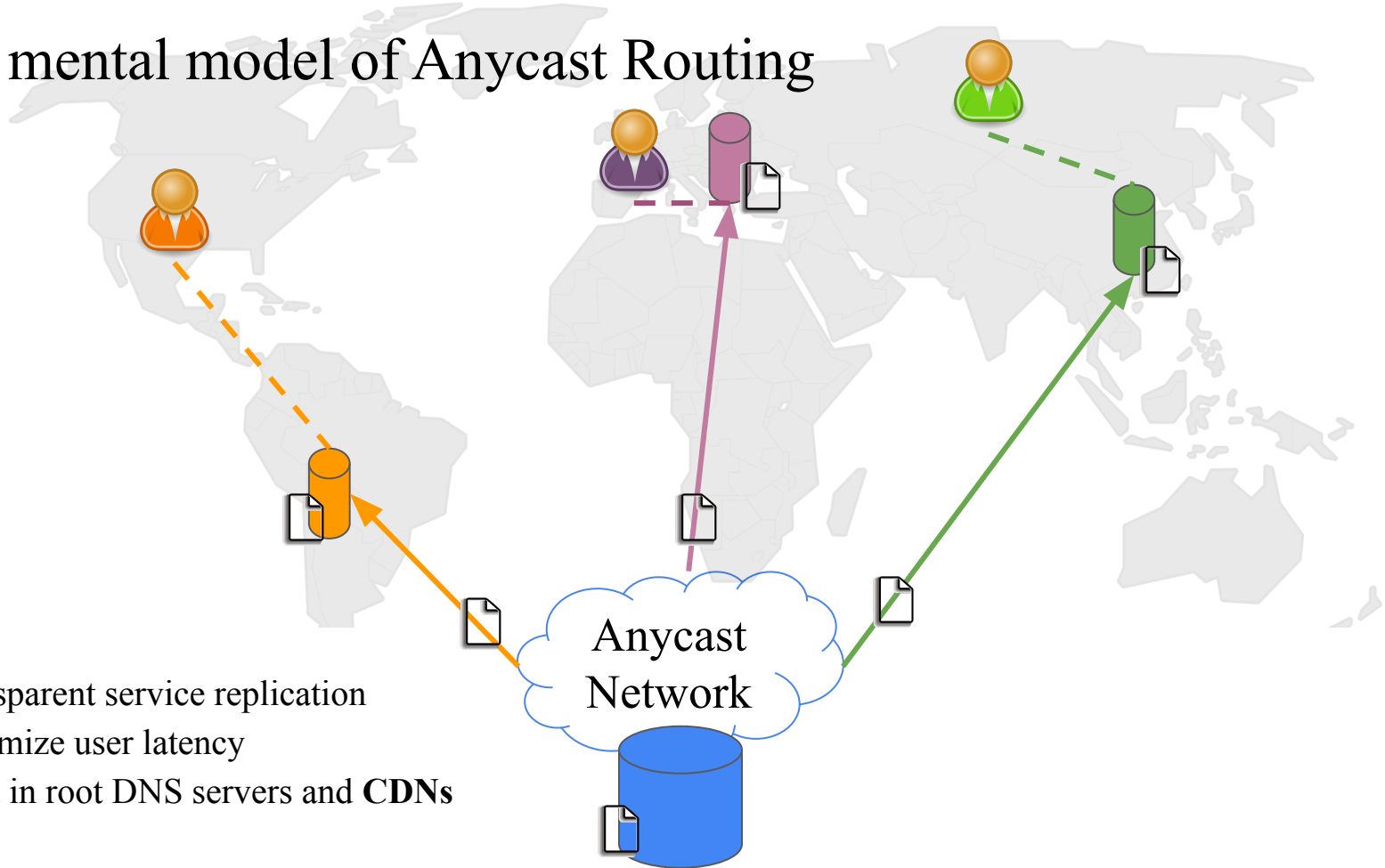


Investigating Location-Aware Advertisements in Anycast IP Networks

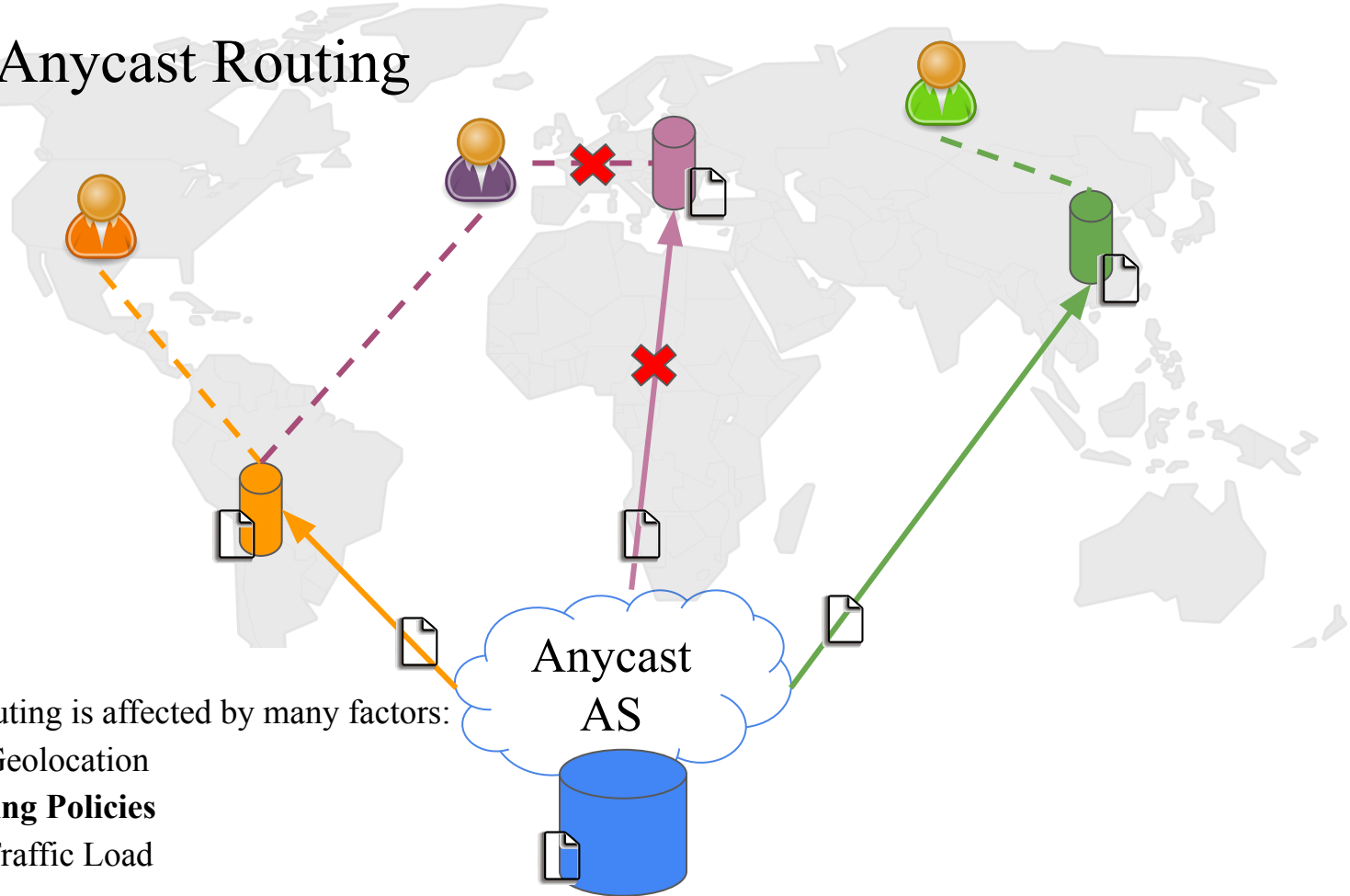
Savvas Kastanakis, Vasileios Giotsas, Ioana Livadariu, Neeraj Suri

Our mental model of Anycast Routing



- ❖ Transparent service replication
- ❖ Minimize user latency
- ❖ Used in root DNS servers and **CDNs**

Actual Anycast Routing

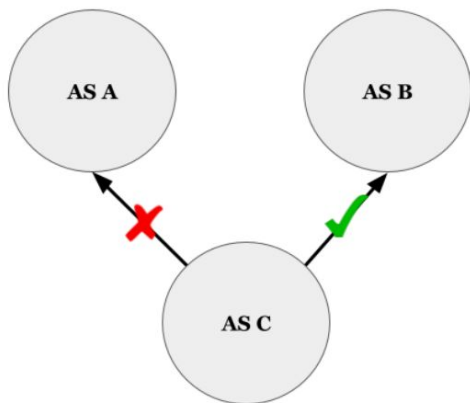


❖ Anycast Routing is affected by many factors:

