# A comprehensive analysis of the IRR landscape


**S. Konstantaras (AMS-IX)**
**M. Wichtlhuber (DE-CIX)**
D. Wagner (DE-CIX)
T. Striffler (DE-CIX)
C. Luik (DE-CIX)

# BCP Proposal

- IXP operator must use only RIR IRR databases (or their official delegates) for Route Server filters

- The adoption of this policy will probably result in a massive transfer of RPSL objects
  - Grace period of 12 months is introduced in which the list of allowed databases is supplemented by IRRs with more than 1% of global route objects
    - RADB
    - RIPE-NONAUTH
    - NTT
    - LEVEL3

# Community Reaction

- Do authoritative IRRs represent operators better than third-party IRRs?
- Is the juice worth the squeeze?
  - Can’t we wait for RPKI to take over?
- What about legacy space?
  - It can’t be transferred

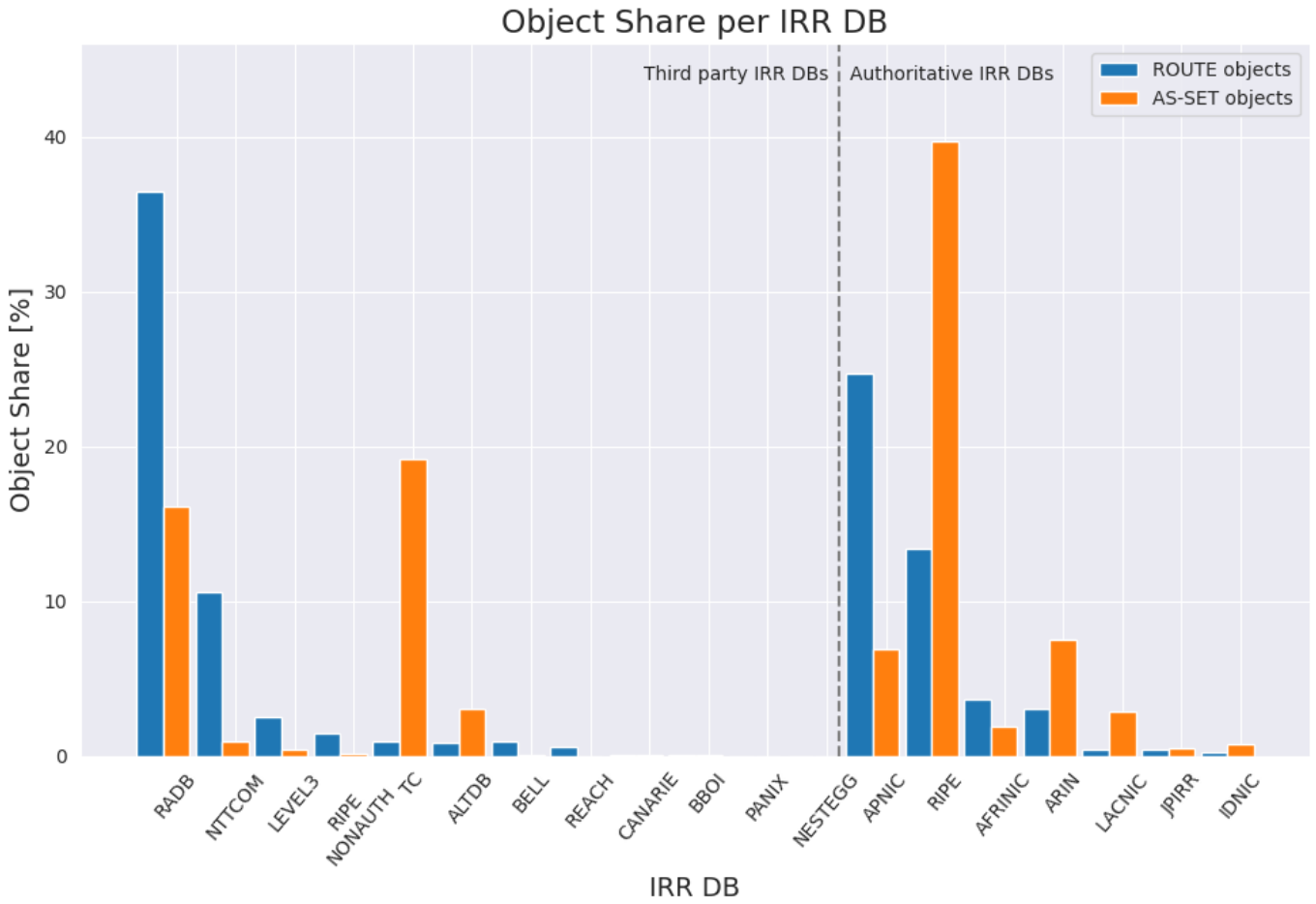
# Method

- We correlate and analyze a large number of data sources
  - WHOIS dumps from all 5 RIRs and 14 third-party IRRs
  - BGP data
    - Route server dumps from AMS-IX and DE-CIX
    - MRT dumps from RIPE RIS collectors
  - RPKI ROA repository data
  - RIR specific sources on legacy data
  - NRO delegation files

- We talked a lot to RIRs about their databases and processes for IRR and legacy space

# Q: Do authoritative IRRs represent operators better than third-party IRRs?

# Where are the objects stored?

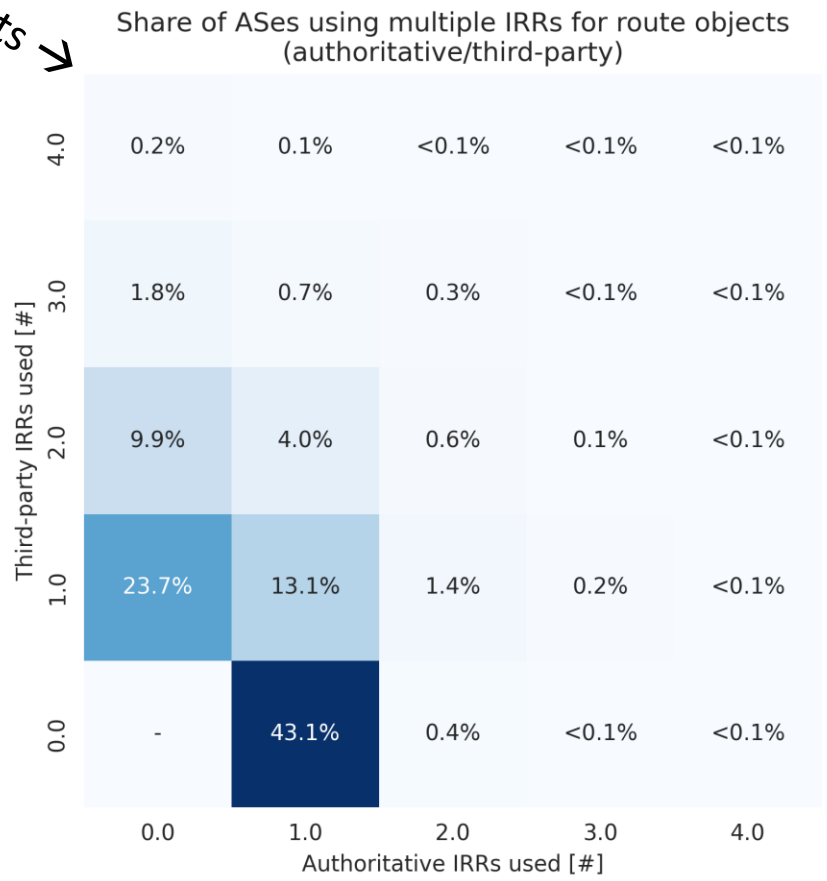



| Object | Authoritative IRRs | Third-party IRRs |
|---|---|---|
| ROUTE objects | 46% | 54% |
| AS-SET objects | 60% | 40% |
| AUT-NUM objects | 79% | 21% |

→ many third-party IRRs hold less than 1% of global objects, some less than 10.

# Do networks use multiple IRR DBs?

ROUTE objects ↘



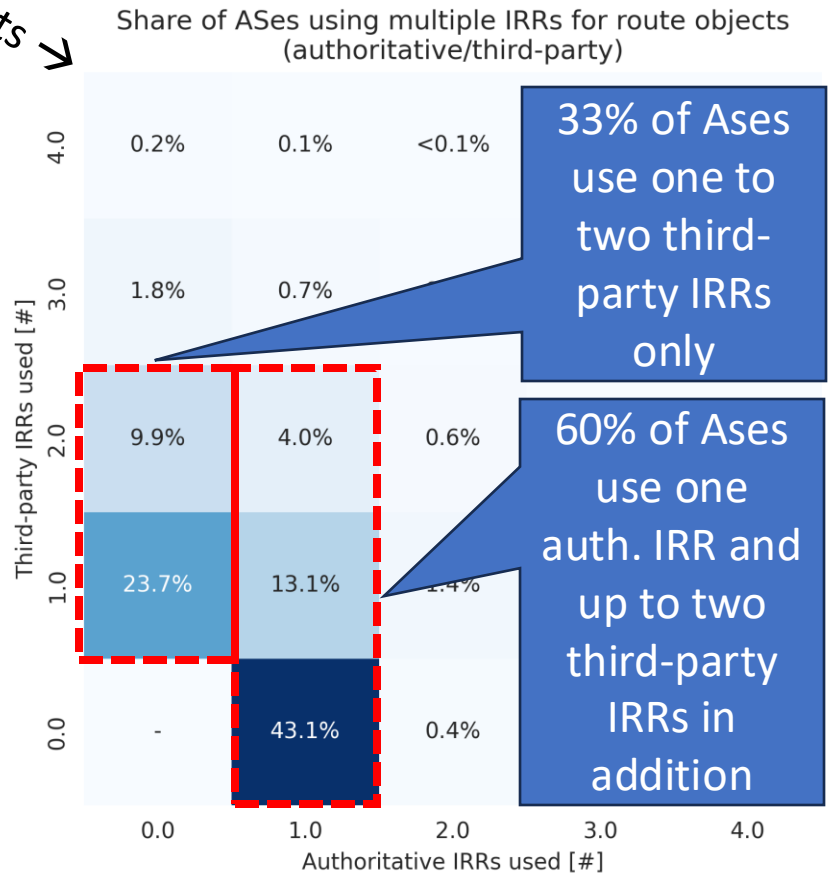

↙ AS-SETs




All values covered by textboxes are below 0.1%

# Do networks use multiple IRR DBs?

ROUTE objects ↘







↙ AS-SETs

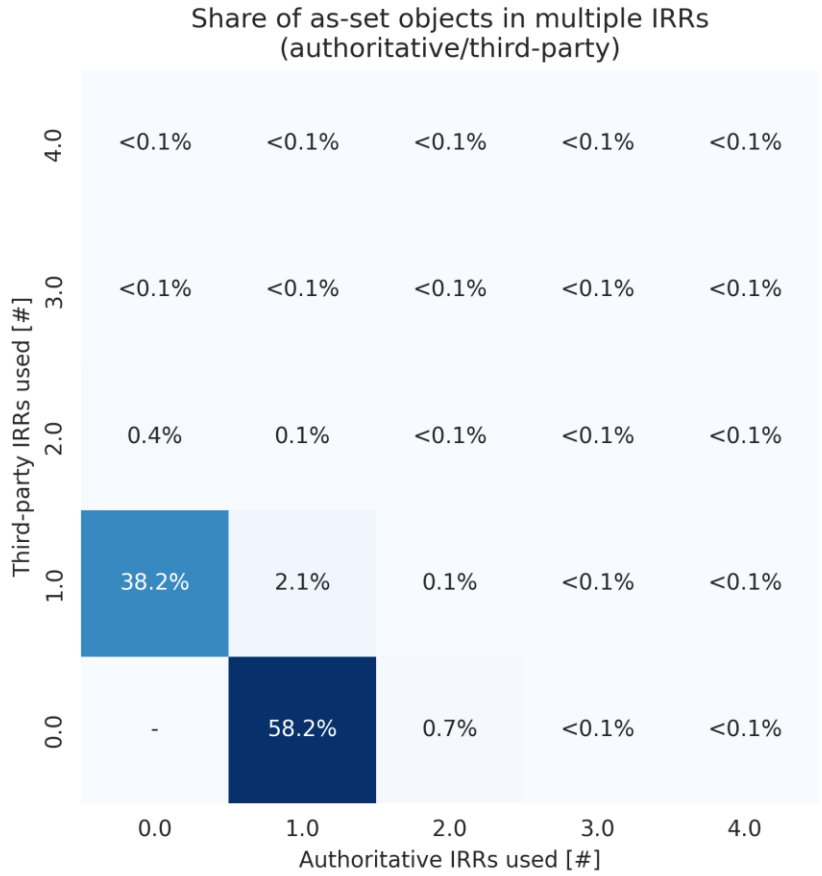
All values covered by textboxes are below 0.1%

