Technical Report

DomainTools

IPv6 Deployment on the Internet:

AAAA Records in Farsight DNSDB

Passive DNS

Joe St Sauver, Ph.D.
Distinguished Scientist

Executive Summary

We've previously reported on the Internet's use of IPv4 address space as seen in count data from Farsight DNSDB. As part of that work, we mapped the Internet's IPv4 address space for a 90 day period, visualizing that data using space filling Hilbert Curve "heatmaps" plus a series of violin plots. This is the IPv6 "companion volume" to that IPv4 report, delivering similar insights for IPv6 counts and unique RRsets over a 90 day period.

Creating this report presented challenges, perhaps the biggest of which was the immense size of the IPv6 address space:

- IPv4 address space theoretically allows for up to 2^32=4,294,967,296 IPs. That may seem like a lot, but actually *not* all that many in a world of over eight billion people.
- IPv6 address space, on the other hand, theoretically allows for up to 2^128= 340,282,366,920,938,463,463,374,607,431,768,211,456 (~340 undecillion, or 340x10^36) IPv6 addresses, although only a tiny fraction of that potential space is currently in use.

Notwithstanding the immense size, we can – and did – efficiently analyze currently-allocated unicast IPv6 address space by making just under a half-a-million DNSDB IPv6 /28 CIDR queries.

This study considered two fundamental metrics for each IPv6 /28 prefix:

<u>Aggregate Count Data Per IPv6 /28 Prefix:</u> We summarize aggregate count data at the IPv6 /28 level for the eight allocated IPv6 /12-equivalents. This was in the form of simple summary statistics, grouped cumulative distribution plots, and a grouped violin plot. We then report on excerpts from the top two dozen prefixes with the highest aggregate cache miss counts, so those curious about the IPv6 prefixes that get the most queries can get some sense of the underlying activity.

<u>Unique RRsets Per IPv6 /28 Prefix:</u> A prefix with a high cache miss count might have all that activity concentrated on just a handful of RRsets; other studied prefixes might not have a huge aggregate count, but might have hundreds of thousands of unique RRsets. So, for this study, we added the number of unique RRsets, summarizing the number of unique RRsets per IPv6 /28 prefix with simple statistics, group cumulative distribution plots, and a grouped violin plot. As we did for "top count" prefixes, we also provided excerpts for the top two dozen prefixes for those who might be curious about these "top RRset" prefixes.

In addition, we also visualized our IPv6 count data as a way of summarizing what we've found using three hierarchical tiers of graphs (IPv6 Count Data Maps):

- We started with a top level "overview" map considering all of 2003::/4, covering the global unicast IPv6 space that's currently in use.
    - We "drilled down" through a set of eight IPv6 /12 prefix maps, with each of those showing one of the eight allocated IPv6 /12's in more detail.
        - We then concluded with a small set of select individual IPv6 /16 maps that allow us to "zoom in" for a closer look at some regions that exhibited atypical macroscopic patterns when viewed at the previous IPv6 /12 level of detail.

All-in-all, we believe this is a unique snapshot of domain-related IPv6 deployment on the public Internet as seen in passive DNS data.

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I. Introduction and a Review of IPv6

In a previous report, we described IPv4 address space as seen in Farsight DNSDB. We visualized data for the entire IPv4 Internet with Hilbert curve heatmaps and violin plots. Since the Internet has been running out of IPv4 address space, many sites are now using IPv6 addresses as well as IPv4 addresses (e.g., they're running "dual-stack"). In this companion report, we will describe the Internet's IPv6 address space as seen in DNSDB.

Note that IPv4 and IPv6 are radically different "animals" (albeit with some similarities). Just to highlight a few quick touch points:

- **IPv4 addresses** are 32 bits long. They're called "dotted quads" because they are normally written using four integer values, each value ranging from 0 to 255, separated by dots. A sample IPv4 address is 192.168.213.20.

  IPv6 addresses, on the other hand, are 128 bits long, and are written with eight groups of four hexadecimal digits separated by colons. A sample IPv6 address is 2600:9000:260f:1600:000b:5c6c:3200:93a1.

- IPv6 **prefix lengths** increase by 4 per hex digit, or 16 per colon-separated group of four hex digits, e.g.:

  X::/4
  XX::/8
  XXX::/12
  XXXX::/16
  XXXX:X:: /20
  XXXX:XX:: /24
  XXXX:XXX::/28
  XXXX:XXXX::/32
  XXXX:XXXX:X::/36
  XXXX:XXXX:XX::/40
  XXXX:XXXX:XXX::/44
  XXXX:XXXX:XXXX::/48
  XXXX:XXXX:XXXX:X::/52
  XXXX:XXXX:XXXX:XX::/56
  XXXX:XXXX:XXXX:XXX:/60
  XXXX:XXXX:XXXX:XXXX::/64
  [etc.]

- In the DNS, domain names get mapped to **IPv4** addresses using **"A" records**, while domain names get mapped to **IPv6** addresses using **"AAAA" ("quad A") records.** Farsight DNSDB indexes and reports on both IPv4 and IPv6 by default.

- One thing that can feel daunting about IPv6 is the sheer size of the address space it offers. IPv4 is relatively small with an upper theoretical limit of "just" **2^32=4,294,967,296 addresses**. That's really not very many addresses for a world with a population of over eight billion people, particularly when you realize that:

  - Many people will have multiple IP "address-using devices" (a laptop, a multifunction printer/scanner, a smart phone, a tablet, a smart watch, a smart TV, a video game console, a smart speaker, smart kitchen appliances, etc.), notwithstanding use of NAT (https://en.wikipedia.org/wiki/Network_address_translation), and

- Many of the available IPv4 addresses actually aren't available for use (as discussed in our earlier report), either being used privately by the Department of Defense, tied up for IP multicast, or tied up as so-called "class E" reserved address space.

IPv6, on the other hand, provides for a much, much larger address space:
2^128=340,282,366,920,938,463,463,374,607,431,768,211,456 (~340 undecillion, or 340x10^{36}) addresses.

- Both IPv4 and IPv6 use "CIDR" (Classless Inter-Domain Routing) notation to refer to network address blocks. Before CIDR addressing, there were only "classful" address assignments, based on "class A," "class B," and "class C" addresses.

For example, when it comes to IPv4, some selected "classful" and CIDR prefix lengths for orientation purpose are:

IPv4 Prefix	Number of Addresses	Notes
/8	16,777,216	Formerly "Class A"
/9	8,388,608	128 x "Class B"
/10	4,194,304	64 x "Class B"
/11	2,097,152	32 x "Class B"
/12	1,048,576	16 x "Class B"
/13	524,288	8 x "Class B"
/14	262,144	4 x "Class B"
/15	131,072	2 x "Class B"
/16	65,536	Formerly "Class B"
/17	32,768	128 x "Class C"
/18	16,384	64 x "Class C"
/19	8,192	32 x "Class C"
/20	4,096	16 x "Class C"
/21	2,048	8 x "Class C"
/22	1,024	4 x "Class C"
/23	512	2 x "Class C"
/24	256	Formerly "Class C." Classic LAN subnet size. BGP routes more specific than /24 normally end up filtered-out at most ISPs.

Now turning to IPv6, some selected CIDR lengths:

IPv6 Prefix	IPv6 /48 subnets	IPv6 /56 subnets	IPv6 /64 subnets	Notes
/12	64G	16T	4,096T	The regional registries (ARIN, RIPE NCC, APNIC, etc.) have each been allocated one or more IPv6 /12's.
/20	256M	64G	16T	For example, Comcast has two /20's.
/23	32M	8G	2T	Used for some early allocations to regional registries
/28	1M	256M	64G	The IPv6 "unit of analysis" we'll be using for querying DNSDB
/32	64K	16M	4G	Minimum initial ISP allocation.
/48	1	256	64K	End-site with multiple locations, each with multiple subnets.
/56	-----------	1	256	End-site with multiple subnets at a single location.
/64	-----------	-----------	1	Minimal end-site assignment (assumes a single subnet).

K = 1,024; **M** = 1024^2 = 1,048,576; **G** = 1024^3 = 1,073,741,824; **T** = 1024^4 = 1,099,511,627,776

Above tables styled after RIPE NCC's "IPv6 Chart," see
https://www.ripe.net/about-us/press-centre/ipv6-chart_2015.pdf

- IPv6 addresses are "doled out" differently than IPv4 addresses, in part because one important goal is a desire to control growth in the size of the IPv6 routing table (you can compare the size and rate of growth of the IPv4 and IPv6 routing tables by looking at https://www.cidr-report.org/as2.0/ vs. https://www.cidr-report.org/v6/as2.0/).

  It tends to be best to think about IPv6 CIDR's hierarchically. Typical allocations/assignment practice looks like:

  - Regional Internet Registries (ARIN, RIPE NCC, APNIC, LACNIC, AFRINIC) have each been allocated at least one IPv6 /12 from the global unicast address space, 2003::/3, by IANA.

    - Even the smallest of ISPs will normally receive at least an IPv6 /32 on request made to their RIR (see https://www.arin.net/resources/guide/ipv6/first_request/#isp). That gives the ISP 65,536 IPv6 /48 prefixes to assign to customer "sites." ISPs receiving a single IPv6 /32 are considered to be "Extra Small," and pay an annual registration service fee of just $1,000 (https://www.arin.net/resources/fees/fee_schedule/).

      Larger ISPs may receive significantly larger allocations. For example, Comcast (AS7922) has two IPv6 /20's: 2601::/20 and 2603:2000::/20. Each of those two IPv6 /20's allows for up to 268,435,456 customer IPv6 /48's.

    - Customer sites in the ARIN region may initially receive an IPv6 /48, an IPv6 /56, or an IPv6 /64 from their ISP, depending upon the expected number of subnets they may require.
      - If a customer receives an IPv6 /48, that's enough IPv6 address space to deploy 256 IPv6 /56 subnets, perhaps across multiple buildings at a company or across a large university campus.
      - If the customer receives an IPv6 /56, that's enough for up to 256 IPv6 /64 subnets at a single location, perhaps a medium-sized branch office.
      - If the customer is certain they won't require multiple subnets, they'll normally receive a single IPv6 /64. Even "just" an IPv6 /64 still represents 2^64 IPv6 addresses, of which only a handful may actually end up used at a typical home or small business site.

In spite of the seemingly absurd size of the IPv6 address space, we can still "dig out" information on the usage of IPv6 from DNSDB by making a series of IPv6 CIDR queries across known-to-be-allocated IPv6 netblocks. DNSDB imposes no limit on the size CIDR query you make, but we are practically limited by the fact that you can only get up to a million unique RRset results/query. That means that if you ask for results from a broad CIDR, you may only receive a portion of the total results that actually exist. You can normally make additional "offset" queries to get additional results up to a total of 4,000,000 results, but again, even 4,000,000 results may not be enough to let DNSDB fully report on all the results that DNSDB knows about a large CIDR netblock (and in our case, `-V summarize` queries don't support use of "offset.")

II. So, What Size IPv6 DNSDB Queries Should We Make?

For our earlier study, we made 16,777,216 IPv4 /24 queries of DNSDB, each looking at an IPv4 /24 (256 IPs). Those 16.7 million queries allowed us to evaluate DNSDB's coverage of the entire IPv4 address space.

But how many and what size queries should we make for our current IPv6 study? Like our IPv4 study, we want prefixes that are "specific enough" to let us identify "hotspots," but not so "overly specific" to the point of making it burdensome to complete the IPv6 study. This is particularly important since many blocks may be totally unused and return zero results. Explicitly, increasing the length prefix we choose to study by one digit doubles the number of queries we need to make; decreasing the length prefix we choose to study by one digit will halve the number of queries we need to make. Thus, prefix length is a pivotal decision we must make!

One factor that impacts our choice is how much of the total IPv6 address space we're going to scrutinize. We consider three potential address extents in arriving at our ultimate choice:

- **We could look at the full IPv6 address space** even though the vast majority of the potential IPv6 address space is neither allocated nor actively routed. See https://www.iana.org/assignments/ipv6-address-space/ipv6-address-space.xhtml
  Why potentially look at the whole IPv6 address space? Well, some miscreants may intentionally use IPv6 space they don't actually control, confident that "no one will notice." Others may use arbitrary IPv6 address space for tunneling, signaling or other non-traditional purposes, not caring that the address space referred to would normally be unreachable.
- **We could look at the entire global unicast space that IANA is currently allocating from** (e.g., 2000::/3). This is nearly as daunting as doing the full IPv6 address space, since even though it has "only" 1/8th the total IPv6 address space, it still encompasses a massive number of IPv6 addresses.
- **Or we could scrutinize JUST the specific IPv6 netblocks listed as allocated** in https://www.iana.org/assignments/ipv6-unicast-address-assignments/ipv6-unicast-address-assignments.xhtml. While not ideal, we believe focusing our attention here is the right pragmatic call to make.

We also need to decide on an explicit "prefix length"-value. We considered values from IPv6 /27's to IPv6 /32's:

If we do /27's:	Full IPv6 address space:	(2^128)/(2^(128-27))=134,217,728 runs	a lot, even at this level!
	All of 2000::/3 only:	(2^(128-3))/(2^(128-27))=16,777,216 runs	better, but still a lot
	Allocated blocks only:	233,216 runs	
If we do /28's:	Full IPv6 address space:	(2^128)/(2^(128-28))=268,435,456 runs	
	All of 2000::/3 only:	(2^(128-3))/(2^(128-28))=33,554,432 runs	
	Allocated blocks only:	**466,432 runs**	**the "sweet spot" we think!**
If we do /29's:	Full IPv6 address space:	(2^128)/(2^(128-29))=536,870,912 runs	
	All of 2000::/3 only:	(2^(128-3))/(2^(128-29))=67,108,864 runs	
	Allocated blocks only:	932,864 runs	doable, but an odd prefix length
If we do /30's:	Full IPv6 address space:	(2^128)/(2^(128-30))=1,073,741,824 runs	
	All of 2000::/3 only:	(2^(128-3))/(2^(128-30))=134,217,728 runs	
	Allocated blocks only:	1,865,728 runs	
If we do /31's:	Full IPv6 address space:	(2^128)/(2^(128-31))=2,147,483,648 runs	
	All of 2000::/3 only:	(2^(128-3))/(2^(128-31))=268,435,456 runs	
	Allocated blocks only:	3,731,456 runs	
If we do /32's:	Full IPv6 address space:	(2^128)/(2^(128-32))=4,294,967,296 runs	
	All of 2000::/3 only:	(2^(128-3))/(2^(128-32))=536,870,912 runs	
	Allocated blocks only:	7,462,912 runs	

Ultimately, we decided that we'd make IPv6 /28 queries across the known-to-be-allocated blocks for this study.

III. What IPv6 Netblocks Are Known to Be Allocated?

As previously mentioned, IANA publishes a report of the IPv6 address blocks it has allocated: "IPv6 Global Unicast Address Assignments," see https://www.iana.org/assignments/ipv6-unicast-address-assignments/ipv6-unicast-address-assignments.xhtml. We repeat it in the table below, sans explanatory notes. We can group those allocations into seven overarching IPv6 netblocks based on IPv6 /12 equivalents (one block is actually effectively an IPv6 /11, consisting of two adjacent IPv6 /12 netblocks):

Prefix	Designation	Status
2001:0000::/23	IANA	ALLOCATED
2001:0200::/23	APNIC	ALLOCATED
2001:0400::/23	ARIN	ALLOCATED
2001:0600::/23	RIPE NCC	ALLOCATED
2001:0800::/22	RIPE NCC	ALLOCATED
2001:0c00::/23	APNIC	ALLOCATED
2001:0e00::/23	APNIC	ALLOCATED
2001:1200::/23	LACNIC	ALLOCATED
2001:1400::/22	RIPE NCC	ALLOCATED
2001:1800::/23	ARIN	ALLOCATED
2001:1a00::/23	RIPE NCC	ALLOCATED
2001:1c00::/22	RIPE NCC	ALLOCATED
2001:2000::/19	RIPE NCC	ALLOCATED
2001:4000::/23	RIPE NCC	ALLOCATED
2001:4200::/23	AFRINIC	ALLOCATED
2001:4400::/23	APNIC	ALLOCATED
2001:4600::/23	RIPE NCC	ALLOCATED
2001:4800::/23	ARIN	ALLOCATED
2001:4a00::/23	RIPE NCC	ALLOCATED
2001:4c00::/23	RIPE NCC	ALLOCATED
2001:5000::/20	RIPE NCC	ALLOCATED
2001:8000::/19	APNIC	ALLOCATED
2001:a000::/20	APNIC	ALLOCATED
2001:b000::/20	APNIC	ALLOCATED
2002:0000::/16	6to4	ALLOCATED
2003:0000::/18	RIPE NCC	ALLOCATED
2400:0000::/12	APNIC	ALLOCATED
2600:0000::/12	ARIN	ALLOCATED
2610:0000::/23	ARIN	ALLOCATED
2620:0000::/23	ARIN	ALLOCATED
2630:0000::/12	ARIN	ALLOCATED
2800:0000::/12	LACNIC	ALLOCATED
2a00:0000::/12	RIPE NCC	ALLOCATED
2a10:0000::/12	RIPE NCC	ALLOCATED
2c00:0000::/12	AFRINIC	ALLOCATED

While IANA has allocated 2000::/3 for global unicast allocations, current allocations have only been made from 2000::/4 (the other half of 2000::/3, 3000::/4, remains "fallow"). Even focusing just on 2000::/4, the Regional Internet Registries (ARIN, RIPE NCC, APNIC, LACNIC, AFRINIC) have only been allocated a tiny fraction of the total available IPv6 Unicast address space, as we'll see later.

IV. How Do We Find the Right IPv6 "Origin IP" for Each of Our DNSDB Queries?

Making DNSDB API CIDR queries require an origin IP and a prefix length for each query. Now that we've settled on the length of each query we're going to make, and what address space we're going to evaluate via DNSDB API, our next step is to find the set of IPv6 /28 IP starting addresses for our DNSDB API CIDR queries.

We'll do that by using the Python3 `ipaddress` library (see https://docs.python.org/3/library/ipaddress.html). For example, to get starting points for the set of IPv6 /28 queries covering 2600::/12, we can use the following small Python3 program:

```
import ipaddress
network_prefix = '2600::/12'
prefix_length = 28
network = ipaddress.IPv6Network(network_prefix)
num_subnets = 65536
subnet_size = int(network.num_addresses / num_subnets)
start_address = network.network_address
for _ in range(num_subnets):
    print(str(start_address)+"/"+str(prefix_length))
    start_address += subnet_size
```

Running that code, it produces a list of 65,536 prefixes which we can then investigate via DNSDB API:

```
2600::/28
2600:10::/28
2600:20::/28
2600:30::/28
2600:40::/28
2600:50::/28
2600:60::/28
2600:70::/28
2600:80::/28
2600:90::/28
2600:a0::/28
2600:b0::/28
2600:c0::/28
2600:d0::/28
2600:e0::/28
2600:f0::/28
2600:100::/28
2600:110::/28
2600:120::/28
2600:130::/28
2600:140::/28
2600:150::/28
2600:160::/28
[…]
260f:fff0::/28
```

If we wanted to create a set of other size prefixes, as we may need for our more-specific Tier 2 and Tier 3 maps, we can modify that little program's parameters:

Network Prefix	Subnet Prefix Length	Number of Subnets
/12	/16	16
/12	/28	65,536
/16	/20	16
/16	/28	4,096

Once we have our list of prefixes, we can easily edit that list to create the actual queries we'll make against DNSDB API:

- Add `dnsdbq -i` to the beginning of each prefix
- add -V summarize -l0 -A90d -j -T qdetail,datefix >> ipv6-output-<whatever>.jsonl to the end of each prefix

For example:

```
dnsdbq -i 2600::/28    -V summarize -l0 -A90d -j -T qdetail,datefix >> ipv6-output-30.jsonl
dnsdbq -i 2600:10::/28 -V summarize -l0 -A90d -j -T qdetail,datefix >> ipv6-output-30.jsonl
dnsdbq -i 2600:20::/28 -V summarize -l0 -A90d -j -T qdetail,datefix >> ipv6-output-30.jsonl
dnsdbq -i 2600:30::/28 -V summarize -l0 -A90d -j -T qdetail,datefix >> ipv6-output-30.jsonl
dnsdbq -i 2600:40::/28 -V summarize -l0 -A90d -j -T qdetail,datefix >> ipv6-output-30.jsonl
dnsdbq -i 2600:50::/28 -V summarize -l0 -A90d -j -T qdetail,datefix >> ipv6-output-30.jsonl
[etc]
```

Note that the API queries we're making via `dnsdbq` are all **"-V summary"** queries. This means that rather than seeing detailed RRset-by-RRset results for each prefix (which might entail tens or hundreds of thousands of lines of output for each query), using **"**`-V summary`**"** means that we'll just get a single summary count for each prefix we check.

Decoding the other command line arguments we'll be using:

`-l0`	shorthand for "return up to a million results" (easier than writing `-l1000000`)
`-A90d`	results seen at least sometime during the last ninety days
`-j`	results in JSON Lines format (https://jsonlines.org/)
`-T qdetail,datefix`	report the query as part of the results; convert the dates from Un*x seconds to human format
`>>` *`filename`*	append the output to the specified filename

For example, looking at some of the output from 2600:0000::/12 (command output reformatted here to fit the available space, normally each of these records would just be one long line):


```
{"count":16288293638,"num_results":576,"time_first":"2011-06-15 07:48:40",
"time_last":"2023-06-23 12:54:54","zone_time_first":"2019-11-11 15:52:29",
"zone_time_last":"2023-06-20 22:50:18","_dnsdbq":{"descr":"rdata/ip/2600%3A%3A,28",
"after":"2023-03-25 12:58:35","limit":0,"gravel":false,"complete":false}}
[…]
{"count":21346605,"num_results":1797,"time_first":"2016-03-24 13:44:42",
"time_last":"2023-06-23 12:32:52","zone_time_first":"2022-01-13 00:04:07",
"zone_time_last":"2023-06-21 23:15:03","_dnsdbq":{"descr":"rdata/ip/2600%3A380%3A%3A,28",
"after":"2023-03-25 12:59:09","limit":0,"gravel":false,"complete":false}}
[…]
{"count":104836561,"num_results":5,"time_first":"2015-12-10 01:41:45",
"time_last":"2023-06-23 11:41:52","zone_time_first":"2023-01-30 21:49:14",
"zone_time_last":"2023-06-21 21:49:05","_dnsdbq":{"descr":"rdata/ip/2600%3A12f0%3A%3A,28",
"after":"2023-03-25 13:01:40", "limit":0,"gravel":false,"complete":false}}
[etc]
```


We can repeat that process for each of the allocated IPv6 prefixes, until we've run our full set of queries.

If you closely review those sample results, you may notice that some `time_first` values go back more than 90 days (our target time window). That's because our time fencing settings returns results that were seen at least some time during the specified window; seldom-modified RRsets may go back far before the specified window, too, as long as they are at least also seen in the specified window.

The "eagle-eyed" reader may also note that there are both `time_first/time_last` and `zone_time_first/zone_time_last` values reported for these observations. That's a sign that the reported results include both data from sensor traffic (tied to the `time_first/time_last` values), and data from ICANN CZDS zone file data (tied to the `zone_time_first/ zone_time_last` values).

Once we've made all those runs, we can extract the counts and query descriptions for prefixes that have non-zero counts.

Looking at the above excerpt, the description of the IPv6 prefixes queried have been encoded for DNSDB API and the JSON Lines format display. This means that colons have been replaced with "%3A", and the normal "/28" prefix is shown as ",28" instead).

We'll use `jq` (see https://jqlang.github.io/jq/), `grep, sed` (the Un*x stream editor), `sort` and GNU `numfmt` to strip unneeded context and make that output a little more readable. Keeping just prefixes with counts above zero, we're left with 23,861 prefixes out of our total of 466,432 IPv6 /28 prefixes, a "hit rate" of 23,861/466,432*100=5.12% percent.

V. Counts Per /28 Prefix Broken Out by /12 Group

We'd like to emphasize that this section is focused on count data from our summarized results. For example:


```
{"count":16288293638,"num_results":576,"time_first":"2011-06-15 07:48:40",
"time_last":"2023-06-23 12:54:54","zone_time_first":"2019-11-11 15:52:29",
"zone_time_last":"2023-06-20 22:50:18","_dnsdbq":{"descr":"rdata/ip/2600%3A%3A,28",
"after":"2023-03-25 12:58:35","limit":0,"gravel":false,"complete":false}}
```


We'll look at the distribution of total counts for our /28 prefix in three different ways: simple summary statistics, distribution plots, and grouped violin plots – in each case, the underlying question is the same: "Are these subgroups distributed the same way?"

1. Simple Summary Statistics

We'll begin by computing simple summary statistics for our count data. The following python code was used to generate the statistics shown below.

```
#!/usr/local/bin/python3
import pandas as pd
import numpy as np

raw_counts = {
    '2001:0000':14501736,
    '2001:0010':2,
    '2001:0020':2,
    '2001:0030':2,
    '2001:0040':2,
    [...]
    '2c0f:ffd0':131
    }

myset = {(n,v) for n,v in raw_counts.items()}
mylist=list(myset)

df2=pd.DataFrame(mylist,columns=['prefix','counts'])

df2['logcounts'] = np.log10(df2.counts)
df2['slash12'] = df2['prefix'].str[:3]
df2['slash8']  = df2['prefix'].str[:2]

df2['myslash12'] = np.where((df2['slash8']=='20'),  '2000\nIANA\nn=2703',
                   np.where((df2['slash8']=='24'),  '2400\nAPNIC\nn=3798',
                   np.where((df2['slash12']=='263'),'2630\nARIN\nn=28',
                   np.where((df2['slash8']=='26'),  '2600\nARIN\nn=2707',
                   np.where((df2['slash8']=='28'),  '2800\nLACNIC\nn=3381',
                   np.where((df2['slash12']=='2a1'),'2a10\nRIPE\nn=1271',
                   np.where((df2['slash8']=='2a'),  '2a00\nRIPE\nn=9530',
                   np.where((df2['slash8']=='2c'),  '2c00\nAFRINIC\nn=444',
                                                     'oops'))))))))

print(df2.groupby('myslash12').count())

print(df2.groupby('myslash12')["counts"].describe())
print(df2.groupby('myslash12')["logcounts"].describe())
```

Transposing that output, we end up with the following two tables, one for raw counts and one for log10(counts). Note that "Count" in the tables below is different from the "count" in our JSON results.

