concrete reflection among the AS is the prefix that the AS announces to the neighbor AS, so we propose a new method that the comparison achieves the purpose of the policy validation between the prefix of the collected As and the prefix of the default declaration according to the relationship among the AS.

THE POLICY ANNOUNCED PRINCIPLE AND THE EXPORTED POLICY DEDUCTION

According to the commercial contract, there are the different types of service relationships among AS that are the main basis for determining the route policy.

the AS relationship

In the Internet, the AS relationships are divided into three forms: provider - customer, peer - peer, and Sibling relationship. Internet inter-domain routing is a collaborative effort between ASes, which interconnect and exchange routing information using the BGP protocol. ASes negotiate contractual agreements to define their business relations and impose technical restrictions on

traffic exchange. On the Internet, connectivity does not imply traffic reachability, which is fundamentally determined by the business relationships between ASes. The AS business relationships are coarsely divided into three categories.

1) *Transit relationship, including customer-to-provider (c2p) and provider-to-customer (p2c). It is established when an AS (customer) pays a better-connected AS (provider) to transit traffic with the Internet.*

2) *Peering relationship, or peer-to-peer (p2p), which allows two ASes to freely exchange traffic between themselves and their customers to avoid the cost of sending traffic through a provider.*

3) *Sibling relationship, which allows two ASes (usually under the same administration) to freely exchange traffic without any cost or routing limitations.*

BGP routes are usually exported following the so-called valley-free rule [6], i.e. a customer route can be exported to any neighbour, but a route from a peer or a provider can only be exported to customers. Hence, a path (of a series of adjacent AS links) is valley-free if it follows such patterns: (1) $n \times c2p + m \times p2c$; or (2) $n \times c2p + p2p + m \times p2c$; where n and $m \geq 0$. The sibling links can be inserted freely without changing the valley-free property of a path.

The valley-free rule describes a typical routing path that is valid for inter-domain routing. Most valid routing paths are valley-free because they comply with the business interest of ASes, i.e. to minimize operation cost and maximize revenue. It should be noted that the valley-free rule is not an enforcement rule. It is observed that a small number of routing paths do not follow this rule.

Most ASes try to hide their business relations. In the last decade researchers have introduced a number of algorithms to infer the AS relationships [6], [7], [8], [9], [10], [11], [12], [13]. These algorithms have produced conflicting results. BGP simulations using such data have produced poor results [14], [15]. If an AS provides Internet connection to another AS, this AS relationship is called providers - user relationship. If a pair of AS provide the connectivity to their respective users, this AS relationship is called peer - peer relationship [15], [16].

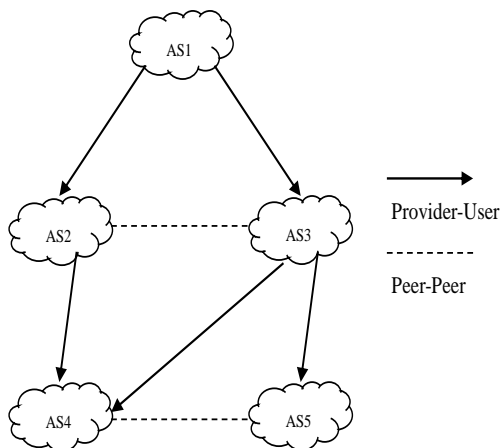


Figure 1. BGP topology With the AS relationship

In the above example, the AS2 is the AS4 providers, the AS4 is the AS2 user, the AS2 and the AS3 are the peer relationship.

Our research mainly relies on the relationship among the AS. Some algorithms can infer the AS relationships from the BGP routing table. Here, we choose the LiXin Gao algorithm [6], this algorithm has been shown to infer the correct rate of the AS relationship can reach 99.1%. This algorithm is used in the AS graphs with the relationship mentioned in the following algorithm.

The policy announced principle based on AS

The BGP router spreads the best path to its neighbors AS. The export policy allows the router to decide whether or not to declare the best path to its neighbors.

The following is the widespread BGP route export policy:

- Exporting to providers: users export the routing of its own and what learn from its users to providers, but don't export the routing that learn from other providers or peers.
- Exporting to users: providers export its routing to its users, and this routing information learns from other user, provider and peers.
- Exporting to peers: peers export its routing to its peers, and this routing comes from its users, but can't come from its providers and other peers.

the exported policy deduction

For users with multiple providers, the export policy of users to providers is more complicated. Through a lot of our monitoring studies, most users choose one of the routing as the optimal route, and the other as a backup route. In this section, we give a method to find how to declare the prefix to its providers, when users have multiple providers.