# Do networks use multiple IRR DBs?

ROUTE objects ↘




↙ AS-SETs



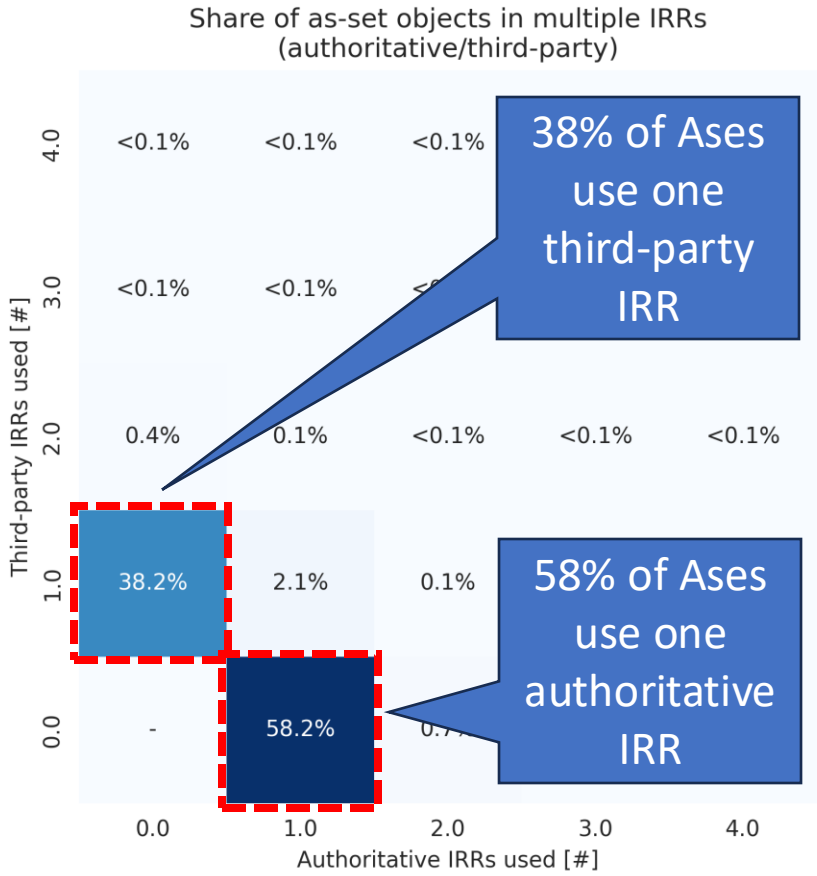

All values covered by textboxes are below 0.1%

# Do networks use multiple IRR DBs?

ROUTE objects →



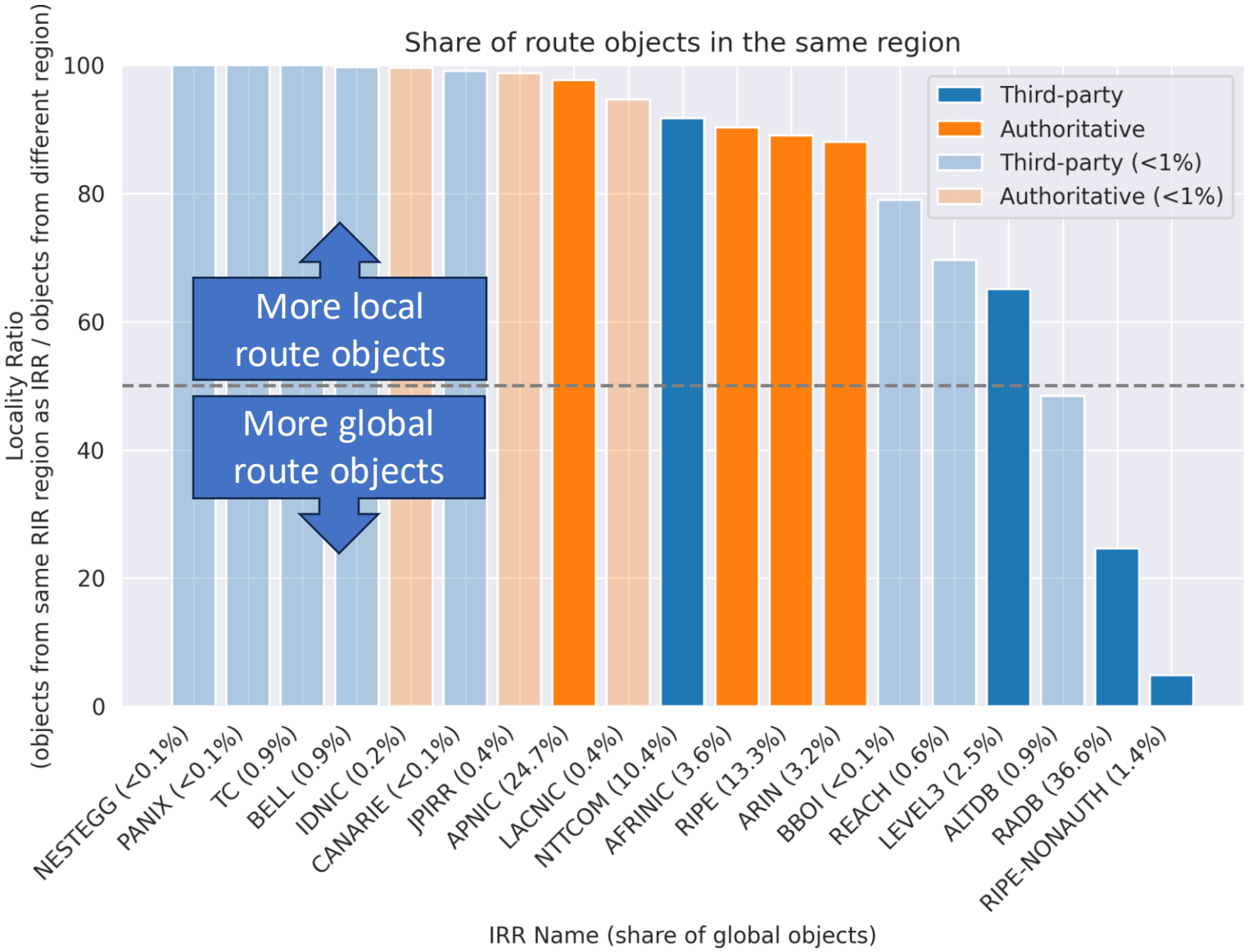

← AS-SETs




All values covered by textboxes are below 0.1%

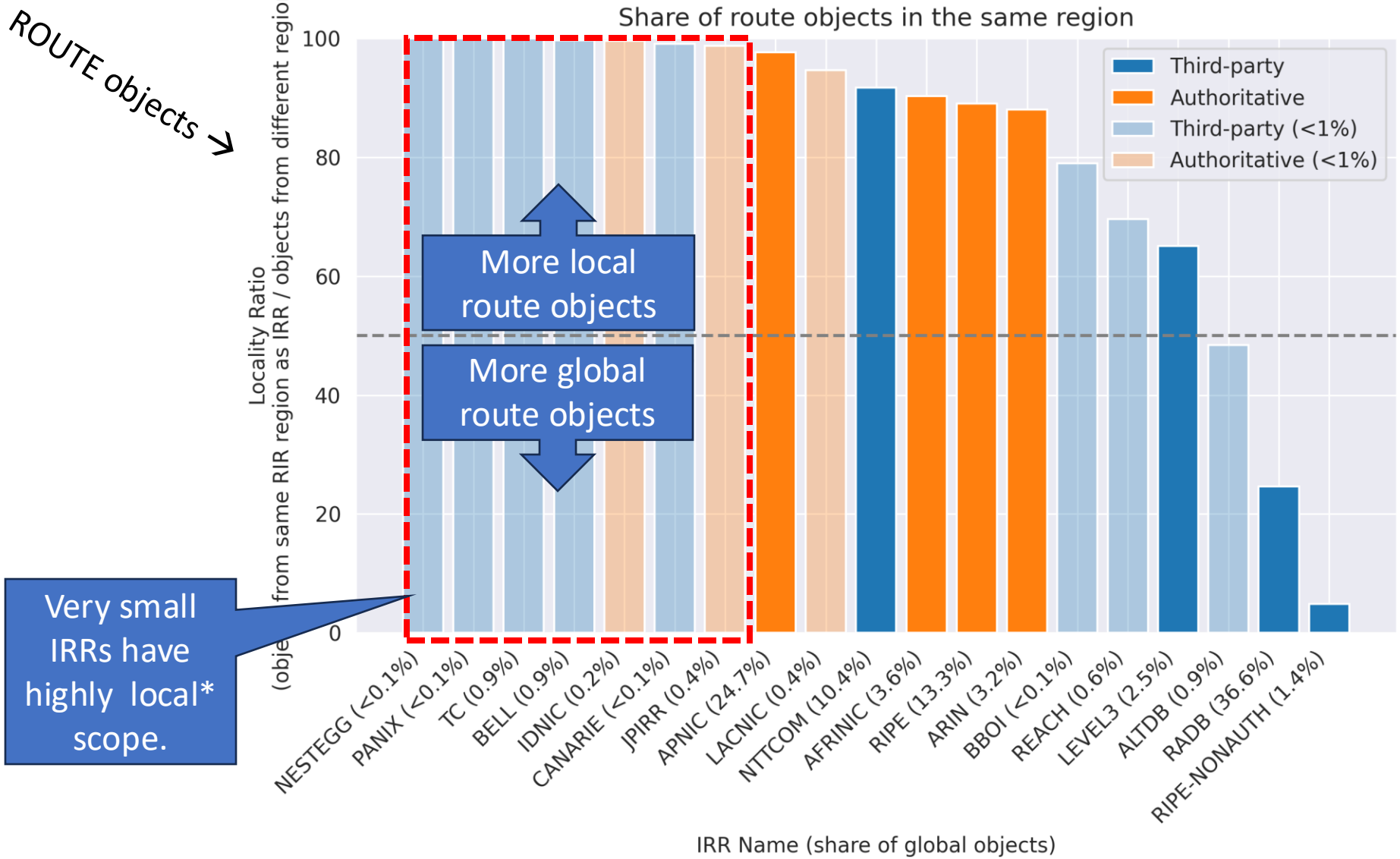
# Global or local* relevance?

