Measuring foreign ASes and off-nets in Greece

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What is an off-net?

- Content providers (“Hypergiants”):
  - delivering the vast majority of Internet traffic
  - deploy servers (off-nets) inside end-user networks to:
    - reduce response time
    - improve the experience of end users
- We refer to these servers as off-nets because they are outside (off) the HG’s own network

Methodology

1. Identify Greek ASes and Foreign ASes present in Greece
2. Correlate with off-net data from "*Seven Years in the Life of Hypergiants'] Off-Nets*."[1] :
    a. Studies 30 largest hypergiants globally
    b. Covers 2013 - 2021
    c. Received Best Paper Award
3. Analyze the evolution of ASes and off-nets in Greece

[1] Petros Gigis, Matt Calder, Lefteris Manassakis, George Nomikos, Vasileios Kotronis, Xenofontas Dimitropoulos, Ethan Katz-Bassett, and Georgios Smaragdakis. 2021. Seven years in the life of Hypergiants' off-nets. In Proceedings of the 2021 ACM SIGCOMM 2021 Conference (SIGCOMM '21). Association for Computing Machinery, New York, NY, USA, 516–533. https://doi.org/10.1145/3452296.3472928

Dataset

- The ACM SIGCOMM 2021 Conference paper:
  - each HG lists the ASes that host its off-net
- CAIDA AS to Organization Mapping Dataset:
  - for each AS the ASN, the country registry and the organization name
- CAIDA Internet eXchange Points (IXPs) Dataset:
  - information about IXPs and their geographic locations, facilities, prefixes, and member ASes
  - derived by combining (union) information from PeeringDB, Hurricane Electric, PCH, and GeoNames
- The above datasets cover 3-month slots within 2013-2021 period

Detecting Greek ASes

- “Greek” ASes characterization based on AS to Organization Mapping Dataset
  - Exploits WHOIS databases from RIRs (ARIN, LACNIC, RIPE NCC, AFRINIC, and APNIC) and NIRs (KRNIC and JPNIC)
  - CAIDA infers the country from:
    - WHOIS that provides this field as an individual field
    - the location addresses reported by administrators

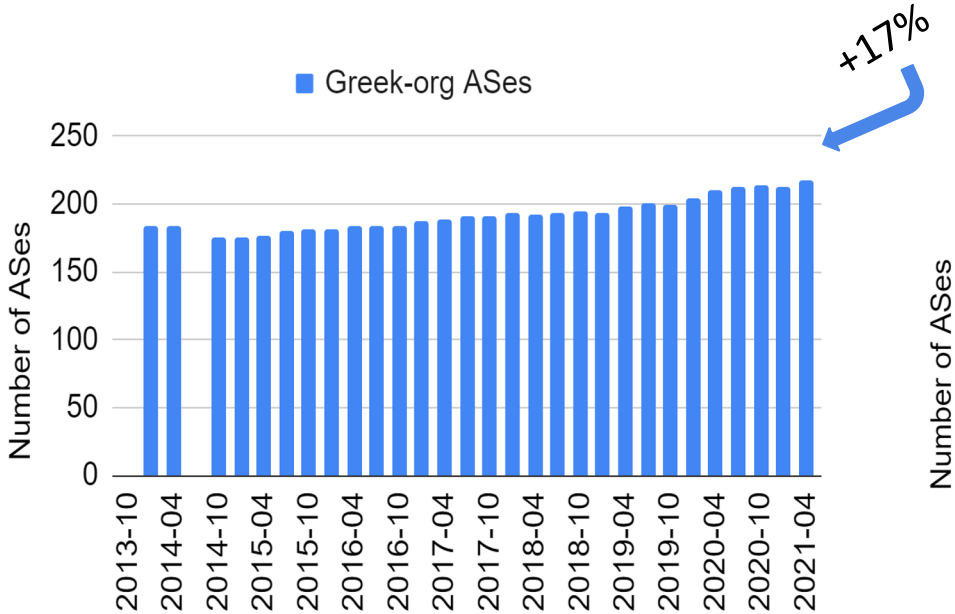

```
{
  "asn": "6799",
  "changed": "20000101",
  "asn_name": "OTENET-GR",
  "org_id":"ORG-OST01-RIPE",
  "source": "RIPE",
  "org_name": "Ote SA",
  "country": "GR"
}
```