COUNTS:

Prefix	2000	2400	2600	2630	2800	2a00	2a10	2c00
Count	2,703	3,798	2,707	28	3,381	9,530	1,271	444
Mean	5.60E8	9.30E7	4.77E8	1.87E3	7.70E7	1.67E8	2.44E6	9.41E6
StdDev	1.20E10	2.61E9	8.14E9	9.72E3	3.80E9	4.06E9	5.44E7	6.52E7
Max	5.99E11	1.57E11	2.93E11	5.15E4	2.21E11	2.28E11	1.86E9	1.09E9
75%	211013	330535.75	3178222	16.5	939491	1409141	264.5	114082
50%	2981	2242.5	3216	5	33254	673	78	373.5
25%	81	238.25	272.5	1	493	217	28	81
Min	1	1	1	1	1	1	1	1

LOG10(COUNT):

Prefix	2000	2400	2600	2630	2800	2a00	2a10	2c00
Count	2,703	3,798	2,707	28	3,381	9,530	1,271	444
Mean	3.942	3.898	4.328	0.825	4.351	3.840	2.341	3.331
StdDev	2.507	2.155	2.411	1.038	1.935	2.507	1.588	2.128
Max	11.777	11.196	11.467	4.712	11.344	11.357	9.269	9.039
75%	5.324	5.519	6.502	1.217	5.973	6.149	2.422	5.057
50%	3.474	3.351	3.507	0.699	4.522	2.828	1.892	2.572
25%	1.908	2.377	2.435	0	2.693	2.336	1.447	1.908
Min	0	0	0	0	0	0	0	0

Those two tables describe the distribution per /12, but tables of values aren't the easiest thing for most people to compare, particularly when scientific notation is involved for some values. Let's look at cumulative distribution functions per /12 next.

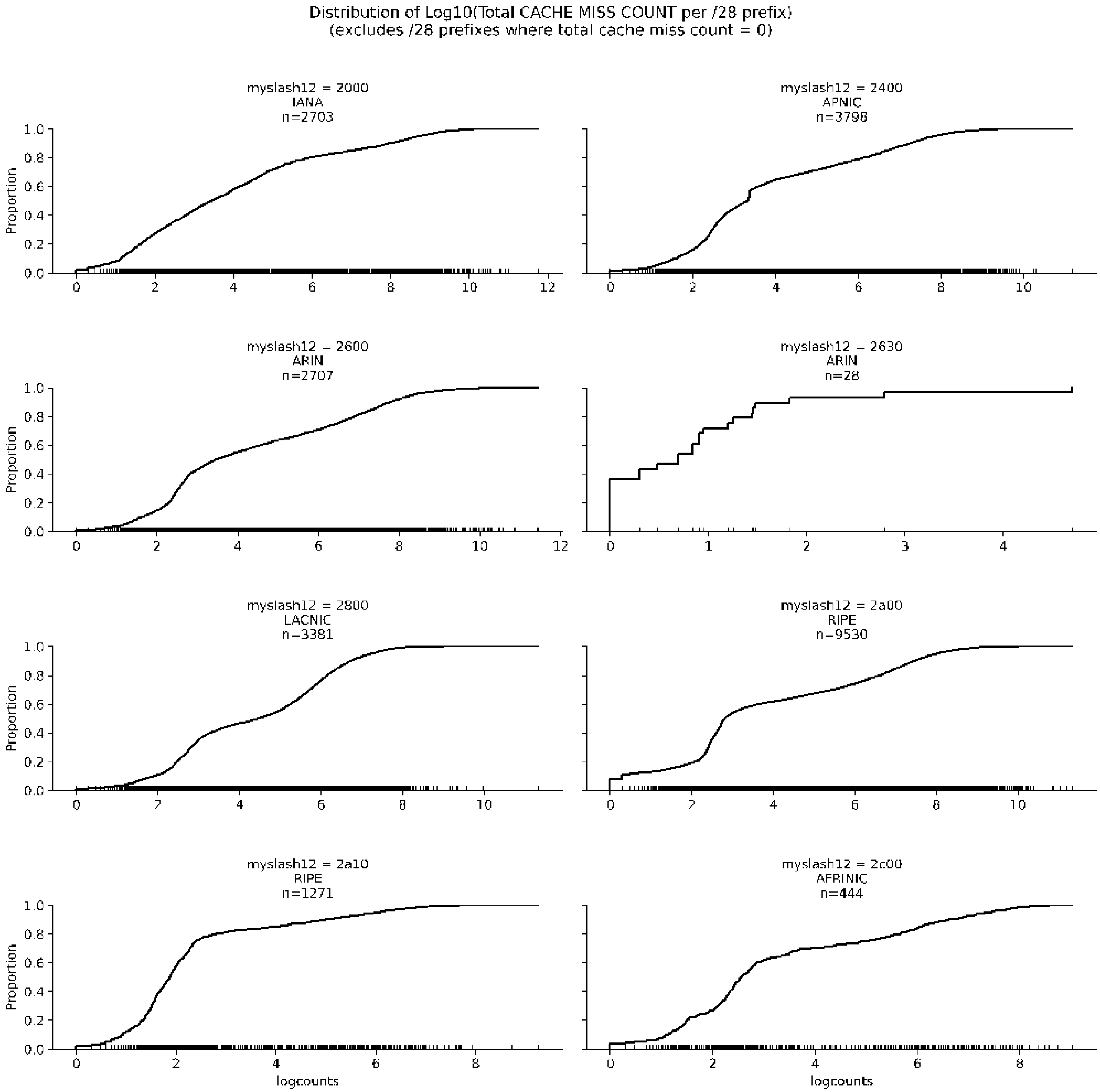
2. Cumulative Distribution Plots

We'll begin by looking at distribution plots for the log10(count) data for our /12 groups. For more about the Seaborn Distplot graphics module, see https://seaborn.pydata.org/generated/seaborn.displot.html

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

raw_counts = {
    '2001:0000':14501736,
    '2001:0010':2,
    '2001:0020':2,
    [...]
    '2c0f:ffd0':131
    }

myset = {(n,v) for n,v in raw_counts.items()}
mylist=list(myset)

df2=pd.DataFrame(mylist,columns=['prefix','counts'])
df2['logcounts'] = np.log10(df2.counts)
df2['slash12'] = df2['prefix'].str[:3]
```

```
df2['slash8']  = df2['prefix'].str[:2]

# note that the more specific case must preceed the more general case in the following
# that is, slash12='263' must preceed slash8='26' or nothing will be found for slash12='263'
df2['myslash12'] = np.where((df2['slash8']=='20'),  '2000\nIANA\nn=2703',
                   np.where((df2['slash8']=='24'),  '2400\nAPNIC\nn=3798',
                   np.where((df2['slash12']=='263'),'2630\nARIN\nn=28',
                   np.where((df2['slash8']=='26'),  '2600\nARIN\nn=2707',
                   np.where((df2['slash8']=='28'),  '2800\nLACNIC\nn=3381',
                   np.where((df2['slash12']=='2a1'),'2a10\nRIPE\nn=1271',
                   np.where((df2['slash8']=='2a'),  '2a00\nRIPE\nn=9530',
                   np.where((df2['slash8']=='2c'),  '2c00\nAFRINIC\nn=444',
                                                   'oops'))))))))

# uncomment the following to confirm per-group counts as embedded in the group labels
# print(df2.groupby('myslash12').count())

g=sns.displot(data=df2,x="logcounts",col="myslash12",
    col_order=['2000\nIANA\nn=2703','2400\nAPNIC\nn=3798','2600\nARIN\nn=2707',
    '2630\nARIN\nn=28','2800\nLACNIC\nn=3381','2a00\nRIPE\nn=9530','2a10\nRIPE\nn=1271',
    '2c00\nAFRINIC\nn=444'],col_wrap=2,kind="ecdf",height=3,aspect=2.0,
    facet_kws={'sharex': False}, rug=True, color="black")


# leave extra space at the top for the supertitle
g.fig.subplots_adjust(top=.87, hspace=.8)
g.fig.suptitle("Distribution of Log10(Total CACHE MISS COUNT per /28 prefix)\n(excludes /28
prefixes where total cache miss count = 0)")
plt.savefig("sample_cdf_plot.pdf", bbox_inches="tight", dpi=300)
```

You can see a copy of the resulting graph below. If the logged values were evenly distributed across the range, the displayed line would be a linear diagonal. Non-linear regions indicate areas of higher (or lower) density.



Carefully note that the X-axis scales on the above graphs, which are showing log10 transformed data. Those X axes have endpoints which vary from 10^4 (10,000) to 10^{12} (1,000,000,000,000). If you were to try running the same plot with UN-logged data, the dramatic data range makes the plot display quite poorly (just a squarish step function near the left edge of the X axis).

Also note the "hash marks" on the X axis (the subplot "rug" feature) show where observations were found. One graph (the one for 2630::/12) has only 28 observations, while the one for 2a00::/12 has 9,530 observations. Where observations are numerous and densely packed, the "rug" will be virtually solid; where observations are more spread out, the individual hash marks will be more readily discernible (as they are for the last graph, the one for 2c00::/12).

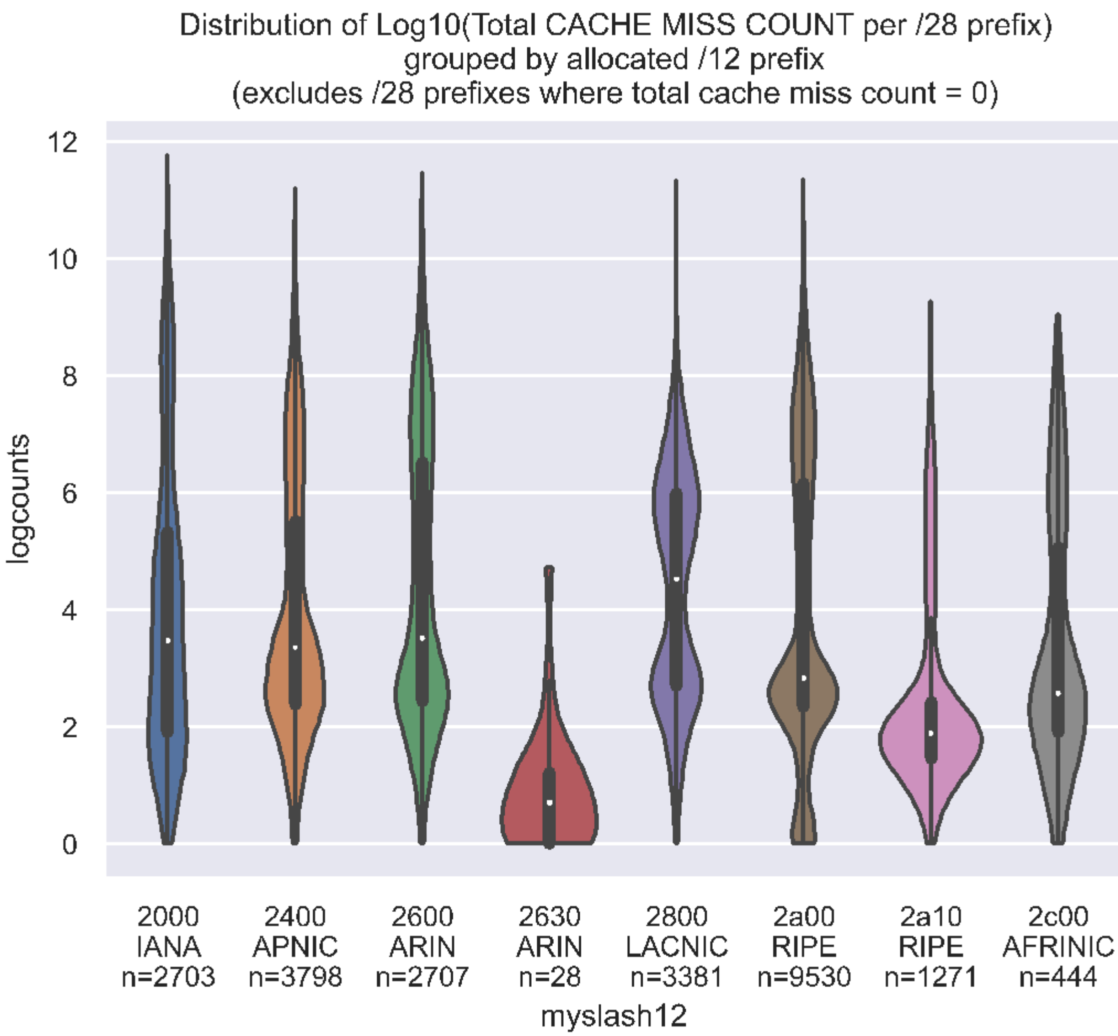
3. Grouped Violin Plot

We'll now also generate a grouped violin plot showing a different way of visualizing the distribution of the logged count for each prefix in our IPv6 /12's. This graph, like the preceding graph, uses Seaborn graphics within Python. For more on Seaborn violin plots, see
https://seaborn.pydata.org/generated/seaborn.violinplot.html

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

raw_counts = {
    '2001:0000':14501736,
    '2001:0010':2,
    '2001:0020':2,
    '2001:0040':4000,
    '2001:0050':1553,
    [...]
    '2c0f:ffc0':740,
    '2c0f:ffd0':131
    }

myset = {(n,v) for n,v in raw_counts.items()}
mylist=list(myset)

df2=pd.DataFrame(mylist,columns=['prefix','counts'])
df2['logcounts'] = np.log10(df2.counts)
df2['slash12'] = df2['prefix'].str[:3]
df2['slash8']  = df2['prefix'].str[:2]

# note that the more specific case must preceed the more general case in the following
# that is, slash12='263' must preceed slash8='26' or nothing will be found for slash12='263'
df2['myslash12'] = np.where((df2['slash8']=='20'),  '2000\nIANA\nn=2703',
                   np.where((df2['slash8']=='24'),  '2400\nAPNIC\nn=3798',
                   np.where((df2['slash12']=='263'),'2630\nARIN\nn=28',
                   np.where((df2['slash8']=='26'),  '2600\nARIN\nn=2707',
                   np.where((df2['slash8']=='28'),  '2800\nLACNIC\nn=3381',
                   np.where((df2['slash12']=='2a1'),'2a10\nRIPE\nn=1271',
                   np.where((df2['slash8']=='2a'),  '2a00\nRIPE\nn=9530',
                   np.where((df2['slash8']=='2c'),  '2c00\nAFRINIC\nn=444',
                                                    'oops'))))))))

# need to scale the fonts so the group labels will fit
sns.set(font_scale=0.9)
myplot = sns.violinplot(data=df2, x=df2.myslash12, y=df2.logcounts,
    inner='box', orient='v', cut=0, order=['2000\nIANA\nn=2703',
        '2400\nAPNIC\nn=3798','2600\nARIN\nn=2707','2630\nARIN\nn=28',
        '2800\nLACNIC\nn=3381','2a00\nRIPE\nn=9530',
        '2a10\nRIPE\nn=1271','2c00\nAFRINIC\nn=444'])

myplot.set_title("Distribution of Log10(Total CACHE MISS COUNT per /28 prefix)\ngrouped by
allocated /12 prefix\n(excludes /28 prefixes where total cache miss count = 0)")

plt.savefig("sample_violin_plot.pdf", bbox_inches="tight", dpi=300)
```

The somewhat odd "group" names we're using are a convenient way of including the associated RIR values and observation counts for each group. We got the counts for inclusion in those names from the commented out `print(df2.groupby('myslash12').count())` command in the preceding section.

The resulting grouped violin plot can be seen below. Note that the Y axis on that graph has been scaled by log10(), so a value of 2 on the Y axis equals 10^2=100, while a value of 11 on the Y axis equals 10^{11}=100,000,000,000.



Both ARIN's 2630::/12 and RIPE's 2a10::/12 have a “lower” logcount profile than the other groups. Both these IPv6 /12's share the unique characteristic of being a "follow on" or "additional" IPv6 /12 block, unlike:

- 2000::/12, which had many miscellaneous global allocations, and
- the other RIRs (APNIC, LACNIC and AFRINIC) which are all working from only one /12 each.

We also note that LACNIC's /12 has a higher-than-normal median count (the "hollow dot" in the middle of the core vertical bar) for its IPv6 /28 prefixes.

All three of our summaries – the simple statistics, the set of cumulative distribution plots, and our grouped violin plots – make it clear that there are definitely differences between the various /12's when it comes to the distribution of counts per IPv6 /28s.

So, with all these summaries, we're naturally curious about the most extreme (highest count) IPv6 /28 prefixes – what specific RRsets seem to be driving those extreme counts? Let's at least look at a couple dozen of the more extreme IPv6 /28 prefixes.

VI. Some High Count RRsets From Highest Count IPv6 Prefixes

We found the "Top Two Dozen" prefixes based on total cache miss count by running the following piped command. Note that we've formatted output to make the columns easier to read.

```
$ cat ipv6-output-*.jsonl | jq -r '"\(.count) \(.num_results) \(._dnsdbq.descr)"' | \
grep -v "^0 " | sort -nr | sed 's#rdata/ip/##' | sed 's/%3A/:/g' | sed 's#,#/#' | \
numfmt --grouping

Counts          RRsets  Prefix
598,233,823,525 12309   2001:500::/28
293,052,827,469 47572   2620:1e0::/28
263,306,494,428 1459    2603::/28
227,601,149,718 964     2a00:1140::/28
220,656,817,816 1000000 2a06:98c0::/28
220,552,063,621 2185    2803:f800::/28
164,397,596,237 585592  2a00:86c0::/28
157,060,046,667 32300   2400:cb00::/28
112,048,558,509 107559  2a02:6b0::/28
99,399,501,606  1000000 2001:670::/28
86,164,581,877  46224   2001:4b90::/28
76,393,645,060  384710  2620:100::/28
74,769,700,237  227     2a02:2090::/28
73,844,947,585  1000000 2600:1800::/28
73,389,304,318  8339    2610:a0::/28
71,832,150,818  346     2a00:bdc0::/28
64,627,377,415  251536  2001:550::/28
59,186,958,986  4126    2001:bf0::/28
38,990,585,430  26630   2603:1030::/28
37,271,495,370  964637  2620:140::/28
35,404,098,903  364432  2001:2030::/28
34,200,128,415  41570   2001:dc0::/28
30,969,551,424  22065   2603:1020::/28
30,193,023,819  1000000 2600:1400::/28
[…]
```

Some of the reported results had exactly 1,000,000 RRsets. That's not a coincidence – that's the maximum number of RRsets returnable by each `-V summarize` query. Normally when we see a million RRsets reported we'd make additional followup offset queries, but we aren't permitted to make "offset" queries when using `-V summarize`. This means that those values represent a "lower floor" rather than an "upper ceiling" for the RRsets associated with each prefix.

Let's now look at some detailed RRsets from those high count IPv6 prefixes. Before we do so, however, reminders:

- Multiple entities may be found in the same IP /28. There are 16 IPv6 /32's in a single IPv6 /28, so one /28 might have 16 different major ISPs in it. The mentioned labels are just for reader convenience and should not be taken as implying that only that entity will be found in that netblock. If you'd like to personally review who has been allocated a given IPv6 netblock or IPv6 IP, visit: https://search.arin.net/rdap/

- You'll notice that the number of observations shown per prefix varies from just a few to several pages worth. We generally truncated the displayed results after a page or so of related values, or when the count drops dramatically relative to the highest reported values. If you're curious to see more, and you have access to DNSDB API, you can always replicate the queries shown and inspect the full output.

1. GTLD Servers; Neustar Security Services; ICANN DNS; Verisign

```
$ dnsdbq -i 2001:500::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2010-06-24 03:07:00 .. 2023-07-04 13:07:06 (~13y ~13d)
;; count: 39263420050
a.gtld-servers.net.  AAAA  2001:503:a83e::2:30

;; record times: 2010-06-24 03:07:00 .. 2023-07-04 15:17:19 (~13y ~13d)
;; count: 38804369759
b.gtld-servers.net.  AAAA  2001:503:231d::2:30

;; record times: 2017-06-15 16:32:48 .. 2023-07-04 13:01:00 (~6y ~19d)
;; count: 27165816294
e.gtld-servers.net.  AAAA  2001:502:1ca1::30

;; record times: 2017-06-15 16:33:09 .. 2023-07-04 12:29:11 (~6y ~19d)
;; count: 27162681487
d.gtld-servers.net.  AAAA  2001:500:856e::30

;; record times: 2017-06-15 16:33:09 .. 2023-07-04 15:39:43 (~6y ~19d)
;; count: 27161626519
f.gtld-servers.net.  AAAA  2001:503:d414::30

;; record times: 2017-06-15 16:32:49 .. 2023-07-04 12:29:11 (~6y ~19d)
;; count: 27160929087
h.gtld-servers.net.  AAAA  2001:502:8cc::30

;; record times: 2017-06-15 16:32:49 .. 2023-07-04 14:10:27 (~6y ~19d)
;; count: 27160012139
l.gtld-servers.net.  AAAA  2001:500:d937::30

;; record times: 2017-06-15 16:33:04 .. 2023-07-04 12:29:11 (~6y ~19d)
;; count: 27159863145
g.gtld-servers.net.  AAAA  2001:503:eea3::30

;; record times: 2017-06-15 16:32:50 .. 2023-07-04 12:29:11 (~6y ~19d)
;; count: 27159442965
i.gtld-servers.net.  AAAA  2001:503:39c1::30

;; record times: 2017-06-15 16:33:01 .. 2023-07-04 12:49:12 (~6y ~19d)
;; count: 27159435199
m.gtld-servers.net.  AAAA  2001:501:b1f9::30

;; record times: 2017-06-15 16:32:59 .. 2023-07-04 12:29:11 (~6y ~19d)
;; count: 27157306164
j.gtld-servers.net.  AAAA  2001:502:7094::30

;; record times: 2017-06-15 16:32:48 .. 2023-07-04 14:59:33 (~6y ~19d)
;; count: 27157250016
c.gtld-servers.net.  AAAA  2001:503:83eb::30

;; record times: 2017-06-15 16:32:48 .. 2023-07-04 15:17:41 (~6y ~19d)
;; count: 27156018580
k.gtld-servers.net.  AAAA  2001:503:d2d::30

;; record times: 2018-03-07 21:40:43 .. 2023-07-04 08:07:41 (~5y ~119d)
;; count: 9799241321
u1.amazonaws.com.  AAAA  2001:502:f3ff::10

;; record times: 2010-06-24 03:10:38 .. 2023-07-04 15:11:59 (~13y ~13d)
;; count: 9070640973
a.root-servers.net.  AAAA  2001:503:ba3e::2:30

;; record times: 2011-06-07 20:50:14 .. 2023-07-04 13:25:44 (~12y ~29d)
```

```
;; count: 8947935530
d.root-servers.net.  AAAA  2001:500:2d::d

;; record times: 2010-06-24 03:10:38 .. 2023-07-04 14:03:13 (~13y ~13d)
;; count: 8896560224
f.root-servers.net.  AAAA  2001:500:2f::f

;; record times: 2010-06-24 03:10:38 .. 2023-07-04 14:29:34 (~13y ~13d)
;; count: 8774645533
j.root-servers.net.  AAAA  2001:503:c27::2:30

;; record times: 2010-06-24 03:07:01 .. 2023-07-04 12:06:16 (~13y ~13d)
;; count: 8513998310
c0.org.afilias-nst.info.  AAAA  2001:500:b::1

;; record times: 2010-06-24 03:07:01 .. 2023-07-04 11:22:23 (~13y ~13d)
;; count: 8510345576
a0.org.afilias-nst.info.  AAAA  2001:500:e::1

;; record times: 2010-06-24 03:07:01 .. 2023-07-04 13:31:30 (~13y ~13d)
;; count: 8487502462
b0.org.afilias-nst.org.  AAAA  2001:500:c::1

;; record times: 2010-06-24 03:07:01 .. 2023-07-04 09:59:49 (~13y ~13d)
;; count: 8486870310
a2.org.afilias-nst.info.  AAAA  2001:500:40::1

;; record times: 2010-06-24 03:07:01 .. 2023-07-04 13:31:30 (~13y ~13d)
;; count: 8484888367
d0.org.afilias-nst.org.  AAAA  2001:500:f::1

;; record times: 2010-06-24 03:07:01 .. 2023-07-04 12:06:16 (~13y ~13d)
;; count: 8482270194
b2.org.afilias-nst.org.  AAAA  2001:500:48::1

;; record times: 2014-03-26 14:42:53 .. 2023-07-04 13:25:44 (~9y ~101d)
;; count: 8193645427
c.root-servers.net.  AAAA  2001:500:2::c

;; record times: 2010-09-23 20:33:28 .. 2023-07-04 14:26:54 (~12y ~286d)
;; count: 5836272425
b.in-addr-servers.arpa.  AAAA  2001:500:87::87

;; record times: 2015-12-01 00:10:34 .. 2023-07-04 16:00:00 (~7y ~217d)
;; count: 4448673340
h.root-servers.net.  AAAA  2001:500:1::53

;; record times: 2016-03-23 21:00:12 .. 2023-07-04 15:55:49 (~7y ~103d)
;; count: 3538446960
l.root-servers.net.  AAAA  2001:500:9f::42

;; record times: 2010-06-24 03:19:15 .. 2023-07-04 12:12:19 (~13y ~13d)
;; count: 3264489733
pdns1.ultradns.net.  AAAA  2001:502:f3ff::1

;; record times: 2010-06-24 03:07:00 .. 2023-07-04 15:54:15 (~13y ~13d)
;; count: 3140073265
nsa.nic.uk.  AAAA  2001:502:ad09::3

;; record times: 2016-08-25 13:46:27 .. 2023-07-04 14:03:49 (~6y ~314d)
;; count: 2809630037
e.root-servers.net.  AAAA  2001:500:a8::e
[etc]
```