ROUTE objects →



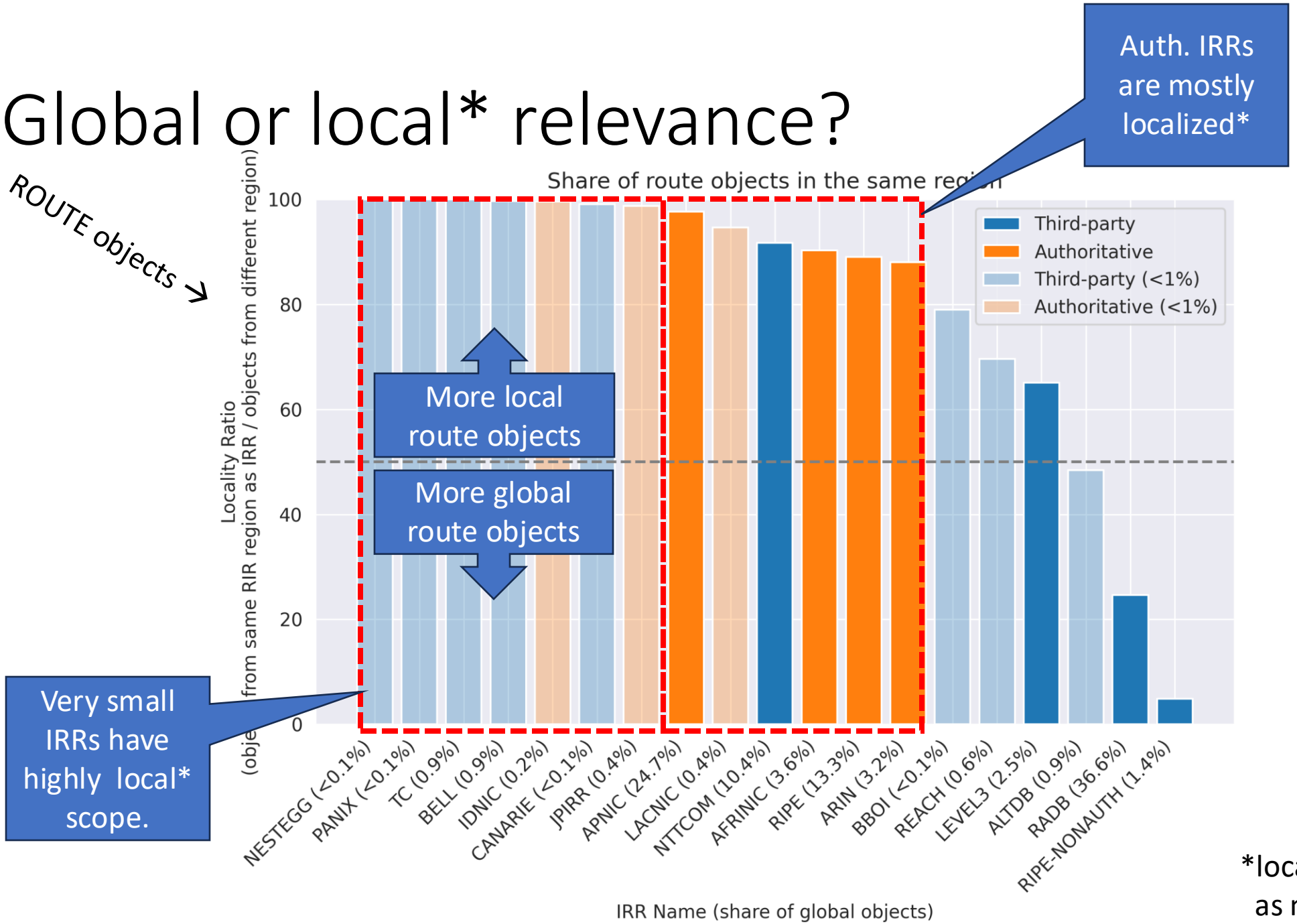

*local = same RIR region as maintainer org's HQ

# Global or local* relevance?



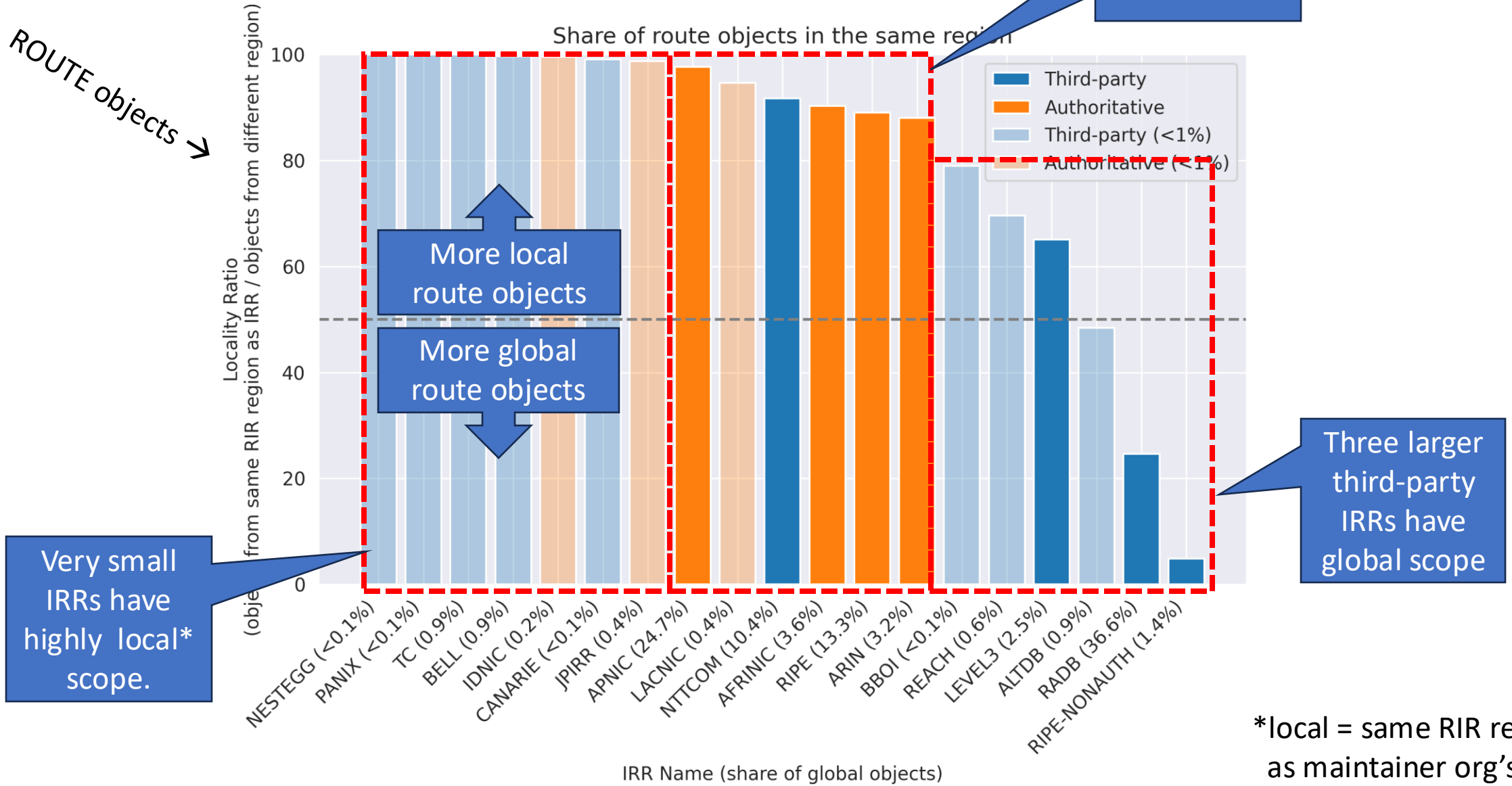

*local = same RIR region as maintainer org's HQ

# Global or local* relevance?




*local = same RIR region as maintainer org's HQ

# Global or local* relevance?




Auth. IRRs are highly localized*

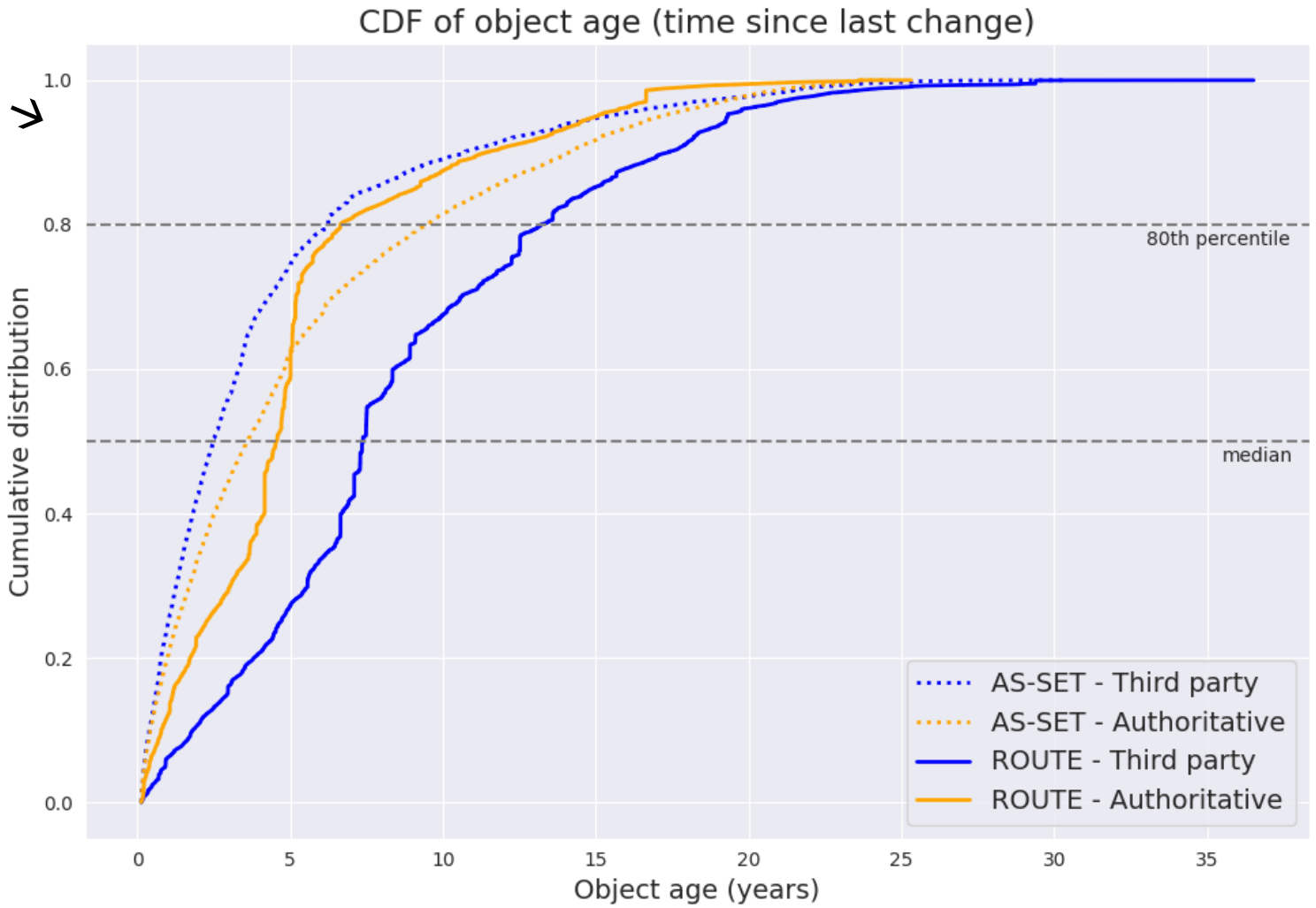
Very small IRRs have highly local* scope.

Three larger third-party IRRs have global scope

*local = same RIR region as maintainer org's HQ

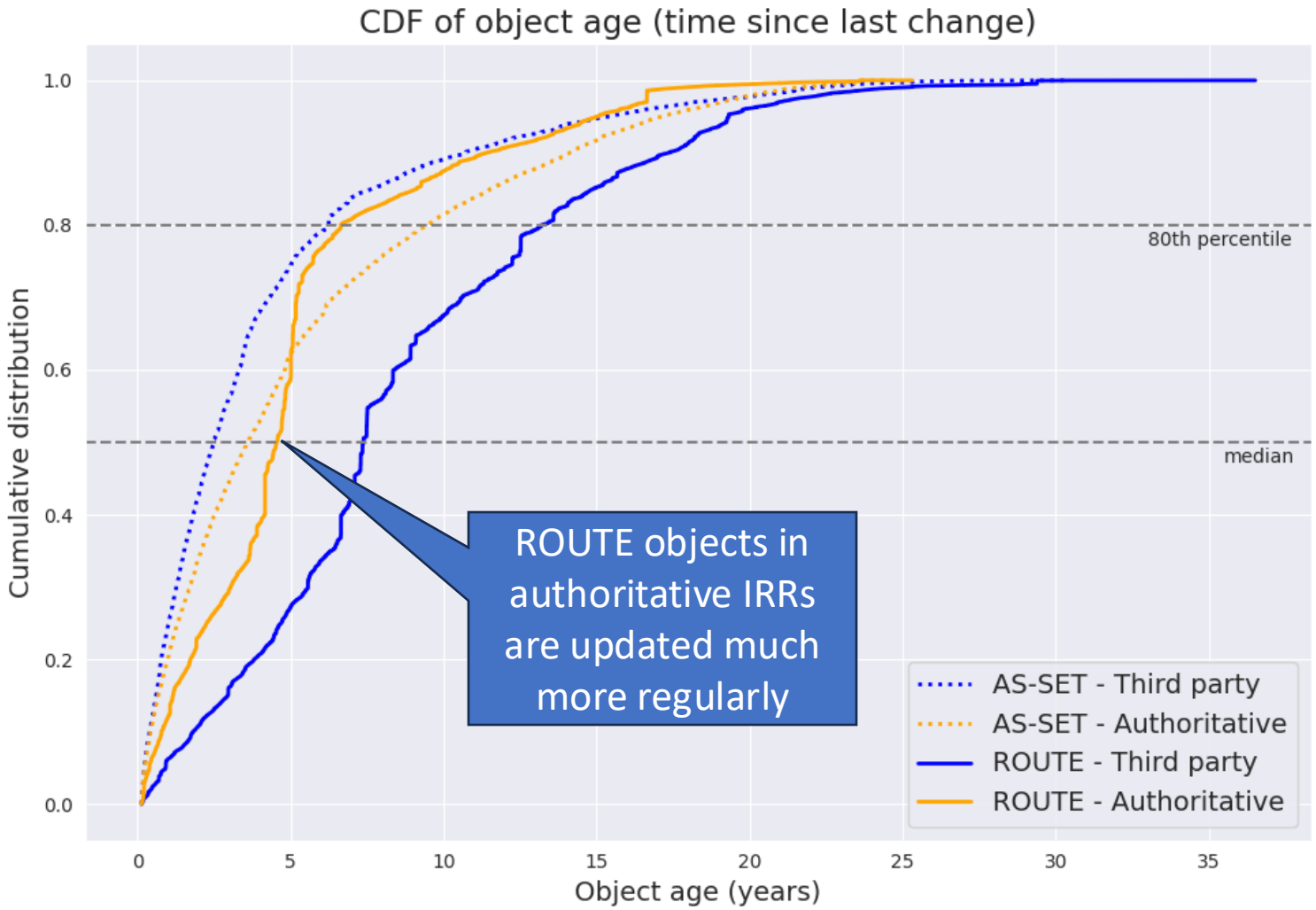
# How often are objects updated?