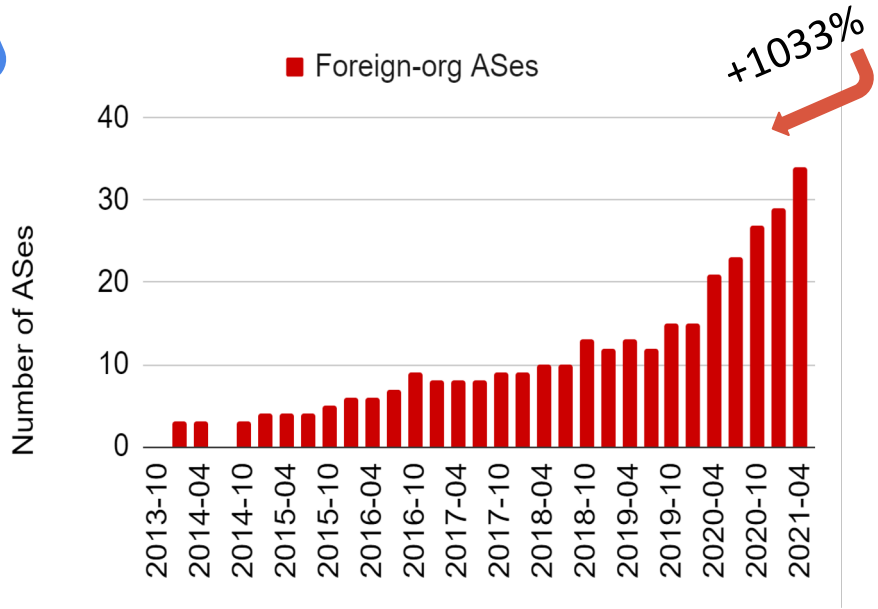
Detecting Foreign ASes

- ASes in Greek IXPs and colocation facilities
- “Foreign” ASes with Organization’s headquarters in other country
  - Exploits WHOIS databases from RIRs (ARIN, LACNIC, RIPE NCC, AFRINIC, and APNIC) and NIRs (KRNIC and JPNIC)
- CAIDA infers the country from:
  - WHOIS that provides this field as an individual field
  - the location addresses reported by administrators


```
{
    "asn": 6939,
    "changed": "20031104",
    "asn_name": "HURRICANE",
    "org_id": "HURC-ARIN",
    "source": "ARIN",
    "org_name": "Hurricane
   Electric LLC",
    "country": "US”
 }
```