2. Microsoft:

```
$ dnsdbq -i 2620:1e0::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2017-08-08 00:00:56 .. 2023-06-28 10:29:41 (~5y ~325d)
;; count: 88,444,215,428
dual-a-0001.a-msedge.net.  AAAA  2620:1ec:c11::200

;; record times: 2019-03-08 19:14:02 .. 2023-06-28 10:30:00 (~4y ~112d)
;; count: 38,024,880,701
s-0005.s-msedge.net.  AAAA  2620:1ec:42::132

;; record times: 2018-04-25 17:20:42 .. 2023-06-28 10:30:02 (~5y ~64d)
;; count: 19,736,190,394
l-0005.l-msedge.net.  AAAA  2620:1ec:21::14

;; record times: 2018-04-25 17:20:42 .. 2023-06-28 10:30:02 (~5y ~64d)
;; count: 19,139,389,651
l-0005.l-msedge.net.  AAAA  2620:1ec:21::14

;; record times: 2018-10-16 19:34:40 .. 2023-06-28 10:30:02 (~4y ~255d)
;; count: 17,494,872,679
l-0007.l-msedge.net.  AAAA  2620:1ec:21::16

;; record times: 2018-10-16 19:34:40 .. 2023-06-28 10:30:02 (~4y ~255d)
;; count: 16,641,911,962
l-0007.l-msedge.net.  AAAA  2620:1ec:21::16

;; record times: 2022-06-22 21:57:16 .. 2023-06-28 10:29:47 (~1y ~5d)
;; count: 6,486,160,174
dual-a-0036.a-msedge.net.  AAAA  2620:1ec:c11::239

;; record times: 2022-06-22 21:57:16 .. 2023-06-28 10:29:47 (~1y ~5d)
;; count: 6,486,160,174
dual-a-0036.a-msedge.net.  AAAA  2620:1ec:12::239

;; record times: 2021-04-12 18:33:26 .. 2023-06-28 13:04:58 (~2y ~76d)
;; count: 5,572,051,058
part-0043.t-0009.t-msedge.net.  AAAA  2620:1ec:bdf::71

;; record times: 2021-04-12 18:33:26 .. 2023-06-28 13:04:58 (~2y ~76d)
;; count: 5,572,051,058
part-0043.t-0009.t-msedge.net.  AAAA  2620:1ec:46::71

;; record times: 2022-06-22 21:57:16 .. 2023-06-28 10:29:47 (~1y ~5d)
;; count: 5,536,114,730
dual-a-0036.a-msedge.net.  AAAA  2620:1ec:12::239
[etc]
```

3. Godaddy:

```
$ dnsdbq -i 2603::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2018-06-19 16:33:53 .. 2023-06-28 18:10:07 (~5y ~10d)
;; count: 3,963,080,594
ns52.domaincontrol.com.  AAAA  2603:5:2292::1a

;; record times: 2018-06-26 16:47:33 .. 2023-06-28 14:21:11 (~5y ~2d)
;; count: 3,735,523,011
ns02.domaincontrol.com.  AAAA  2603:5:2240::1

;; record times: 2018-11-15 16:32:35 .. 2023-06-28 16:58:35 (~4y ~226d)
;; count: 3,702,939,369
ns51.domaincontrol.com.  AAAA  2603:5:2192::1a

;; record times: 2018-06-19 16:17:58 .. 2023-06-28 18:31:17 (~5y ~10d)
;; count: 3,663,533,094
ns44.domaincontrol.com.  AAAA  2603:5:2252::16

;; record times: 2018-06-19 16:17:43 .. 2023-06-28 17:54:40 (~5y ~10d)
;; count: 3,590,421,160
ns42.domaincontrol.com.  AAAA  2603:5:2242::15

;; record times: 2018-06-18 16:48:10 .. 2023-06-28 14:18:59 (~5y ~10d)
;; count: 3,483,724,466
ns26.domaincontrol.com.  AAAA  2603:5:2261::d

;; record times: 2018-11-13 16:40:30 .. 2023-06-28 14:21:11 (~4y ~227d)
;; count: 3,465,988,444
ns01.domaincontrol.com.  AAAA  2603:5:2140::1

;; record times: 2018-06-19 16:20:19 .. 2023-06-28 16:30:37 (~5y ~10d)
;; count: 3,465,110,924
ns48.domaincontrol.com.  AAAA  2603:5:2272::18

;; record times: 2018-06-21 14:11:25 .. 2023-06-28 14:35:27 (~5y ~8d)
;; count: 3,438,538,849
ns66.domaincontrol.com.  AAAA  2603:5:2264::2b
[etc]
```

4. VK; Mail.RU:

```
$ dnsdbq -i 2a00:1140::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2014-04-07 15:05:28 .. 2023-06-28 10:29:45 (~9y ~83d)
;; count: 45,801,078,906
ns2.mail.ru.  AAAA  2a00:1148:db00::1

;; record times: 2014-04-07 15:05:28 .. 2023-06-28 10:29:30 (~9y ~83d)
;; count: 44,852,757,553
ns1.mail.ru.  AAAA  2a00:1148:db00::2

;; record times: 2014-04-07 15:05:28 .. 2023-04-27 13:05:10 (~9y ~21d)
;; count: 30,976,718,288
ns3.mail.ru.  AAAA  2a00:1148:db00::2

;; record times: 2014-09-01 14:44:15 .. 2023-06-28 10:29:24 (~8y ~301d)
;; count: 25,406,177,438
bns2.mail.ru.  AAAA  2a00:1148:db00::4

;; record times: 2014-09-01 14:44:15 .. 2023-06-28 10:29:24 (~8y ~301d)
;; count: 25,404,828,637
bns1.mail.ru.  AAAA  2a00:1148:db00::3

;; record times: 2014-09-01 14:47:55 .. 2023-06-28 16:50:19 (~8y ~302d)
;; count: 17,177,753,071
bns6.mail.ru.  AAAA  2a00:1148:db00::4

;; record times: 2014-09-01 14:47:55 .. 2023-06-28 16:03:01 (~8y ~302d)
;; count: 17,175,047,198
bns3.mail.ru.  AAAA  2a00:1148:db00::3

;; record times: 2014-09-01 14:47:55 .. 2023-06-28 16:03:01 (~8y ~302d)
;; count: 17,173,022,098
bns5.mail.ru.  AAAA  2a00:1148:db00::3

;; record times: 2015-07-03 13:10:28 .. 2023-06-28 14:29:58 (~7y ~362d)
;; count: 1,260,872,450
r.mail.ru.  AAAA  2a00:1148:db00::17
[etc]
```

5. Cloudflare #1 (RIPE NCC):

```
$ dnsdbq -i 2a06:98c0::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-06-28 19:22:02]: Database API limit: Result limit reached
;; record times: 2020-07-14 13:05:53 .. 2023-06-28 18:48:49 (~2y ~349d)
;; count: 1,341,082,186
adrian.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2039

;; record times: 2020-07-14 13:08:08 .. 2023-06-28 16:29:30 (~2y ~349d)
;; count: 1,330,338,333
erin.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2071

;; record times: 2020-07-14 13:22:12 .. 2023-06-28 11:22:07 (~2y ~348d)
;; count: 1,323,029,285
peyton.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:21dd

;; record times: 2020-07-14 13:16:30 .. 2023-06-28 18:15:56 (~2y ~349d)
;; count: 1,311,093,435
cody.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:216b

;; record times: 2020-07-14 13:06:56 .. 2023-06-28 17:11:49 (~2y ~349d)
;; count: 1,144,941,130
bella.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:204a

;; record times: 2020-07-14 13:07:42 .. 2023-06-28 18:34:55 (~2y ~349d)
;; count: 1,063,956,243
terry.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:21ed

;; record times: 2020-07-14 13:06:55 .. 2023-06-28 16:34:31 (~2y ~349d)
;; count: 979,331,433
lisa.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2083

;; record times: 2020-07-14 13:07:39 .. 2023-06-28 18:12:22 (~2y ~349d)
;; count: 963,965,032
lily.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2082

;; record times: 2020-07-14 13:19:20 .. 2023-06-28 17:50:33 (~2y ~349d)
;; count: 951,855,443
ivan.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2178

;; record times: 2020-07-14 13:11:34 .. 2023-06-28 18:43:08 (~2y ~349d)
;; count: 902,255,661
emma.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2070

;; record times: 2020-07-14 13:05:08 .. 2023-06-28 16:01:22 (~2y ~349d)
;; count: 889,777,386
andy.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2165

;; record times: 2020-07-14 13:08:31 .. 2023-06-28 16:18:59 (~2y ~349d)
;; count: 878,953,030
dana.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2069

;; record times: 2020-07-14 13:08:30 .. 2023-06-28 18:13:20 (~2y ~349d)
;; count: 873,806,126
woz.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2196

;; record times: 2020-07-14 13:07:47 .. 2023-06-28 13:32:17 (~2y ~349d)
;; count: 867,320,972
pete.ns.cloudflare.com.  AAAA  2a06:98c1:50::ac40:2188
[etc]
```

6. Cloudflare #2 (LACNIC):

```
$ dnsdbq -i 2803:f800::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2020-07-14 13:05:53 .. 2023-06-28 18:48:49 (~2y ~349d)
;; count: 1,341,082,189
adrian.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c039

;; record times: 2020-07-14 13:08:08 .. 2023-06-28 16:29:30 (~2y ~349d)
;; count: 1,330,338,335
erin.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c071

;; record times: 2020-07-14 13:22:12 .. 2023-06-28 18:46:08 (~2y ~349d)
;; count: 1,323,032,247
peyton.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c1dd

;; record times: 2020-07-14 13:16:30 .. 2023-06-28 18:15:56 (~2y ~349d)
;; count: 1,311,093,443
cody.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c16b

;; record times: 2020-07-14 13:06:56 .. 2023-06-28 17:11:49 (~2y ~349d)
;; count: 1,144,941,133
bella.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c04a

;; record times: 2020-07-14 13:07:42 .. 2023-06-28 18:34:55 (~2y ~349d)
;; count: 1,063,956,339
terry.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c1ed

;; record times: 2020-07-14 13:06:55 .. 2023-06-28 16:34:31 (~2y ~349d)
;; count: 979,331,481
lisa.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c083

;; record times: 2020-07-14 13:07:39 .. 2023-06-28 18:12:22 (~2y ~349d)
;; count: 963,965,032
lily.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c082

;; record times: 2020-07-14 13:19:20 .. 2023-06-28 17:50:33 (~2y ~349d)
;; count: 951,855,450
ivan.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c178

;; record times: 2020-07-14 13:11:34 .. 2023-06-28 18:43:08 (~2y ~349d)
;; count: 902,255,667
emma.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c070

;; record times: 2020-07-14 13:05:08 .. 2023-06-28 16:01:22 (~2y ~349d)
;; count: 889,777,386
andy.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c165

;; record times: 2020-07-14 13:08:31 .. 2023-06-28 16:18:59 (~2y ~349d)
;; count: 878,953,030
dana.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c069

;; record times: 2020-07-14 13:08:30 .. 2023-06-28 18:48:11 (~2y ~349d)
;; count: 873,806,128
woz.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c196

;; record times: 2020-07-14 13:07:47 .. 2023-06-28 13:32:17 (~2y ~349d)
;; count: 867,320,977
pete.ns.cloudflare.com.  AAAA  2803:f800:50::6ca2:c188
[etc]
```

7. Netflix:

```
$ dnsdbq -i 2a00:86c0::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2016-12-01 21:28:40 .. 2023-06-28 14:29:16 (~6y ~209d)
;; count: 69,999,681,641
f.ns.nflxso.net.  AAAA  2a00:86c0:2009::1

;; record times: 2016-12-01 21:28:40 .. 2023-06-28 14:29:16 (~6y ~209d)
;; count: 69,996,783,463
e.ns.nflxso.net.  AAAA  2a00:86c0:2008::1

;; record times: 2019-06-27 22:23:42 .. 2023-06-28 11:15:21 (~4y ~1d)
;; count: 7,630,206,910
ixanycast.ftl.netflix.com.  AAAA  2a00:86c0:2040::1

;; record times: 2019-06-27 22:23:42 .. 2023-06-28 11:15:21 (~4y ~1d)
;; count: 7,630,206,364
ixanycast.ftl.netflix.com.  AAAA  2a00:86c0:2041::1
[etc]
```

8. Cloudflare #3 (APNIC):

```
$ dnsdbq -i 2400:cb00::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2017-10-15 06:50:05 .. 2023-06-28 19:19:26 (~5y ~257d)
;; count: 16,096,830,375
dns6.gandi.net.  AAAA  2400:cb00:2049:1::a29f:186f

;; record times: 2017-10-15 06:50:05 .. 2023-06-28 19:19:26 (~5y ~257d)
;; count: 16,096,830,342
dns6.gandi.net.  AAAA  2400:cb00:2049:1::a29f:19d5

;; record times: 2016-01-06 18:31:26 .. 2023-06-28 19:06:57 (~7y ~175d)
;; count: 11,609,735,354
ns2.linode.com.  AAAA  2400:cb00:2049:1::a29f:1827

;; record times: 2016-01-08 19:08:36 .. 2023-06-28 17:56:23 (~7y ~172d)
;; count: 11,608,329,832
ns1.linode.com.  AAAA  2400:cb00:2049:1::a29f:1a63

;; record times: 2016-01-06 16:51:58 .. 2023-06-28 12:42:52 (~7y ~174d)
;; count: 11,289,030,360
ns3.linode.com.  AAAA  2400:cb00:2049:1::a29f:1981

;; record times: 2016-01-07 15:56:40 .. 2023-06-28 16:28:05 (~7y ~174d)
;; count: 11,128,515,635
ns4.linode.com.  AAAA  2400:cb00:2049:1::a29f:1b48

;; record times: 2016-01-07 14:04:27 .. 2023-06-28 17:00:46 (~7y ~174d)
;; count: 10,602,917,054
ns5.linode.com.  AAAA  2400:cb00:2049:1::a29f:1819

;; record times: 2014-03-17 19:27:53 .. 2023-06-28 19:09:59 (~9y ~104d)
;; count: 5,391,759,350
ns1.digitalocean.com.  AAAA  2400:cb00:2049:1::adf5:3a33

;; record times: 2014-03-17 19:27:53 .. 2023-06-28 19:07:05 (~9y ~104d)
;; count: 5,389,834,622
ns2.digitalocean.com.  AAAA  2400:cb00:2049:1::adf5:3b29

;; record times: 2014-03-17 19:27:53 .. 2023-06-28 17:45:51 (~9y ~104d)
;; count: 5,066,604,241
ns3.digitalocean.com.  AAAA  2400:cb00:2049:1::c629:dead

;; record times: 2016-11-15 15:04:01 .. 2023-06-28 18:40:15 (~6y ~226d)
;; count: 4,827,862,689
dns1.easydns.com.  AAAA  2400:cb00:2049:1::a29f:1835

;; record times: 2014-07-22 03:16:50 .. 2023-06-28 18:21:32 (~8y ~343d)
;; count: 4,602,891,034
dns2.easydns.net.  AAAA  2400:cb00:2049:1::c629:defe

;; record times: 2015-08-11 17:49:14 .. 2023-06-28 16:14:57 (~7y ~322d)
;; count: 2,589,778,240
ns2.dnsimple.com.  AAAA  2400:cb00:2049:1::a29f:1904

;; record times: 2015-10-20 15:18:33 .. 2023-06-28 14:01:56 (~7y ~252d)
;; count: 2,575,727,639
ns1.dnsimple.com.  AAAA  2400:cb00:2049:1::a29f:1804
[etc]
```

9. Yandex:

```
$ dnsdbq -i 2a02:6b0::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2011-02-15 10:32:52 .. 2023-06-28 18:29:13 (~12y ~136d)
;; count: 32,507,504,355
ns1.yandex.ru.  AAAA  2a02:6b8::1

;; record times: 2013-01-24 12:24:19 .. 2023-06-28 18:29:13 (~10y ~157d)
;; count: 32,394,180,582
ns2.yandex.ru.  AAAA  2a02:6b8:0:1::1

;; record times: 2011-02-03 18:34:25 .. 2023-06-28 19:16:02 (~12y ~148d)
;; count: 8,503,888,575
ns1.yandex.net.  AAAA  2a02:6b8::1

;; record times: 2013-01-24 12:24:18 .. 2023-06-28 19:16:02 (~10y ~157d)
;; count: 8,471,466,823
ns2.yandex.net.  AAAA  2a02:6b8:0:1::1

;; record times: 2012-01-26 07:41:40 .. 2023-06-28 18:29:57 (~11y ~156d)
;; count: 6,840,966,407
ns2.rambler.ru.  AAAA  2a02:6b0:6:2::1:53

;; record times: 2012-01-26 07:41:40 .. 2023-06-28 14:29:55 (~11y ~156d)
;; count: 6,759,828,417
ns4.rambler.ru.  AAAA  2a02:6b0:6:2::2:53

;; record times: 2013-06-17 10:12:48 .. 2023-06-28 12:58:14 (~10y ~13d)
;; count: 1,500,831,272
ns4.yandex.ru.  AAAA  2a02:6b8:0:1::1:1

;; record times: 2013-06-17 20:27:08 .. 2023-06-28 13:51:27 (~10y ~12d)
;; count: 1,500,823,527
ns3.yandex.ru.  AAAA  2a02:6b8::1001
[etc]
```

10. RIPE Anycast DNS:

```
$ dnsdbq -i 2001:670::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-06-28 20:05:05]: Database API limit: Result limit reached
;; record times: 2011-01-27 20:44:08 .. 2023-06-28 19:17:49 (~12y ~154d)
;; count: 5,405,398,131
f.in-addr-servers.arpa.  AAAA  2001:67c:e0::1

;; record times: 2011-11-12 16:22:34 .. 2023-06-28 18:52:54 (~11y ~231d)
;; count: 5,015,495,555
a.ns.tk.  AAAA  2001:678:50::1

;; record times: 2011-11-12 16:22:34 .. 2023-06-28 19:21:43 (~11y ~231d)
;; count: 5,015,425,688
b.ns.tk.  AAAA  2001:678:54::1

;; record times: 2011-11-12 16:22:34 .. 2023-06-28 18:05:51 (~11y ~231d)
;; count: 5,015,317,814
d.ns.tk.  AAAA  2001:678:5c::1

;; record times: 2011-11-12 16:22:34 .. 2023-06-28 15:55:22 (~11y ~230d)
;; count: 5,015,242,179
c.ns.tk.  AAAA  2001:678:58::1

;; record times: 2010-06-24 03:07:00 .. 2023-06-28 19:36:16 (~13y ~7d)
;; count: 4,752,648,827
e.dns.ripn.net.  AAAA  2001:678:15:0:193:232:142:17

;; record times: 2010-06-24 03:07:00 .. 2023-06-28 19:36:16 (~13y ~7d)
;; count: 4,752,080,457
f.dns.ripn.net.  AAAA  2001:678:14:0:193:232:156:17

;; record times: 2012-03-13 13:35:11 .. 2023-06-28 15:20:55 (~11y ~109d)
;; count: 4,735,634,618
ns.ripe.net.  AAAA  2001:67c:e0::6

;; record times: 2011-11-24 16:07:49 .. 2023-06-28 19:36:16 (~11y ~219d)
;; count: 4,329,829,115
d.dns.ripn.net.  AAAA  2001:678:18:0:194:190:124:17

;; record times: 2012-04-10 13:27:18 .. 2023-06-28 19:36:16 (~11y ~81d)
;; count: 4,202,049,016
a.dns.ripn.net.  AAAA  2001:678:17:0:193:232:128:6

;; record times: 2012-03-19 08:54:00 .. 2023-06-28 19:36:16 (~11y ~103d)
;; count: 4,199,953,396
b.dns.ripn.net.  AAAA  2001:678:16:0:194:85:252:62

;; record times: 2010-06-24 03:07:02 .. 2023-06-28 19:14:47 (~13y ~7d)
;; count: 3,322,462,695
a.nic.de.  AAAA  2001:678:2::53

;; record times: 2018-09-21 02:19:30 .. 2023-06-28 17:46:14 (~4y ~281d)
;; count: 3,282,769,274
nslu1.mega.co.nz.  AAAA  2001:678:25c:2215::554

;; record times: 2020-05-05 03:47:46 .. 2023-06-28 18:30:22 (~3y ~54d)
;; count: 2,648,247,512
nslu2.mega.co.nz.  AAAA  2001:678:25c:2215::559
[etc]
```

11. Gandi:

```
$ dnsdbq -i 2001:4b90::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2013-05-16 10:18:06 .. 2023-06-28 19:19:26 (~10y ~45d)
;; count: 16,349,901,282
dns1.gandi.net.  AAAA  2001:4b98:d:1::45

;; record times: 2013-05-16 10:19:01 .. 2023-06-28 19:19:26 (~10y ~45d)
;; count: 16,349,838,284
dns0.gandi.net.  AAAA  2001:4b98:d:1::39

;; record times: 2013-05-16 10:19:01 .. 2023-06-28 19:19:26 (~10y ~45d)
;; count: 16,348,869,962
dns2.gandi.net.  AAAA  2001:4b98:d:589::211

;; record times: 2015-04-14 12:19:32 .. 2023-06-28 19:19:26 (~8y ~77d)
;; count: 16,268,565,484
dns4.gandi.net.  AAAA  2001:4b98:dc2:90:217:70:186:184

;; record times: 2016-12-06 12:37:25 .. 2023-06-28 19:19:26 (~6y ~205d)
;; count: 16,198,461,140
dns3.gandi.net.  AAAA  2001:4b98:c:13::14

;; record times: 2015-03-09 11:15:17 .. 2023-06-28 20:00:44 (~8y ~113d)
;; count: 1,484,737,254
b.dns.gandi.net.  AAAA  2001:4b98:abcb::1
[etc]
```

12. Pandora Media:

```
$ dnsdbq -i 2620:100::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2018-01-31 17:36:51 .. 2023-06-28 16:17:40 (~5y ~148d)
;; count: 781,550,150
cont-1.p-cdn.us.  AAAA  2620:106:e001:f00f::34

;; record times: 2018-01-31 17:36:51 .. 2023-06-28 18:11:53 (~5y ~149d)
;; count: 780,912,017
cont-1.p-cdn.us.  AAAA  2620:106:e001:f00f::33

;; record times: 2018-01-31 17:36:51 .. 2023-06-28 18:16:33 (~5y ~149d)
;; count: 776,490,320
cont-1.p-cdn.us.  AAAA  2620:106:e002:f00f::31

;; record times: 2018-01-31 17:36:51 .. 2023-06-28 13:32:05 (~5y ~148d)
;; count: 775,292,211
cont-1.p-cdn.us.  AAAA  2620:106:e002:f00f::32

;; record times: 2018-01-31 17:43:18 .. 2023-06-28 19:03:39 (~5y ~149d)
;; count: 738,839,854
cont-3.p-cdn.us.  AAAA  2620:106:e001:f00f::34

;; record times: 2018-01-31 17:42:18 .. 2023-06-28 17:57:17 (~5y ~149d)
;; count: 738,715,241
cont-2.p-cdn.us.  AAAA  2620:106:e001:f00f::34

;; record times: 2018-01-31 17:44:07 .. 2023-06-28 19:16:46 (~5y ~149d)
;; count: 738,434,573
cont-4.p-cdn.us.  AAAA  2620:106:e001:f00f::34

;; record times: 2018-01-31 17:44:42 .. 2023-06-28 19:42:44 (~5y ~149d)
;; count: 738,386,282
cont-5.p-cdn.us.  AAAA  2620:106:e001:f00f::34

;; record times: 2014-11-10 14:18:15 .. 2023-06-28 20:34:01 (~8y ~232d)
;; count: 738,373,926
ns1.d-zone.ca.  AAAA  2620:10a:80eb::2

;; record times: 2018-01-31 17:43:18 .. 2023-06-28 19:03:39 (~5y ~149d)
;; count: 738,174,247
cont-3.p-cdn.us.  AAAA  2620:106:e001:f00f::33

;; record times: 2018-01-31 17:42:18 .. 2023-06-28 21:00:51 (~5y ~149d)
;; count: 738,010,336
cont-2.p-cdn.us.  AAAA  2620:106:e001:f00f::33

;; record times: 2018-01-31 17:44:07 .. 2023-06-28 21:07:31 (~5y ~149d)
;; count: 737,782,796
cont-4.p-cdn.us.  AAAA  2620:106:e001:f00f::33

;; record times: 2018-01-31 17:44:42 .. 2023-06-28 20:59:01 (~5y ~149d)
;; count: 737,744,589
cont-5.p-cdn.us.  AAAA  2620:106:e001:f00f::33

;; record times: 2014-11-10 14:18:15 .. 2023-06-28 20:34:01 (~8y ~232d)
;; count: 735,962,592
ns2.d-zone.ca.  AAAA  2620:10a:80ec::2
[etc]
```