Good performance



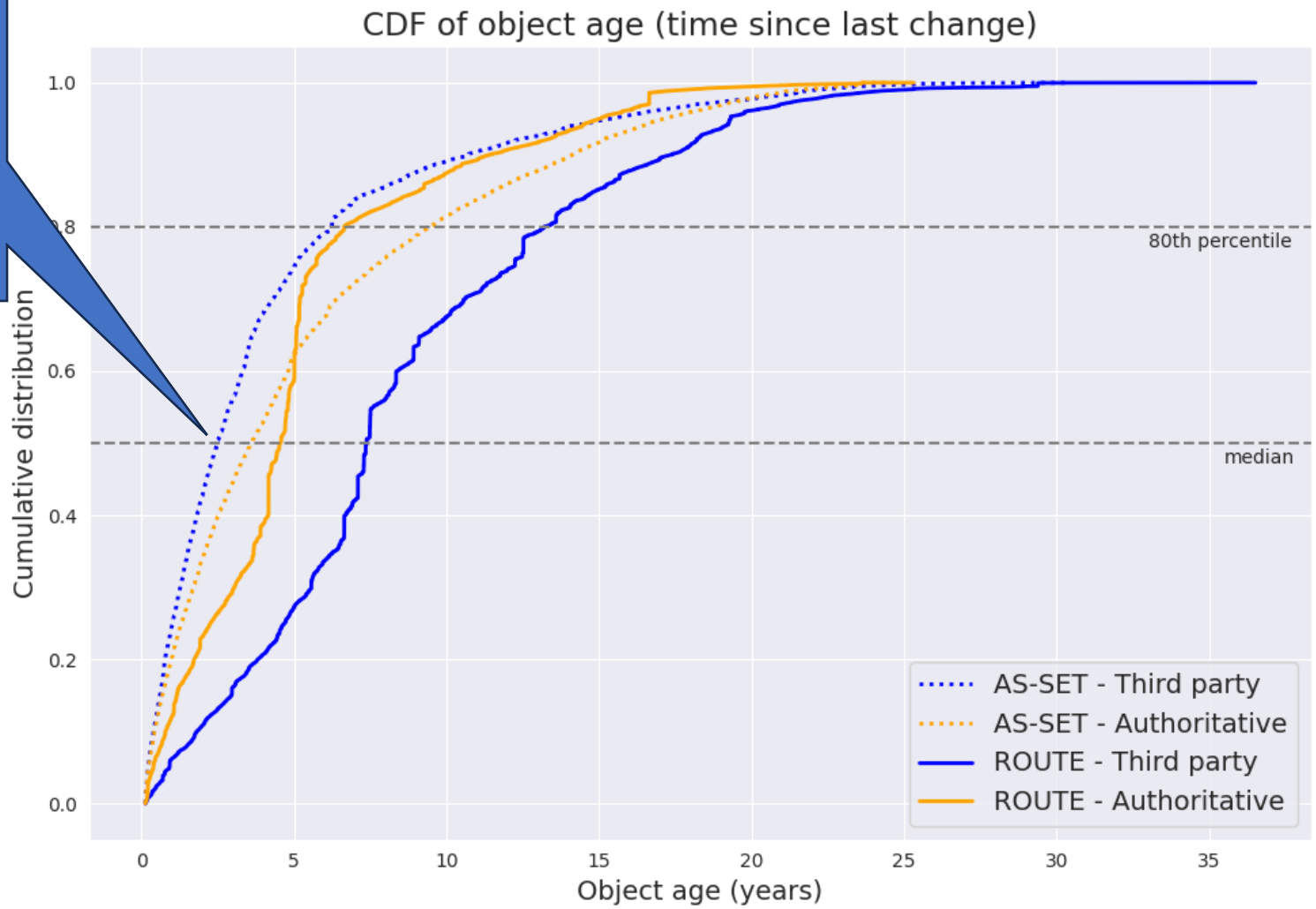

bad performance

# How often are objects updated?



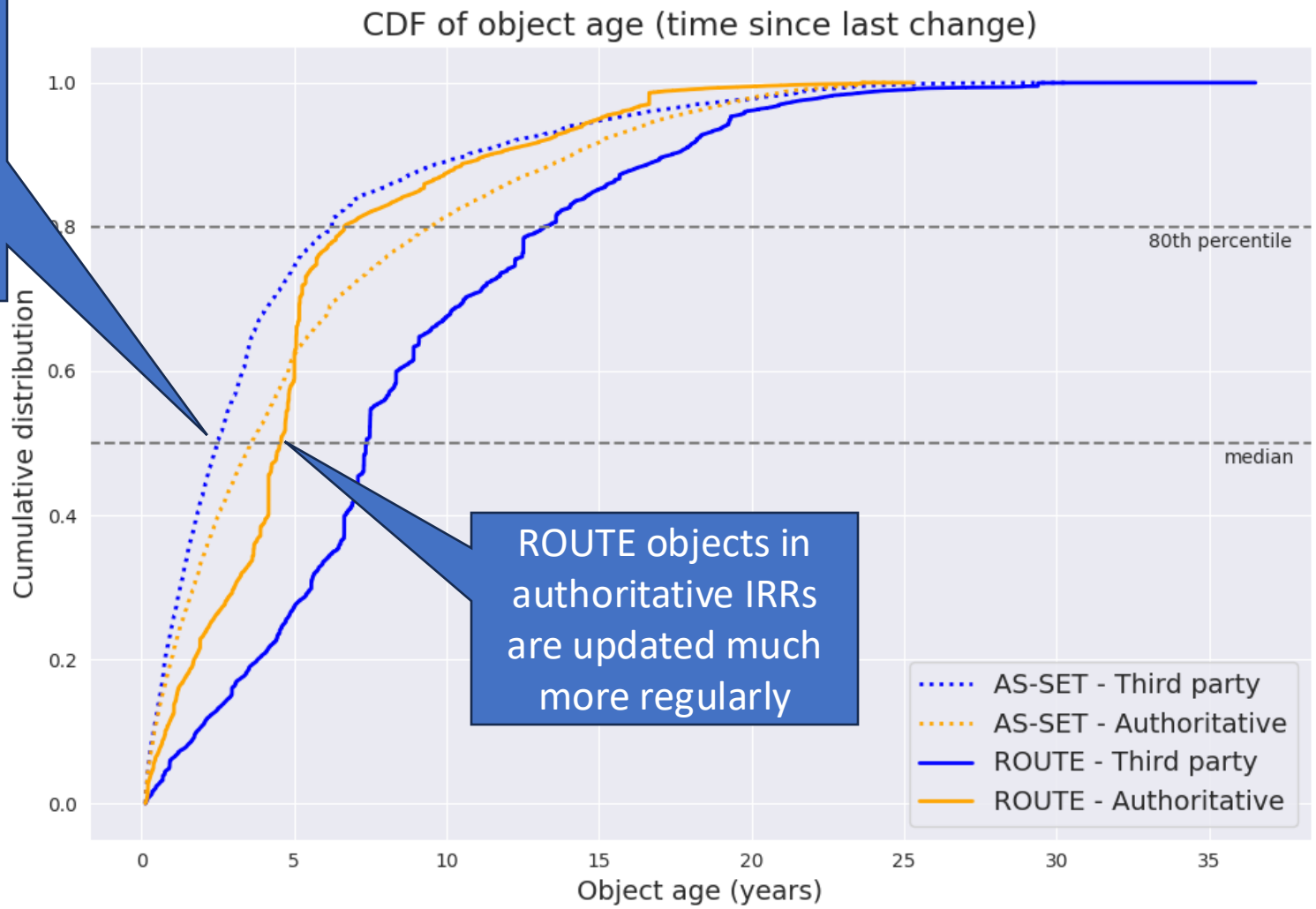
# How often are objects updated?

AS-SET updates look a bit better for third-party IRRs. *This is caused by TC!*



# How often are objects updated?

AS-SET updates look a bit better for third-party IRRS. *This is caused by TC!*



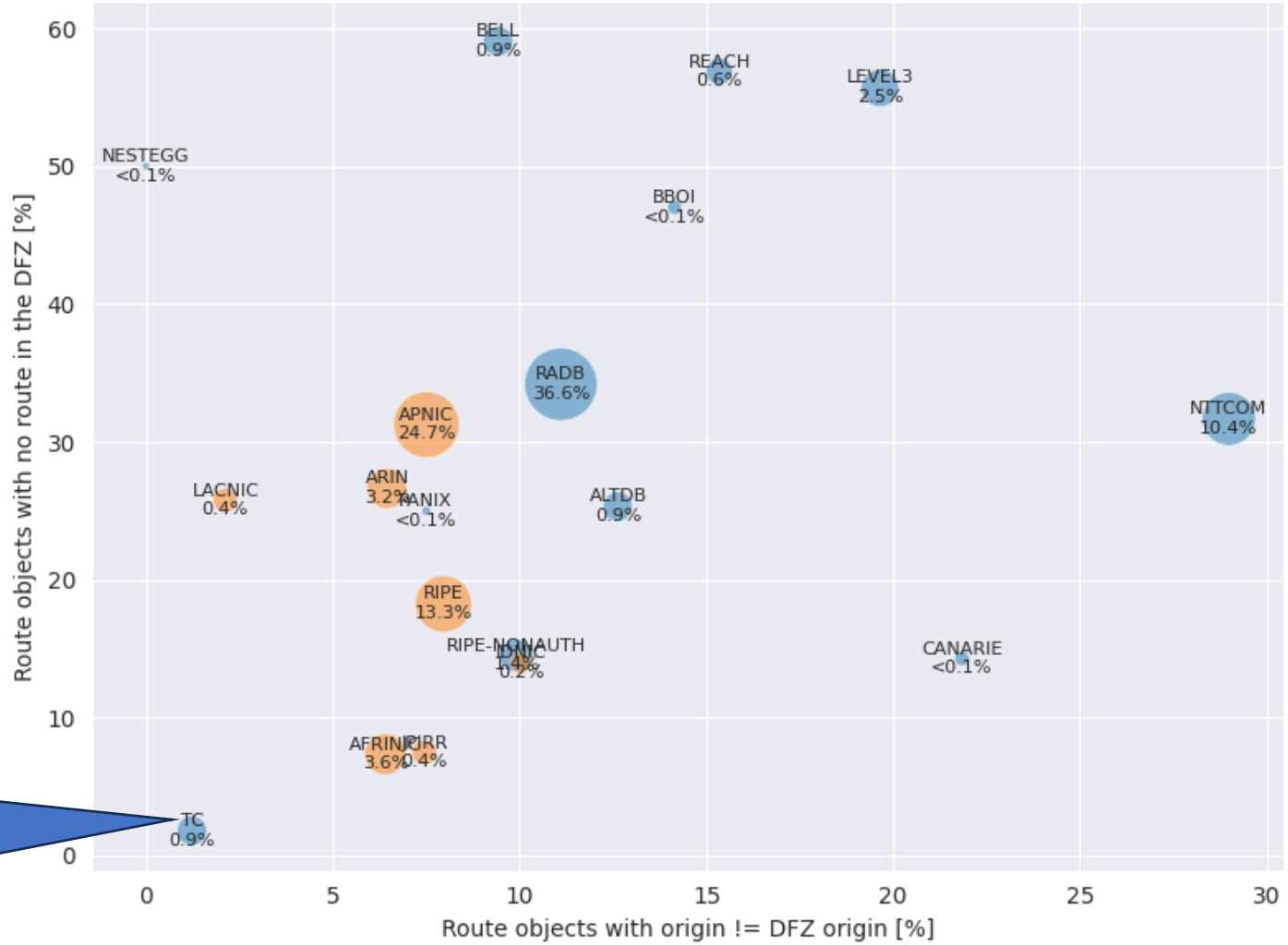

ROUTE objects in authoritative IRRs are updated much more regularly

# Do objects match with the DFZ?


← bad performance

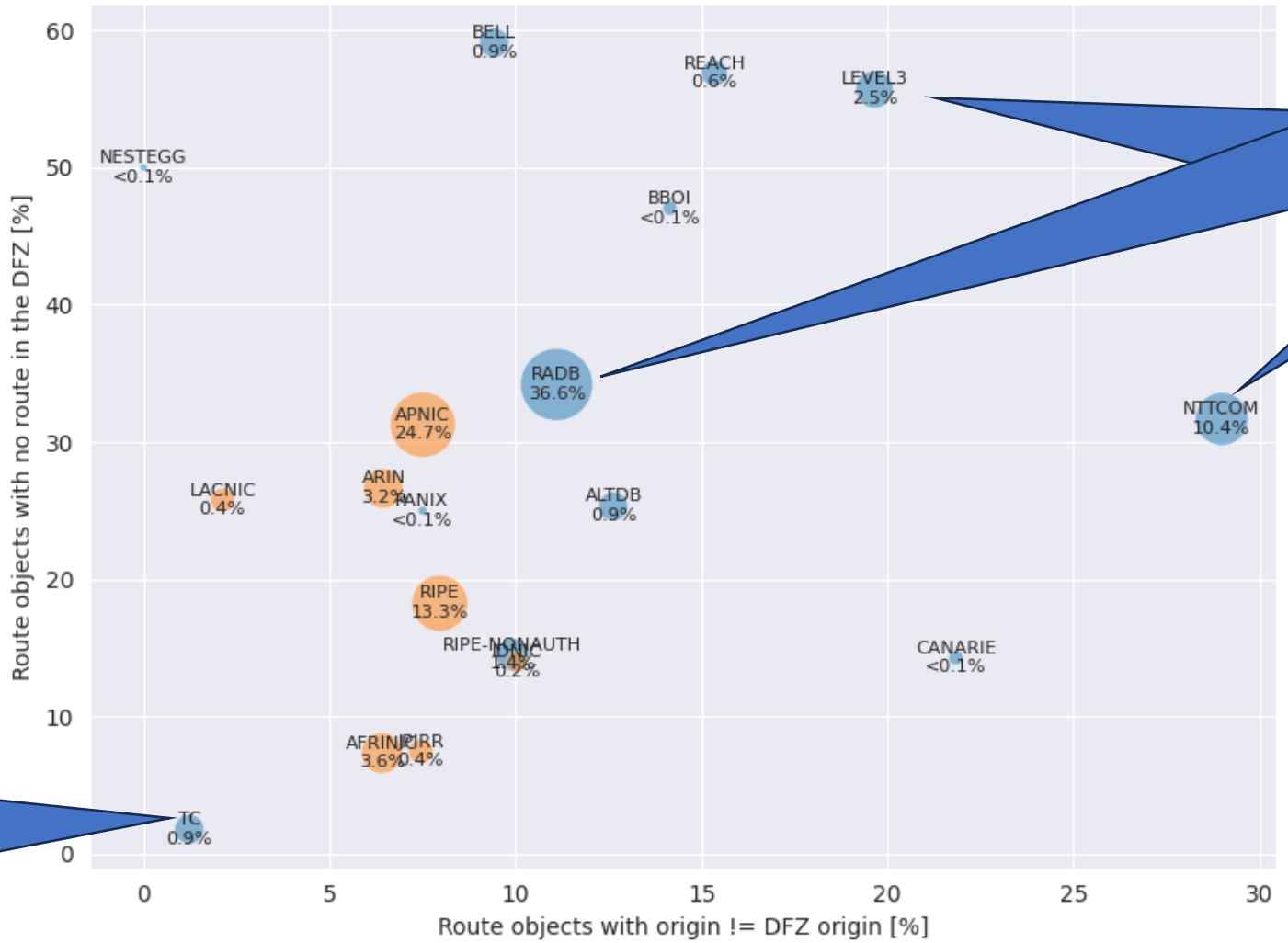
Good performance →

# Do objects match with the DFZ?




TC is the unlikely winner. We asked them: they enforce strict rules.