- PoP Geolocation
- **Routing Policies**
- PoP Traffic Load

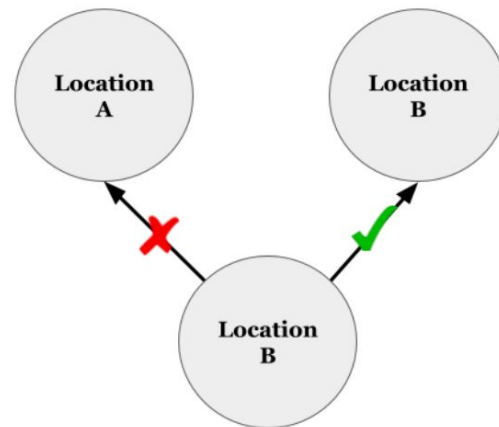
Selective Announcements

IMC'23



(a) Selective announcement per AS.

ANRW'24



(b) Selective announcement per location.

An Anycast AS can selectively announce its prefixes to specific ASes or locations in order to load balance traffic and costs.

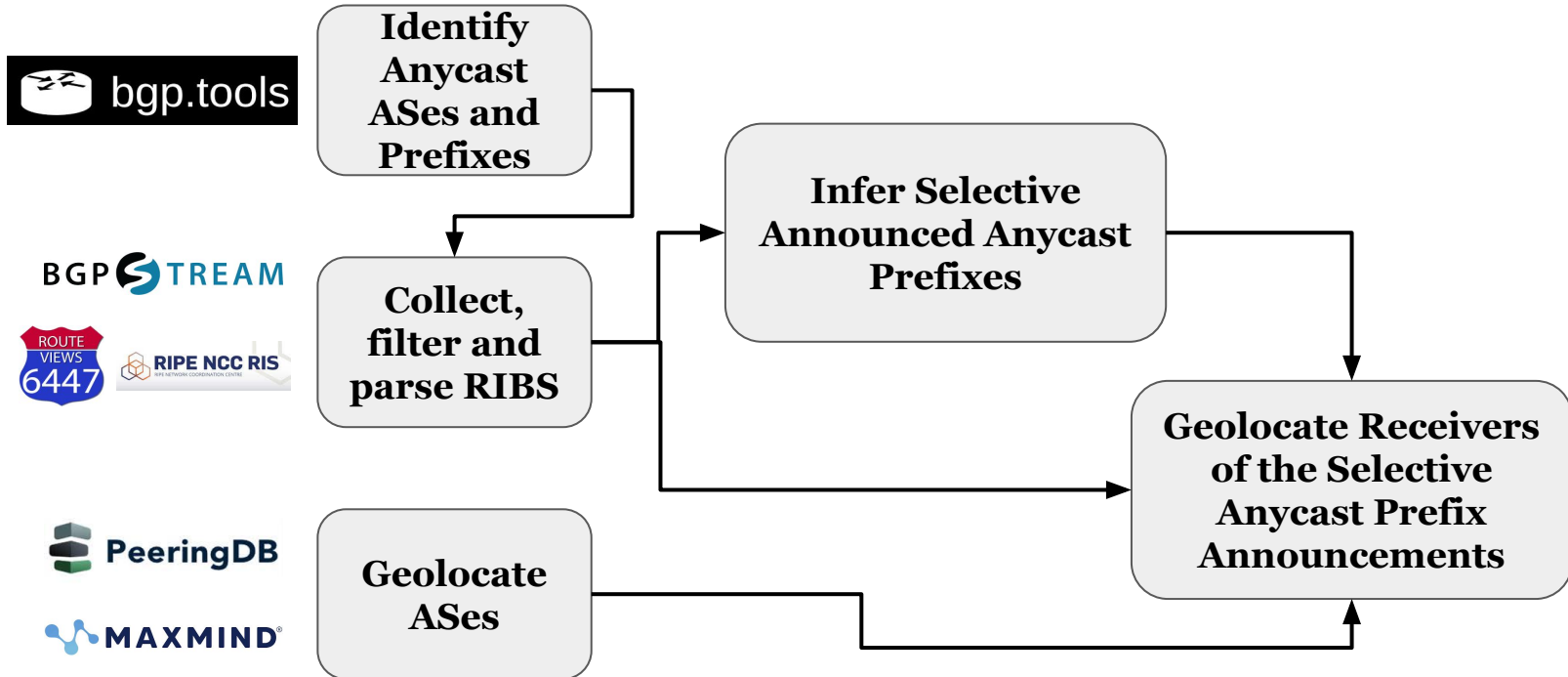
Contributions

In this work:

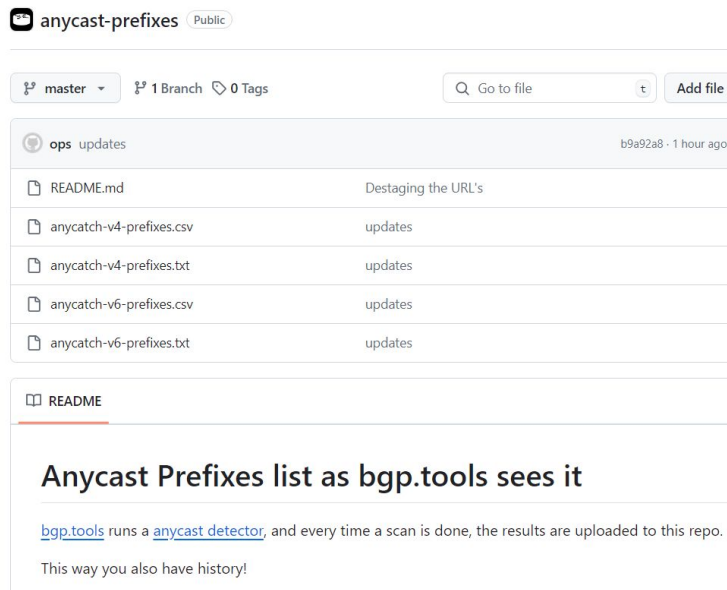
1. We measure the adoption of *Selective Announcements* across Anycast ASes
2. We identify the *Receivers of Selective Anycast Prefix Announcements*
3. We measure the *Regionality of Receivers*, i.e., the degree at which an AS decides to propagate an anycast prefix across regional over global neighbors

The results of our work underscore the necessity to *take geolocation into consideration* when modelling the Interdomain Routing System.

Methodology Overview: How to geolocate the Receivers of Selective Anycast Prefix Announcements?



Step 1: Identify Anycast IP Networks and IP Prefixes



The screenshot shows the GitHub repository page for 'anycast-prefixes'. The repository is public and has a 'master' branch with 1 branch and 0 tags. The file list includes:

- ops updates (b9a92a8 - 1 hour ago)
- README.md (Destaging the URL's)
- anycatch-v4-prefixes.csv (updates)
- anycatch-v4-prefixes.txt (updates)
- anycatch-v6-prefixes.csv (updates)
- anycatch-v6-prefixes.txt (updates)

The README content is as follows:

Anycast Prefixes list as bgp.tools sees it

[bgp.tools](#) runs a [anycast detector](#), and every time a scan is done, the results are uploaded to this repo.

This way you also have history!



```
"2484": [
  "2001:678:c::/48",
  "194.0.9.0/24"
],
"35052": [
  "2001:678:1c::/48",
  "192.76.243.0/24",
  "192.92.125.0/24"
],
"201612": [
  "2001:678:24::/48"
],
"8882": [
  "2001:678:244::/48"
```

We extract all anycast ASes and their respective anycast prefixes through the **bgp.tools API** and the **bgp.tools Github repository**