13. RU-Center:

```
$ dnsdbq -i 2a02:2090::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2011-11-22 16:35:14 .. 2023-06-28 19:27:17 (~11y ~221d)
;; count: 21,232,761,760
ns5.nic.ru.  AAAA  2a02:2090:e800:9000:31:177:67:100

;; record times: 2012-06-14 11:23:18 .. 2023-06-28 19:27:17 (~11y ~16d)
;; count: 21,217,553,586
ns6.nic.ru.  AAAA  2a02:2090:ec00:9040:31:177:74:100

;; record times: 2015-04-15 12:18:16 .. 2023-06-28 19:27:17 (~8y ~76d)
;; count: 20,899,687,021
ns9.nic.ru.  AAAA  2a02:2090:e400:7000:31:177:85:186

;; record times: 2011-12-01 06:21:06 .. 2023-06-28 19:44:43 (~11y ~212d)
;; count: 7,098,077,659
ns7.nic.ru.  AAAA  2a02:2090:ec00:9000:31:177:71:100

;; record times: 2015-08-04 11:56:57 .. 2023-06-28 17:54:28 (~7y ~330d)
;; count: 1,325,772,883
ns1.sweb.ru.  AAAA  2a02:2090:e800:9000:31:177:67:100

;; record times: 2015-08-04 11:56:57 .. 2023-06-28 17:54:28 (~7y ~330d)
;; count: 1,325,458,053
ns2.sweb.ru.  AAAA  2a02:2090:ec00:9040:31:177:74:100

;; record times: 2015-08-04 22:05:24 .. 2023-06-28 17:54:28 (~7y ~329d)
;; count: 1,324,968,708
ns4.sweb.ru.  AAAA  2a02:2090:e400:7000:31:177:85:186
[etc]
```

14. DNSMadeEasy:

```
$ dnsdbq -i 2600:1800::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 16:25:43]: Database API limit: Result limit reached
;; record times: 2011-05-12 19:34:25 .. 2023-07-04 15:33:01 (~12y ~55d)
;; count: 7625168522
ns3.dnsmadeeasy.com.  AAAA  2600:1801:3::1

;; record times: 2011-05-12 19:34:51 .. 2023-07-04 12:00:19 (~12y ~55d)
;; count: 6921981895
ns4.dnsmadeeasy.com.  AAAA  2600:1802:4::1

;; record times: 2011-05-12 19:35:48 .. 2023-07-04 15:38:26 (~12y ~55d)
;; count: 6600144554
ns13.dnsmadeeasy.com.  AAAA  2600:1801:13::1

;; record times: 2011-05-12 19:35:48 .. 2023-07-04 14:19:52 (~12y ~55d)
;; count: 5873647291
ns14.dnsmadeeasy.com.  AAAA  2600:1802:14::1

;; record times: 2017-09-11 17:08:12 .. 2023-07-04 11:18:31 (~5y ~296d)
;; count: 5722599649
ns1.dnsmadeeasy.com.  AAAA  2600:1801:1::1

;; record times: 2017-09-11 17:08:12 .. 2023-07-04 10:58:37 (~5y ~296d)
;; count: 5684905114
ns0.dnsmadeeasy.com.  AAAA  2600:1800::1

;; record times: 2017-09-11 17:08:12 .. 2023-07-04 11:01:27 (~5y ~296d)
;; count: 5575092528
ns2.dnsmadeeasy.com.  AAAA  2600:1802:2::1
[etc]
```

15. Neustar:

```
$ dnsdbq -i 2610:a0::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2019-12-16 09:53:30 .. 2023-07-04 15:48:55 (~3y ~201d)
;; count: 14166721301
dns1.registrar-servers.com.  AAAA  2610:a1:1024::200

;; record times: 2019-12-18 11:41:51 .. 2023-07-04 13:23:38 (~3y ~199d)
;; count: 14153833024
dns2.registrar-servers.com.  AAAA  2610:a1:1025::200

;; record times: 2018-03-07 21:40:40 .. 2023-07-04 11:32:02 (~5y ~119d)
;; count: 9799511859
u2.amazonaws.com.  AAAA  2610:a1:1014::10

;; record times: 2012-04-26 19:18:57 .. 2023-07-04 14:46:56 (~11y ~70d)
;; count: 3054533166
pdns2.ultradns.net.  AAAA  2610:a1:1014::1

;; record times: 2019-12-16 10:15:30 .. 2023-07-04 12:57:08 (~3y ~201d)
;; count: 1969842866
dns1.namecheaphosting.com.  AAAA  2610:a1:1024::200

;; record times: 2018-03-07 21:40:53 .. 2023-07-04 14:17:35 (~5y ~119d)
;; count: 1908927253
u3.amazonaws.com.  AAAA  2610:a1:1015::10

;; record times: 2018-03-07 21:40:39 .. 2023-07-04 09:03:45 (~5y ~119d)
;; count: 1908915114
u5.amazonaws.com.  AAAA  2610:a1:1016::10

;; record times: 2018-03-07 21:40:53 .. 2023-07-04 06:05:31 (~5y ~119d)
;; count: 1908630408
u6.amazonaws.com.  AAAA  2610:a1:1017::10

;; record times: 2019-12-18 15:53:47 .. 2023-07-04 14:36:41 (~3y ~198d)
;; count: 1844510892
dns2.namecheaphosting.com.  AAAA  2610:a1:1025::200

;; record times: 2018-06-02 03:36:01 .. 2023-07-04 13:06:38 (~5y ~33d)
;; count: 719453374
udns3.salesforce.com.  AAAA  2610:a1:1009::8

;; record times: 2018-06-02 03:36:01 .. 2023-07-04 13:06:38 (~5y ~33d)
;; count: 712151146
udns4.salesforce.com.  AAAA  2610:a1:1010::8
[etc]
```

16. VK:

```
$ dnsdbq -i 2a00:bdc0::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2013-05-24 22:17:56 .. 2023-07-04 14:40:45 (~10y ~42d)
;; count: 20314974512
ns3.vkontakte.ru.  AAAA  2a00:bdc0:ff:3::2

;; record times: 2013-05-24 22:17:56 .. 2023-07-04 14:40:45 (~10y ~42d)
;; count: 17225709548
ns2.vkontakte.ru.  AAAA  2a00:bdc0:ff:2::2

;; record times: 2013-05-24 22:17:56 .. 2023-07-04 14:40:45 (~10y ~42d)
;; count: 17215588728
ns4.vkontakte.ru.  AAAA  2a00:bdc0:ff:4::2

;; record times: 2013-05-24 22:17:56 .. 2023-07-04 15:50:16 (~10y ~42d)
;; count: 17106079729
ns1.vkontakte.ru.  AAAA  2a00:bdc0:ff:1::2
[etc]
```

17. Cogentco; Comcast:

```
$ dnsdbq -i 2001:550::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2010-06-24 03:07:00 .. 2023-07-04 13:47:43 (~13y ~13d)
;; count: 5157695459
auth1.dns.cogentco.com.  AAAA  2001:550:1:a::d

;; record times: 2010-06-24 03:07:00 .. 2023-07-04 13:47:43 (~13y ~13d)
;; count: 4505145352
auth2.dns.cogentco.com.  AAAA  2001:550:1:b::d

;; record times: 2010-12-03 17:46:47 .. 2023-07-04 13:13:24 (~12y ~215d)
;; count: 1268090933
dns102.comcast.net.  AAAA  2001:558:1004:7:68:87:85:132

;; record times: 2011-03-25 20:06:18 .. 2023-07-04 12:00:04 (~12y ~103d)
;; count: 1229082236
dns103.comcast.net.  AAAA  2001:558:1014:c:68:87:76:228

;; record times: 2011-02-11 18:25:41 .. 2023-07-04 09:51:04 (~12y ~145d)
;; count: 1228703928
dns105.comcast.net.  AAAA  2001:558:100e:5:68:87:72:244

;; record times: 2011-04-27 19:22:32 .. 2023-07-04 12:44:44 (~12y ~70d)
;; count: 1221259300
dns104.comcast.net.  AAAA  2001:558:100a:5:68:87:68:244

;; record times: 2012-09-25 08:18:16 .. 2023-07-04 11:50:03 (~10y ~284d)
;; count: 1211173724
dns101.comcast.net.  AAAA  2001:558:fe23:8:69:252:250:103
[etc]
```

18. Myfritz.net:

```
$ dnsdbq -i 2001:bf0::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2019-01-29 20:15:26 .. 2023-07-04 13:55:42 (~4y ~156d)
;; count: 29396151765
ns2.myfritz.net.  AAAA  2001:bf0:244::13

;; record times: 2020-08-13 08:57:01 .. 2023-07-04 13:14:18 (~2y ~325d)
;; count: 29392029760
ns3.myfritz.net.  AAAA  2001:bf0:212::76
[etc]
```

19. Cloudapp:

```
$ dnsdbq -i 2603:1030::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2020-05-24 10:16:04 .. 2023-07-04 10:18:59 (~3y ~41d)
;; count: 229700102
trouter2-azsc-uswc-0-b.cloudapp.net.  AAAA  2603:1030:b00::85

;; record times: 2020-06-19 09:58:01 .. 2023-07-04 09:52:11 (~3y ~14d)
;; count: 219255538
trouter2-azsc-uswc-0-a.cloudapp.net.  AAAA  2603:1030:b00::6

;; record times: 2020-07-21 16:38:57 .. 2023-07-04 09:53:32 (~2y ~347d)
;; count: 207092700
trouter2-azsc-uswc-2-a.cloudapp.net.  AAAA  2603:1030:b00::1b9

;; record times: 2020-07-21 16:39:07 .. 2023-07-04 12:41:30 (~2y ~347d)
;; count: 204534822
trouter2-azsc-uswc-2-b.cloudapp.net.  AAAA  2603:1030:b00::212

;; record times: 2020-11-19 10:11:12 .. 2023-07-04 10:03:30 (~2y ~226d)
;; count: 200582077
trouter2-azsc-usce-0-b.cloudapp.net.  AAAA  2603:1030:7:6::3c

;; record times: 2020-11-19 10:10:03 .. 2023-07-04 13:37:18 (~2y ~227d)
;; count: 200014708
trouter2-azsc-usce-0-a.cloudapp.net.  AAAA  2603:1030:7:6::3d

;; record times: 2020-11-19 10:10:20 .. 2023-07-04 14:57:49 (~2y ~227d)
;; count: 199785973
trouter2-azsc-usce-1-a.cloudapp.net.  AAAA  2603:1030:7:6::16

;; record times: 2020-11-19 10:09:54 .. 2023-07-04 07:37:10 (~2y ~226d)
;; count: 192062055
trouter2-azsc-usce-1-b.cloudapp.net.  AAAA  2603:1030:7:6::39

;; record times: 2020-11-19 10:11:28 .. 2023-07-04 13:35:59 (~2y ~227d)
;; count: 190752639
trouter2-azsc-usce-2-b.cloudapp.net.  AAAA  2603:1030:7:6::3a

;; record times: 2020-11-19 10:11:07 .. 2023-07-04 12:34:58 (~2y ~227d)
;; count: 190572265
trouter2-azsc-usce-2-a.cloudapp.net.  AAAA  2603:1030:7:6::3b

;; record times: 2021-05-26 15:36:29 .. 2023-07-04 15:42:14 (~2y ~39d)
;; count: 126511533
trouter2-azsc-uswc-3-a.cloudapp.net.  AAAA  2603:1030:b00::4de
[etc]
```

20. Apple:

```
$ dnsdbq -i 2620:140::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2017-02-13 05:20:00 .. 2023-07-04 16:06:50 (~6y ~142d)
;; count: 872430498
a.ns.apple.com.  AAAA  2620:149:ae0::53

;; record times: 2020-06-11 23:49:09 .. 2023-07-04 15:30:43 (~3y ~22d)
;; count: 737539559
b.ns.apple.com.  AAAA  2620:149:ae7::53

;; record times: 2021-06-21 17:46:10 .. 2023-07-04 16:38:56 (~2y ~12d)
;; count: 338826074
safebrowsing-proxy.g.aaplimg.com.  AAAA  2620:149:a00:f000::7

;; record times: 2021-06-21 17:46:10 .. 2023-07-04 16:24:28 (~2y ~12d)
;; count: 326733443
safebrowsing-proxy.g.aaplimg.com.  AAAA  2620:149:a00:f100::8

;; record times: 2020-09-10 23:59:57 .. 2023-07-04 14:24:09 (~2y ~296d)
;; count: 245661297
get-bx.g.aaplimg.com.  AAAA  2620:149:a00:f100::8

;; record times: 2020-09-11 00:00:39 .. 2023-07-04 16:01:06 (~2y ~296d)
;; count: 239851138
get-bx.g.aaplimg.com.  AAAA  2620:149:a00:f000::7

;; record times: 2021-06-21 17:45:34 .. 2023-07-04 16:38:49 (~2y ~12d)
;; count: 218850968
safebrowsing-proxy.g.aaplimg.com.  AAAA  2620:149:a0c:f000::11

;; record times: 2021-06-21 17:45:34 .. 2023-07-04 16:38:49 (~2y ~12d)
;; count: 216781107
safebrowsing-proxy.g.aaplimg.com.  AAAA  2620:149:a0c:f100::12
[etc]
```

21. Akamai:

```
$ dnsdbq -i 2001:2030::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2020-09-11 04:45:42 .. 2023-07-04 16:02:42 (~2y ~296d)
;; count: 562957468
e9413.dscb.akamaiedge.net.  AAAA  2001:2030:21:187::24c5

;; record times: 2020-09-11 04:45:42 .. 2023-07-04 12:00:19 (~2y ~296d)
;; count: 562060027
e9413.dscb.akamaiedge.net.  AAAA  2001:2030:21:188::24c5

;; record times: 2020-09-11 04:36:24 .. 2023-07-04 16:10:36 (~2y ~296d)
;; count: 550715718
e8652.dscx.akamaiedge.net.  AAAA  2001:2030:21:188::21cc

;; record times: 2020-09-11 04:36:36 .. 2023-07-04 16:10:36 (~2y ~296d)
;; count: 482186542
e8652.dscx.akamaiedge.net.  AAAA  2001:2030:21:18a::21cc

;; record times: 2021-03-19 19:40:17 .. 2023-07-04 15:11:26 (~2y ~106d)
;; count: 463939398
e6858.dscx.akamaiedge.net.  AAAA  2001:2030:21:1ad::1aca

;; record times: 2021-03-19 23:11:24 .. 2023-07-04 16:03:24 (~2y ~106d)
;; count: 445659729
e6858.dscx.akamaiedge.net.  AAAA  2001:2030:21:1b4::1aca

;; record times: 2020-12-14 10:31:09 .. 2023-07-04 14:56:02 (~2y ~202d)
;; count: 408626818
ns9.z5h64q92x9.net.  AAAA  2001:2030:20::78

;; record times: 2011-05-26 12:40:45 .. 2023-07-04 12:35:58 (~12y ~41d)
;; count: 371332832
dns49.de.telia.net.  AAAA  2001:2030:c000:5::4

;; record times: 2020-12-29 15:33:10 .. 2023-07-04 14:14:05 (~2y ~186d)
;; count: 212916604
e9413.dscb.akamaiedge.net.  AAAA  2001:2030:15:183::24c5

;; record times: 2020-12-29 15:33:10 .. 2023-07-04 15:37:35 (~2y ~187d)
;; count: 212011078
e9413.dscb.akamaiedge.net.  AAAA  2001:2030:15:1ab::24c5

;; record times: 2020-09-21 06:12:37 .. 2023-07-04 01:59:09 (~2y ~285d)
;; count: 169690844
a117.dscd.akamai.net.  AAAA  2001:2030:21::3e73:fca8

;; record times: 2020-09-21 06:12:37 .. 2023-07-04 01:59:09 (~2y ~285d)
;; count: 167043647
a117.dscd.akamai.net.  AAAA  2001:2030:21::3e73:fca2

;; record times: 2021-03-19 19:40:39 .. 2023-07-04 15:51:01 (~2y ~106d)
;; count: 155759967
e4518.dscapi7.akamaiedge.net.  AAAA  2001:2030:21:1aa::11a6

;; record times: 2020-09-21 06:12:39 .. 2023-07-03 21:58:54 (~2y ~285d)
;; count: 151189439
a27.dscd.akamai.net.  AAAA  2001:2030:21::3e73:fce0
[etc]
```

22. APNIC Nameservers:

```
$ dnsdbq -i 2001:dc0::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2010-06-24 03:10:38 .. 2023-07-04 11:10:37 (~13y ~13d)
;; count: 8771562950
m.root-servers.net.  AAAA  2001:dc3::35

;; record times: 2010-06-24 03:07:01 .. 2023-07-04 13:58:43 (~13y ~13d)
;; count: 3654654561
a.dns.cn.  AAAA  2001:dc7::1

;; record times: 2010-06-24 03:07:01 .. 2023-07-04 13:58:43 (~13y ~13d)
;; count: 3625486374
d.dns.cn.  AAAA  2001:dc7:1000::1

;; record times: 2010-06-24 03:07:51 .. 2023-07-04 11:30:48 (~13y ~13d)
;; count: 1517191957
a.dns.jp.  AAAA  2001:dc4::1

;; record times: 2010-06-24 03:07:51 .. 2023-07-04 16:20:50 (~13y ~13d)
;; count: 1517071176
b.dns.jp.  AAAA  2001:dc2::1

;; record times: 2010-06-24 03:07:55 .. 2023-07-04 15:22:28 (~13y ~13d)
;; count: 1046126235
e.dns.kr.  AAAA  2001:dcc:5::100

;; record times: 2010-06-24 03:07:55 .. 2023-07-04 15:22:28 (~13y ~13d)
;; count: 1045870091
g.dns.kr.  AAAA  2001:dc5:a::1

;; record times: 2010-06-24 03:07:19 .. 2023-07-04 13:15:42 (~13y ~13d)
;; count: 772181187
sec1.apnic.net.  AAAA  2001:dc0:2001:a:4608::59

;; record times: 2021-11-04 07:50:48 .. 2023-07-04 16:11:56 (~1y ~242d)
;; count: 410361686
w.gtld.biz.  AAAA  2001:dcd:1::13

;; record times: 2021-11-04 07:50:48 .. 2023-07-04 14:06:56 (~1y ~242d)
;; count: 410160789
x.gtld.biz.  AAAA  2001:dcd:2::13

;; record times: 2021-11-04 07:50:48 .. 2023-07-04 16:41:04 (~1y ~242d)
;; count: 409963727
y.gtld.biz.  AAAA  2001:dcd:3::13
[etc]
```

23. Cloudapp; Azure; Office.com:

```
$ dnsdbq -i 2603:1020::/28 -l0 -A90d -S -k count -T datefix
;; record times: 2021-03-02 12:57:06 .. 2023-07-04 10:37:29 (~2y ~123d)
;; count: 337521741
trouter-azsc-ukwe-0-a.cloudapp.net.  AAAA  2603:1020:600::213

;; record times: 2021-03-02 12:57:08 .. 2023-07-04 11:29:17 (~2y ~123d)
;; count: 321240795
trouter-azsc-ukwe-0-b.cloudapp.net.  AAAA  2603:1020:600::21c

;; record times: 2021-10-05 23:55:29 .. 2023-06-28 17:40:38 (~1y ~265d)
;; count: 156858460
dnsz-secureclock-germanywestcentral-1.germanywestcentral.cloudapp.azure.com.  AAAA
2603:1020:c01:2::67

;; record times: 2020-04-29 11:05:06 .. 2023-07-04 12:58:15 (~3y ~66d)
;; count: 123052039
trouter2-azsc-euwe-0-a.cloudapp.net.  AAAA  2603:1020:200::682f:a1e2

;; record times: 2019-11-01 06:42:55 .. 2023-07-04 16:45:37 (~3y ~246d)
;; count: 92445404
fra-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:20::2

;; record times: 2020-01-17 02:36:09 .. 2023-07-04 16:25:37 (~3y ~169d)
;; count: 86011271
fra-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:34::2

;; record times: 2019-11-16 23:36:16 .. 2023-07-04 16:45:02 (~3y ~230d)
;; count: 84745201
fra-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:2a::2

;; record times: 2021-04-02 14:39:31 .. 2023-07-04 16:44:36 (~2y ~93d)
;; count: 83780603
hhn-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:c02::2

;; record times: 2021-04-03 02:33:09 .. 2023-07-04 16:46:06 (~2y ~92d)
;; count: 83345347
hhn-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:c07::2

;; record times: 2021-04-09 08:34:19 .. 2023-07-04 16:44:49 (~2y ~86d)
;; count: 82961518
hhn-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:806::2

;; record times: 2021-04-08 08:33:44 .. 2023-07-04 16:46:21 (~2y ~87d)
;; count: 82915297
hhn-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:802::2

;; record times: 2021-04-12 14:34:02 .. 2023-07-04 16:46:12 (~2y ~83d)
;; count: 80899645
hhn-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:807::2

;; record times: 2021-04-02 20:34:56 .. 2023-07-04 16:46:58 (~2y ~92d)
;; count: 80272550
hhn-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:803::2

;; record times: 2021-05-24 14:34:01 .. 2023-07-04 16:45:48 (~2y ~41d)
;; count: 79088601
hhn-efz.ms-acdc.office.com.  AAAA  2603:1026:c0d:c03::2
[etc]
```

24. Akamai; Dell:

```
$ dnsdbq -i 2600:1400::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 16:53:41]: Database API limit: Result limit reached
;; record times: 2013-03-29 20:07:50 .. 2023-07-04 15:39:08 (~10y ~98d)
;; count: 555112393
ns1-244.akam.net.  AAAA  2600:1401:2::f4

;; record times: 2013-03-29 20:05:34 .. 2023-07-04 15:10:53 (~10y ~98d)
;; count: 554306475
ns1-193.akam.net.  AAAA  2600:1401:2::c1

;; record times: 2013-03-28 16:12:55 .. 2023-07-04 10:19:52 (~10y ~99d)
;; count: 534776399
ns1-125.akam.net.  AAAA  2600:1401:2::7d

;; record times: 2013-03-29 20:13:32 .. 2023-07-04 09:45:14 (~10y ~98d)
;; count: 500363426
ns1-212.akam.net.  AAAA  2600:1401:2::d4

;; record times: 2013-11-12 10:19:36 .. 2023-07-04 12:05:01 (~9y ~236d)
;; count: 481509443
a6-66.akam.net.  AAAA  2600:1401:1::42

;; record times: 2022-05-12 18:16:45 .. 2023-07-04 11:33:16 (~1y ~52d)
;; count: 451349055
ns3ak.dell.com.  AAAA  2600:1401:1::40

;; record times: 2022-05-12 18:16:45 .. 2023-07-04 15:30:30 (~1y ~52d)
;; count: 451304361
ns1ak.dell.com.  AAAA  2600:1401:2::41

;; record times: 2013-10-15 19:12:13 .. 2023-07-04 15:57:47 (~9y ~263d)
;; count: 386143291
a6-65.akam.net.  AAAA  2600:1401:1::41

;; record times: 2014-04-02 03:14:52 .. 2023-07-04 14:21:37 (~9y ~95d)
;; count: 338577472
a1-245.akam.net.  AAAA  2600:1401:2::f5

;; record times: 2014-05-13 02:36:49 .. 2023-07-04 16:00:32 (~9y ~54d)
;; count: 260839500
a6-67.akam.net.  AAAA  2600:1401:1::43

;; record times: 2020-08-28 05:25:15 .. 2023-07-04 12:15:24 (~2y ~310d)
;; count: 243163735
ns1.twdcns.com.  AAAA  2600:1401:2::40

;; record times: 2014-02-23 05:31:17 .. 2023-07-04 16:01:27 (~9y ~133d)
;; count: 206391081
a6-64.akam.net.  AAAA  2600:1401:1::40

;; record times: 2014-04-19 05:10:17 .. 2023-07-04 13:36:32 (~9y ~78d)
;; count: 198332018
a1-164.akam.net.  AAAA  2600:1401:2::a4

;; record times: 2013-11-14 20:49:59 .. 2023-07-04 12:20:50 (~9y ~233d)
;; count: 194006103
a1-67.akam.net.  AAAA  2600:1401:2::43
[etc]
```

VII. RRsets Per /28 Prefix Broken Out by /12 Group

The previous two sections of this report focused on the count data. This tends to show the prefixes that have the most aggregate IPv6 query activity, but that activity might be concentrated on just a relative handful of RRsets. Thus, a given /28 prefix might see a lot of queries, but only for one small part of the whole prefix.

Another metric of per-IPv6-prefix activity we might consider is the total number of unique RRsets known from a given prefix, what's labeled the "num_results" in the following sample output from a DNSDB API "`-V summarize`" query:


```
{"count":24468337681,"num_results":1000000,"time_first":"2012-06-06 00:21:19",
"time_last":"2023-06-24 01:05:03","_dnsdbq":{"descr":"rdata/ip/2a00%3A1450%3A%3A,28",
"after":"2023-03-26 01:08:19","limit":0,"gravel":false,"complete":false}}
```


Why would anyone have a large number of unique RRsets in a given IPv6 /12 netblock? IAn IPv6 /28 represents 16 IPv6 /32's, some or all of which may be assigned to different ISPs. Given that, the amazing thing is that all /28's don't contain a million or more unique RRsets! Most regional registries are intentionally not densely assigning IPv6 allocations, thereby ensuring that ISPs will have room to grow without needing additional non-contiguous netblocks. That practice tends to reduce the number of /32s per /28 that are in use.

In any event, just as we did for the count data previously, we first show summary statistics, then per-group distribution plots, and then a grouped violin plot for our RRsets data.