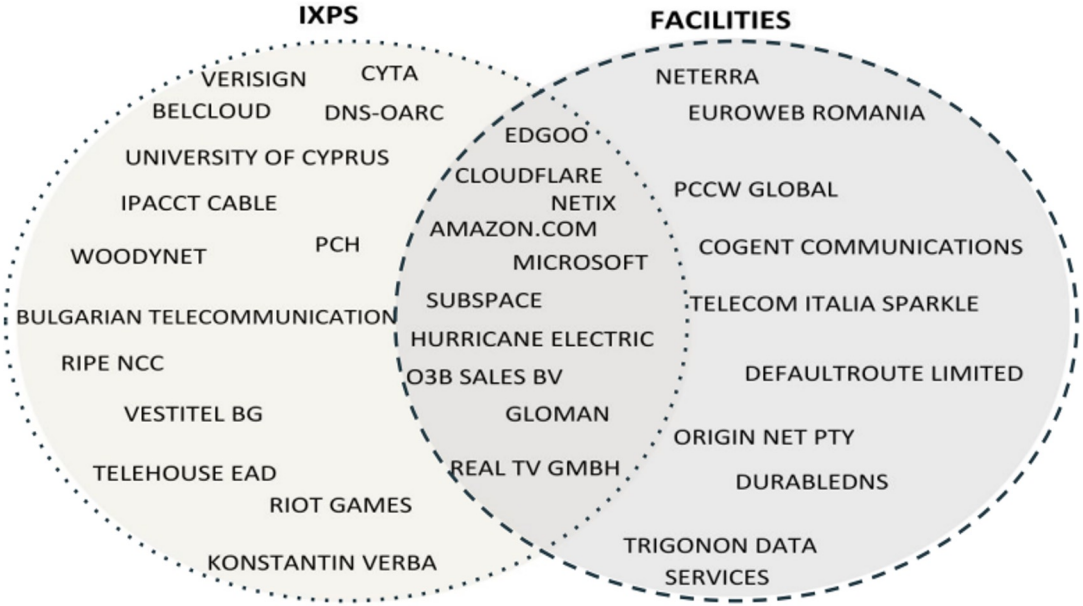
Greek and Foreign ASes over time

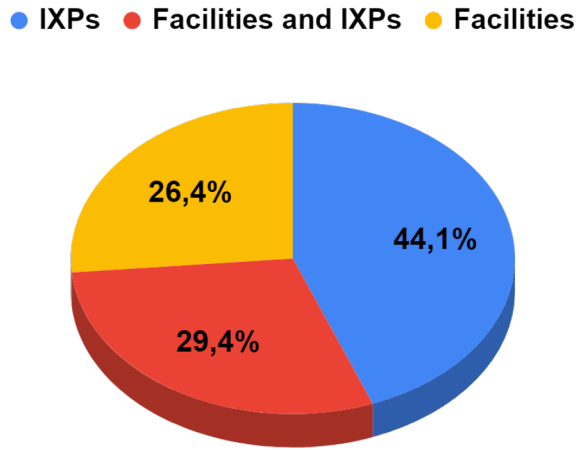




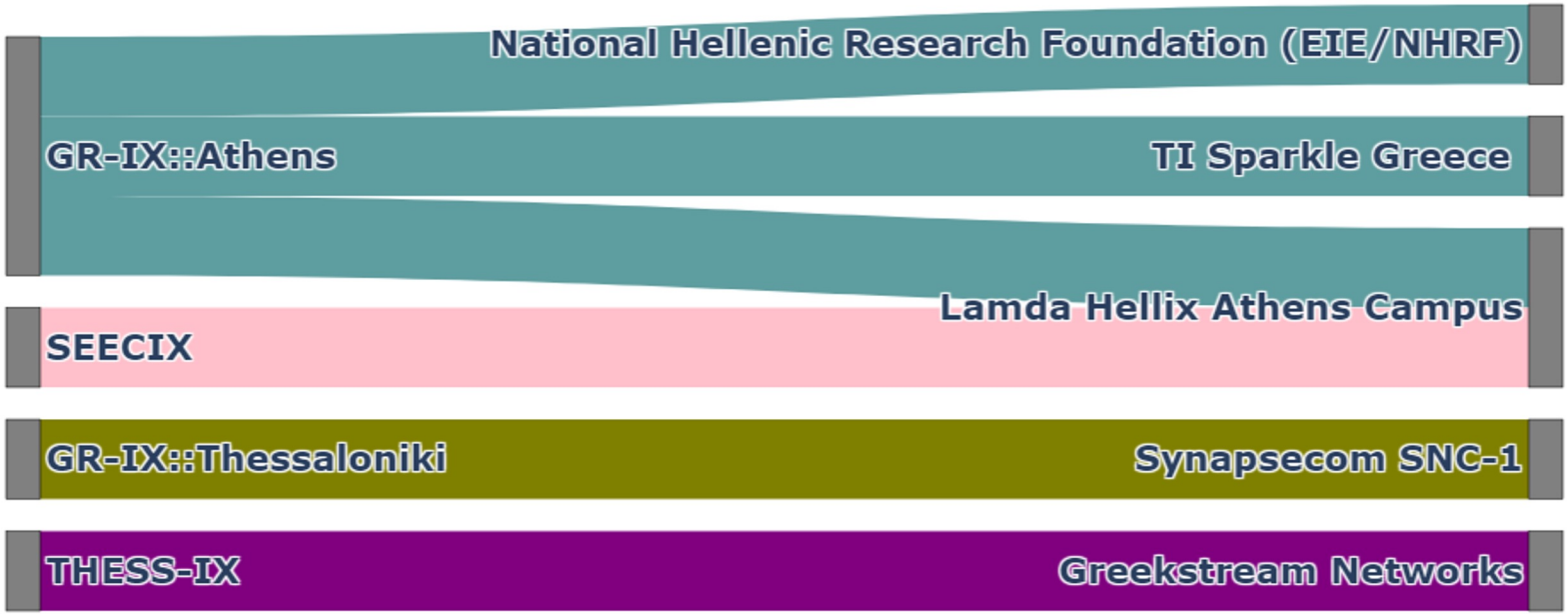
Foreign ASes in Greek IXPs or Facilities