Step 2: Collect, Filter and Parse Routing Tables



Route Collectors



BGPStream API

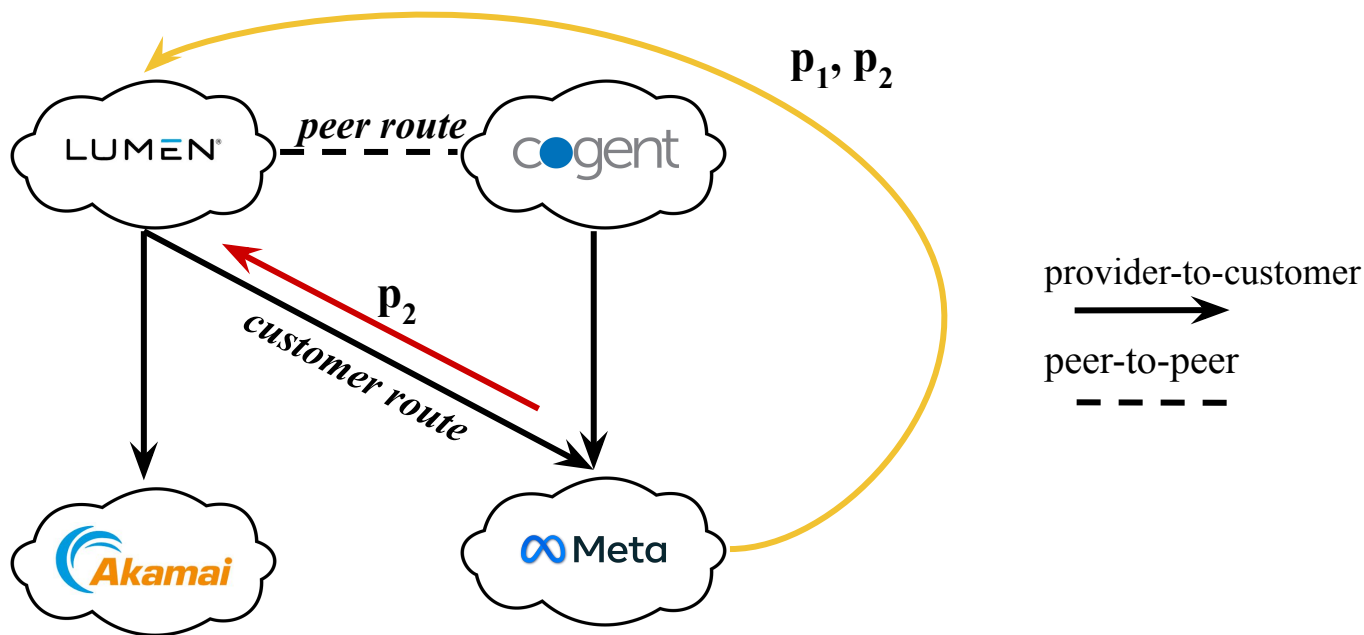


Routing Table

```
<dump-type> | <elem-type> | <record-ts> | <project> | <collector> |  
<router-name> | <router-ip> | <peer-ASn> | <peer-IP> | <prefix> | <next-hop-IP> |  
<AS-path> | <origin-AS> | <communities> | <old-state> | <new-state>
```

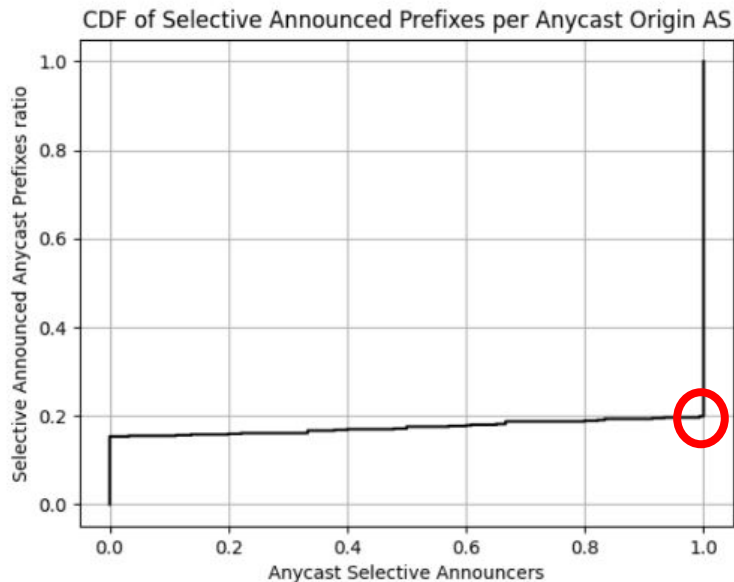
For each anycast *prefix* observed through BGPStream we collect all the *AS-paths* installed in the routing tables of the vantage points