1. Summary Statistics

```
import pandas as pd
import numpy as np

raw_rrsets = {
    '2001:500::/28':12309,
    '2620:1e0::/28':47572,
    '2603::/28':1459,
    [...]
    '2001:21f0::/28':1
    }

myset = {(n,v) for n,v in raw_rrsets.items()}
mylist=list(myset)
df2=pd.DataFrame(mylist,columns=['prefix','rrsets'])
df2['logrrsets'] = np.log10(df2.rrsets)
df2['slash12'] = df2['prefix'].str[:3]
df2['slash8']  = df2['prefix'].str[:2]

df2['myslash12'] = np.where((df2['slash8']=='20'),  '2000\nIANA\nn=2703',
                   np.where((df2['slash8']=='24'),  '2400\nAPNIC\nn=3798',
                   np.where((df2['slash12']=='263'),'2630\nARIN\nn=27',
                   np.where((df2['slash8']=='26'),  '2600\nARIN\nn=2707',
                   np.where((df2['slash8']=='28'),  '2800\nLACNIC\nn=3381',
                   np.where((df2['slash12']=='2a1'),'2a10\nRIPE\nn=1271',
                   np.where((df2['slash8']=='2a'),  '2a00\nRIPE\nn=9530',
                   np.where((df2['slash8']=='2c'),  '2c00\nAFRINIC\nn=444',
                                                    'oops'))))))))

print(df2.groupby('myslash12')["rrsets"].describe())
print(df2.groupby('myslash12')["logrrsets"].describe())
```

Transposing that output, we end up with the following two tables, one for raw RRsets and one for log10(RRsets):

RRsets:

Prefix	2000	2400	2600	2630	2800	2a00	2a10	2c00
Count	2,703	3,798	2,707	27	3,381	9,530	1,271	444
Mean	6024.157	2947.789	6356.931	1.037	213.107	4892.641	301.039	78.282
StdDev	60582.098	35020.329	70551.963	0.192	4106.577	58400.515	5172.291	486.765
Max	1000000	1000000	1000000	2	214611	1000000	156092	8292
75%	75.5	49	92.5	1	47	53	6	27
50%	13	12	13	1	17	5	1	4
25%	3	2	2	1	6	1	1	1
Min	1	1	1	1	1	1	1	1

LOG10(RRsets):

Prefix	2000	2400	2600	2630	2800	2a00	2a10	2c00
Count	2,703	3,798	2,707	27	3,381	9,530	1,271	444
Mean	1.337	1.182	1.274	0.011	1.237	1.040	0.501	0.827
StdDev	1.130	1.062	1.158	0.058	0.747	1.148	0.771	0.848
Max	6	6	6	0.301	5.332	6	5.193	3.919
75%	1.878	1.690	1.966	0	1.672	1.724	0.778	1.431
50%	1.114	1.079	1.114	0	1.230	0.699	0	0.602
25%	0.477	0.301	0.301	0	0.778	0	0	0
Min	0	0	0	0	0	0	0	0

As mentioned for the distribution of counts, those two tables describe the RRset distribution per /12, but tables of values aren't the easiest thing for most people to compare. Let's look at cumulative distribution functions per /12 next.

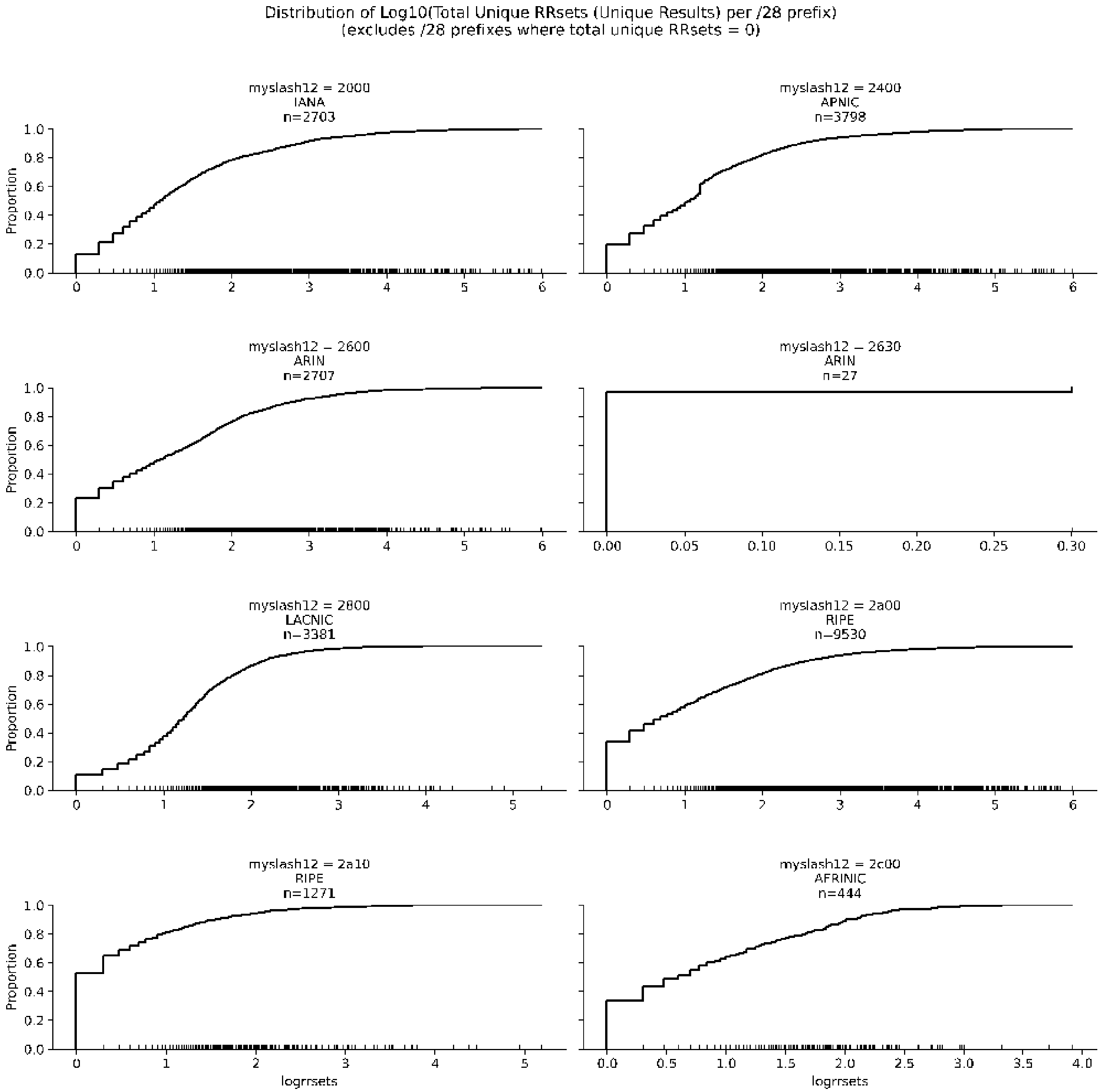
2. Per Group Distribution Plots

Now we can do the grouped distribution plots. The code to do that looks like:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

raw_rrsets = {
    '2001:500::/28':12309,
    '2620:1e0::/28':47572,
    '2603::/28':1459,
    [...]
    '2001:21f0::/28':1
    }

myset = {(n,v) for n,v in raw_rrsets.items()}
mylist=list(myset)
df2=pd.DataFrame(mylist,columns=['prefix','rrsets'])
df2['logrrsets'] = np.log10(df2.rrsets)
df2['slash12'] = df2['prefix'].str[:3]
df2['slash8']  = df2['prefix'].str[:2]

df2['myslash12'] = np.where((df2['slash8']=='20'),  '2000\nIANA\nn=2703',
                 np.where((df2['slash8']=='24'),  '2400\nAPNIC\nn=3798',
                 np.where((df2['slash12']=='263'),'2630\nARIN\nn=27',
                 np.where((df2['slash8']=='26'),  '2600\nARIN\nn=2707',
                 np.where((df2['slash8']=='28'),  '2800\nLACNIC\nn=3381',
```

```
                 np.where((df2['slash12']=='2a1'),'2a10\nRIPE\nn=1271',
                 np.where((df2['slash8']=='2a'),  '2a00\nRIPE\nn=9530',
                 np.where((df2['slash8']=='2c'),  '2c00\nAFRINIC\nn=444',
                                                  'oops'))))))))

# to get counts per group for the group names, uncomment and run the following
# print(df2.groupby('myslash12').count())

g=sns.displot(data=df2, x="logrrsets", col="myslash12",
col_order=['2000\nIANA\nn=2703','2400\nAPNIC\nn=3798',

'2600\nARIN\nn=2707','2630\nARIN\nn=27','2800\nLACNIC\nn=3381','2a00\nRIPE\nn=9530','2a10\nRI
PE\nn=1271',
     '2c00\nAFRINIC\nn=444'], col_wrap=2, kind="ecdf", height=3, aspect=2.0,
facet_kws={'sharex': False}, rug=True,
     color="black")

g.fig.subplots_adjust(top=.87, hspace=.8)
g.fig.suptitle("Distribution of Log10(Total Unique RRsets (Unique Results) per /28
prefix)\n(excludes /28 prefixes where total unique RRsets = 0)")
plt.savefig("sample_cdf_plot-2.pdf", bbox_inches="tight", dpi=300)
```

That cumulative distribution plot for total unique RRsets (after they've been log10 transformed) looks like:



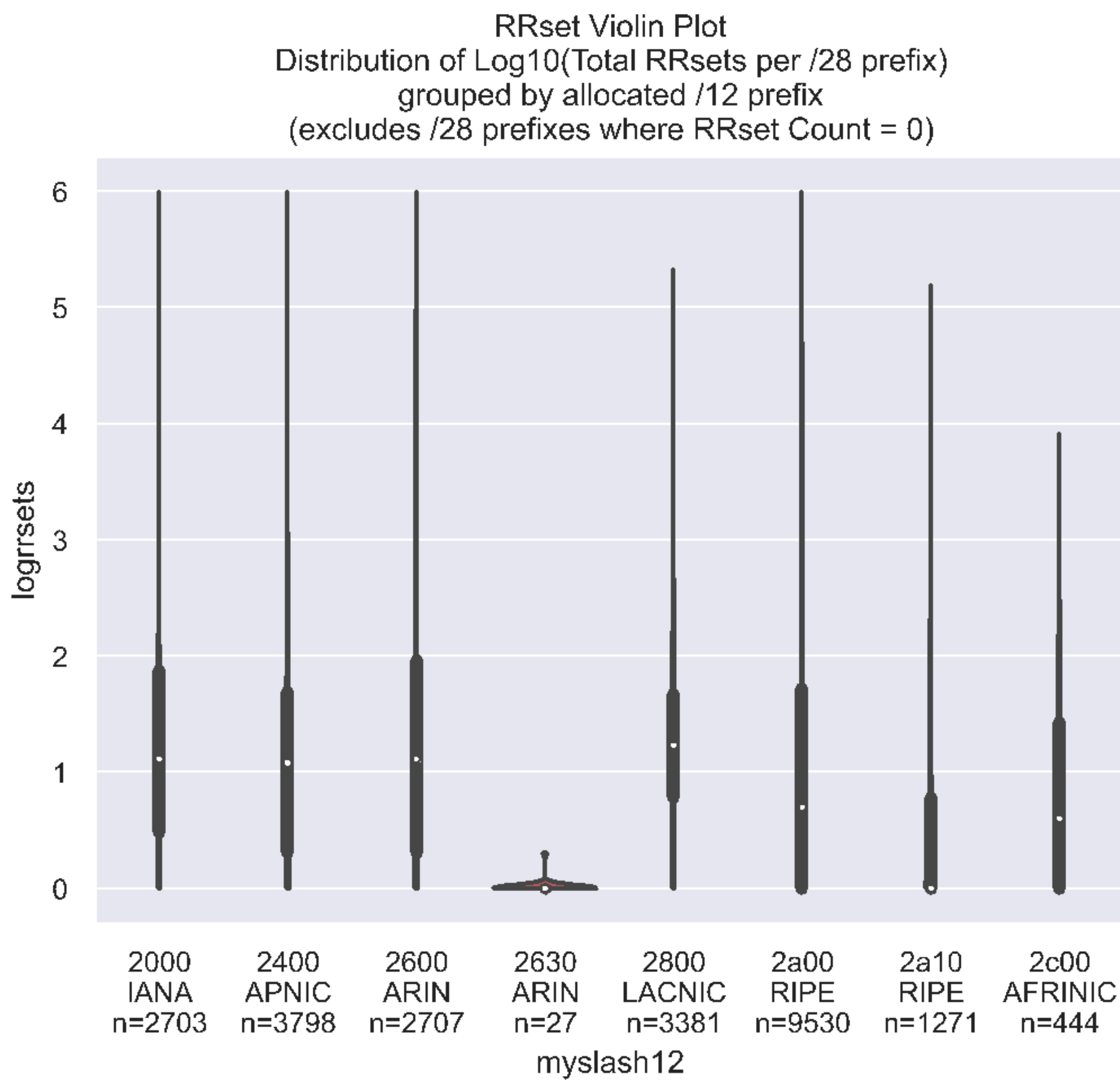
3. Violin Plot

Finally we compute this violin plot with:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

raw_rrsets = {
'2001:500::/28':12309,
```

```
'2620:1e0::/28':47572,
'2603::/28':1459,
[...]
'2001:21f0::/28':1
}

myset = {(n,v) for n,v in raw_rrsets.items()}
mylist=list(myset)
df2=pd.DataFrame(mylist,columns=['prefix','myrrsets'])
df2['logrrsets'] = np.log10(df2.myrrsets)
df2['slash12'] = df2['prefix'].str[:3]
df2['slash8']  = df2['prefix'].str[:2]

df2['myslash12'] = np.where((df2['slash8']=='20'),  '2000\nIANA\nn=2703',
                 np.where((df2['slash8']=='24'),  '2400\nAPNIC\nn=3798',
                 np.where((df2['slash12']=='263'),'2630\nARIN\nn=27',
                 np.where((df2['slash8']=='26'),  '2600\nARIN\nn=2707',
                 np.where((df2['slash8']=='28'),  '2800\nLACNIC\nn=3381',
                 np.where((df2['slash12']=='2a1'),'2a10\nRIPE\nn=1271',
                 np.where((df2['slash8']=='2a'),  '2a00\nRIPE\nn=9530',
                 np.where((df2['slash8']=='2c'),  '2c00\nAFRINIC\nn=444',
                                                  'oops'))))))))

sns.set(font_scale=0.9)
myplot = sns.violinplot(data=df2, x=df2.myslash12, y=df2.logrrsets,
    inner='box', orient='v', cut=0, order=['2000\nIANA\nn=2703',
        '2400\nAPNIC\nn=3798','2600\nARIN\nn=2707','2630\nARIN\nn=27',
        '2800\nLACNIC\nn=3381','2a00\nRIPE\nn=9530',
        '2a10\nRIPE\nn=1271','2c00\nAFRINIC\nn=444'])

myplot.set_title("RRset Violin Plot\nDistribution of Log10(Total RRsets per /28
prefix)\ngrouped by allocated /12 prefix\n(excludes /28 prefixes where RRset Count = 0)")
plt.savefig("sample_violin_plot-2.pdf", bbox_inches="tight", dpi=300)
```

The resulting violin plot can be seen below where we will note the parallel behavior of ARIN's second allocation (2630) to their overall count results.


RRset Violin Plot
Distribution of Log10(Total RRsets per /28 prefix)
grouped by allocated /12 prefix
(excludes /28 prefixes where RRset Count = 0)
logrrsets
6
5
4
3
2
1
0
2000
IANA
n=2703
2400
APNIC
n=3798
2600
ARIN
n=2707
2630
ARIN
n=27
2800
LACNIC
n=3381
2a00
RIPE
n=9530
2a10
RIPE
n=1271
2c00
AFRINIC
n=444
myslash12

VIII. Some Prefixes with A Million RRsets Ordered by Descending Total Count

In the preceding section, we looked at the prefixes that had the largest total counts – prefixes that saw a lot of cache miss traffic. In this section we're focusing on the prefixes from which we saw at least a million unique RRset results. Recall that because we're using -V summarize, we can't get more than 1,000,000 RRsets for any given prefix we may query.

The following command will guide our analysis:

```
$ cat ipv6-output-*.jsonl | jq -r '"\(.num_results) \(.count) \(._dnsdbq.descr)"' | grep -v "^0 " |
sort -nr | sed 's#rdata/ip/##' | sed 's/%3A/:/g' | sed 's#,#/#' | numfmt --grouping >
high-count-results.txt
```

We're going to exclude the four already described "million entries" reported on in the preceding section, and show the remaining top 24 prefixes. Note that multiple entities may be found in the same IP /28 (e.g., 16 IPv6 /32's in a single IPv6 /28); prefix "labels" are just for reader convenience and should not be taken as implying that only that entity will be found in that netblock.

RRsets	Counts	Prefix
1,000,000	24,468,337,681	2a00:1450::/28
1,000,000	22,448,451,869	2001:41d0::/28
1,000,000	20,830,910,060	2001:8d0::/28
1,000,000	19,352,355,174	2607:f8b0::/28
1,000,000	16,982,185,793	2a02:26f0::/28
1,000,000	16,600,288,607	2600:3c00::/28
1,000,000	16,072,151,751	2a04:4e40::/28
1,000,000	10,733,300,185	2a01:4f0::/28
1,000,000	10,637,181,896	2a03:2880::/28
1,000,000	9,783,554,036	2001:4860::/28
1,000,000	8,000,478,044	2406:da00::/28
1,000,000	7,754,788,819	2620::/28
1,000,000	5,642,405,263	2600:1410::/28
1,000,000	5,046,152,582	2a03:b0c0::/28
1,000,000	4,788,888,705	2a01:480::/28
1,000,000	4,118,692,139	2600:1900::/28
1,000,000	4,031,446,374	2600:1f10::/28
1,000,000	3,874,251,771	2a01:230::/28
1,000,000	3,658,717,329	2a00:d70::/28
1,000,000	2,699,346,150	2a01:7c0::/28
1,000,000	2,484,834,724	2606:4700::/28
1,000,000	1,933,425,816	2a03:6f00::/28
1,000,000	1,819,475,447	2607:f1c0::/28
1,000,000	1,683,409,483	2001:570::/28

Drilling down on those, we see the following heavy allocators:

1. Google; AMP Project:

```
$ dnsdbq -i 2a00:1450::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 17:28:20]: Database API limit: Result limit reached
;; record times: 2016-04-14 18:19:53 .. 2023-07-04 07:49:18 (~7y ~81d)
;; count: 5367296834
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:80e::2001

;; record times: 2016-03-02 10:21:52 .. 2023-07-04 15:01:47 (~7y ~125d)
;; count: 3696718574
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:809::2001

;; record times: 2016-04-06 14:04:21 .. 2023-07-04 10:15:09 (~7y ~89d)
;; count: 3652991711
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:803::2001

;; record times: 2016-02-24 14:44:06 .. 2023-07-04 13:22:20 (~7y ~131d)
;; count: 3560854184
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:808::2001

;; record times: 2016-04-06 14:00:21 .. 2023-07-04 09:26:16 (~7y ~89d)
;; count: 3396699214
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:802::2001

;; record times: 2016-03-17 15:54:33 .. 2023-07-04 10:34:26 (~7y ~109d)
;; count: 3134017740
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:800::2001

;; record times: 2016-04-06 13:48:24 .. 2023-07-04 10:38:50 (~7y ~89d)
;; count: 2997115528
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:801::2001

;; record times: 2016-03-08 08:46:31 .. 2023-07-04 14:17:59 (~7y ~119d)
;; count: 1070573959
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:80b::2001

;; record times: 2015-11-24 12:23:16 .. 2023-07-04 15:09:39 (~7y ~224d)
;; count: 1024685335
pagead-googlehosted.l.google.com.  AAAA  2a00:1450:4001:806::2001

;; record times: 2021-01-25 16:32:31 .. 2023-07-04 06:29:06 (~2y ~159d)
;; count: 136646385
cdn-content.ampproject.org.  AAAA  2a00:1450:4001:80e::2001

;; record times: 2018-12-08 16:53:22 .. 2023-07-04 06:57:23 (~4y ~208d)
;; count: 107974277
cdn-content.ampproject.org.  AAAA  2a00:1450:4001:809::2001

;; record times: 2018-12-04 09:45:36 .. 2023-07-04 04:06:14 (~4y ~212d)
;; count: 106271092
cdn-content.ampproject.org.  AAAA  2a00:1450:4001:808::2001
[etc]
```

2. DomainDiscount24; srv53; OVH:

```
$ dnsdbq -i 2001:41d0::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 17:33:46]: Database API limit: Result limit reached
;; record times: 2015-05-20 12:00:19 .. 2023-07-04 16:34:27 (~8y ~47d)
;; count: 2142710060
ns1.domaindiscount24.net.  AAAA  2001:41d0:c:388:94:23:153:36

;; record times: 2015-01-05 23:22:18 .. 2023-07-04 17:14:39 (~8y ~181d)
;; count: 805062882
nsa1.srv53.org.  AAAA  2001:41d0:b:a74:178:32:247:3

;; record times: 2014-12-24 15:28:03 .. 2023-07-04 16:52:01 (~8y ~194d)
;; count: 781331844
nsa1.srv53.net.  AAAA  2001:41d0:b:a74:5:39:10:94

;; record times: 2015-01-05 23:22:21 .. 2023-07-04 15:30:33 (~8y ~181d)
;; count: 739126457
nsa1.srv53.com.  AAAA  2001:41d0:b:a74:178:32:247:7

;; record times: 2011-02-11 08:50:05 .. 2023-07-04 16:37:01 (~12y ~146d)
;; count: 578488690
sdns2.ovh.net.  AAAA  2001:41d0:1:4a8d::1

;; record times: 2011-02-14 13:09:02 .. 2023-07-04 14:08:48 (~12y ~143d)
;; count: 568764546
ns10.ovh.net.  AAAA  2001:41d0:1:1981::1
[etc]
```

3. 1&1; home.pl ns14.net; ui-dns.com:

```
$ dnsdbq -i 2001:8d0::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 17:40:02]: Database API limit: Result limit reached
;; record times: 2013-04-16 01:57:19 .. 2023-07-04 11:52:51 (~10y ~81d)
;; count: 1356619022
ns-us.1and1-dns.com.  AAAA  2001:8d8:fe:53:0:d9a0:5202:100

;; record times: 2019-09-24 06:58:16 .. 2023-07-04 16:47:10 (~3y ~284d)
;; count: 961828448
dns.home.pl.  AAAA  2001:8d8:fe:53:6870::1

;; record times: 2019-09-30 05:35:21 .. 2023-07-04 16:47:10 (~3y ~278d)
;; count: 959491445
dns2.home.pl.  AAAA  2001:8d8:fe:53:6870::2

;; record times: 2012-06-08 10:28:39 .. 2023-07-04 10:33:09 (~11y ~28d)
;; count: 483068498
b.ns14.net.  AAAA  2001:8d8:580:401:217:160:113:32

;; record times: 2016-11-16 14:54:35 .. 2023-07-04 15:53:05 (~6y ~231d)
;; count: 358527116
ns1045.ui-dns.com.  AAAA  2001:8d8:fe:53:0:d9a0:522d:100

;; record times: 2013-04-29 16:20:39 .. 2023-07-04 17:11:13 (~10y ~68d)
;; count: 254141565
ns-uk.1and1-dns.com.  AAAA  2001:8d8:fe:53:0:d9a0:5203:100

;; record times: 2013-04-29 14:35:32 .. 2023-07-04 13:14:18 (~10y ~67d)
;; count: 251479689
ns-es.1and1-dns.com.  AAAA  2001:8d8:fe:53:0:d9a0:5205:100

;; record times: 2014-02-08 17:43:14 .. 2023-07-04 14:35:37 (~9y ~147d)
;; count: 236795029
ipv6.connman.net.  AAAA  2001:8d8:8b4:c861:5826:fa5f:6690:0

;; record times: 2011-01-01 17:41:30 .. 2023-07-04 16:08:18 (~12y ~186d)
;; count: 192333734
ns-biz.ui-dns.biz.  AAAA  2001:8d8:fe:53:0:d9a0:51c3:100

;; record times: 2013-04-29 15:30:47 .. 2023-07-04 17:04:50 (~10y ~68d)
;; count: 165059643
ns-de.1and1-dns.com.  AAAA  2001:8d8:fe:53:0:d9a0:5201:100

;; record times: 2013-04-29 10:39:57 .. 2023-07-04 14:51:18 (~10y ~68d)
;; count: 156333744
ns-fr.1and1-dns.com.  AAAA  2001:8d8:fe:53:0:d9a0:5204:100

;; record times: 2019-05-08 11:19:04 .. 2023-07-04 12:05:32 (~4y ~58d)
;; count: 153695980
ns51.1and1.com.  AAAA  2001:8d8:fe:53:0:d9a0:501e:100

;; record times: 2019-05-06 06:52:36 .. 2023-07-04 11:50:53 (~4y ~60d)
;; count: 153659968
ns52.1and1.com.  AAAA  2001:8d8:fe:53:0:d9a0:511d:100

;; record times: 2013-04-25 08:49:03 .. 2023-07-04 14:50:15 (~10y ~72d)
;; count: 127205842
ns-us.1and1-dns.org.  AAAA  2001:8d8:fe:53:0:d9a0:5302:100

;; record times: 2023-01-31 11:49:25 .. 2023-07-04 15:24:10 (~154d 3h 34m)
;; count: 124820643
ns2.livedns.co.uk.  AAAA  2001:8d8:fe:53:fa::2
[etc]
```

4. Google:

```
$ dnsdbq -i 2607:f8b0::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 17:44:07]: Database API limit: Result limit reached
;; record times: 2017-07-11 15:58:27 .. 2023-07-03 10:03:36 (~5y ~357d)
;; count: 794686925
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:80e::2001

;; record times: 2018-08-09 10:41:37 .. 2023-07-03 10:03:06 (~4y ~328d)
;; count: 724791260
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:817::2001

;; record times: 2016-02-24 14:45:03 .. 2023-07-03 10:01:10 (~7y ~130d)
;; count: 688979922
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:806::2001

;; record times: 2016-03-08 08:32:27 .. 2023-07-03 09:57:57 (~7y ~118d)
;; count: 687544969
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:808::2001

;; record times: 2015-09-17 16:31:00 .. 2023-07-03 10:12:24 (~7y ~290d)
;; count: 667356922
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:801::2001

;; record times: 2021-05-26 15:44:07 .. 2023-07-03 10:27:17 (~2y ~37d)
;; count: 586012954
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:805::2001

;; record times: 2021-08-02 16:48:09 .. 2023-07-03 10:13:37 (~1y ~334d)
;; count: 531592559
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:819::2001

;; record times: 2021-08-02 16:53:25 .. 2023-07-03 10:18:17 (~1y ~334d)
;; count: 519687800
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:81a::2001

;; record times: 2015-09-17 18:22:55 .. 2023-07-03 10:26:58 (~7y ~290d)
;; count: 511218951
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:800::2001

;; record times: 2016-03-02 10:25:18 .. 2023-07-03 10:11:06 (~7y ~123d)
;; count: 507907983
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:809::2001

;; record times: 2014-10-16 14:32:17 .. 2023-07-03 10:11:36 (~8y ~261d)
;; count: 487133230
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:80a::2001

;; record times: 2021-08-02 16:55:54 .. 2023-07-03 10:10:37 (~1y ~334d)
;; count: 469279483
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:81b::2001

;; record times: 2016-02-03 00:24:27 .. 2023-07-03 10:19:59 (~7y ~152d)
;; count: 467466048
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:807::2001

;; record times: 2016-03-10 20:12:30 .. 2023-07-03 10:03:22 (~7y ~115d)
;; count: 416112225
pagead-googlehosted.l.google.com.  AAAA  2607:f8b0:4000:803::2001
[etc]
```