- Time period: April 2021



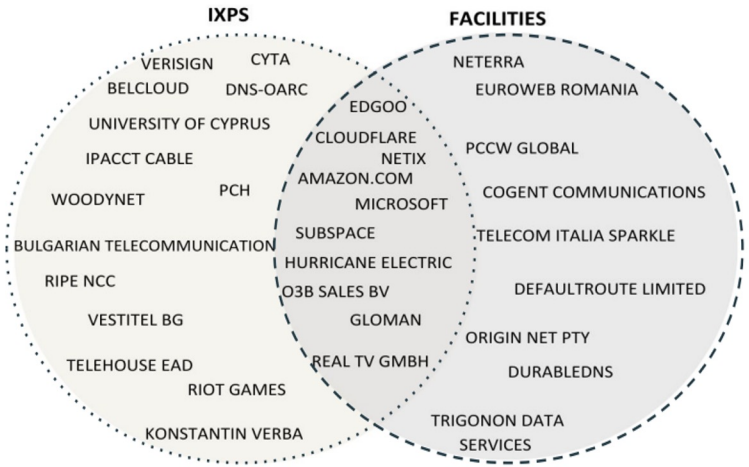


Present Greek IXPs in Greek Facilities

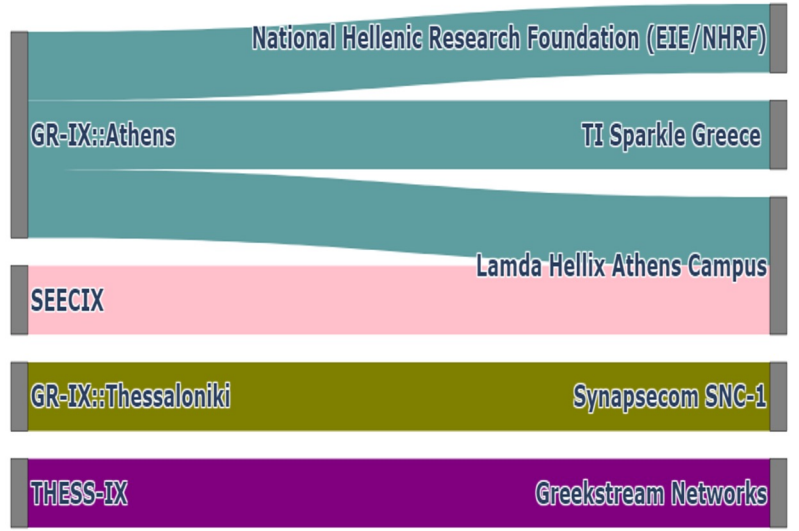


Difficulty in characterizing “Foreign ASes”(1/2)

- IXPs Dataset



- IXP to facility mapping



Difficulty in characterizing “Foreign ASes”(2/2)

- ASes may have different routing policies within an IXP compared to when they are present in a colocation facility
- Some ASes might only peer within the IXP and not establish direct connections within the colocation facility