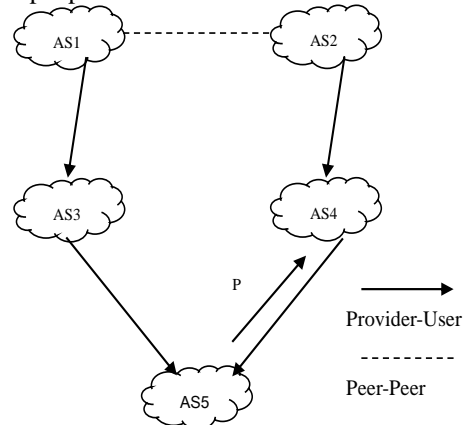


Figure 2. The propagation of the indirect declared prefix

The export policy of the most direct inferring users is that the BGP routing tables are used from its providers. We search the prefix from the users in BGP tables of the provider. If the prefix comes directly from users of providers, it indicates that the user exports the prefix to the provider. Conversely, those prefixes don't exist or don't directly come from its user, but come from its peers or providers, it indicates that the user don't directly export this prefix to the provider.

Therefore, we can infer the user's export policy from the provider. We have mentioned that the user can export the prefix to all providers or providers' subset. For a given provider, if this provider receives a prefix from its user through its peer path instead of the path of its user, we call this prefix the indirect declared prefix. For example, in Fig.2, the user AS5 exports the prefix p to AS4, a subset of the provider. In the BGP table of AS1, the prefix p is from its peer AS2, and not from its user AS3, which is called the indirect declared prefix. We know that the routing from the subscriber is better than other routing. In the BGP table of the provider, if the route of a prefix user exists, the route is a best routing. If the user route does not exist, the best route is the peer or the provider routing.

Algorithm for inferring export policy to providers

Input:

an annotated AS graph G

a set of Prefix {P} originated by an AS o

the as_path of each prefix by an AS u

Output:

export policy of AS o

Phase1: Initiation

selected node set $S = \{u\}$

selected as_path set $T = \{e\}$

Phase2: Investigate if AS o is a customer of AS u

while there is a selected node

for each node v that is a customer of the

selected node

if v is the node o

o is a customer of u

go to Phase3

else add v into S

node o is not a customer of u

return

Phase3: find the route of AS o to AS u

for each prefix f originated by AS o

if the prefix's as_path isn't in T

add the as_path into T

else the number of the as_path of T

increase by 1

if the maximal element e of T

the as_path e is AS o's export route

The first step of the algorithm is to find whether a AS is the user of the specified provider. This problem can use the Depth First Search (DFS), finding the route from the user in the directed graph. If there is one user path from this AS to the provider, it is the user of the provider.

Next, we count the number of the different as_path to a particular user AS prefix in the provider BGP routing table. Then the as_path of the largest path number is the optimum route which the user export to the provider.

ROUTING POLICY VERIFICATION ALGORITHM BASED ON THE AS RELATIONSHIP

The paper adopts the routing policy configuration principle based on AS as the basis of the routing policy verification. Comparing with the actual routing policy configuration, it identify the inconsistencies of the declared prefix, and find the potential errors declaration.

The steps of the algorithm are:

1) infer the declare sets of the prefix(Inferprefixset) based on AS relationship

2) realprefixset, the prefix set of the actual declaration
3) compare Inferprefixset and Realprefixset, and finding potential errors declaration.

VERIFICATION EXPERIMENT

Experiment data acquisition

The analysis data is from the RIS project of the RIPE NCC. The purpose of the project is the collection of the BGP routing information in some of the main switching node of the Internet, and data are stored in the database, so that network operators can analysis data and find the routing problem. There are 12 data collection points, distributing in Europe, North America and Asia.

The routing information collector run the route management software, GNU-Zebra, establish BGP peer relationship with ISP or backbone node routers, and collect BGP UPDATE messages from the peer routers and BGP routing tables.

4.2 Experiment

It is very difficult that judging a AS declaration is an error. The best way is to ask your network administrator. Ratul Mahajan has counted the routing update information from 23peers of 19 Ass of route-views2.oregon-ix.net. He categorizes those update information according to time, and verifies these routing update information by e-mail. Here we select data for the same time period in order to use his results. We select AT&T AS7018 and AS701.

TABLE I. Policy verification between AS7018 and AS701

ITEM	NUMBER
Quality of prefix in the Inferprefixset(AS7018 should declare AS701)	23395
Quality of prefix in the Realprefixset(AS7018 to AS701)	23609
Quality of the potential error declarations(quality of actual declaration prefix number not in the Inferprefixset)	227
Quality of Ratul,M verification in the potential error declarations	127
Quality of the confirmed error declaration in the potential error declarations	107

By TableI, in the declarations of Ratul, M, we have discovered 84.3% mistaken declaration to use our policy verification method, which achieves good results. At the same time, we find that there are a lot of the error declarations of AS, probably accounting for 0.96% of all declared prefix. It illustrates further that the AS routing policy validation is necessary.

SUMMARY

With the popularity of the network, people become increasingly dependent on the internet. How to ensure the stability of the internet is an important task in the face of network managers. It has been found that AS's prefix declaration always follows the AS relation principle according to a large number of studies. We take this principle as the basis of the routing strategy verification. Comparing with actual AS outward declared prefix is found the inconsistency of the prefix, realizing the routing strategy validation. As far as we are concerned, this is the first time to put forward AS routing strategy verification method by analyzing the actual routing information. This method is very good to find the non-conformant routing policy declaration, and proves that most declarations are wrong by verification. Network managers can find potential errors declarations by this way, avoiding network fault to generate.

