DYNAMIX: A Dynamic Agreement Marketplace on Internet eXchange Points

Pedro de B. Marcos
UFRGS and FURG, Brazil

Alexandre G. Wermann
UFRGS, Brazil

Marinho P. Barcellos
UFRGS, Brazil

Leandro Bertholdo
IX.BR and RNP, Brazil

ABSTRACT

Internet eXchange Points (IXPs) play a central role on the Internet topology. Their increasing popularity is directly related to the business relationships between Autonomous Systems (ASes), which are interconnecting through IXPs to reduce transit costs and shorten paths. Nevertheless, establishing agreements between ASes continues to take days or weeks, limiting the ability to respond to changes in the topology or loads. Additionally, their prices do not reflect fluctuations of link offer-demand, resulting in long-term contracts with over-provisioned links. We propose leveraging the characteristics of IXPs as the foundation of DYNAMIX, a dynamic agreement marketplace.

1. INTRODUCTION

Context. IXPs play a central role on the Internet topology. Large IXPs interconnect more than 800 ASes and are responsible for exchanging, on average, more than 3 Tbps, a volume similar to a tier-1 provider [1]. Their increasing popularity is directly related to the business relationships between ASes, which are interconnecting through IXPs to reduce transit costs and shorten paths.

Motivation. Despite advances brought about by IXPs, the way ASes establish their business relationships remains unaltered. Agreements have a static nature, take days or weeks to be settled, and limit the ability to respond to changes in the topology or loads. Additionally, link prices do not reflect fluctuations between offer and demand, resulting in long-term contracts with over-provisioned links [9]. Over-provisioning a contract leads to unnecessary costs and resource sub-utilization. The introduction of dynamic agreements gives a new perspective on the business relationships between ASes.

Proposal. Considering the IXP characteristics and the recent advances promoted by SDX (Software Defined eXchange) [7], we propose leveraging IXPs as the foundation of DYNAMIX (Dynamic Agreement Marketplace on Internet eXchange points). Our goal is to provide a marketplace where ASes can advertise agreement proposals, query advertisements, and establish contracts in much shorter time frames. The advertisements contain information related to economics, policy, technical and time aspects. These elements allow the representation of the current contracts while providing the flexibility to create new arrangements.

Expected benefits. (i) Dynamism: Internet traffic patterns are known to have peaks and valleys. The contracts, however, are settled considering the peak demands, leading both sides of the relation to having idle resources. The marketplace allows an AS to establish short-term agreements and vary its prices based on different criteria, such as the period of the day, demands, the current load of its infrastructure, and the existence of similar offers. This dynamism benefits ASes that are facing unplanned scenarios, such as flash crowds. A content provider experiencing congestion to a particular AS can query the marketplace to establish a temporary agreement to reduce the transient congestion. Also, a short-term contract can be settled for a planned traffic increase, such as the ones caused by software and game releases. (ii) New types of agreement: the rich environment of IXPs combined with the dynamism allowed by a marketplace will provide a suitable scenario for the creation of new kinds of settlements. One possibility is reselling unused capacity. (iii) Disputes: conflicts between ASes have become more common on the Internet and may lead to the segmentation of the network. The underlying causes of conflict are related to application demands and the static nature of the agreements between ASes. Our marketplace can provide alternatives to mitigate these scenarios through the establishment of flexible settlements.

Related work. Previous work [2, 3, 8, 10–12] has struggled to find ways to provide more dynamism to the relationships between ASes. We contribute to this line of research by providing an approach with large potential for implementation.

2. DESIGN

Overview. Coined DYNAMIX, the approach consists of two components, namely the marketplace and the announcers, located respectively at the IXP and at each participant AS (market membership is optional).

The marketplace is responsible for storing advertisements received from announcers and replying to queries from ASes. Announcers are responsible for creating advertisements, requesting existing ones from the marketplace, and establishing contracts with other announcers. Figure 1 presents an overview of our approach.