5. Akamai:

```
$ dnsdbq -i 2a02:26f0::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 17:47:09]: Database API limit: Result limit reached
;; record times: 2013-11-10 07:42:54 .. 2023-07-04 14:52:19 (~9y ~238d)
;; count: 535919463
a20-65.akam.net.  AAAA  2a02:26f0:67::41

;; record times: 2018-03-30 13:17:57 .. 2023-07-04 15:42:38 (~5y ~97d)
;; count: 264299577
e673.dsce9.akamaiedge.net.  AAAA  2a02:26f0:e2:584::2a1

;; record times: 2018-03-30 13:17:57 .. 2023-07-04 08:39:52 (~5y ~96d)
;; count: 245367258
e673.dsce9.akamaiedge.net.  AAAA  2a02:26f0:e2:59b::2a1

;; record times: 2018-05-17 03:42:37 .. 2023-04-11 19:07:55 (~4y ~330d)
;; count: 194535147
e10204.dsca.akamaiedge.net.  AAAA  2a02:26f0:e2:498::27dc

;; record times: 2019-05-13 18:54:58 .. 2023-05-07 08:45:11 (~3y ~359d)
;; count: 186933028
a771.dscq.akamai.net.  AAAA  2a02:26f0:98::210:9a41

;; record times: 2013-11-14 20:40:44 .. 2023-07-04 14:00:22 (~9y ~233d)
;; count: 185569176
a20-66.akam.net.  AAAA  2a02:26f0:67::42

;; record times: 2020-12-02 01:34:55 .. 2023-05-08 07:54:40 (~2y ~157d)
;; count: 179227740
a1887.dscq.akamai.net.  AAAA  2a02:26f0:98::210:9a4b

;; record times: 2018-05-17 03:42:37 .. 2023-04-11 19:07:55 (~4y ~330d)
;; count: 136595280
e10204.dsca.akamaiedge.net.  AAAA  2a02:26f0:e2:49c::27dc

;; record times: 2014-04-14 21:48:04 .. 2023-07-04 16:29:23 (~9y ~82d)
;; count: 133981007
asia9.akam.net.  AAAA  2a02:26f0:67::40

;; record times: 2021-06-10 19:28:17 .. 2023-06-25 19:12:33 (~2y ~14d)
;; count: 133611401
a117.dscd.akamai.net.  AAAA  2a02:26f0:98::58dd:84ca

;; record times: 2018-05-11 18:30:03 .. 2023-07-04 11:20:10 (~5y ~54d)
;; count: 119496051
e1553.dspg.akamaiedge.net.  AAAA  2a02:26f0:e2:485::611

;; record times: 2018-05-11 18:30:03 .. 2023-06-02 05:06:06 (~5y ~22d)
;; count: 119322668
e1553.dspg.akamaiedge.net.  AAAA  2a02:26f0:e2:484::611

;; record times: 2021-02-22 21:11:00 .. 2023-06-25 19:12:31 (~2y ~122d)
;; count: 114124096
a1488.dscd.akamai.net.  AAAA  2a02:26f0:98::58dd:84d0

;; record times: 2021-06-10 20:06:04 .. 2023-06-25 19:12:31 (~2y ~14d)
;; count: 112149885
a1488.dscd.akamai.net.  AAAA  2a02:26f0:98::58dd:84e1
[etc]
```

6. Linode:

```
$ dnsdbq -i 2600:3c00::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 17:51:16]: Database API limit: Result limit reached
;; record times: 2020-12-17 14:39:31 .. 2023-07-04 06:51:24 (~2y ~198d)
;; count: 949077999
sinkhole2.vsbad.net.  AAAA  2600:3c01::f03c:92ff:fe78:6e04

;; record times: 2012-07-06 22:37:23 .. 2023-07-04 17:43:04 (~10y ~364d)
;; count: 948220510
ns3.corp.ventraip.net.au.  AAAA  2600:3c01::f03c:91ff:feae:d042

;; record times: 2012-11-10 18:21:10 .. 2023-07-04 11:43:14 (~10y ~237d)
;; count: 832255693
v6frontends.b5p.us.  AAAA  2600:3c01::f03c:91ff:fe96:257

;; record times: 2014-11-09 08:30:43 .. 2023-07-04 11:43:14 (~8y ~239d)
;; count: 832255101
v6frontends.b5p.us.  AAAA  2600:3c02::f03c:91ff:fe6e:9b70

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813445326
v6frontends.b5p.us.  AAAA  2600:3c01::f03c:91ff:fea9:6efb

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813445174
v6frontends.b5p.us.  AAAA  2600:3c02::f03c:91ff:fe22:c7f

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813445058
v6frontends.b5p.us.  AAAA  2600:3c02::f03c:91ff:fec9:2491

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813444985
v6frontends.b5p.us.  AAAA  2600:3c02::f03c:91ff:fe22:c36

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813444747
v6frontends.b5p.us.  AAAA  2600:3c01::f03c:91ff:fee7:3c

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813444657
v6frontends.b5p.us.  AAAA  2600:3c01::f03c:91ff:fec9:2489

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813444559
v6frontends.b5p.us.  AAAA  2600:3c02::f03c:91ff:fee7:4a

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813444438
v6frontends.b5p.us.  AAAA  2600:3c02::f03c:91ff:fe22:c4d

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813444379
v6frontends.b5p.us.  AAAA  2600:3c01::f03c:91ff:fe5e:eba3

;; record times: 2019-05-02 20:40:47 .. 2023-07-04 11:43:14 (~4y ~63d)
;; count: 813444379
v6frontends.b5p.us.  AAAA  2600:3c01::f03c:91ff:fe5e:ac07

;; record times: 2017-10-04 13:43:52 .. 2023-07-04 15:45:14 (~5y ~274d)
;; count: 227437986
ns-zoo.i.bitbit.net.  AAAA  2600:3c00::f03c:91ff:febd:d3ff
[etc]
```

7. Fastly:

```
$ dnsdbq -i 2a04:4e40::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 17:55:42]: Database API limit: Result limit reached
;; record times: 2017-03-16 21:31:47 .. 2023-07-04 11:09:42 (~6y ~110d)
;; count: 191796609
wikia.com.  AAAA  2a04:4e42::194

;; record times: 2019-06-10 11:40:56 .. 2023-07-04 09:34:39 (~4y ~24d)
;; count: 149993591
config2.mparticle.com.  AAAA  2a04:4e42::645

;; record times: 2020-01-14 12:34:44 .. 2023-04-12 13:05:02 (~3y ~89d)
;; count: 115829444
nativesdks.mparticle.com.  AAAA  2a04:4e42::645

;; record times: 2017-06-16 04:00:13 .. 2023-07-04 15:54:46 (~6y ~19d)
;; count: 104210330
dualstack.prod.iheart.map.fastly.net.  AAAA  2a04:4e42:6::269

;; record times: 2021-09-06 11:10:50 .. 2023-07-04 13:04:06 (~1y ~301d)
;; count: 103107214
polyfill.io.  AAAA  2a04:4e42::282

;; record times: 2020-05-11 15:58:12 .. 2023-07-04 15:13:03 (~3y ~53d)
;; count: 101596644
jssdks.mparticle.com.  AAAA  2a04:4e42::645

;; record times: 2017-01-06 15:55:42 .. 2023-07-04 16:23:49 (~6y ~180d)
;; count: 97304817
turner-tls.map.fastly.net.  AAAA  2a04:4e42:6::323

;; record times: 2020-05-11 15:55:26 .. 2023-07-04 10:23:48 (~3y ~53d)
;; count: 95445490
jssdkcdns.mparticle.com.  AAAA  2a04:4e42::645

;; record times: 2018-09-12 00:05:27 .. 2023-07-04 15:25:33 (~4y ~296d)
;; count: 95242348
prod.globalsign.map.fastly.net.  AAAA  2a04:4e42:3a::645

;; record times: 2020-10-12 23:37:26 .. 2023-07-04 15:32:54 (~2y ~264d)
;; count: 94925974
fastly3.cedexis.fastlylb.net.  AAAA  2a04:4e42::517

;; record times: 2017-05-26 00:33:53 .. 2023-07-04 15:59:46 (~6y ~40d)
;; count: 94639711
dualstack.iheartmedia.map.fastly.net.  AAAA  2a04:4e42:6::596

;; record times: 2016-11-09 19:15:02 .. 2023-07-04 15:27:11 (~6y ~237d)
;; count: 91620330
dualstack.pinterest.map.fastly.net.  AAAA  2a04:4e42:6::84

;; record times: 2018-01-20 15:15:01 .. 2023-07-04 15:28:48 (~5y ~166d)
;; count: 82229454
dualstack.f6.shared.global.fastly.net.  AAAA  2a04:4e42:6::714

;; record times: 2019-01-22 20:08:11 .. 2023-07-04 11:51:30 (~4y ~163d)
;; count: 72929898
mparticle.map.fastly.net.  AAAA  2a04:4e42:6::645
[etc]
```

8. Hetzner:

```
$ dnsdbq -i 2a01:4f0::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 17:59:18]: Database API limit: Result limit reached
;; record times: 2013-04-11 08:07:23 .. 2023-07-04 11:50:44 (~10y ~86d)
;; count: 1097250315
ns.second-ns.com.  AAAA  2a01:4f8:0:a101::b:1

;; record times: 2020-09-17 06:28:35 .. 2023-07-04 17:09:28 (~2y ~290d)
;; count: 744590582
speedcdn.cloud.funkedigital.de.  AAAA  2a01:4f8:c0:2ba8::1

;; record times: 2020-09-17 06:28:35 .. 2023-07-04 17:09:28 (~2y ~290d)
;; count: 744590582
speedcdn.cloud.funkedigital.de.  AAAA  2a01:4f8:c0:1440::1

;; record times: 2020-09-17 06:28:35 .. 2023-07-04 17:09:28 (~2y ~290d)
;; count: 744590582
speedcdn.cloud.funkedigital.de.  AAAA  2a01:4f8:c0:1421::1

;; record times: 2020-09-17 06:28:35 .. 2023-07-04 17:09:28 (~2y ~290d)
;; count: 744590582
speedcdn.cloud.funkedigital.de.  AAAA  2a01:4f8:c0:141c::1

;; record times: 2017-12-05 08:00:55 .. 2023-07-04 14:59:46 (~5y ~212d)
;; count: 707963433
ns45.grserver.gr.  AAAA  2a01:4f8:13b:238a::2

;; record times: 2017-11-25 20:12:42 .. 2023-07-04 14:59:46 (~5y ~221d)
;; count: 706624478
ns183.grserver.gr.  AAAA  2a01:4f8:120:6057::2

;; record times: 2018-10-10 09:48:03 .. 2023-07-04 17:33:39 (~4y ~268d)
;; count: 385292372
h2.ndm9.xyz.  AAAA  2a01:4f8:d1:1d00::100

;; record times: 2018-10-08 16:31:11 .. 2023-06-28 06:40:44 (~4y ~263d)
;; count: 256488538
hz.ndm9.xyz.  AAAA  2a01:4f8:d1:1d00::110

;; record times: 2021-07-03 17:20:09 .. 2023-07-04 13:30:52 (~2y)
;; count: 236914134
h2.knt9.xyz.  AAAA  2a01:4f8:d1:1d00::100
[etc]
```

9. Meta:

```
$ dnsdbq -i 2a03:2880::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 18:02:37]: Database API limit: Result limit reached
;; record times: 2021-06-19 17:09:06 .. 2023-07-04 15:26:48 (~2y ~14d)
;; count: 1397085294
b.ns.c10r.instagram.com.  AAAA  2a03:2880:f0fd:b:face:b00c:0:99

;; record times: 2021-06-19 17:09:06 .. 2023-07-04 15:26:48 (~2y ~14d)
;; count: 1397074816
a.ns.c10r.instagram.com.  AAAA  2a03:2880:f0fc:b:face:b00c:0:99

;; record times: 2020-03-03 19:46:23 .. 2023-07-04 15:55:10 (~3y ~122d)
;; count: 840848730
b.ns.facebook.com.  AAAA  2a03:2880:f0fd:c:face:b00c:0:35

;; record times: 2020-03-05 20:28:09 .. 2023-07-04 15:55:10 (~3y ~120d)
;; count: 840228509
a.ns.facebook.com.  AAAA  2a03:2880:f0fc:c:face:b00c:0:35

;; record times: 2015-05-05 15:34:41 .. 2023-07-04 12:06:46 (~8y ~61d)
;; count: 664343588
star.c10r.facebook.com.  AAAA  2a03:2880:f00a:8:face:b00c:0:2

;; record times: 2016-07-07 01:12:37 .. 2023-07-04 10:12:37 (~6y ~363d)
;; count: 484354139
star-mini.c10r.facebook.com.  AAAA  2a03:2880:f10a:83:face:b00c:0:25de

;; record times: 2017-06-03 19:45:52 .. 2023-05-05 05:38:45 (~5y ~336d)
;; count: 170922119
star.c10r.facebook.com.  AAAA  2a03:2880:f01c:800e:face:b00c:0:2

;; record times: 2020-01-16 19:04:44 .. 2023-07-04 16:58:12 (~3y ~169d)
;; count: 170193684
a.ns.c10r.facebook.com.  AAAA  2a03:2880:f0fc:b:face:b00c:0:99

;; record times: 2020-01-16 19:04:44 .. 2023-07-04 15:25:58 (~3y ~169d)
;; count: 170185573
b.ns.c10r.facebook.com.  AAAA  2a03:2880:f0fd:b:face:b00c:0:99

;; record times: 2020-01-16 18:19:20 .. 2023-07-04 12:32:11 (~3y ~169d)
;; count: 141020285
a.ns.fna.fbcdn.net.  AAAA  2a03:2880:f0fc:b:face:b00c:0:99

;; record times: 2020-01-16 18:19:20 .. 2023-07-04 12:32:11 (~3y ~169d)
;; count: 141004572
b.ns.fna.fbcdn.net.  AAAA  2a03:2880:f0fd:b:face:b00c:0:99
[etc]
```

10. Google:

```
$ dnsdbq -i 2001:4860::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 18:05:32]: Database API limit: Result limit reached
;; record times: 2018-01-22 23:13:06 .. 2023-07-04 17:23:38 (~5y ~163d)
;; count: 8515588586
ns1.google.com.  AAAA  2001:4860:4802:32::a

;; record times: 2014-12-17 18:16:47 .. 2023-07-04 15:51:22 (~8y ~200d)
;; count: 122190086
ns5.googledomains.com.  AAAA  2001:4860:4802:32::a

;; record times: 2016-09-15 00:25:23 .. 2023-07-04 11:05:53 (~6y ~293d)
;; count: 104800968
snap.com.  AAAA  2001:4860:4802:32::15

;; record times: 2014-01-09 10:39:50 .. 2023-07-04 12:10:30 (~9y ~178d)
;; count: 87976032
virustotal.com.  AAAA  2001:4860:4802:32::15

;; record times: 2019-04-16 10:06:09 .. 2023-07-04 11:44:41 (~4y ~80d)
;; count: 63224982
utils.global-e.com.  AAAA  2001:4860:4802:32::15

;; record times: 2017-10-11 01:02:32 .. 2023-07-04 18:00:08 (~5y ~267d)
;; count: 58427279
apps.accounts.nintendo.com.  AAAA  2001:4860:4802:32::15

;; record times: 2017-12-06 16:04:34 .. 2023-06-28 11:45:15 (~5y ~204d)
;; count: 51280037
us.geo.ngtv.io.  AAAA  2001:4860:4802:32::15

;; record times: 2018-08-31 20:14:29 .. 2023-07-04 13:55:12 (~4y ~307d)
;; count: 32467299
x.mdhv.io.  AAAA  2001:4860:4802:32::15

;; record times: 2019-04-08 19:46:18 .. 2023-07-04 16:33:26 (~4y ~87d)
;; count: 23581232
boxoffice.urbanairship.com.  AAAA  2001:4860:4802:32::15

;; record times: 2018-08-21 19:40:42 .. 2023-07-04 14:09:54 (~4y ~317d)
;; count: 22821046
pdst.fm.  AAAA  2001:4860:4802:32::15

;; record times: 2019-08-19 22:24:57 .. 2023-07-04 15:35:05 (~3y ~319d)
;; count: 21943896
zeronaught.com.  AAAA  2001:4860:4802:32::15

;; record times: 2017-01-26 00:07:07 .. 2023-07-04 16:11:19 (~6y ~160d)
;; count: 16246598
ns1.ipv6test.com.  AAAA  2001:4860:4802:32::a

;; record times: 2017-01-10 13:20:22 .. 2023-07-04 16:42:24 (~6y ~176d)
;; count: 15253963
track.scoota.co.  AAAA  2001:4860:4802:32::15

;; record times: 2021-05-06 14:12:57 .. 2023-07-04 13:42:39 (~2y ~58d)
;; count: 14480482
csi.gstatic.com.  AAAA  2001:4860:4802:32::3

;; record times: 2020-04-21 15:10:22 .. 2023-07-04 13:47:34 (~3y ~73d)
;; count: 11726225
ota-cache1.googlezip.net.  AAAA  2001:4860:3::4
[etc]
```

11. Amazon:

```
$ dnsdbq -i 2406:da00::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 18:10:04]: Database API limit: Result limit reached
;; record times: 2018-07-29 23:32:54 .. 2023-07-04 16:45:26 (~4y ~340d)
;; count: 170845571
bitbucket.org.  AAAA  2406:da00:ff00::22cd:e0db

;; record times: 2018-08-07 08:03:21 .. 2023-07-04 16:45:26 (~4y ~332d)
;; count: 164216450
bitbucket.org.  AAAA  2406:da00:ff00::22c5:2ef4

;; record times: 2018-08-07 22:28:17 .. 2023-07-04 16:45:26 (~4y ~331d)
;; count: 160092351
bitbucket.org.  AAAA  2406:da00:ff00::22c0:3470

;; record times: 2018-08-07 22:29:16 .. 2023-07-04 16:45:26 (~4y ~331d)
;; count: 143741855
bitbucket.org.  AAAA  2406:da00:ff00::22e9:9f55

;; record times: 2018-07-29 23:32:54 .. 2023-07-04 16:45:26 (~4y ~340d)
;; count: 142395469
bitbucket.org.  AAAA  2406:da00:ff00::3403:4be7

;; record times: 2016-09-13 18:09:15 .. 2023-06-27 22:03:11 (~6y ~288d)
;; count: 64341675
appboot.us-east-1.prodaa.netflix.com.  AAAA  2406:da00:ff00::342c:895d

;; record times: 2016-09-21 09:30:58 .. 2023-06-27 22:03:08 (~6y ~280d)
;; count: 57487042
appboot.us-east-1-sa.prodaa.netflix.com.  AAAA  2406:da00:ff00::342c:895d

;; record times: 2017-01-20 23:18:11 .. 2023-07-03 15:26:59 (~6y ~164d)
;; count: 44686666
appboot.us-east-1.prodaa.netflix.com.  AAAA  2406:da00:ff00::3417:36fb

;; record times: 2016-09-13 18:24:54 .. 2023-07-01 16:23:43 (~6y ~291d)
;; count: 42414562
nmtracking.us-east-1.prodaa.netflix.com.  AAAA  2406:da00:ff00::36ae:735c

;; record times: 2018-09-24 15:51:29 .. 2023-06-08 13:53:06 (~4y ~257d)
;; count: 39367059
api.bitbucket.org.  AAAA  2406:da00:ff00::3448:67ee

;; record times: 2017-02-27 01:47:54 .. 2023-07-04 03:03:55 (~6y ~128d)
;; count: 37228132
customerevents.us-east-1.prodaa.netflix.com.  AAAA  2406:da00:ff00::34ca:889b

;; record times: 2017-01-20 23:18:20 .. 2023-07-03 15:26:59 (~6y ~164d)
;; count: 36773563
appboot.us-east-1.prodaa.netflix.com.  AAAA  2406:da00:ff00::3436:ce8a

;; record times: 2016-09-13 18:24:54 .. 2023-07-01 16:23:43 (~6y ~291d)
;; count: 34966081
nmtracking.us-east-1.prodaa.netflix.com.  AAAA  2406:da00:ff00::34c8:42eb

;; record times: 2018-08-19 14:52:55 .. 2023-07-03 12:27:50 (~4y ~318d)
;; count: 34590445
appboot.us-east-1-sa.prodaa.netflix.com.  AAAA  2406:da00:ff00::3407:9f12

;; record times: 2018-08-25 20:34:36 .. 2023-06-26 03:32:05 (~4y ~305d)
;; count: 34523314
appboot.us-east-1-sa.prodaa.netflix.com.  AAAA  2406:da00:ff00::3210:4e32
[etc]
```

12. Microsoft; Ford; PCH, ICANN; Wikipedia:

```
$ dnsdbq -i 2620::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 18:13:06]: Database API limit: Result limit reached
;; record times: 2014-11-13 17:57:28 .. 2023-07-04 17:33:20 (~8y ~234d)
;; count: 1571622279
ns1.msft.net.  AAAA  2620:0:30::53

;; record times: 2014-12-10 18:53:10 .. 2023-07-04 17:33:20 (~8y ~207d)
;; count: 1450295510
ns3.msft.net.  AAAA  2620:0:34::53

;; record times: 2014-04-09 22:02:43 .. 2023-07-04 17:33:20 (~9y ~87d)
;; count: 1435313821
ns4.msft.net.  AAAA  2620:0:37::53

;; record times: 2014-04-24 17:40:34 .. 2023-07-04 17:33:20 (~9y ~72d)
;; count: 1429026399
ns2.msft.net.  AAAA  2620:0:32::53

;; record times: 2020-02-05 18:56:09 .. 2023-07-04 16:11:28 (~3y ~149d)
;; count: 170642855
extdns014.ford.com.  AAAA  2620:0:403:2001::1:10

;; record times: 2020-02-05 18:56:09 .. 2023-07-04 12:11:41 (~3y ~149d)
;; count: 170613734
extdns011.ford.com.  AAAA  2620:0:402:2001::1:8

;; record times: 2020-02-05 18:56:09 .. 2023-07-04 15:20:29 (~3y ~149d)
;; count: 170610709
extdns013.ford.com.  AAAA  2620:0:403:2001::1:8

;; record times: 2020-02-05 18:56:09 .. 2023-07-04 15:22:53 (~3y ~149d)
;; count: 170606384
extdns012.ford.com.  AAAA  2620:0:402:2001::1:10

;; record times: 2014-05-13 07:30:59 .. 2023-07-04 15:33:54 (~9y ~54d)
;; count: 154315590
ns3.pch.net.  AAAA  2620:0:872::231:3

;; record times: 2010-08-11 21:24:10 .. 2023-07-04 16:43:40 (~12y ~329d)
;; count: 101244153
gtm1.lax.icann.org.  AAAA  2620:0:2d0:296::252

;; record times: 2014-09-09 15:32:34 .. 2023-07-04 16:28:33 (~8y ~300d)
;; count: 86110977
upload.wikimedia.org.  AAAA  2620:0:863:ed1a::2:b

;; record times: 2014-09-09 15:32:45 .. 2023-07-04 11:46:24 (~8y ~299d)
;; count: 58357145
upload.wikimedia.org.  AAAA  2620:0:861:ed1a::2:b

;; record times: 2019-05-09 13:42:39 .. 2023-07-04 10:55:04 (~4y ~56d)
;; count: 52832795
dyna.wikimedia.org.  AAAA  2620:0:862:ed1a::1

;; record times: 2019-05-09 13:43:24 .. 2023-07-04 13:43:36 (~4y ~57d)
;; count: 48529171
dyna.wikimedia.org.  AAAA  2620:0:863:ed1a::1

;; record times: 2010-07-16 20:11:40 .. 2023-07-04 11:45:16 (~12y ~355d)
;; count: 43016827
ianawhois.vip.icann.org.  AAAA  2620:0:2d0:200::59
[etc]
```

13. Akamai:

```
$ dnsdbq -i 2600:1410::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 18:18:28]: Database API limit: Result limit reached
;; record times: 2018-11-13 17:51:35 .. 2023-07-03 13:33:30 (~4y ~232d)
;; count: 17400832
a58.dscg10.akamai.net.  AAAA  2600:141b:7000::173f:f0a3

;; record times: 2018-11-13 17:51:35 .. 2023-07-03 13:33:30 (~4y ~232d)
;; count: 17349124
a58.dscg10.akamai.net.  AAAA  2600:141b:7000::173f:f0ab

;; record times: 2021-08-21 02:01:19 .. 2023-07-01 22:06:29 (~1y ~314d)
;; count: 10503204
a1968.dsct.akamai.net.  AAAA  2600:141b:e800:11::172c:8384

;; record times: 2021-08-21 02:01:19 .. 2023-07-01 22:06:29 (~1y ~314d)
;; count: 10473021
a1968.dsct.akamai.net.  AAAA  2600:141b:e800:11::172c:8386

;; record times: 2021-06-02 14:53:53 .. 2023-07-04 08:48:40 (~2y ~31d)
;; count: 8206933
a1952.dscq.akamai.net.  AAAA  2600:141b:e800:c::172c:8599

;; record times: 2021-06-02 14:53:53 .. 2023-07-04 08:48:40 (~2y ~31d)
;; count: 8189026
a1952.dscq.akamai.net.  AAAA  2600:141b:e800:c::172c:85a3
[etc]
```