Hypergiants with offnets in Greece

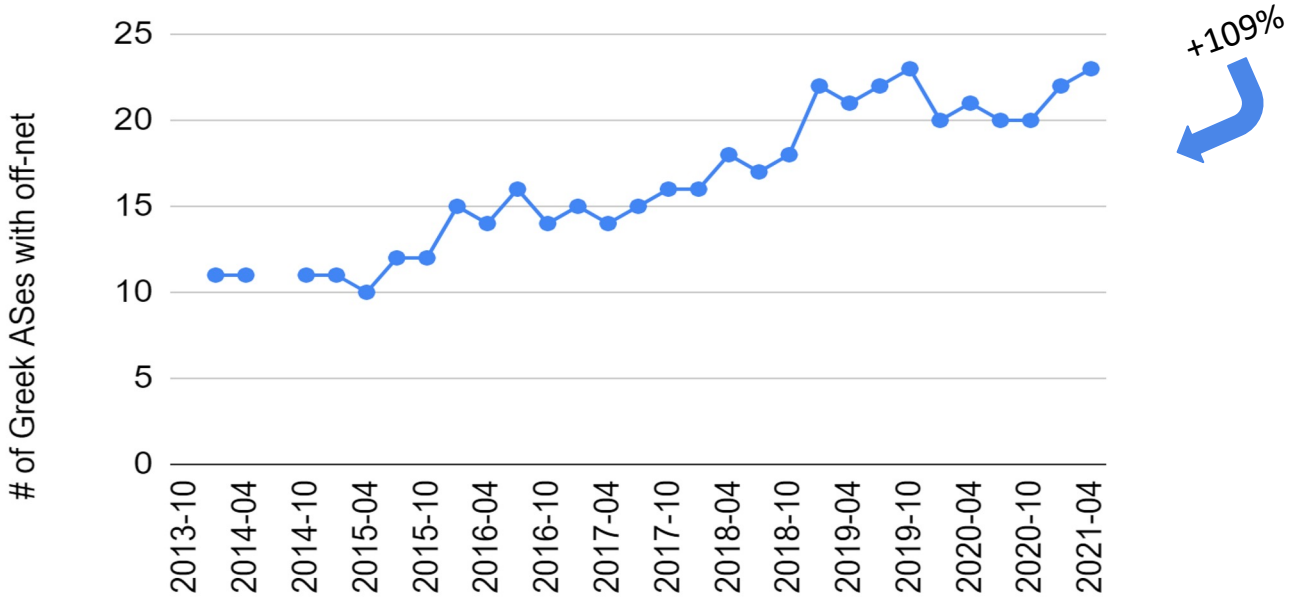
Responsible for 95% of off-nets in Greece