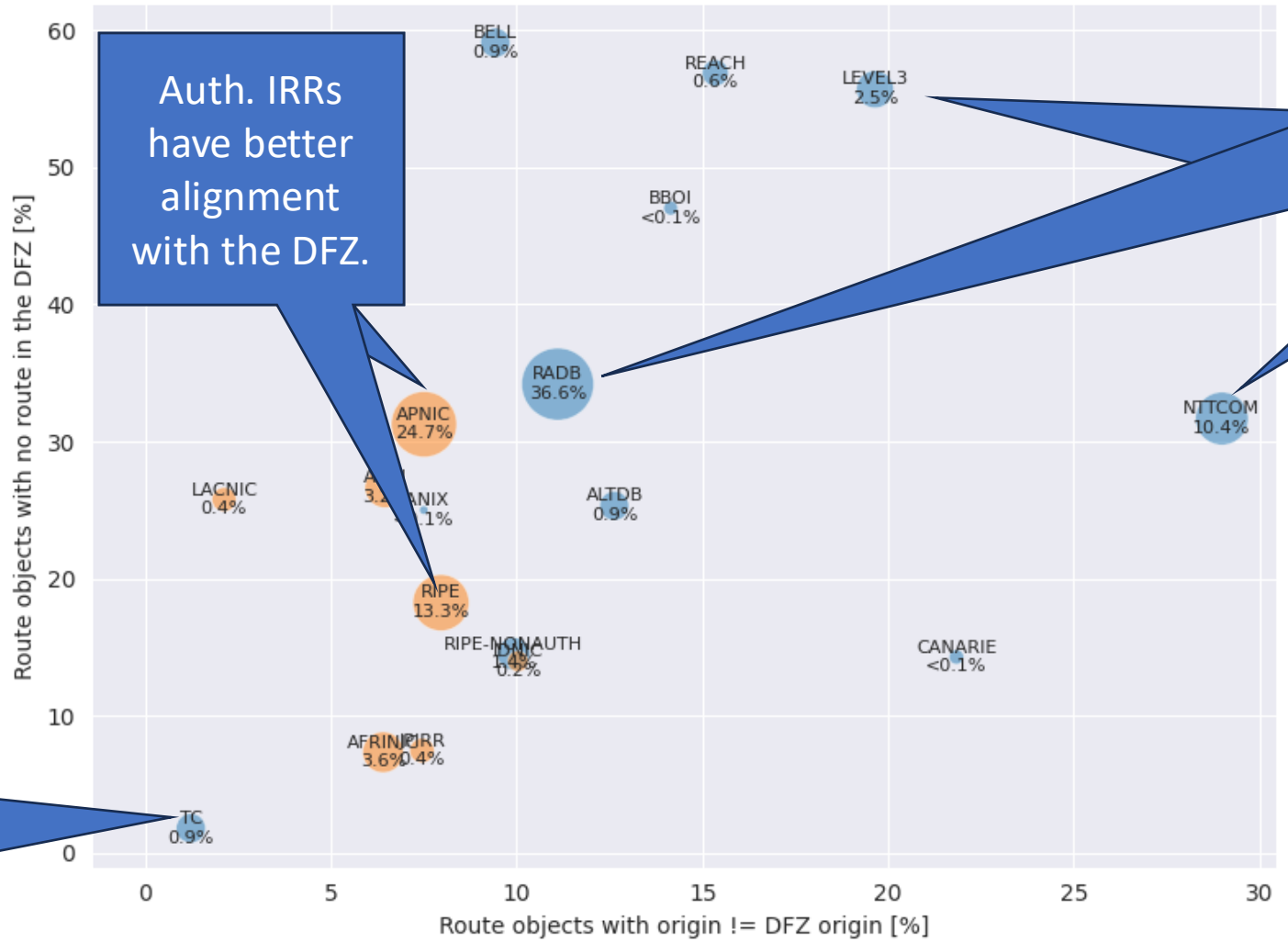
# Do objects match with the DFZ?




Nearly all third-party IRRs have worse alignment with the DFZ.

TC is the unlikely winner. We asked them: they enforce strict rules.

# Do objects match with the DFZ?




Auth. IRRs have better alignment with the DFZ.

Nearly all third-party IRRs have worse alignment with the DFZ.

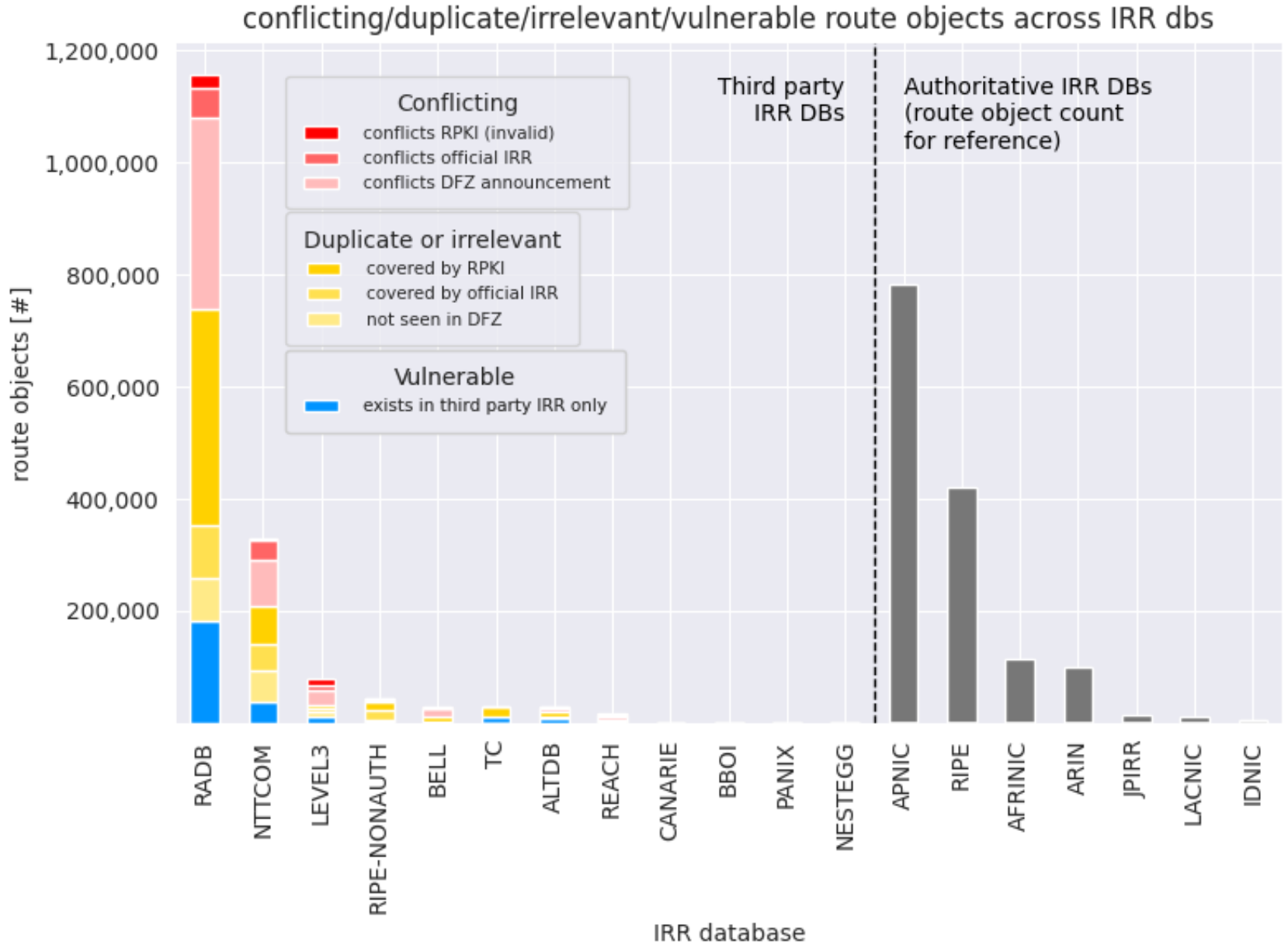
TC is the unlikely winner. We asked them: they enforce strict rules.

# Q: Do authoritative IRRs represent operators better than third-party IRRs?

A: Yes. Authoritative IRRs are **less in conflict with the DFZ** and have a **higher object update frequency**. The only exception is TC, which has highly localized relevance in LACNIC (Brazil) and holds <1% of the global route objects.

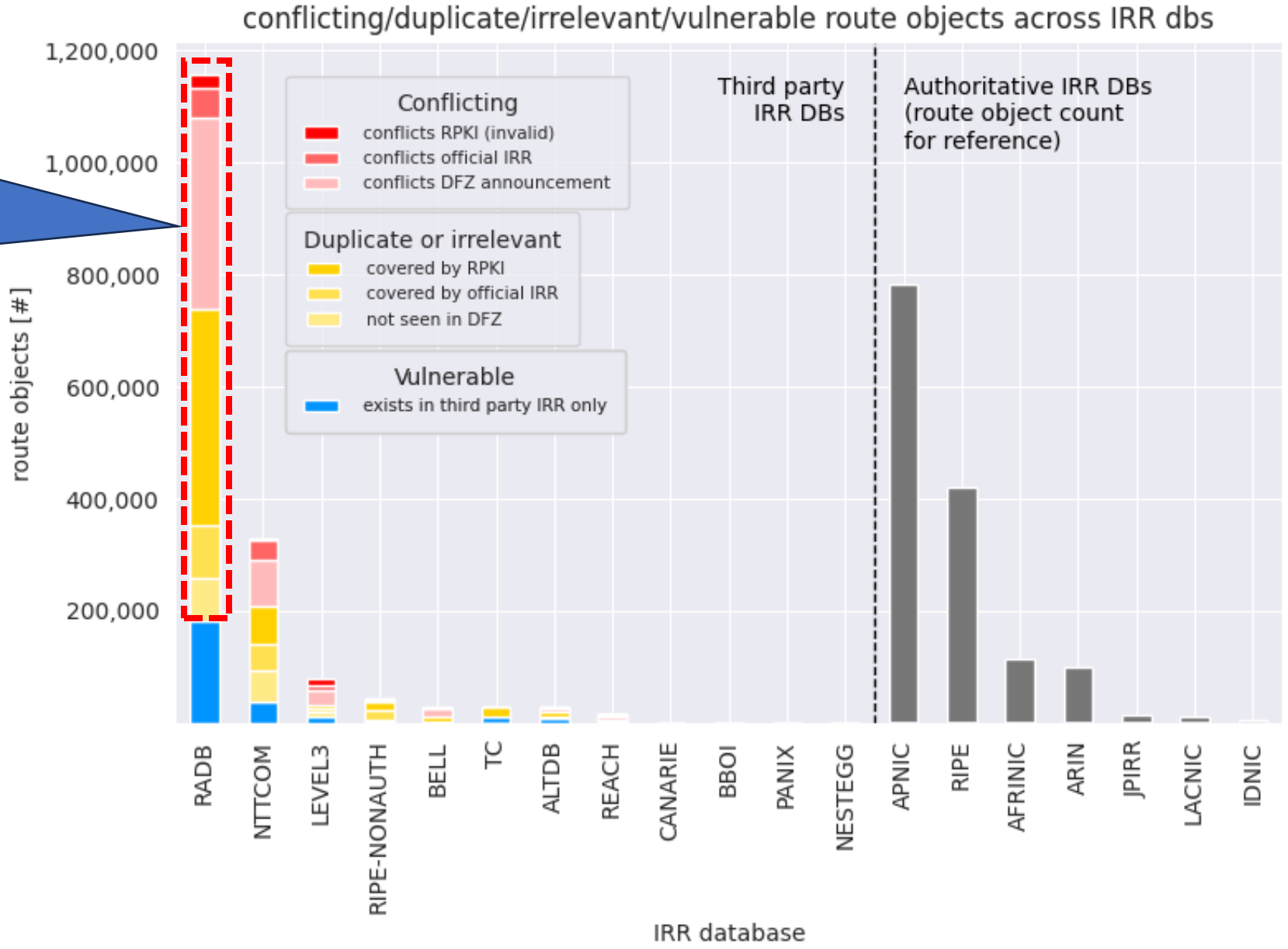
# Q: Is the juice worth the squeeze?

# What about data quality of route objects?

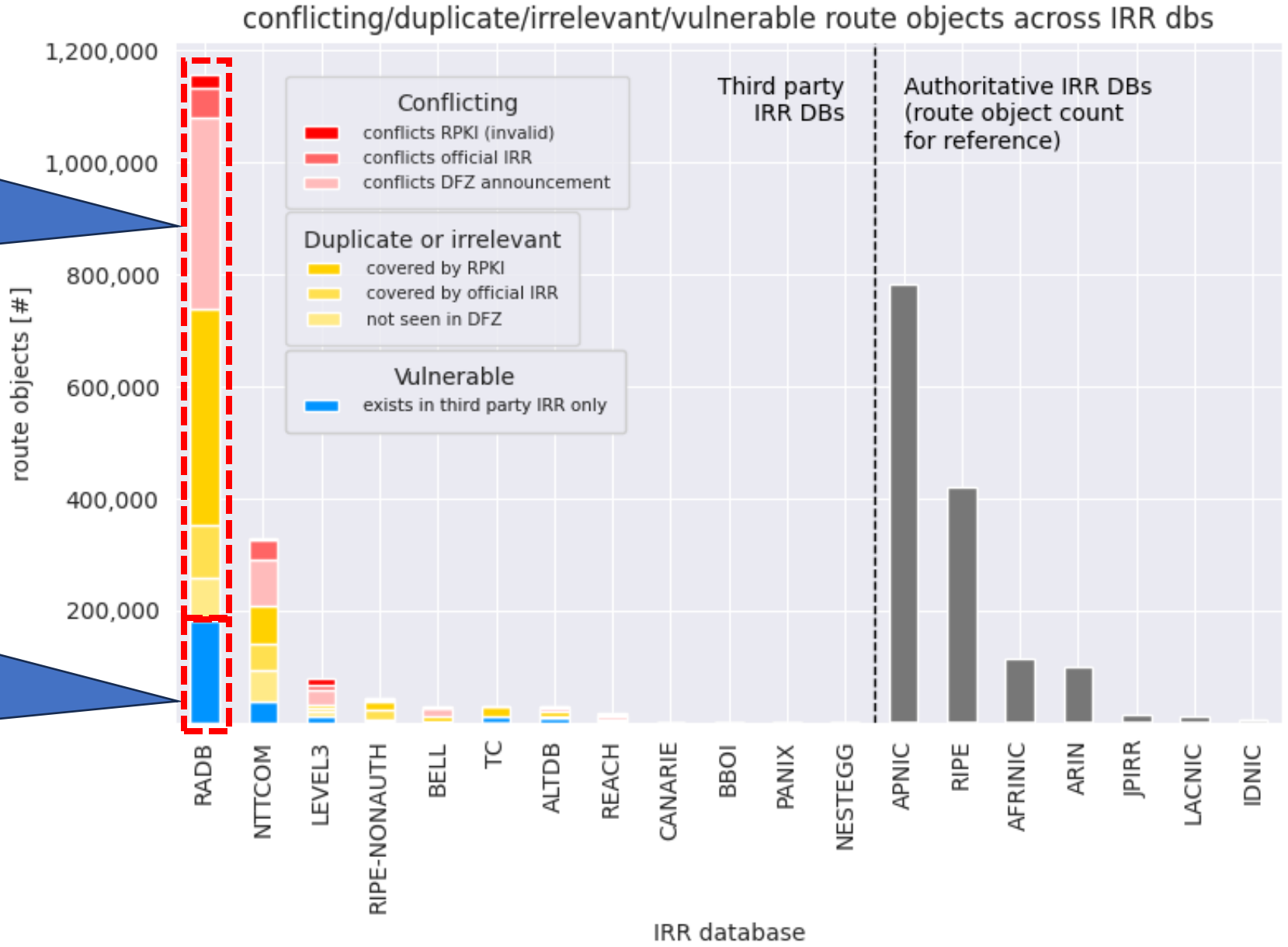


# What about data quality of route objects?

1M route objects (84%) in RADB are conflicting or irrelevant.