14. DigitalOcean:

```
$ dnsdbq -i 2a03:b0c0::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 18:20:43]: Database API limit: Result limit reached
;; record times: 2021-08-24 10:42:31 .. 2023-07-04 13:46:51 (~1y ~314d)
;; count: 146180967
ns2.34sp.com.  AAAA  2a03:b0c0:1:d0::c04:4001

;; record times: 2018-03-24 21:45:35 .. 2023-07-04 15:57:48 (~5y ~102d)
;; count: 146174488
ns3.of.pl.  AAAA  2a03:b0c0:0:1010::92:c001

;; record times: 2017-07-08 22:17:09 .. 2023-06-29 00:58:22 (~5y ~356d)
;; count: 126122343
nsi2.axc.nl.  AAAA  2a03:b0c0:1:a1::df1:1

;; record times: 2016-09-24 23:13:30 .. 2023-07-04 16:26:02 (~6y ~283d)
;; count: 100244165
dns2.level27.eu.  AAAA  2a03:b0c0:0:1010::536:b001

;; record times: 2015-09-29 07:32:39 .. 2023-07-04 17:11:31 (~7y ~280d)
;; count: 94694306
ns1.forex-dns.net.  AAAA  2a03:b0c0:2:d0::7a:8001

;; record times: 2015-02-16 08:05:09 .. 2023-07-04 13:35:31 (~8y ~140d)
;; count: 86294420
dns4.thzhost.com.  AAAA  2a03:b0c0:0:1010::2d:6001

;; record times: 2017-12-19 19:27:26 .. 2023-07-04 16:47:42 (~5y ~197d)
;; count: 76845702
gamma.host-telecom.com.  AAAA  2a03:b0c0:0:1010::75:c001

;; record times: 2015-08-31 16:25:54 .. 2023-07-04 16:26:50 (~7y ~309d)
;; count: 69195994
ns3.zxcs.nl.  AAAA  2a03:b0c0:2:d0::57:1001

;; record times: 2017-10-29 20:11:23 .. 2023-07-04 17:31:24 (~5y ~248d)
;; count: 68712332
ns2.eu.bitnames.com.  AAAA  2a03:b0c0:2:d0::20:1001

;; record times: 2022-02-01 10:36:29 .. 2023-07-04 13:15:50 (~1y ~153d)
;; count: 66711950
ns1.dnsbackup.net.  AAAA  2a03:b0c0:1:d0::1090:2001

;; record times: 2015-04-30 00:40:33 .. 2023-07-04 17:48:28 (~8y ~67d)
;; count: 58026536
ns1.hoasted.nl.  AAAA  2a03:b0c0:2:d0::2a:a001

;; record times: 2019-06-12 09:48:39 .. 2023-07-04 17:14:26 (~4y ~23d)
;; count: 56362251
ns2.yoursrs.com.  AAAA  2a03:b0c0:1:e0::445:9001

;; record times: 2016-01-04 18:47:14 .. 2023-07-04 13:33:50 (~7y ~182d)
;; count: 56290984
ns2.lipowered.net.  AAAA  2a03:b0c0:0:1010::aa:6001

;; record times: 2016-03-12 01:49:57 .. 2023-07-04 11:50:42 (~7y ~115d)
;; count: 50913129
ns1.thirdeye-it.com.  AAAA  2a03:b0c0:0:1010::15a:a001
[etc]
```

15. HostEurope:

```
$ dnsdbq -i 2a01:480::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 21:40:38]: Database API limit: Result limit reached
;; record times: 2019-10-28 10:39:04 .. 2023-07-04 14:25:03 (~3y ~250d)
;; count: 1436651864
dns2.hosteurope.de.  AAAA  2a01:488::53

;; record times: 2019-10-28 10:39:04 .. 2023-07-04 14:25:03 (~3y ~250d)
;; count: 1428709215
dns.hosteurope.de.  AAAA  2a01:488::35

;; record times: 2017-03-30 07:08:19 .. 2023-07-04 20:43:07 (~6y ~97d)
;; count: 33018584
ns2.evolver.de.  AAAA  2a01:488:66:1000:53a9:1608:0:1

;; record times: 2019-10-21 10:23:55 .. 2023-07-04 19:30:26 (~3y ~257d)
;; count: 31854198
ns2.hans.hosteurope.de.  AAAA  2a01:488::1000:53

;; record times: 2019-10-21 10:24:10 .. 2023-07-04 17:54:51 (~3y ~257d)
;; count: 17188885
ns1.hans.hosteurope.de.  AAAA  2a01:488::1000:35

;; record times: 2015-06-05 21:50:08 .. 2023-07-04 14:26:39 (~8y ~30d)
;; count: 15640006
ns1.xentonix.net.  AAAA  2a01:480:1000::20

;; record times: 2021-06-10 10:57:52 .. 2023-07-04 16:28:15 (~2y ~24d)
;; count: 9640136
ns03.uni-trier.de.  AAAA  2a01:488:66:1000:2ea3:4db3:0:1

;; record times: 2019-01-03 08:10:25 .. 2023-07-04 20:02:38 (~4y ~183d)
;; count: 9057428
ns03.uni-trier.de.  AAAA  2a01:488:66:1000:57e6:d90:0:1

;; record times: 2022-02-16 15:35:53 .. 2023-07-04 14:17:35 (~1y ~137d)
;; count: 7954159
ns2.vm-dns.de.  AAAA  2a01:488:66:1000:53a9:38b:0:1
[etc]
```

16. Google Cloud

```
$ dnsdbq -i 2600:1900::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 21:43:46]: Database API limit: Result limit reached
;; record times: 2020-01-21 10:23:34 .. 2023-07-04 17:17:56 (~3y ~165d)
;; count: 241029736
sessions.bugsnag.com.  AAAA  2600:1901:0:7a0b::

;; record times: 2022-11-20 17:54:58 .. 2023-07-04 20:51:59 (~226d 2h 57m)
;; count: 142282234
agent-gateway-api-prod-us.traps.paloaltonetworks.com.  AAAA  2600:1901:0:53f1::

;; record times: 2017-06-29 19:52:47 .. 2023-07-04 20:25:37 (~6y ~6d)
;; count: 114944199
six.cdn-net.com.  AAAA  2600:1901:0:d1c::

;; record times: 2017-07-07 21:06:16 .. 2023-07-04 20:25:37 (~5y ~362d)
;; count: 114842813
six.cdn-net.com.  AAAA  2600:1901:0:ff7::

;; record times: 2019-09-26 14:20:43 .. 2023-07-04 14:06:08 (~3y ~281d)
;; count: 91940232
balanced-collect.deltadna.net.  AAAA  2600:1901:0:15bb::

;; record times: 2019-09-26 14:20:43 .. 2023-07-04 19:06:49 (~3y ~282d)
;; count: 72679785
balanced-engage.deltadna.net.  AAAA  2600:1901:0:4f32::
[etc]
```

17. Amazon Web Services

```
$ dnsdbq -i 2600:1f10::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 21:45:53]: Database API limit: Result limit reached
;; record times: 2017-11-28 15:45:04 .. 2023-07-04 17:46:34 (~5y ~219d)
;; count: 256681871
ns1.brandsight-dns.com.  AAAA  2600:1f14:391:8610:b09f:edaa:2cd8:5d0b

;; record times: 2022-03-01 06:35:04 .. 2023-07-04 15:44:26 (~1y ~125d)
;; count: 147054456
message-apigateway-eb5d9f211edfb6ac.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a702:aa1a:6857:e05c:8f33

;; record times: 2022-03-01 06:35:03 .. 2023-07-04 15:44:26 (~1y ~125d)
;; count: 147049591
message-apigateway-eb5d9f211edfb6ac.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a701:b415:627e:7b00:35e0

;; record times: 2022-03-14 01:07:36 .. 2023-07-04 13:31:07 (~1y ~112d)
;; count: 117757656
njbp-api-9bff73004758ee77.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a703:609:1465:99f8:249c

;; record times: 2022-03-14 01:07:55 .. 2023-07-04 13:31:07 (~1y ~112d)
;; count: 117757631
njbp-api-9bff73004758ee77.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a702:91d7:5502:40cc:a638

;; record times: 2022-03-14 01:08:09 .. 2023-07-04 13:31:07 (~1y ~112d)
;; count: 117754388
njbp-api-9bff73004758ee77.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a701:7652:34ba:2590:e59f

;; record times: 2022-11-03 00:00:07 .. 2023-07-04 13:41:44 (~243d 13h 41m)
;; count: 86562476
ns3.netgate.com.  AAAA  2600:1f10:4c5e:6701:e4b2:c059:13c5:64fb

;; record times: 2022-03-01 06:31:20 .. 2023-07-04 16:00:44 (~1y ~125d)
;; count: 80420221
emanual-2a913c880c45fa05.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a701:8ed3:d549:cee6:9ba5

;; record times: 2022-10-04 14:27:48 .. 2023-07-04 18:31:48 (~273d 4h 4m)
;; count: 78953779
v6.route53.arpanet.jp.  AAAA  2600:1f13:475:4201:1f17:8114:d1c6:b0d8

;; record times: 2022-03-01 06:24:50 .. 2023-07-04 16:43:15 (~1y ~125d)
;; count: 78882607
account-nginx-hismarttv-ext-7f14e0c1c1eac4a0.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a702:ac71:499f:2dcc:3016

;; record times: 2022-03-01 06:25:06 .. 2023-07-04 16:43:15 (~1y ~125d)
;; count: 78880762
account-nginx-hismarttv-ext-7f14e0c1c1eac4a0.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a701:93e0:6748:3095:71c5

;; record times: 2022-03-01 06:32:33 .. 2023-07-04 19:37:36 (~1y ~125d)
;; count: 62806381
hiupgrade-nginx-hismarttv-ext-ea902929cafd6970.elb.us-west-2.amazonaws.com.  AAAA
2600:1f14:4ce:a701:f3f6:3611:aea2:77ff
[etc]
```

18. Strato AG:

```
$ dnsdbq -i 2a01:230::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 21:49:18]: Database API limit: Result limit reached
;; record times: 2011-09-16 09:30:30 .. 2023-07-04 19:09:32 (~11y ~294d)
;; count: 675814183
ns.stratoserver.net.  AAAA  2a01:238:10b:2300:2:1:51a9:a328

;; record times: 2011-09-16 09:30:30 .. 2023-07-04 19:09:32 (~11y ~294d)
;; count: 675741235
ns2.stratoserver.net.  AAAA  2a01:238:10a:2300:2:1:51a9:9429

;; record times: 2011-06-08 18:51:59 .. 2023-07-04 13:39:52 (~12y ~28d)
;; count: 103702909
pns.rz-ip.net.  AAAA  2a01:238:10b:2300:2:1:51a9:a32b

;; record times: 2011-09-16 09:15:37 .. 2023-07-04 16:40:43 (~11y ~294d)
;; count: 103611026
pns2.rz-ip.net.  AAAA  2a01:238:10a:2300:2:1:51a9:942b

;; record times: 2022-03-13 11:29:50 .. 2023-07-04 18:53:59 (~1y ~113d)
;; count: 94069417
ns1.love.ru.  AAAA  2a01:230:2:41::20c

;; record times: 2011-09-16 09:15:01 .. 2023-07-04 17:26:01 (~11y ~294d)
;; count: 65865760
ns.serverkompetenz.de.  AAAA  2a01:238:10b:2300:2:1:51a9:a326

;; record times: 2011-09-16 09:15:01 .. 2023-07-04 16:02:39 (~11y ~294d)
;; count: 65862880
ns2.serverkompetenz.de.  AAAA  2a01:238:10a:2300:2:1:51a9:9425

;; record times: 2021-12-01 18:57:21 .. 2023-07-04 17:33:39 (~1y ~214d)
;; count: 62606006
r6.ndm9.xyz.  AAAA  2a01:230:2:85::7

;; record times: 2022-03-13 11:29:49 .. 2023-07-04 16:22:56 (~1y ~113d)
;; count: 34768205
ns1.mylove.ru.  AAAA  2a01:230:2:41::20c

;; record times: 2021-10-14 09:39:36 .. 2023-07-04 17:56:27 (~1y ~263d)
;; count: 33459910
ns2.ispvds.com.  AAAA  2a01:230:2:75::4

;; record times: 2021-05-07 00:10:33 .. 2023-07-04 19:30:01 (~2y ~58d)
;; count: 30110179
ns1.ispvds.com.  AAAA  2a01:230:2:74::4

;; record times: 2011-06-08 18:51:19 .. 2023-07-04 19:15:16 (~12y ~29d)
;; count: 18154483
ns.rz-ip.net.  AAAA  2a01:238:10b:2300:2:1:51a9:a327

;; record times: 2011-09-16 09:15:37 .. 2023-07-04 16:24:06 (~11y ~294d)
;; count: 17935689
ns2.rz-ip.net.  AAAA  2a01:238:10a:2300:2:1:51a9:9428

;; record times: 2016-07-20 08:53:06 .. 2023-07-04 16:01:03 (~6y ~350d)
;; count: 11010959
download.ispsystem.com.  AAAA  2a01:230:2:fffe::2

;; record times: 2020-11-19 09:36:20 .. 2023-07-04 14:49:24 (~2y ~227d)
;; count: 10359918
com4.strato.de.  AAAA  2a01:238:20a:202::51a9:91ed
[etc]
```

19. Hostpoint.ch:

```
$ dnsdbq -i 2a00:d70::/28  -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 21:53:37]: Database API limit: Result limit reached
;; record times: 2011-05-16 14:09:34 .. 2023-07-04 18:20:12 (~12y ~52d)
;; count: 1236282128
ns.hostpoint.ch.  AAAA  2a00:d70:0:b::d

;; record times: 2012-07-02 16:50:30 .. 2023-07-04 21:23:31 (~11y ~4d)
;; count: 1222044598
ns2.hostpoint.ch.  AAAA  2a00:d70:0:b::1d

;; record times: 2011-05-16 11:29:17 .. 2023-07-04 20:41:40 (~12y ~52d)
;; count: 1144116764
ns3.hostpoint.ch.  AAAA  2a00:d70:0:a::d

;; record times: 2021-04-27 01:43:21 .. 2023-07-04 18:27:40 (~2y ~68d)
;; count: 2057536
ns-ch.hostpoint.ch.  AAAA  2a00:d70:0:a::d

;; record times: 2011-06-14 20:01:55 .. 2023-07-04 14:29:37 (~12y ~22d)
;; count: 1626290
mail.adm.hostpoint.ch.  AAAA  2a00:d70:0:a::e0

;; record times: 2018-01-09 07:20:30 .. 2023-07-04 16:12:47 (~5y ~177d)
;; count: 1392821
sites.hostpoint.com.  AAAA  2a00:d70:0:a::339
[etc]
```

20. TransIP BV:

```
$ dnsdbq -I 2a01:7c0::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 21:56:29]: Database API limit: Result limit reached
;; record times: 2018-11-28 14:38:03 .. 2023-07-04 15:46:02 (~4y ~219d)
;; count: 1417677506
ns1.transip.nl.  AAAA  2a01:7c8:7000:195::195

;; record times: 2018-09-14 12:19:50 .. 2023-07-04 21:29:19 (~4y ~294d)
;; count: 246441832
ns2.transip.eu.  AAAA  2a01:7c8:f:c1f::195

;; record times: 2016-08-09 12:03:23 .. 2023-07-04 20:30:28 (~6y ~330d)
;; count: 36388590
ns3.thednscompany.com.  AAAA  2a01:7c8:aab5:5b3::1

;; record times: 2021-11-05 09:13:27 .. 2023-07-04 14:00:21 (~1y ~241d)
;; count: 34622892
ns1.sonexo.eu.  AAAA  2a01:7c8:aabb:2f::1

;; record times: 2018-08-31 11:21:39 .. 2023-07-04 20:59:05 (~4y ~308d)
;; count: 32143817
ns11.net.  AAAA  2a01:7c8:f:c1f::95

;; record times: 2016-03-23 12:24:05 .. 2023-07-04 19:50:00 (~7y ~104d)
;; count: 25710042
ns3.asp4all.nl.  AAAA  2a01:7c8:aab5:4f7::2:1

;; record times: 2011-04-26 15:24:57 .. 2023-07-04 17:06:43 (~12y ~72d)
;; count: 21921819
ns.tsua.net.  AAAA  2a01:7c0:4:1::3

;; record times: 2018-11-28 14:25:54 .. 2023-07-04 21:46:14 (~4y ~219d)
;; count: 18885348
ns5.be.  AAAA  2a01:7c8:7000:195::95

;; record times: 2019-11-28 08:40:06 .. 2023-07-04 14:53:49 (~3y ~219d)
;; count: 17026906
ns1.prezent.nl.  AAAA  2a01:7c8:aab2:ce:5054:ff:fe66:ffdd
[etc]
```

21. Cloudflare:

```
$ dnsdbq -i 2606:4700::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 22:00:25]: Database API limit: Result limit reached
;; record times: 2018-11-01 17:06:01 .. 2023-07-04 18:46:46 (~4y ~246d)
;; count: 44103977
target.clickfunnels.com.  AAAA  2606:4700::6810:fc2

;; record times: 2018-11-01 17:06:01 .. 2023-07-04 18:46:46 (~4y ~246d)
;; count: 44103952
target.clickfunnels.com.  AAAA  2606:4700::6810:cc2

;; record times: 2018-11-01 17:06:01 .. 2023-07-04 18:46:46 (~4y ~246d)
;; count: 44103951
target.clickfunnels.com.  AAAA  2606:4700::6810:dc2

;; record times: 2018-11-01 17:06:01 .. 2023-07-04 18:46:46 (~4y ~246d)
;; count: 44103917
target.clickfunnels.com.  AAAA  2606:4700::6810:ec2

;; record times: 2018-10-31 20:32:30 .. 2023-07-04 17:18:05 (~4y ~246d)
;; count: 39195513
cdn.navdmp.com.  AAAA  2606:4700::6810:ef3

;; record times: 2018-10-31 20:32:30 .. 2023-07-04 17:18:05 (~4y ~246d)
;; count: 39195486
cdn.navdmp.com.  AAAA  2606:4700::6810:ff3
[etc]
```

22. Timeweb.ru:

```
$ dnsdbq -i 2a03:6f00::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 22:05:52]: Database API limit: Result limit reached
;; record times: 2015-12-09 18:08:53 .. 2023-07-04 15:06:50 (~7y ~208d)
;; count: 445335241
mx2.timeweb.ru.  AAAA  2a03:6f00:3::5c35:7433

;; record times: 2011-10-07 12:34:20 .. 2023-07-04 16:42:04 (~11y ~273d)
;; count: 444119073
mx1.timeweb.ru.  AAAA  2a03:6f00:3::5c35:742f

;; record times: 2016-11-15 12:14:30 .. 2023-07-04 16:42:55 (~6y ~232d)
;; count: 84804938
ns1.timeweb.ru.  AAAA  2a03:6f00:1::10

;; record times: 2016-11-15 12:14:30 .. 2023-07-04 16:47:51 (~6y ~232d)
;; count: 82369472
ns2.timeweb.ru.  AAAA  2a03:6f00:1::20

;; record times: 2020-02-01 14:31:25 .. 2023-07-04 21:15:09 (~3y ~154d)
;; count: 13224391
ns0.s0t.ru.  AAAA  2a03:6f00:4::bce1:57d7

;; record times: 2019-10-26 01:14:29 .. 2023-07-04 17:51:33 (~3y ~252d)
;; count: 7938101
ns2.expired.timeweb.ru.  AAAA  2a03:6f00:1:2::5c35:7466
[etc]
```

23. IONOS (1&1) :

```
$ dnsdbq -i 2607:f1c0::/28 -l0 -A90d -S -k count -T datefix | more
dnsdbq [2023-07-04 22:08:51]: Database API limit: Result limit reached
;; record times: 2022-04-19 07:27:02 .. 2023-07-04 21:24:17 (~1y ~76d)
;; count: 293594129
dns3.home.pl.  AAAA  2607:f1c0:fe:53:185:132:34:251

;; record times: 2023-01-31 11:49:25 .. 2023-07-04 19:55:01 (~154d 8h 5m)
;; count: 113507271
ns3.livedns.co.uk.  AAAA  2607:f1c0:fe:53:185:132:35:244

;; record times: 2017-09-01 11:54:16 .. 2023-07-04 21:36:16 (~5y ~307d)
;; count: 67090241
ns4.internex.at.  AAAA  2607:f1c0:849:fe00:74:208:254:60

;; record times: 2021-07-13 07:41:10 .. 2023-07-04 15:06:47 (~1y ~356d)
;; count: 49211590
ns-biz.ui-dns.de.  AAAA  2607:f1c0:fe:53:185:132:32:195

;; record times: 2021-07-13 07:40:43 .. 2023-07-04 16:03:36 (~1y ~356d)
;; count: 46071012
ns-com.ui-dns.de.  AAAA  2607:f1c0:fe:53:185:132:32:194

;; record times: 2017-09-01 11:57:08 .. 2023-07-04 19:13:42 (~5y ~307d)
;; count: 35473104
nsd.domain-robot.org.  AAAA  2607:f1c0:849:fe00:74:208:254:55

;; record times: 2020-10-30 13:45:17 .. 2023-07-04 19:27:33 (~2y ~247d)
;; count: 27131090
ns04.compositiv.com.  AAAA  2607:f1c0:849:fe00:74:208:254:4

;; record times: 2022-03-23 13:01:07 .. 2023-07-04 19:32:52 (~1y ~103d)
;; count: 25015799
shades19.rzone.de.  AAAA  2607:f1c0:fe:53:185:132:34:146

;; record times: 2022-03-23 13:01:02 .. 2023-07-04 16:20:35 (~1y ~103d)
;; count: 24139001
shades20.rzone.de.  AAAA  2607:f1c0:fe:53:185:132:34:147

;; record times: 2022-03-23 13:01:02 .. 2023-07-04 19:30:29 (~1y ~103d)
;; count: 23897604
shades05.rzone.de.  AAAA  2607:f1c0:fe:53:185:132:34:132

;; record times: 2022-03-23 13:01:02 .. 2023-07-04 19:47:59 (~1y ~103d)
;; count: 23495068
shades10.rzone.de.  AAAA  2607:f1c0:fe:53:185:132:34:137

;; record times: 2022-03-23 13:01:01 .. 2023-07-04 19:53:56 (~1y ~103d)
;; count: 23401228
shades17.rzone.de.  AAAA  2607:f1c0:fe:53:185:132:34:144

;; record times: 2022-03-23 13:01:02 .. 2023-07-04 19:40:37 (~1y ~103d)
;; count: 23143298
shades18.rzone.de.  AAAA  2607:f1c0:fe:53:185:132:34:145

;; record times: 2022-03-23 13:01:02 .. 2023-07-04 21:48:18 (~1y ~103d)
;; count: 22910542
shades07.rzone.de.  AAAA  2607:f1c0:fe:53:185:132:34:134
[etc]
```

24. Cox:

```
$ dnsdbq -i 2001:570::/28 -l0 -A90d -S -k count -T datefix
dnsdbq [2023-07-04 22:12:22]: Database API limit: Result limit reached
;; record times: 2015-05-14 19:47:36 .. 2023-07-01 18:57:08 (~8y ~49d)
;; count: 124739578
dukecdcrs0001.rd.at.cox.net.  AAAA  2001:578:15:4a00:174:79:69:4

;; record times: 2015-05-14 19:47:36 .. 2023-07-01 18:57:08 (~8y ~49d)
;; count: 124727873
dukecdcrs0002.rd.at.cox.net.  AAAA  2001:578:15:4a00:174:79:69:5

;; record times: 2015-10-13 13:04:48 .. 2023-07-03 19:48:40 (~7y ~265d)
;; count: 105855768
fed1cdcrs0002.wcdn.cox.net.  AAAA  2001:578:2:4e03:174:79:69:69

;; record times: 2015-10-13 13:04:48 .. 2023-07-04 08:36:01 (~7y ~265d)
;; count: 105796836
fed1cdcrs0001.wcdn.cox.net.  AAAA  2001:578:2:4e03:174:79:69:68

;; record times: 2015-08-27 15:06:25 .. 2023-07-01 18:57:08 (~7y ~310d)
;; count: 105490216
dukecdcrs0001.wcdn.cox.net.  AAAA  2001:578:15:4a00:174:79:69:4

;; record times: 2015-08-27 15:06:11 .. 2023-06-13 13:58:08 (~7y ~291d)
;; count: 105396045
dukecdcrs0002.wcdn.cox.net.  AAAA  2001:578:15:4a00:174:79:69:5

;; record times: 2019-04-08 04:37:08 .. 2023-07-04 19:38:15 (~4y ~88d)
;; count: 95987990
cox-mds-az.gslb2.comcast.com.  AAAA  2001:578:15:50bf:184:184:234:104

;; record times: 2019-04-08 04:37:08 .. 2023-07-04 15:00:41 (~4y ~88d)
;; count: 93052444
cox-mds-az.gslb2.comcast.com.  AAAA  2001:578:16:509f:184:184:232:235

;; record times: 2015-08-27 14:38:39 .. 2023-07-04 16:56:41 (~7y ~313d)
;; count: 78492031
fed1cdcrs0001.rd.sd.cox.net.  AAAA  2001:578:2:4e03:174:79:69:68

;; record times: 2015-08-27 14:44:30 .. 2023-07-04 16:56:41 (~7y ~313d)
;; count: 78458309
fed1cdcrs0002.rd.sd.cox.net.  AAAA  2001:578:2:4e03:174:79:69:69

;; record times: 2015-06-06 00:19:08 .. 2023-07-04 20:04:11 (~8y ~30d)
;; count: 54638902
scontent.fphx1-2.fna.fbcdn.net.  AAAA  2001:578:28:301:face:b00c:0:a7

;; record times: 2015-06-05 01:31:41 .. 2023-07-04 19:23:54 (~8y ~31d)
;; count: 53803079
scontent.fphx1-1.fna.fbcdn.net.  AAAA  2001:578:28:201:face:b00c:0:a7

;; record times: 2019-06-05 16:08:08 .. 2023-07-04 18:55:19 (~4y ~30d)
;; count: 51932601
cox-bet-az.gslb2.comcast.com.  AAAA  2001:578:16:509f:184:184:232:233

;; record times: 2019-06-05 16:08:08 .. 2023-07-04 18:55:19 (~4y ~30d)
;; count: 51852612
cox-bet-az.gslb2.comcast.com.  AAAA  2001:578:15:50bf:184:184:234:102
[etc]
```

IX. A Bug We Discovered

One of the reasons we like to conduct comprehensive studies of this sort is that they can help shake out dormant bugs.