CLOUDFLARE

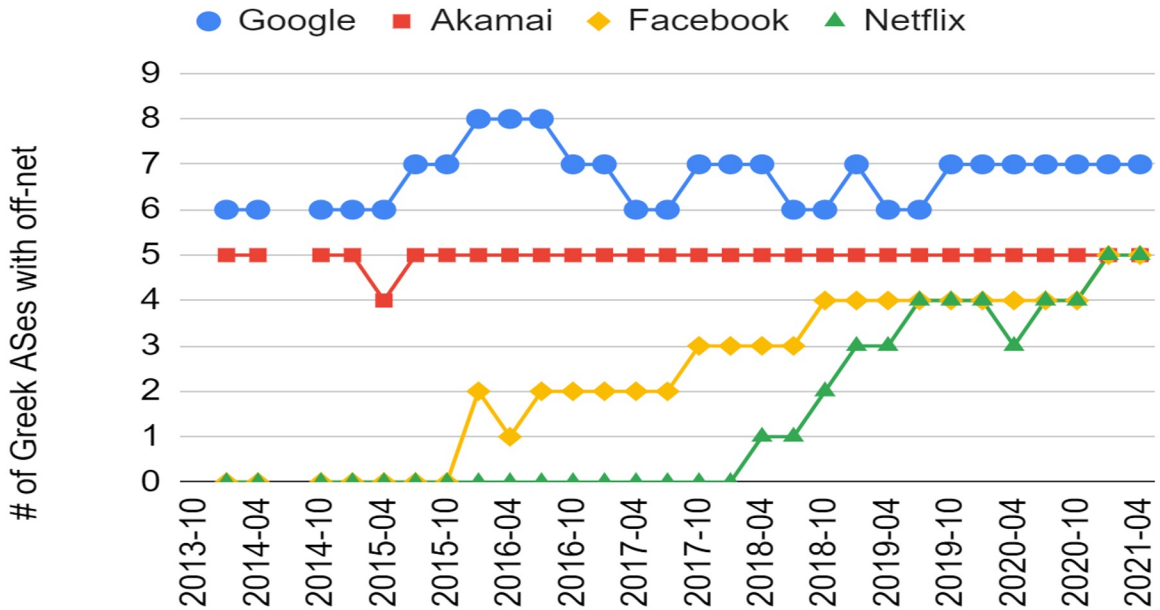
amazon

Alibaba.com

Number of Greek ASes with an off-net over time



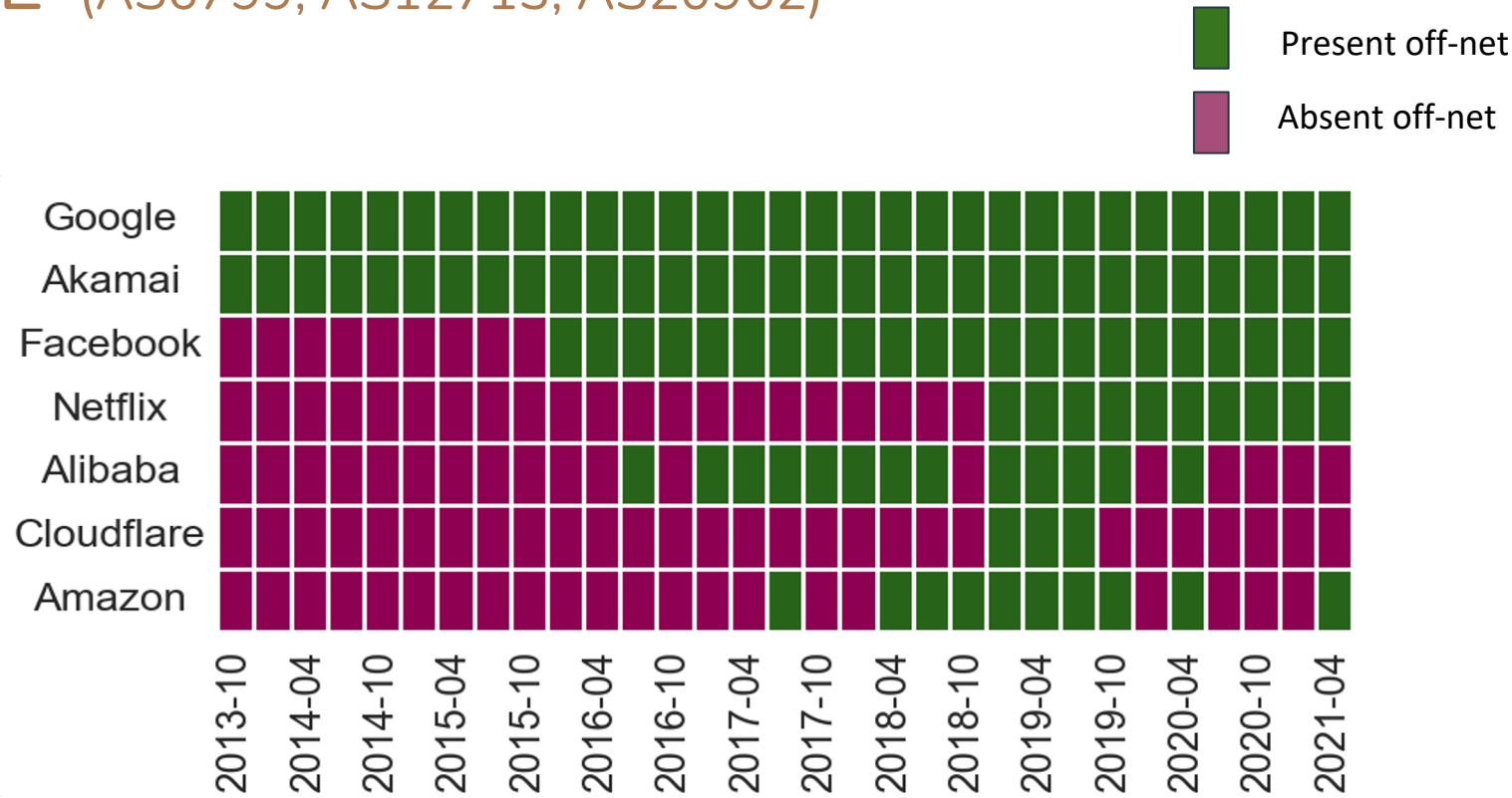
Number of Top-4 HG Off-nets' in Greek ASes over time