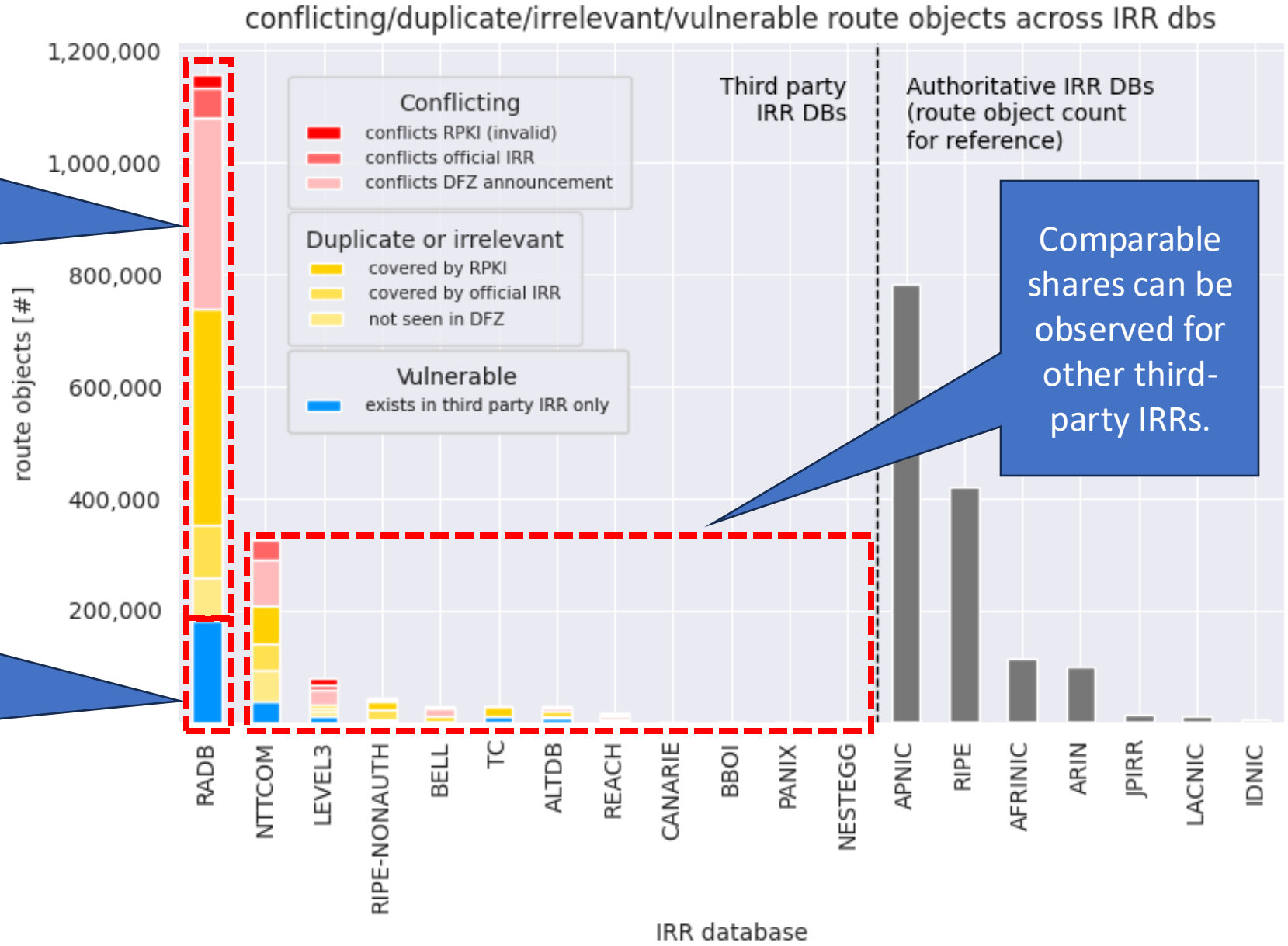
# What about data quality of route objects?




1M route objects (84%) in RADB are conflicting or irrelevant.

However 200k relevant vulnerable route objects remain (16%).

# What about data quality of route objects?

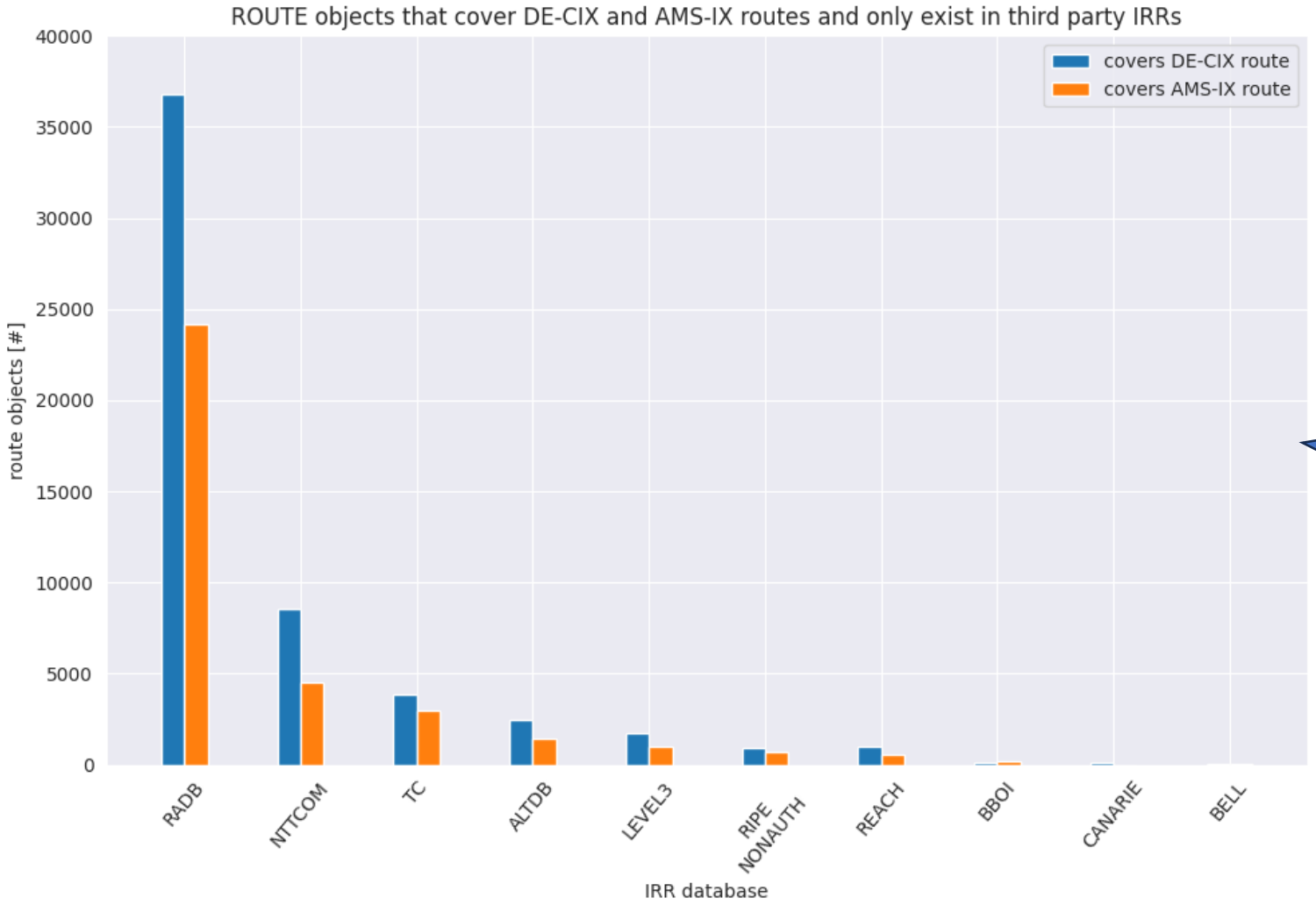



1M route objects (84%) in RADB are conflicting or irrelevant.

However 200k relevant vulnerable route objects remain (16%).

Comparable shares can be observed for other third-party IRRs.

# Vulnerable objects covering AMS-IX/DE-CIX routes

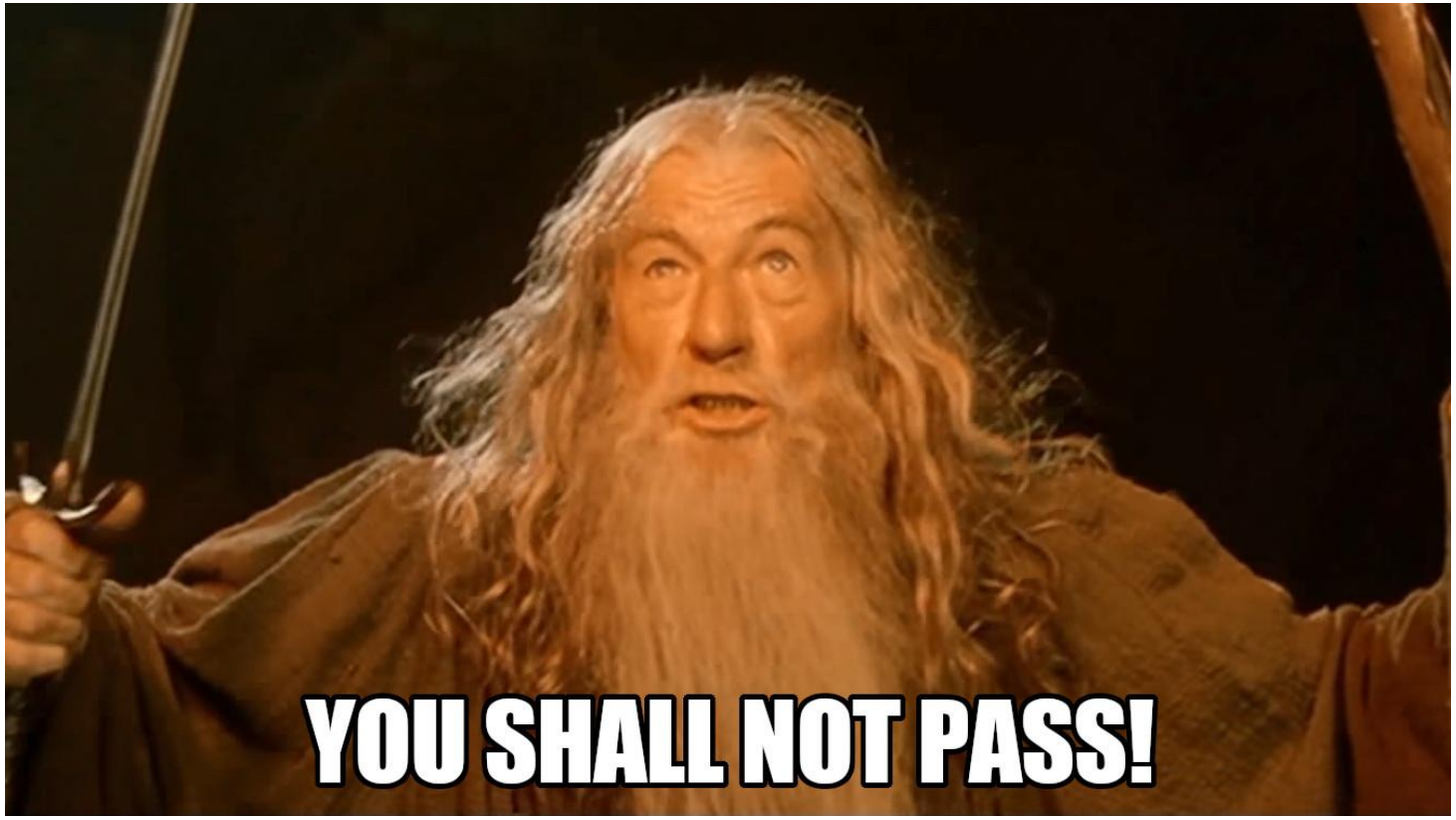



In total we identified 36k/56k vulnerable route objects relevant for AMS-IX/DE-CIX routes. >50% of them are in RADB.

