# Poster: Investigating Traffic Engineering Properties at Internet eXchange Points

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## CCS Concepts

• **Networks** → **Network measurement**.

**ACM Reference Format:**
Joaquim Pereira and Pedro Marcos. 2024. Poster: Investigating Traffic Engineering Properties at Internet eXchange Points. In *Proceedings of the 2024 ACM Internet Measurement Conference (IMC '24), November 4–6, 2024, Madrid, Spain.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3646547.3689676

## 1 Introduction

Efficient traffic delivery is a key aspect of Internet operations, as many modern Internet services have strict service requirements. To achieve this goal, network operators rely on expanding their footprint and performing inbound traffic engineering to influence other ASes' route decisions.

Internet eXchange Points (IXPs) are fundamental elements as they allow the interconnection of thousands of Autonomous Systems (ASes) in a single place [1]. While there are hundreds of IXPs worldwide, the decision of where to interconnect directly impacts the AS' traffic delivery as each IXP offers different connectivity options. For example, an AS may be present at multiple IXPs but announcing different prefixes in each one. The AS may also announce only a small fraction of its address space at the IXP. Understanding these behaviors is fundamental for making the best interconnection decision.

While previous research focused on understanding the ecosystem and benefits of joining IXPs [2, 4], the traffic engineering aspects have not been deeply investigated. Motivated by this gap we conducted an analysis of routing data from five IXPs. Our study examines the announced address space, evaluates whether ASes connected to multiple IXPs employ traffic engineering to signal a preferred IXP for traffic exchange, and explores the traffic engineering techniques utilized to influence routing decisions of other ASes.

We identify that half of the IXP members announce their entire address space at the IXP. We also observe that ASes connected to multiple IXPs tend to announce the same prefixes in both. Finally, when giving preference to a particular IXP, most ASes use a single inbound traffic engineering technique but have no clear preference for a given technique.


*IMC '24, November 4–6, 2024, Madrid, Spain*

ACM ISBN 979-8-4007-0592-2/24/11
https://doi.org/10.1145/3646547.3689676

## 2 Datasets

**Routing data.** We use routing information collected on the 17th of April, 2024, from four of the largest IXPs globally in terms of ASes, along with one additional large IXP. Specifically, IX.br São Paulo, AMS-IX Amsterdam, LINX London, IX.br Fortaleza, and IX.br Rio de Janeiro. This selection aims to maximize the likelihood of capturing ASes that are present across multiple IXPs. We collected data from the Brazilian IXPs through their Looking Glasses [5]. For AMS-IX and LINX, we collected the route server data from RouteViews' Routing Information Base. In Table 1 we show the number of ASes connected to each IXP Route Server (RS).

**Table 1: ASes connected to each IXP Route Server.**

| IXP | City | IPv4 | IPv6 |
|---|---|---|---|
| IX.br-SP | São Paulo | 2007 | 1887 |
| IX.br-CE | Fortaleza | 612 | 563 |
| AMS-IX | Amsterdam | 596 | 487 |
| IX.br-RJ | Rio de Janeiro | 572 | 475 |
| LINX | London | 562 | 398 |

**Announced prefixes.** We use the CAIDA prefix-to-AS mapping dataset [3] to estimate the number of prefixes each AS announces on the Internet.

**Sanitation.** We remove from our analyses prefixes more specific than /24 for IPv4 and more specific than /48 for IPv6.

## 3 Preliminary Analyses

We aim to explore traffic engineering properties at IXPs. We start analyzing the **proportion of address space** an AS announces to the IXP RS. Then, we examine the **announcement behavior** of ASes connected to multiple IXPs. Finally, we investigate the **traffic engineering techniques** used by ASes to indicate a preference for one IXP over the other.

**Address space fraction.** Our goal is to understand whether an AS announces its entire address space at the IXP or not. For each AS member of the IXP, we analyze the originated routes and then compare them with the address space the AS is announcing across the Internet. To that end, we combine our routing dataset with CAIDA's prefix-to-AS mapping dataset and compute the proportion of address space announced at the IXP in relation to the Internet. We show the results of our analyses in Figure 1. To reduce the bias introduced by small ASes, we show the results considering only ASes with at least 10 announced prefixes.