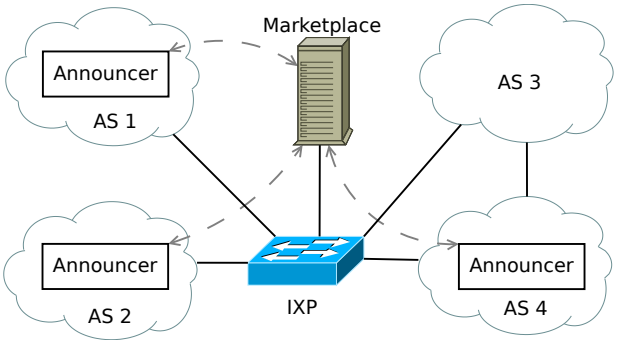

Figure 1: DYNAMIX overview.

Advertisements. Our proposal provides to IXP members an advertisement system to assist in finding an agreement matching their requirements. Each advertisement has a set of destinations and is composed of four dimensions. The *economics* attributes define the cost of the agreement, which can be expressed through a function (e.g., bandwidth per time). The *technical* dimension contains information relative to bandwidth and latency. *Policies* are expressed through a list of ASes included in the paths to the announced destinations. Finally, the *time* dimension includes the duration of the agreement, which can be a period or a traffic threshold, and the offer expiration.

Operations. The announcer can perform four different operations: *create, update, query*, and *propose*. The first two are used to create an advertisement and to update information about a particular offer, respectively. The *query* operation is used to find contracts according to a filter, while the *propose* message starts the establishment of a contract between the ASes.

A simple use case. The process begins with an AS (AS1) publishing an advertisement on the marketplace. After some time, another AS (AS2) queries the marketplace for offers matching some criteria. If the market contains offers corresponding the specified criteria, it will return a list of offers to the AS. Otherwise, it will return a message informing that no offer matches the informed criteria. Assuming that a list was returned, the AS2 can choose among one of the current offers. Supposing that the advertisement from AS1 is selected, the AS2 will send a *propose agreement* message to AS1. Two scenarios can be derived from here: (a) if the AS1 accepts the agreement with AS2, both ASes will update their policy information and AS1 may update the offer in the marketplace; (b) otherwise, if AS1 refuses the agreement (e.g. if the offer became invalid because AS1 already settled with another AS a contract related to the offer), AS2 may query the marketplace again to find another advertisement. Figure 2 presents the establishment of an agreement.

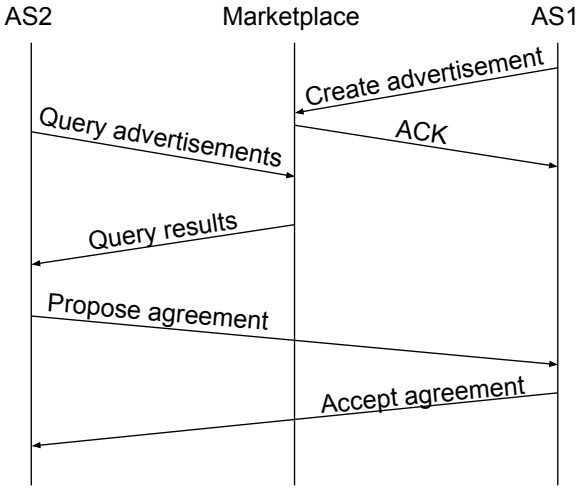

Figure 2: Establishment of an agreement.

A more complex example. The marketplace allows the development of more complex negotiations. Our approach can be used to establish agreements based on a bidding process in two different scenarios: (a) when an AS has a limited capacity available and seeks to maximize its profits; (b) when an AS wants to settle an agreement minimizing its costs. In both cases, the marketplace acts as the coordinator of the process.

3. FINAL REMARKS

The business relationships between ASes evolved and made the Internet topology flatter [4,5]. In this position paper, we provide a preliminary proposal to leverage IXPs to make agreements between ASes more dynamic. Since 1% of existing IXPs concentrate 40% of the Internet prefixes (and 91% if we consider prefixes located at most one hop from the IXPs) [8], changes in a few IXPs could benefit a significant portion of the Internet.