Step 3: Infer Selectively Announced Anycast IP Prefixes



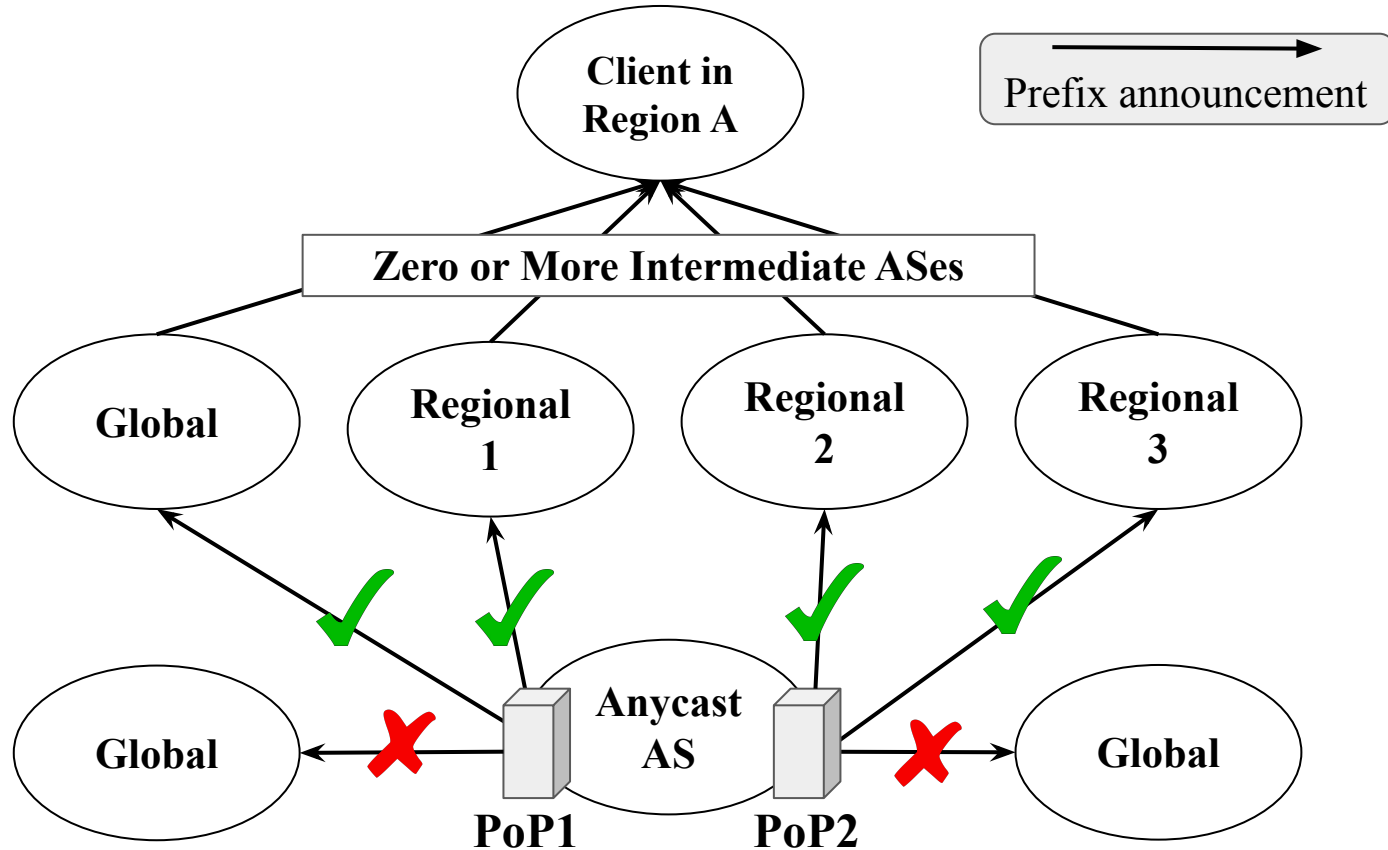
When an AS receives a route towards an anycast prefix through a more expensive route than expected, the prefix is labeled as ***Selective Announced Prefix***.

Selective Announcements is a common practice in Anycast ASes



From a total of 691 anycast ASes, 84.06% announce at least one selective anycast prefix and **80% of the selective anycasters announce *all* of their prefixes selectively.**

Group the Receivers of Selective Announcements per Region



Step 4: Augment ASes with Country-level Characteristics

Prefixes Announced

```
"18106": {  
  "ipv4": {  
    "SG": 93.22999999999999,  
    "HK": 0.96,  
    "TW": 0.96,  
    "US": 2.4,  
    "MY": 0.96,  
    "DE": 0.48,  
    "ID": 0.96  
  },  
  "ipv6": {  
    "SG": 65.3,  
    "HK": 32.65,  
    "US": 2.04  
  }  
}
```

Peering Locations

```
"18106": {  
  "DE": 6.896551724137931,  
  "MY": 6.896551724137931,  
  "GB": 3.4482758620689653,  
  "SG": 51.724137931034484,  
  "HK": 6.896551724137931,  
  "US": 20.689655172413794,  
  "NL": 3.4482758620689653  
}
```

To uncover regional trends and disparities in anycast deployment we geolocate all ASes into their respective *countries* through Maxmind and PeeringDB.