# Q: Is the juice worth the squeeze?

A: Yes. There are **still >230k route objects that are only stored in third-party IRRs** that can be easily hijacked. All of these **are routed** in the DFZ and **36k/56k cover AMS-IX/DE-CIX routes.**

# Q: What about Legacy Space?



# Let’s talk about Legacy space

- In general, Legacy space is the space allocated to Organizations before the 5 RIRs where established
  - But not all RIRs were established at the same time
  - Oldest: RIPE NCC, founded in April 1992
    Youngest: AFRINIC, established in October 2004
- Different ways of handling their corresponding Legacy space

# Different RIR, different legacy approach

| RIR | IRR access | RPKI access | Due diligence process |
|---|---|---|---|
| AFRINIC | no service agreement | service agreement | Yes* |
| APNIC | All** APNIC legacy space is under contract or was returned to IANA. | | |
| ARIN | service agreement | service agreement | Yes* |
| LACNIC | no service agreement | no service agreement | Yes* |
| RIPE NCC | no service agreement | service agreement | Yes* |

* for service agreement
** To a level of 99%

# Different RIR, different legacy approach

| RIR | IRR access | RPKI access | Due diligence process |
|---|---|---|---|
| AFRINIC | no service agreement | service agreement | Yes* |
| APNIC | All APNIC legacy space is under contract or was returned to IANA. | | |
| ARIN | service agreement | service agreement | Yes* |
| LACNIC | no service agreement | no service agreement | Yes* |
| RIPE NCC | no service agreement | service agreement | Yes* |

ARIN legacy remains the main obstacle.

* for service agreement

# Different RIR, different legacy approach

All RIRs require due diligence for service agreement.

| RIR | IRR access | RPKI access | Due diligence process |
|---|---|---|---|
| AFRINIC | no service agreement | service agreement | Yes* |
| APNIC | All APNIC legacy space is under contract or was returned to IANA. | | |
| ARIN | service agreement | service agreement | Yes* |
| LACNIC | no service agreement | no service agreement | Yes* |
| RIPE NCC | no service agreement | service agreement | Yes* |

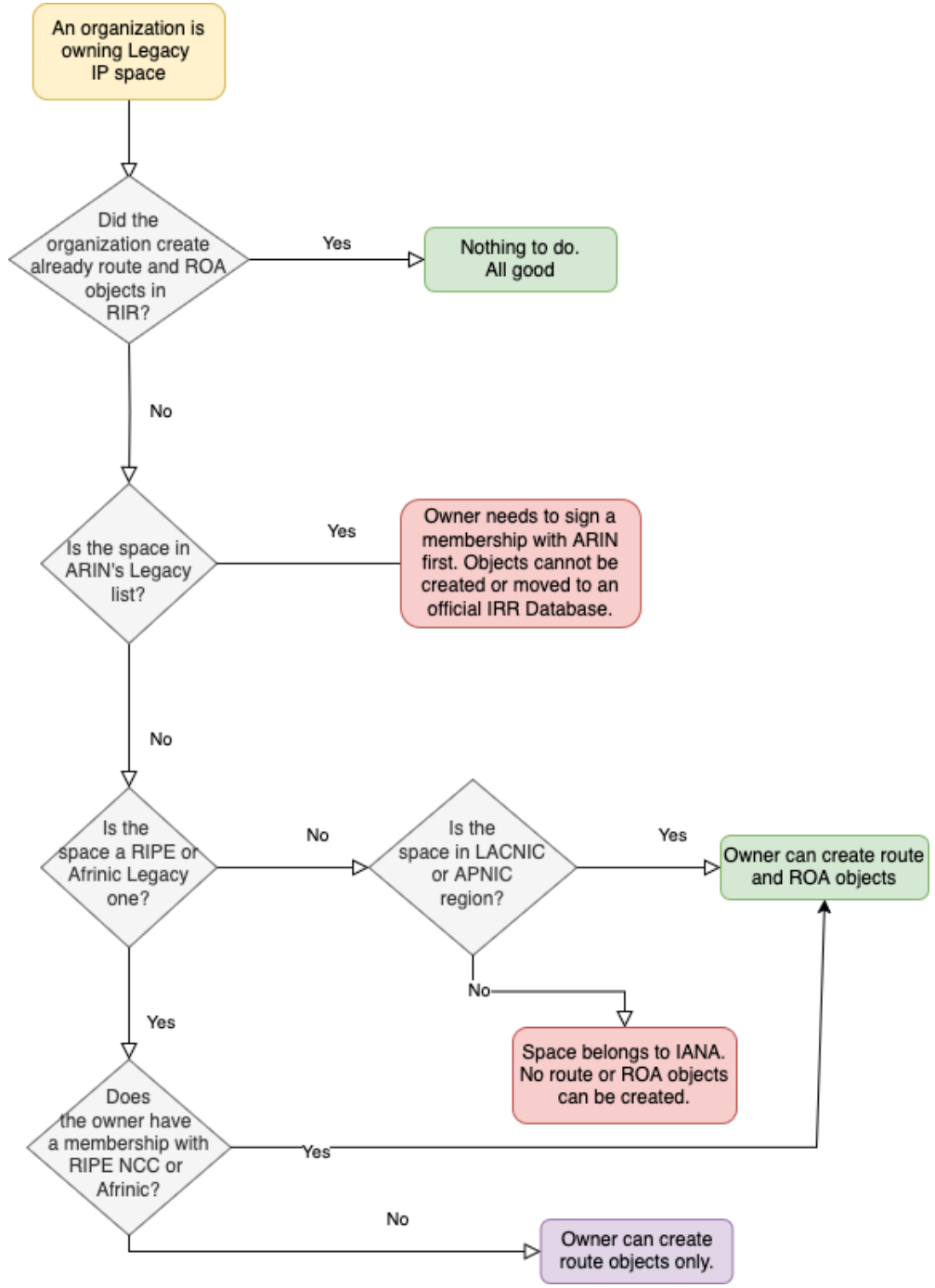
ARIN legacy remains the main obstacle.

* for service agreement

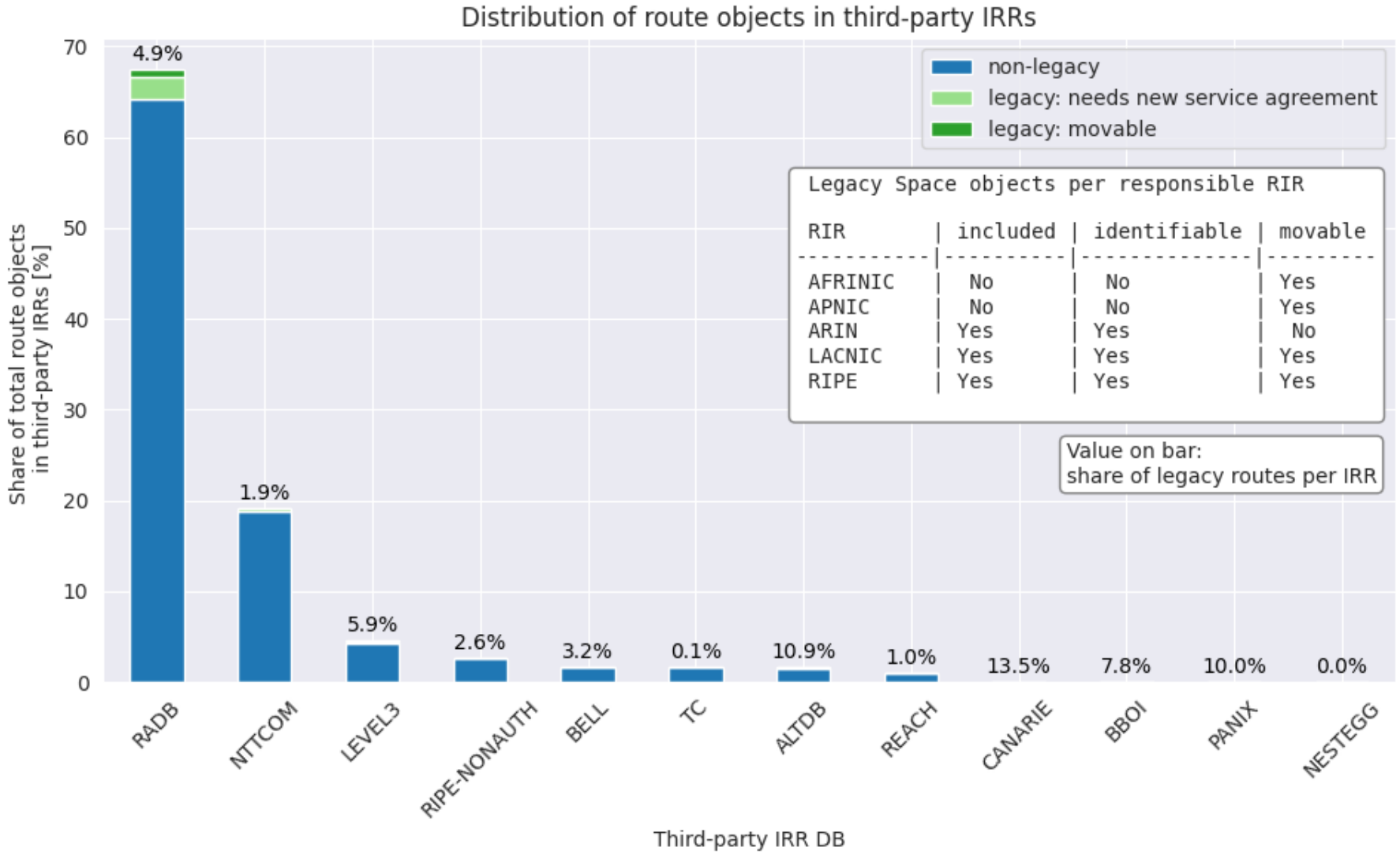
# Legacy space reconsidered

Legacy Space is not an issue for everyone

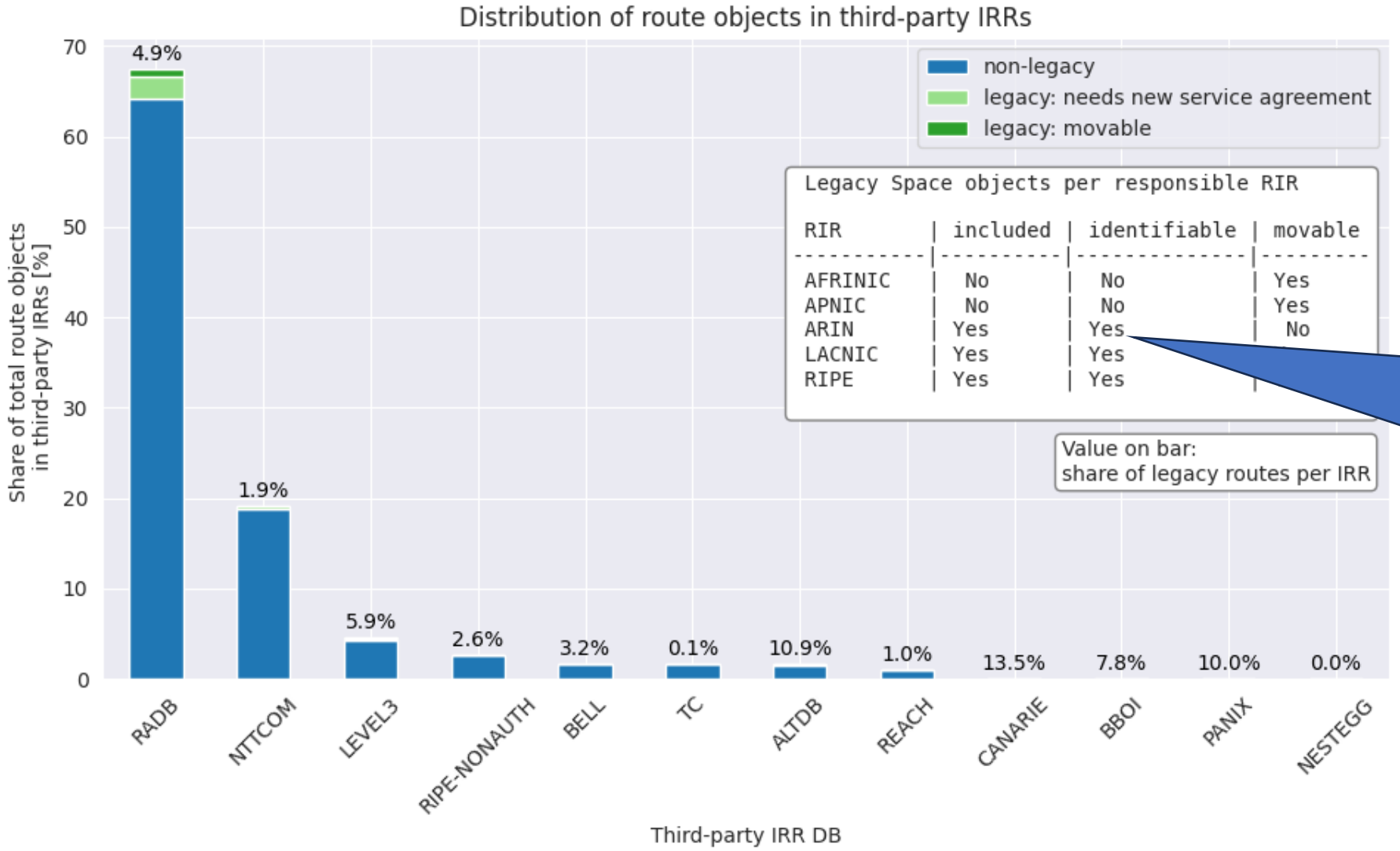
- All legacy space except ARIN is “movable” to authoritative IRRs without a new service agreement
- ARIN legacy space requires a new service agreement
- New service agreement → convince RIR the space is yours