ACKNOWLEDGMENT

This work was financially supported by the third batch science and technology plan fund of the education department of shandong province(J08LJ56) "network measurement research based on network behavior"and "worm detection and control based on network behavior" of the Jining science and technology development project.

REFERENCES

- [1] R. V. Oliveira, B. Zhang, and L. Zhang, "Observing the evolution of internet AS topology," *SIGCOMM Comput. Commun. Rev.*, vol. 37, no. 4, pp. 313–324, 2007.
- [2] M. Roughan, S. J. Tuke, and O. Maennel, "Bigfoot, sasquatch, the yeti and other missing links: what we don't know about the as graph," in *Proceedings of the 8th ACM SIGCOMM conference on Internet measurement*, ser. IMC '08. New York, NY, USA: ACM, 2008, pp. 325–330. [Online]. Available: <http://doi.acm.org/10.1145/1452520.1452558>
- [3] A. Dhamdhere and C. Dovrolis, "Twelve years in the evolution of the internet ecosystem," *Networking*, IEEE/ACM Transactions on, vol. PP, no. 99, p. 1, 2011.
- [4] B. Donnet and T. Friedman, "Internet topology discovery: A survey," *Communications Surveys Tutorials*, IEEE, vol. 9, no. 4, pp. 56–69, quarter 2007.
- [5] S. Zhou and R. Mondragon, "The rich-club phenomenon in the internet topology," *Communications Letters*, IEEE, vol. 8, no. 3, pp. 180–182, march 2004.
- [6] L. Gao, "On inferring autonomous system relationships in the internet," *IEEE/ACM Trans. Netw.*, vol. 9, no. 6, pp. 733–745, 2001.
- [7] L. Subramanian, S. Agarwal, J. Rexford, and R. H. Katz, "Characterizing the internet hierarchy from multiple vantage points," in *In Proc. IEEE INFOCOM*. Berkeley, CA, USA: University of California at Berkeley, 2001.
- [8] X. Dimitropoulos, D. Krioukov, M. Fomenkov, B. Huffaker, Y. Hyun, k. claffy, and G. Riley, "AS relationships: inference and validation," *SIGCOMM Comput. Commun. Rev.*, vol. 37, no. 1, pp. 29–40, 2007.
- [9] W. W. B. Z. L. Z. Ricardo Oliveira, Dan Pei, "Quantifying the completeness of the observed internet AS-level structure," *UCLA Computer Science, Tech. Rep. TR-080026*, 2008. [Online]. Available: <http://fmdb.cs.ucla.edu/Treports/TR080026.pdf>
- [10] J. Xia and L. Gao, "On the evaluation of as relationship inferences [internet reachability/traffic flow applications]," in *Global Telecommunications Conference, 2004. GLOBECOM '04*. IEEE, vol. 3, nov.-3 dec. 2004, pp. 1373–1377 Vol.3.
- [11] T. Erlebach, A. Hall, and T. Schank, "Classifying customer-provider relationships in the internet," in *IASTED International Conference on Communications and Computer Networks*. Cambridge, Massachusetts, USA: ACTA, November 2002.
- [12] G. D. Battista, M. Patrignani, and M. Pizzonia, "Computing the types of the relationships between autonomous systems," in *IEEE INFOCOM 2003 - IEEE International Conference on Computer Communications*, March 2003, pp. 156–165.
- [13] U. Weinsberg, Y. Shavitt, and E. Shir, "Near-deterministic inference of AS relationships," in *INFOCOM'09: Proceedings of the 28th IEEE international conference on Computer Communications Workshops*. Piscataway, NJ, USA: IEEE Press, 2009, pp. 377–378.
- [14] W. Mühlbauer, A. Feldmann, O. Maennel, M. Roughan, and S. Uhlig, "Building an AS-topology model that captures route diversity," in *Proceedings of the 2006 conference on Applications, technologies, architectures, and protocols for computer communications*, ser. SIGCOMM '06. New York, NY, USA: ACM, 2006, pp. 195–206.
- [15] W. Mühlbauer, S. Uhlig, B. Fu, M. Meulle, and O. Maennel, "In search for an appropriate granularity to model routing policies," *SIGCOMM Comput. Commun. Rev.*, vol. 37, pp. 145–156, August 2007.
- [16] V. Giotsas, S. Zhou, M. Luckie, and k claffy, "Inferring Multilateral Peering ," *Proceedings of the 9th International Conference on emerging Networking EXperiments and Technologies (ACM CoNEXT)*, pp. 247–258, December 2013
- [17] M. Luckie, B. Huffaker, k. claffy, A. Dhamdhere, and V. Giotsas, "AS Relationships, Customer Cones, and Validation," In *IMC '13*, pages 243–256, 2013.