We observe at least 50% of ASes announcing nearly all (>96%) of their IPv4 address space to the Route Server. Additionally, in IX.br São Paulo, most ASes (75%) share at least 80% of their addresses

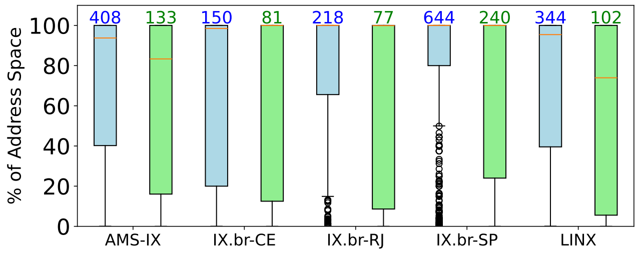


**Figure 1: % of ASes' address space announced at IXPs. Blue boxes are for IPv4, and green boxes are for IPv6. The top values indicate the number of analyzed ASes.**

with the Route Server. For AMS-IX and LINX, we observe a similar pattern, where 75% of ASes announce at least 40% of their address space. Conversely, at the Fortaleza IXP, most ASes announce slightly more than 20% of their total address space. For IPv6, while for the Brazilian IXPs, again, most ASes announce the entire address space, there are more ASes announcing less address space than on IPv4. A similar behavior is observed for the European IXPs.

**Announcement behavior.** Our goal is to understand if ASes are announcing the same prefixes in both IXPs or if they are using some traffic engineering technique to indicate preferred IXP. Thus, we focus on ASes that are directly connected to multiple IXPs. For each pair of IXPs, we analyze every AS that is present in both IXPs and classify them into one of the following categories: *no visible preference*, for ASes that announce exactly the same prefixes in both IXPs; *always prefers X*, for ASes that, when showing some preference, prefers IXP X and; *prefers both*, for ASes that for some prefixes indicate preference for one IXP and for other prefixes prefer the other IXP. Figure 2 shows the results.

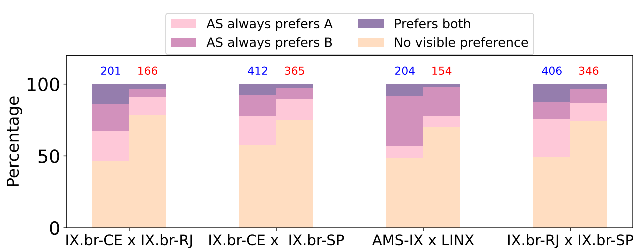


**Figure 2: Behavior of ASes connected to multiple IXPs. The top values indicate the number of analyzed ASes. Dashed (right) bars are IPv6.**

We observe that, in general, for IPv4, half of the ASes indicate no preference between the IXPs, meaning that they announce exactly the same prefixes in both IXPs. When indicating preference, the most common (and expected) case is for the AS to always prefer one IXP over the other. However, we spot a few cases where the AS indicates preference depending on the prefix. For IPv6, 70% of ASes connected to multiple IXPs announce the same routes, with most of the remaining cases indicating a preference for a single IXP. Finally, it is interesting to note that even though IX.br São Paulo being the largest IXP, it was not the most preferred for AS connected to other Brazilian IXPs. Among European IXPs, there is a clear preference for London.

**Traffic engineering techniques.** Now, our goal is to understand *how many* and *which* traffic engineering techniques (i.e., AS-Path Prepend, more specific and selective announcements) ASes use to indicate a preference for a given IXP over the other. We show the results in Figure 3.

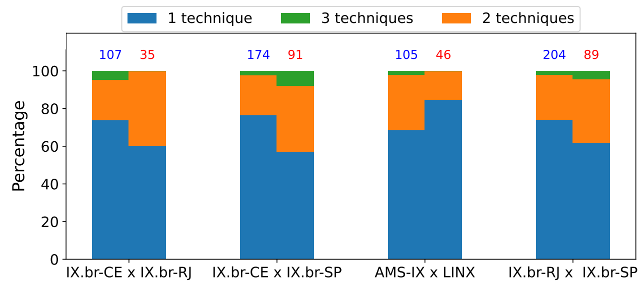


**Figure 3: Number of traffic engineering techniques used by ASes. The top values indicate the number of analyzed ASes. Dashed (right) bars are IPv6.**

We observe that whenever indicating preference, ASes tend to use a single traffic engineering technique for both IPv4 and IPv6. We also note that there is no clear preference for a specific technique, which may indicate that ASes have different favorite traffic engineering techniques. For example, ASes connected to the IXPs in São Paulo and Rio de Janeiro predominantly use the more specific announcements IPv4. Conversely, at the IXPs in Amsterdam and London, the most common technique is selective announcements. Finally, we identify that when using more than one technique, ASes tend to use more specific announcements combined with one of the other techniques.

## 4 Final Remarks

Traffic engineering plays an important role on the Internet and this is no different at IXPs. Our study identified that while half of the ASes tend to announce their entire address space at the IXP, the other half do not, indicating the use of traffic engineering. Also, ASes connected to multiple IXPs tend to announce the same prefixes in both locations and when giving a preference to a specific IXP, they usually use a single technique. Our research agenda includes expanding the set of analyzed IXPs, performing a longitudinal analysis of the ASes' use of traffic engineering, and investigating traffic engineering usage deeply in the AS address space.

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