# Where does legacy live?



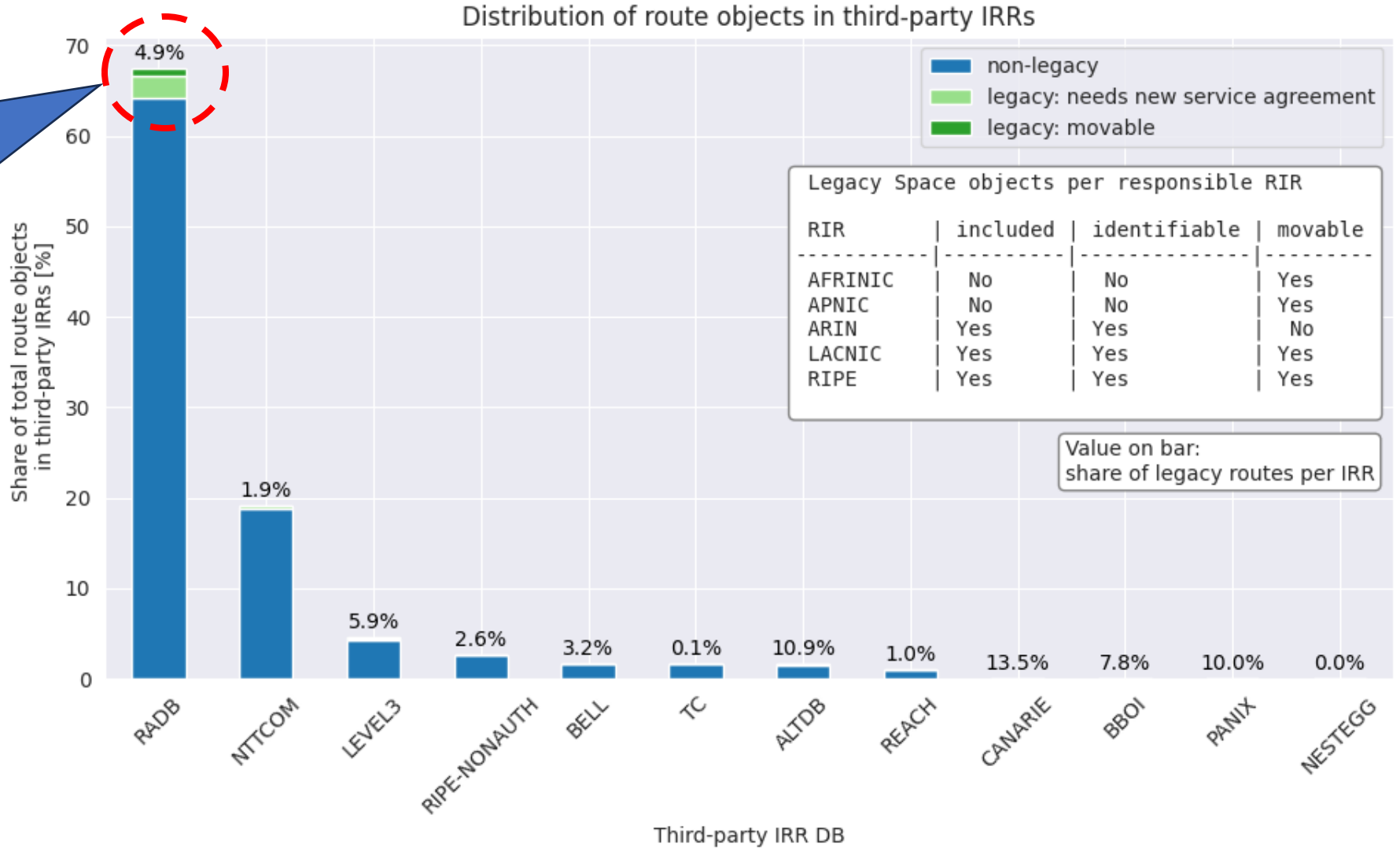
# Where does legacy live?



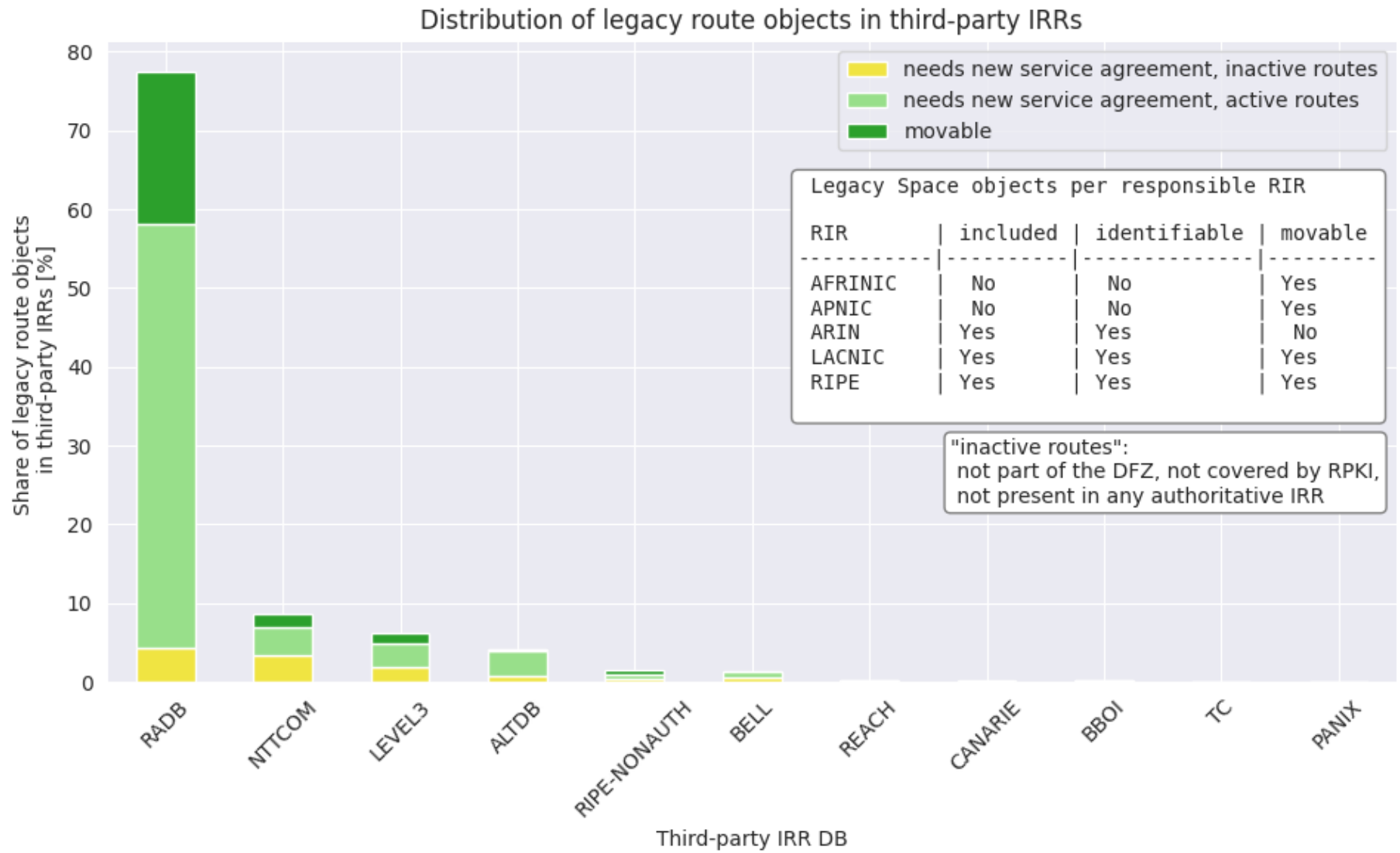

Only based on ARIN, LACNIC, RIPE data

# Where does legacy live?

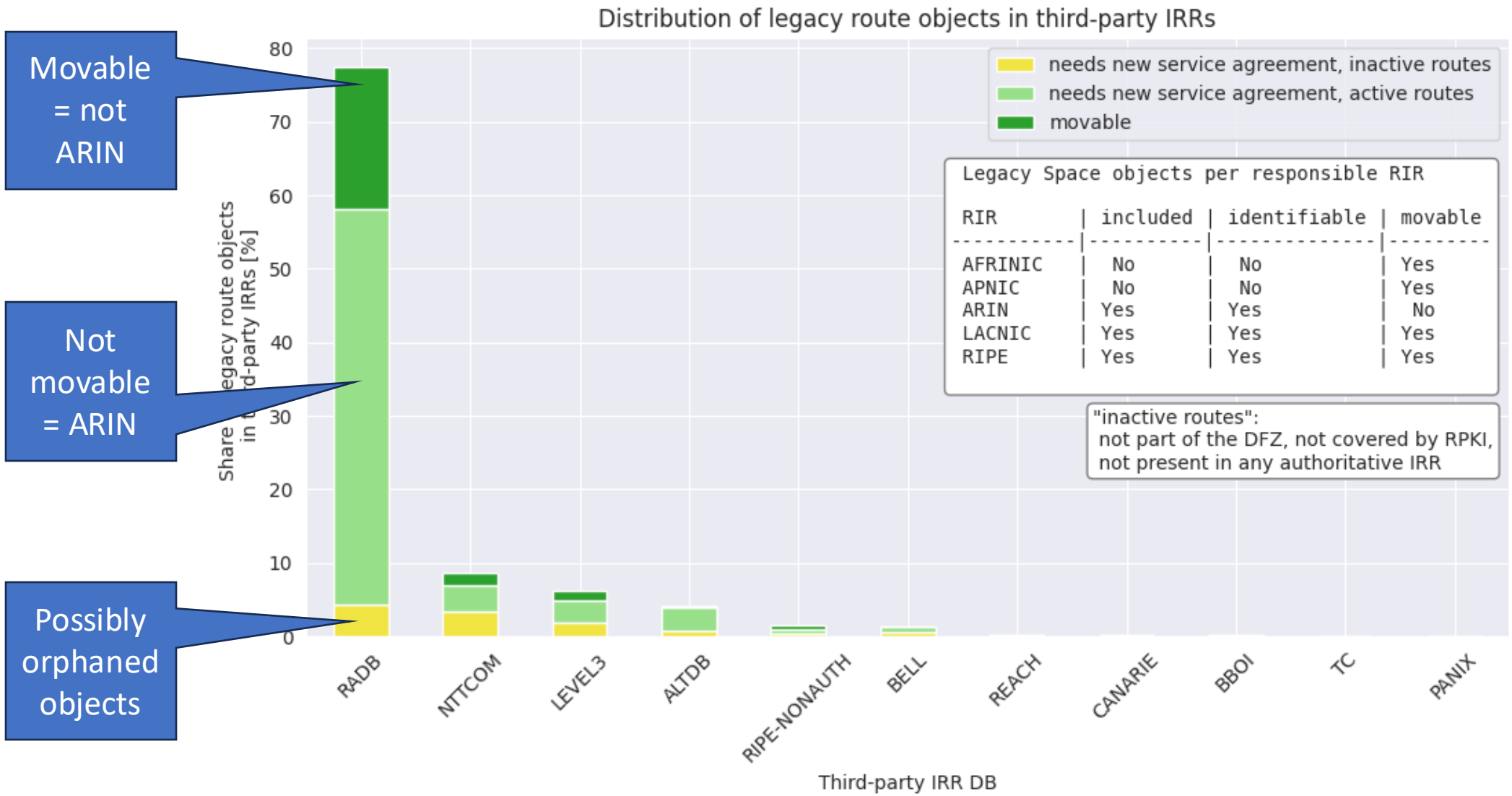
Mainly in RADB (4.9% of RADB objects)



# Global share per third-party IRR



# Global share per third-party IRR



# Q: What about Legacy Space?

A: **3 of 4* relevant RIRs provide IRR services** to **non-member legacy space** holders. ARIN legacy remains problematic with a share of 3.27% of all global route objects in third-party IRRs. These route objects need a new service agreement.

* excluding APNIC

# Conclusions

- Do authoritative IRRs represent operators better than third-party IRRs?
  - They do → more frequent updates, more coherence with DFZ
- Is the juice worth the squeeze?
  - >80% of low quality objects exist in third-party IRRs like RADB
  - We found more than 230k injectable/vulnerable route objects
- What about legacy space?
  - ARIN remains problematic, for other RIRs non-member IRR services exists
  - We found 3.27% ARIN legacy route objects in third-party IRRs, mostly in RADB

# Outlook

The following study will be conducted during the next period

- Extract the vulnerable prefixes that exist in AMS-IX/DE-CIX Route Servers
- Identify the ones that might be lost and map them to organizations
- Measure the amount of traffic flowing into the lost prefixes.

# Thank you

# RIPE NCC & AFRINIC

- Both follow the same approach
  - Legacy resource holders without a membership signed have access to WHOIS DB and are allowed to create RPSL objects
  - Without a membership signed, resource holders are excluded from RPKI
  - It is possible to import your Legacy space and have it fully registered by completing the necessary paperwork (and thus receive RPKI services).

# Conclusions

From the presented results, we can safely conclude that data quality in third party IRR DBs is disappointing

- Contain outdated or irrelevant information
- Contain duplicated information
- Authorization model cannot be applied, posing serious trust and security risks

# APNIC and LACNIC

- All LACNIC assigned space (even the legacy one) already exists in the DB.
  - Legacy resource holders without membership are allowed to both IRR and RPKI services (but these are very few cases).

- APNIC reclaimed their legacy space (without active contract) via a policy. After several years of effort this project is concluded and even some of the reclaimed space was given back to IANA.
  - Nowadays, all APNIC account holders with historical resources can now access RPKI services

# The ARIN way

- If a user or a company wants to import its legacy space in ARIN, he needs to sign an agreement with ARIN and pay full ARIN membership.
  - If no agreement is signed, no IRR and RPKI services are given to them by ARIN (but they can have an account and maintain e.g. reverse DNS delegations).
  - ARIN keeps track of its legacy space which is being exported in a separate FTP export.

- **HOWEVER**: On January 16th former US president Biden ordered the FCEB agencies to take actions to ensure that all of their assigned Internet number resources (IP address blocks and ASNs) are covered by a Registration Services Agreement with the American Registry for Internet Numbers or another appropriate regional Internet registry.