The next step in our research will be to evaluate the benefits of the dynamism and the involved costs, such as the impact on the Internet stability and the privacy aspects regarding ASes policies. We envision the Internet with automated agents interacting on the marketplace to establish the most valuable agreements for their ASes. We intend to propose and evaluate strategies to explore the new possibilities created by DYNAMIX. Finally, we plan to integrate our marketplace with iSDX [6] and to consider the operational issues of deploying dynamic agreements on IXPs.

4. REFERENCES

[1] Ager, B., Chatzis, N., Feldmann, A., Sarrar, N., Uhlig, S., and Willinger, W. Anatomy of a large european ixp. In *Proceedings of the ACM SIGCOMM 2012 Conference on Applications, Technologies, Architectures, and Protocols for Computer Communication* (New York, NY, USA, 2012), SIGCOMM '12, ACM, pp. 163–174.

[2] Akella, A., Chawla, S., Esquivel, H., and Muthukrishnan, C. De-ossifying internet routing through intrinsic support for end-network and isp selfishness. In *Proceedings of the ACM SIGMETRICS Joint International Conference on Measurement and Modeling of Computer Systems* (New York, NY, USA, 2011), SIGMETRICS '11, ACM, pp. 145–146.

[3] Castro, I., Panda, A., Raghavan, B., Shenker, S., and Gorinsky, S. Route bazaar: Automatic interdomain contract negotiation. In *Proceedings of the 15th USENIX Conference on Hot Topics in Operating Systems* (Berkeley, CA, USA, 2015), HOTOS'15, USENIX Association, pp. 9–9.

[4] Chiu, Y.-C., Schlinker, B., Radhakrishnan, A. B., Katz-Bassett, E., and Govindan, R. Are we one hop away from a better internet? In *Proceedings of the 2015 ACM Conference on Internet Measurement Conference* (New York, NY, USA, 2015), IMC '15, ACM, pp. 523–529.

[5] Dhamdhere, A., and Dovrolis, C. The internet is flat: Modeling the transition from a transit hierarchy to a peering mesh. In *Proceedings of the 6th International COnference* (New York, NY, USA, 2010), Co-NEXT '10, ACM, pp. 21:1–21:12.

[6] Gupta, A., MacDavid, R., Birkner, R., Canini, M., Feamster, N., Rexford, J., and Vanbever, L. An industrial-scale software defined internet exchange point. In *Proceedings of the 13th Usenix Conference on Networked Systems Design and Implementation* (Berkeley, CA, USA, 2016), NSDI'16, USENIX Association, pp. 1–14.

[7] Gupta, A., Vanbever, L., Shahbaz, M., Donovan, S. P., Schlinker, B., Feamster, N., Rexford, J., Shenker, S., Clark, R., and Katz-Bassett, E. Sdx: A software defined internet exchange. In *Proceedings of the 2014 ACM Conference on SIGCOMM* (New York, NY, USA, 2014), SIGCOMM '14, ACM, pp. 551–562.

[8] Kotronis, V., Rost, M., Georgopoulos, B. A., Ager, B., Schmid, S., and Dimitropoulos, X. Stitching inter-domain paths over ixps. In *Proceedings of the Symposium on SDN Research* (2016).

[9] Norton, W. B. *The Internet peering playbook: connecting to the core of the Internet*. DrPeering Press, 2014.

[10] Valancius, V., Feamster, N., Johari, R., and Vazirani, V. Mint: A market for internet transit. In *Proceedings of the 2008 ACM CoNEXT Conference* (New York, NY, USA, 2008), CoNEXT '08, ACM, pp. 70:1–70:6.

[11] Wolf, T., Griffioen, J., Calvert, K. L., Dutta, R., Rouskas, G. N., Baldin, I., and Nagurney, A. Choicenet: Toward an economy plane for the internet. *SIGCOMM Comput. Commun. Rev. 44*, 3 (July 2014), 58–65.

[12] Yuksel, M., Gupta, A., Kar, K., and Kalyanaraman, S. *Contract-Switching for Managing Inter-Domain Dynamics*. Cambridge University Press, 2010, pp. 136–153.