Step 4: Reduce the country-level to region-level granularity

Country or Area
+ World
+ Africa
+ Americas
+ Latin America and the Caribbean
+ Northern America
Antarctica
+ Asia
+ Europe
Landlocked Developing Countries (LLDC)
Least Developed Countries (LDC)
+ Oceania
Small Island Developing States (SIDS)

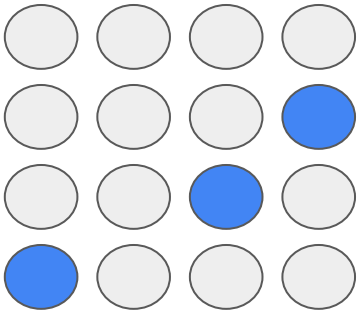


```
"TL": "South-eastern Asia",  
"VN": "South-eastern Asia",  
"AF": "Southern Asia",  
"BD": "Southern Asia",  
"BT": "Southern Asia",  
"IN": "Southern Asia",  
"IR": "Southern Asia",  
"MV": "Southern Asia",  
"NP": "Southern Asia",  
"PK": "Southern Asia",  
"LK": "Southern Asia",  
"AM": "Western Asia",  
"AZ": "Western Asia",  
"BH": "Western Asia",  
"CY": "Western Asia",  
"GE": "Western Asia",  
"IQ": "Western Asia",  
"IL": "Western Asia",  
"JO": "Western Asia",  
"KW": "Western Asia",  
"LB": "Western Asia",
```

An AS is labeled as 'regional' if: **more than 90% of its prefixes AND more than 90% of its peering locations** reside under the same region.

Step 5: Group the Receivers of Selective Announcements per Region

We group all direct neighbors of the Anycast AS per the end-user (source AS) region:

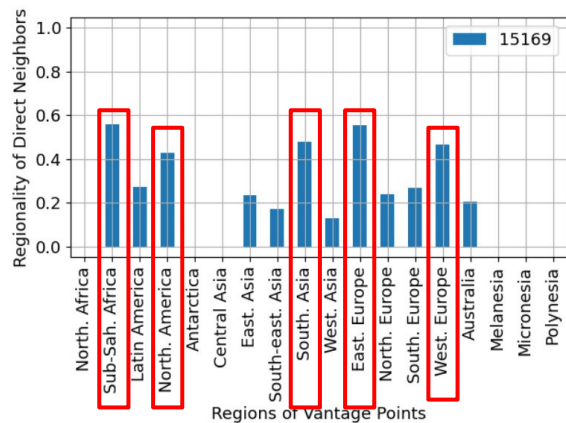


- AS-path to a Selective Anycast Prefix
- Anycast Origin AS
- Receiver of Selective Anycast Prefix
- Region of Source AS

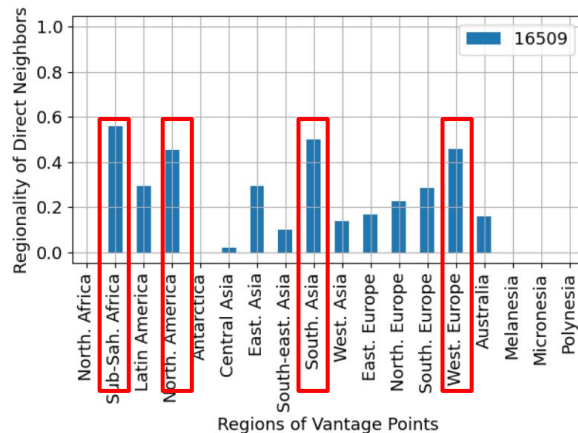


```
"10122": {  
  "164.90.86.0/24": {  
    "Northern America": {  
      "US": [  
        "174",  
        "1299",  
        "6453"  
      ],  
      "CA": [  
        "1299",  
        "174"  
      ]  
    },  
    "Western Europe": {  
      "DE": [  
        "1299",  
        "6453",  
        "174",  
        "41327",  
        "33891",  
        "21412",  
        "23764"  
      ],  
    }  
  }  
}
```