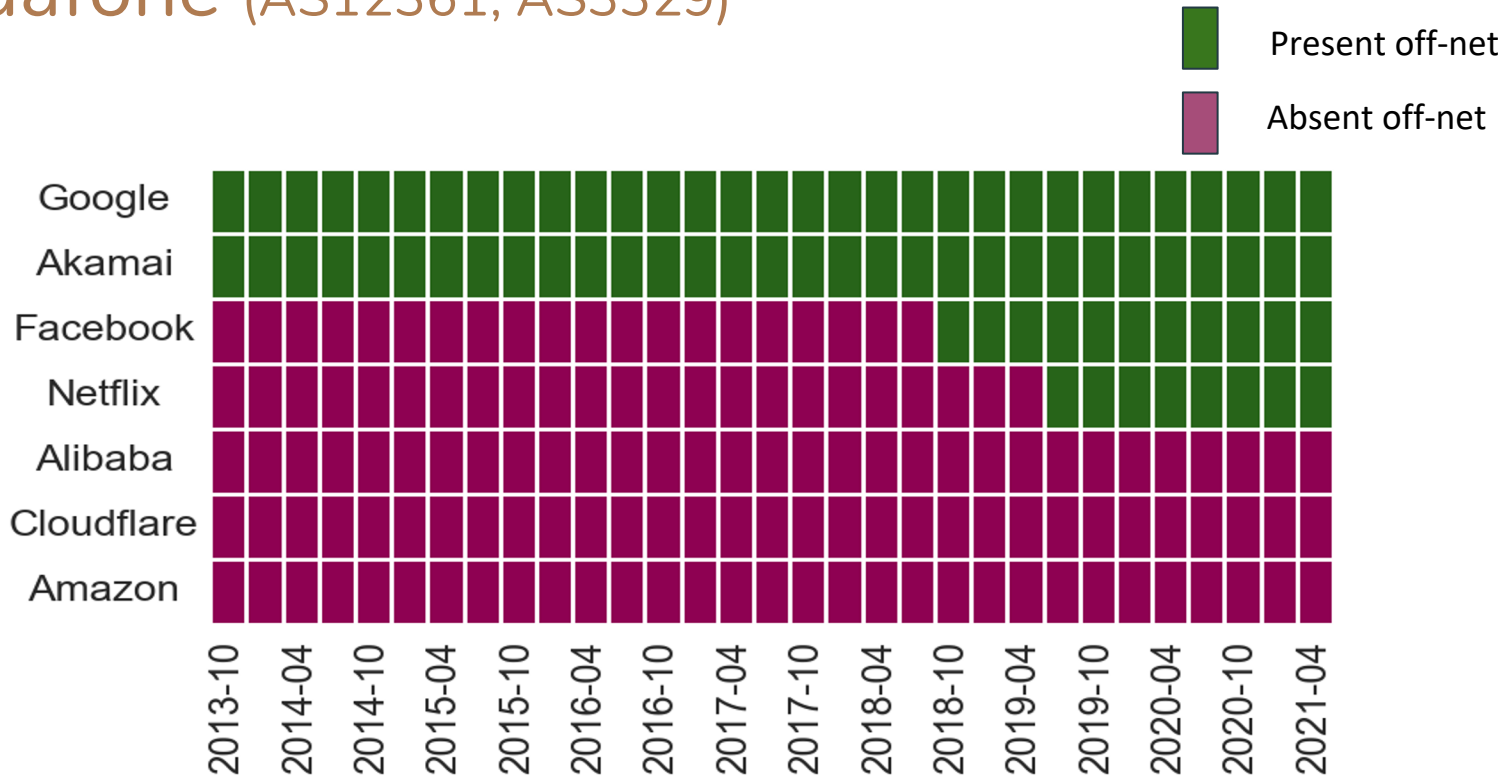
Large Greek ISPs with Off-nets

OTE	Founded in 1949	• offering fixed-line, mobile, and Internet services
Vodafone	Founded in 1949	• communications, introducing cutting-edge technologies and services, and contributing to the country's digital connectivity
Wind	Established in 1992	• mobile, fixed-line, and Internet services

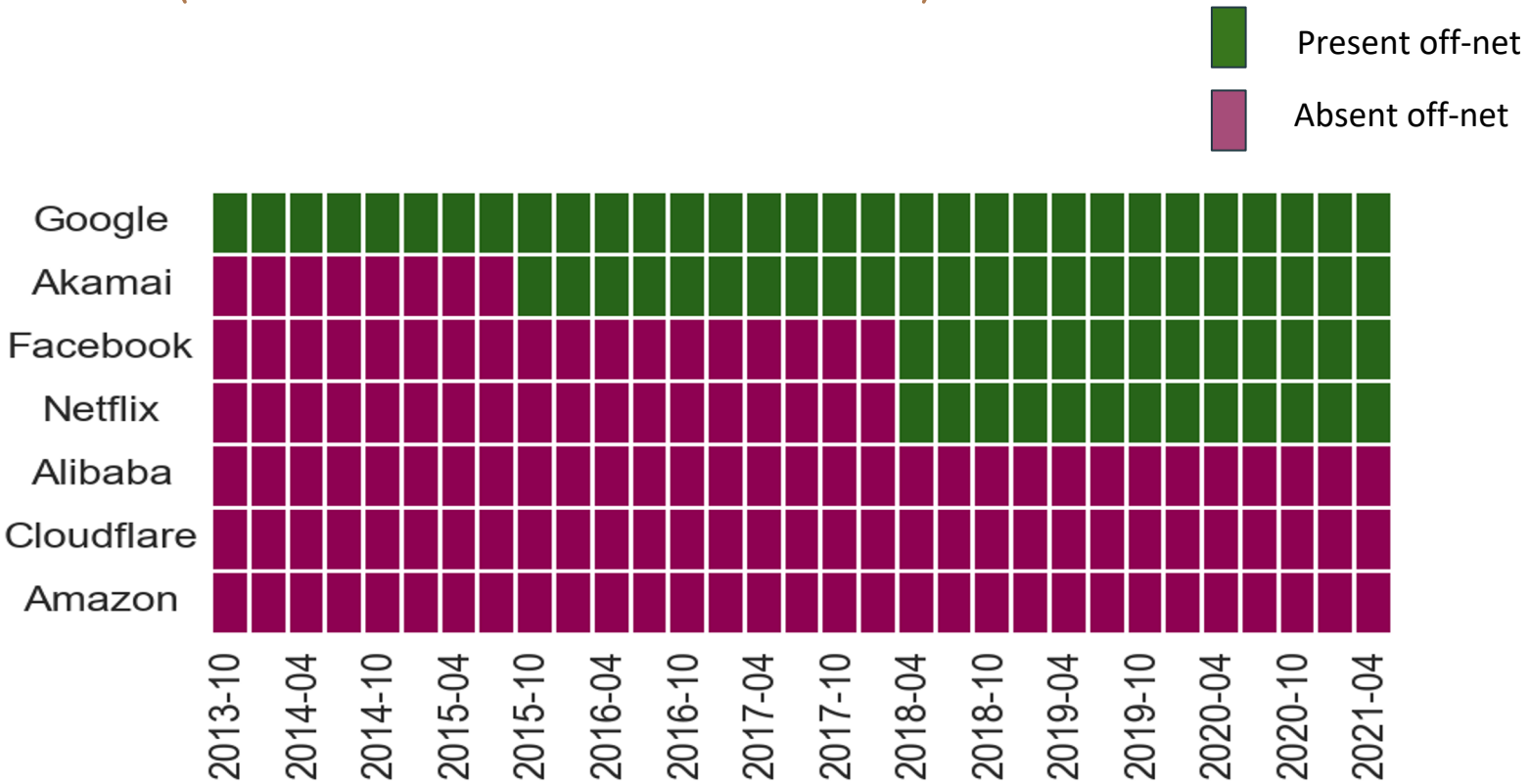
OTE (AS6799, AS12713, AS20962)



Vodafone (AS12361, AS3329)



WIND (AS15617, AS25472, AS24897)



Conclusions

- The number of the foreign ASes in Greece increased much faster than that of the Greek ones
- The top-4 HGs are responsible for 95% of the off-nets in Greek ASes
  - Google and Akamai had the most off-nets in Greek ASes
  - Facebook and Netflix entered the Greek Internet around 2018
- They did not host all the ASes of the organizations we are considering for HGs

Future Work

- Extend the work timescale until 2023
- Investigate the partial presence of the HGs in Greek ISPs
- Cross validation of the CAIDA datasets with other databases

Thank you!

Methodology of the paper

1. Learn HG's TLS fingerprints by scanning its on-nets
2. Search for the TLS fingerprint in scans of off-net IP addresses to identify candidates
    - Indicates ownership of the service rather than the underlying hardware
3. Learn the HG's HTTP(S) header fingerprint by scanning on-nets
4. Confirm the off-net candidates by scanning them for the HTTP(S) header fingerprints