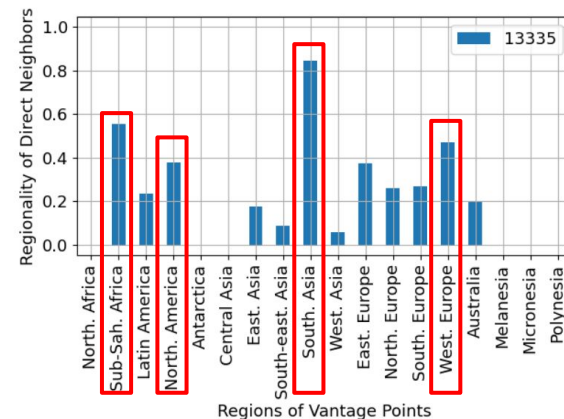
Regionality of the Receivers of Selective Announcements



(l) Google.



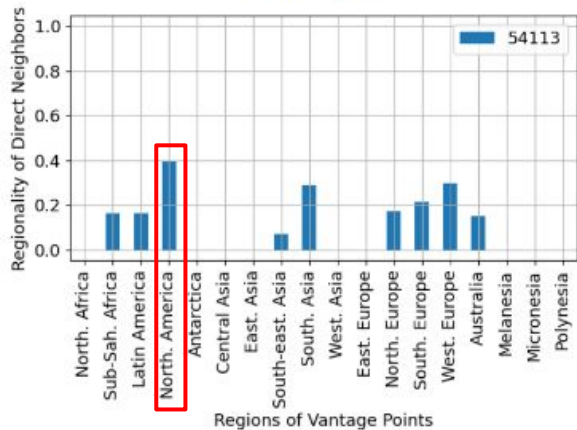
(d) Amazon.



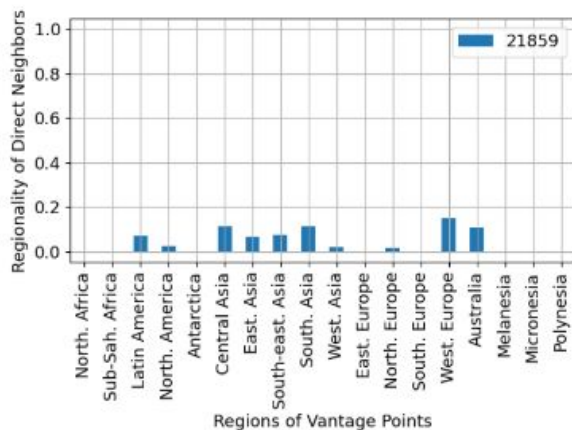
(a) Cloudflare.

Regionality = # of regional neighbors / # of total neighbors

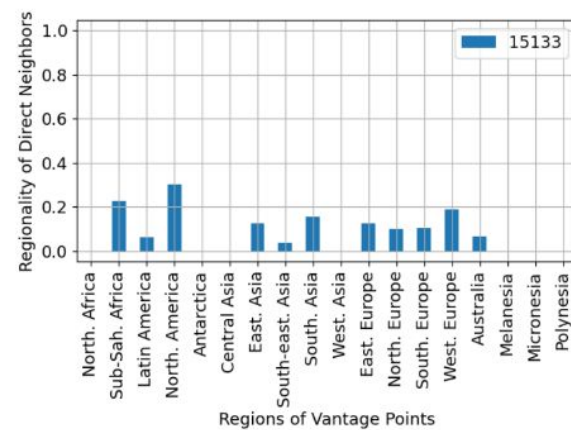
Regionality of the Receivers of Selective Announcements



(i) Fastly.



(f) Zenlayer.



(b) BytePlus.

$$\text{Regionality} = \# \text{ of regional neighbors} / \# \text{ of total neighbors}$$

Future Work: Reasoning on Regionality

Factors which drive the need for selective routing towards regional neighbors:

- a. **deficiency of a centralized backbone** by the anycast AS



- b. lower transit fees



- c. strict regulatory conditions



Take-away Message



- A. User-to-site mapping in anycast deployments relies heavily not only on the geolocation factor but also on the routing policies across ASes.
- B. Large part of anycast ASes deploy selective announcements for all of their anycast prefixes restricting the propagation of anycast prefixes for traffic engineering purposes.
- C. Anycast networks often resort to leveraging regional providers to establish connections between their PoPs and the end-users.

Contact: s.kastanakis@lancaster.ac.uk