In this case, we uncovered an obscure latent bug in the DNSDB API IPv6 processing code that caused exactly 16 of our attempted queries to abort:

> 2407:b9c0::/28, 2606:400::/28, 2606:34c0::/28, 2606:4900::/28, 2606:4d00::/28, 2606:83c0::/28, 2606:8440::/28, 2606:8b80::/28, 2606:9e40::/28, 2606:b400::/28, 2606:b780::/28, 2606:b840::/28, 2606:bf00::/28, 2606:e280::/28, 2a06:9a40::/28, 2a02:e660::/28

Since we used dnsdbq in Version 2 mode with Streaming API Framing support (see https://www.domaintools.com/resources/user-guides/farsight-streaming-api-framing-protocol-documentation/), the error we encountered presented itself as the following:

```
$ dnsdbq -i 2407:b9c0::/28 -l0 -A90d -V summarize
dnsdbq [2023-07-01 05:25:45]: API response missing: Data transfer failed -- No SAF terminator
at end of stream
```

While this report doesn't include data for those 16 prefixes, DomainTools has identified and patched the production DNSDB API so future analysis will be better for everyone.

X. Visualizing Our IPv6 Results: A Quick Review of the Prior Art

Many have already wrestled with the complexities of graphically representing IPv6-attribute data across the IPv6 address space, albeit without DNSDB-specific count data as part of the picture. Some noteworthy work in this area includes, in alphabetical order:

- **Vasco Asturiano's "Hilbert Map of IPv6 address space,"** https://observablehq.com/@vasturiano/hilbert-map-of-ipv6-address-space and https://github.com/vasturiano/hilbert-chart

  This graph is live/interactive – you can zoom in and the IPv6 address under your cursor will be reported as you go across the graph, which is all quite impressive, but not directly exploitable for a printed report such as this one.

- **Tristan Brun's IPv6 visualization code** from his Master's degree thesis "Network Reconnaissance in IPv6-based Residential Broadband Networks," see https://arxiv.org/abs/2012.10652

  We were very impressed by the SVG graphics Brun produced with his Python code.

- **Ryan Finnie's IPv4 and IPv6 Hilbert curve work**, including his posters showing Internet address space allocations as shown by Oregon Routeviews, see https://vad.solutions/ipmap/ and https://github.com/rfinnie/vad-ipmap

  Finnie's work is excellent, but his IPv6 work suffers from the scale problem we've previously mentioned. The vast majority of his IPv6 poster consists of blank space, which means that the actual data-rich areas suffer from data compression.

- **HCIL Classified Treemaps,** see https://www.cs.umd.edu/hcil/treemap/ (as used in Barrera and Oorschot's "Security Visualization Tools and IPv6 Addresses," see https://people.scs.carleton.ca/~paulv/papers/vizsec09.pdf)

  The Treemap graphs are visually appealing, but the code is Java 1.4 based (https://en.wikipedia.org/wiki/Java_version_history says "Public support and security updates for Java 1.4 ended in October 2008") and requires licensing for commercial use.

  The site itself also notes, emphasis in the original, "THIS A VERY OLD HCIL PROJECT i.e. we are very happy that it still runs - as of June 2014, but do not have the resources to update the code." For those reasons, we've excluded this tool.

- **Zesplot's squarified treemaps,** see https://ipv6hitlist.github.io/zesplot/ and https://github.com/zesplot/zesplot

  This is another interactive graphics package that is obviously powerful when used interactively. However, when used to produce static plots, at least some of the sample plots produced with Zesplot become difficult to interpret.

We ultimately elected to use a locally modified version of Tristan Brun's code for the IPv6 plots shown in the body of this report. We greatly appreciate Tristan's making his code available for our use, thank you! Because we've made some minor modifications to that code to meet the unique needs for this study, any issues with the results, should there be any, are solely our responsibility.

XI. IPv6 Maps

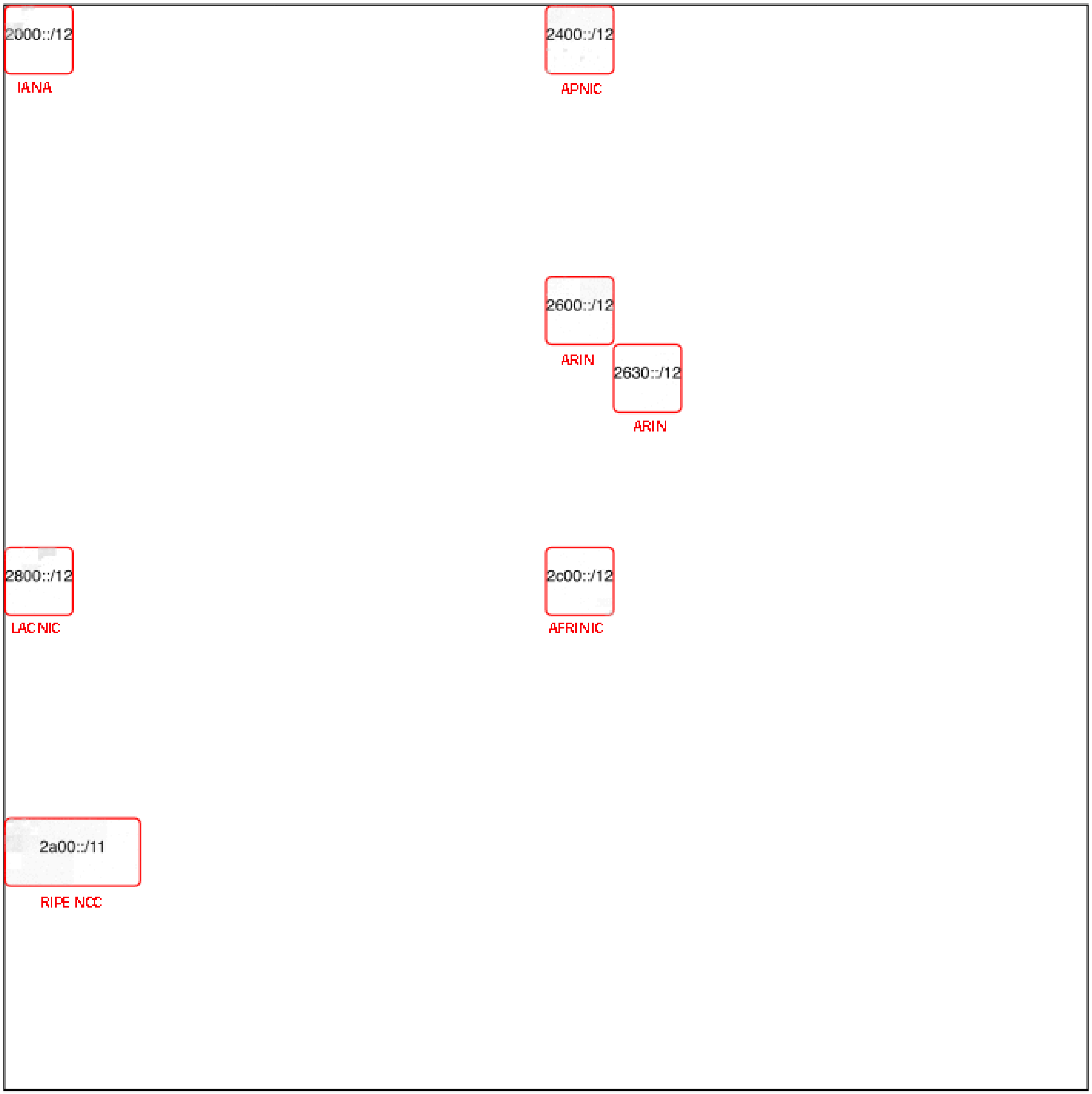
Plotting per-prefix characterizations for thousands of IPv6 prefixes shares many of the challenges associated with IPv4 visualizations, including data with values ranging over many orders of magnitude. This is further complicated by the breadth of the underlying address space and the sparse distribution of the data ("hits" were seen on just 23,861 prefixes out of 466,432 we checked).

In producing our graphs, we decided to produce several "tiers" of maps for our IPv6 address space reporting:

- “Tier One” is a single map covering the entire currently used global Unicast address space, 2000::/4
- “Tier Two” consists of a set of eight maps, one map for each /12
- “Tier Three” consists of a set of selected prefixes where we "zoomed in" for a closer look at what was going on.

We'll begin by looking at our one "Tier One" map.

Tier 1: IPv6 Unicast Address Space: Top Level Map



You may be able to see slight discolorations in each of those blocks, but in most cases, the space used may be nearly invisible because even within each of those allocated /12's, much of the available address space remains unused.

This huge address space, and the intentional sparse allocation scheme and low utilization levels, make presenting a meaningful visualization of DNSDB's IPv6 address space challenging – the above graph is nowhere near as visually compelling as the Hilbert Curve heatmaps we previously presented in our earlier report showing IPv4 utilization. It also represents visually the sheer vastness of IPv6 address space and the room to grow.

Nonetheless, let's dig in on those IPv6 /12's a little.

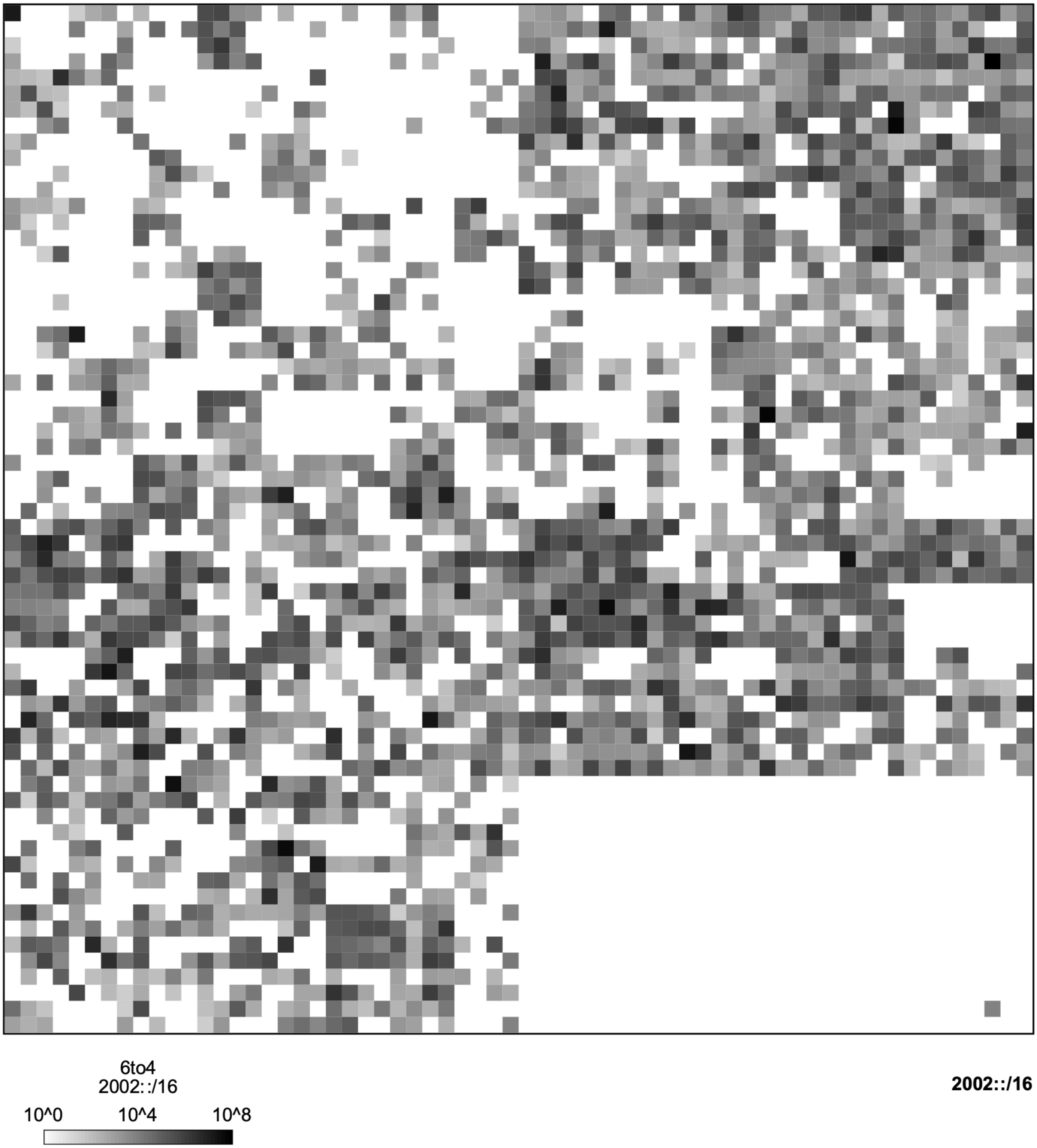
It is hard for us to show some of the finer-grained allocations (such as /23's) in a larger-scale map, but let's show what we can, starting with 2001::/14.

Tier 2, Map 1: 2000::/12 (actually, we'll "zoom in" on just 2001::/14)

The block of gray points in the region not enclosed in a red box represents the /23's allocated out of 2001::/14.

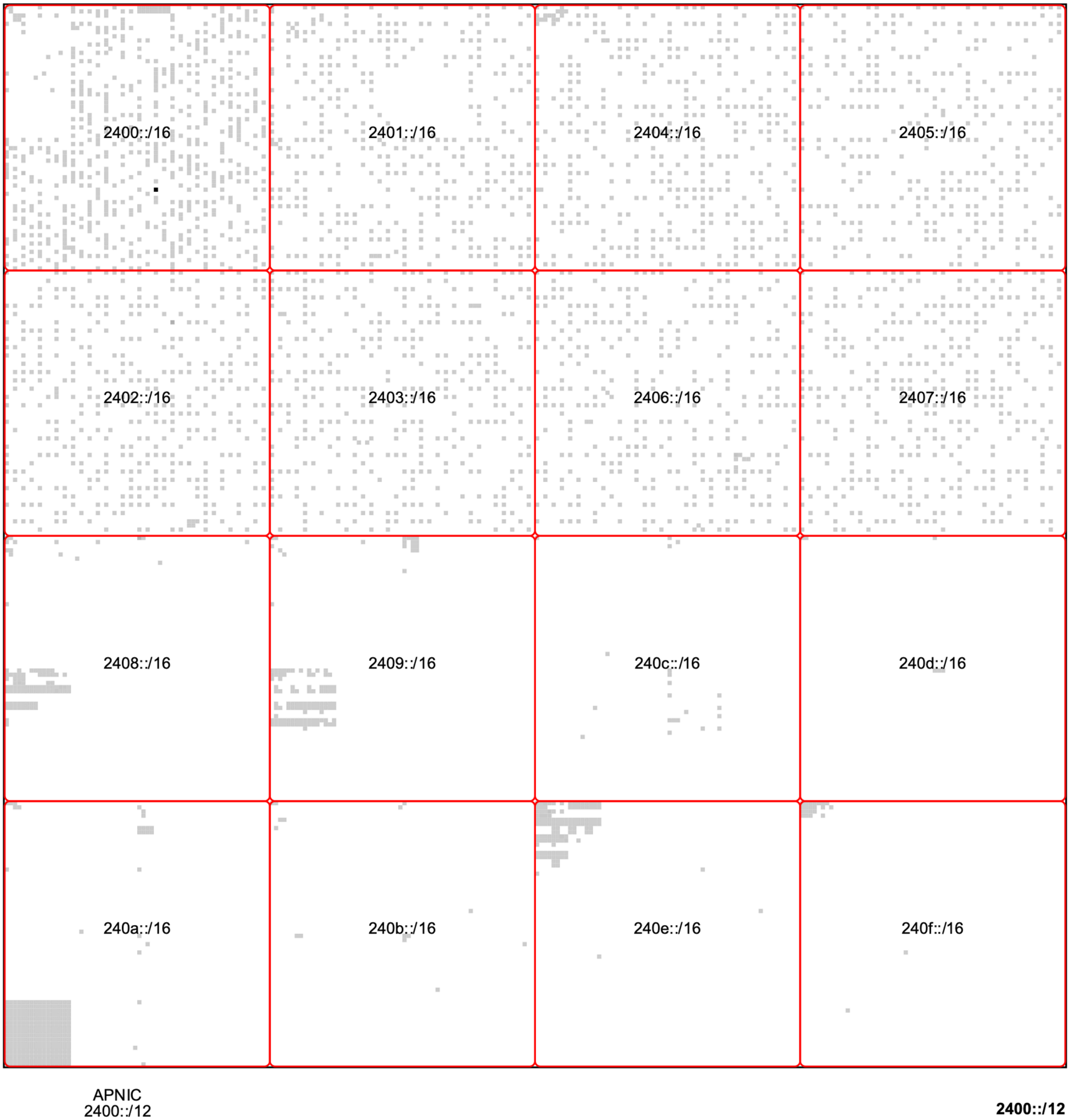
This /12 includes a number of atypical prefixes, including 2002::/16 (used for 6to4). The other /12's we'll look at in "cousin" Tier 2 /12 maps, below, are more conventional.

Tier 3, Map 1.1: 2002::/16 (6to4)



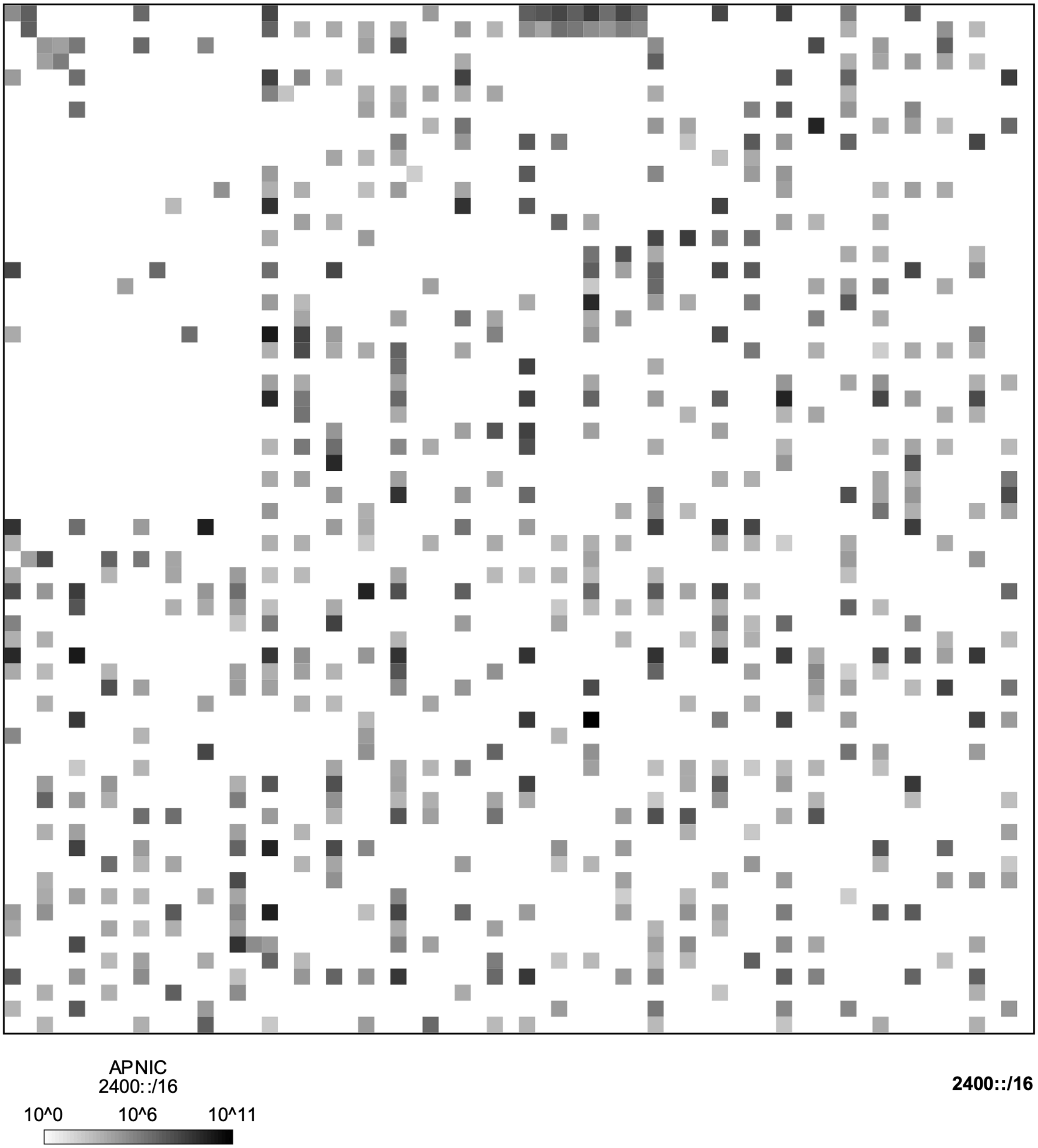
The large blank region in the southeastern corner is consistent with the multicast and "class E" address space of IPv4 address space.

Tier 2, Map 2: 2400::/12 (APNIC)



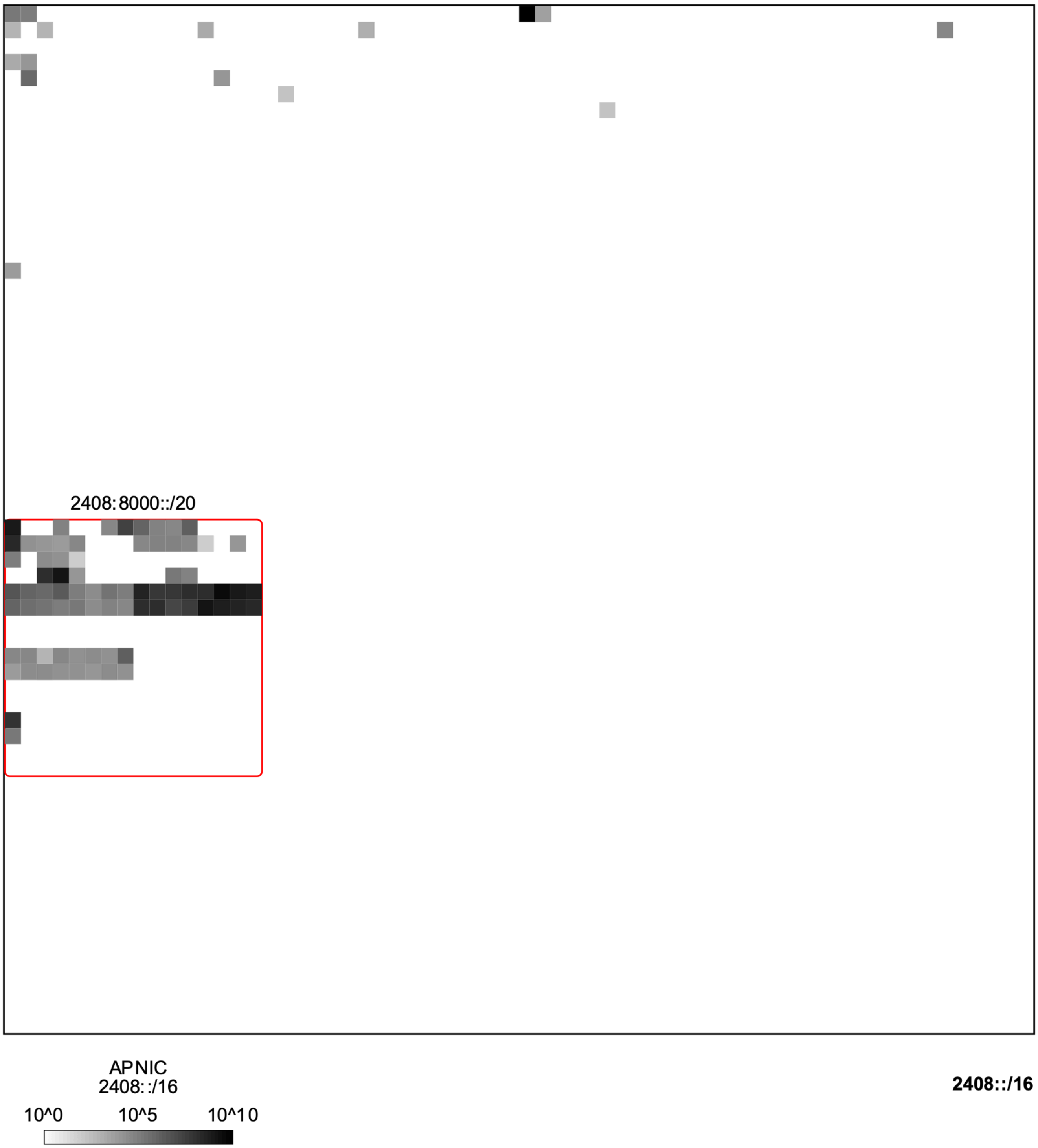
We'll now dig in on one "normal" looking allocation, plus we'll check some APNIC IPv6 allocations that don't seem to follow the normal sparse allocation pattern. The first graph we'll look at is one that looks pretty "normal."

Tier 3, Map 2.1: 2400::/16



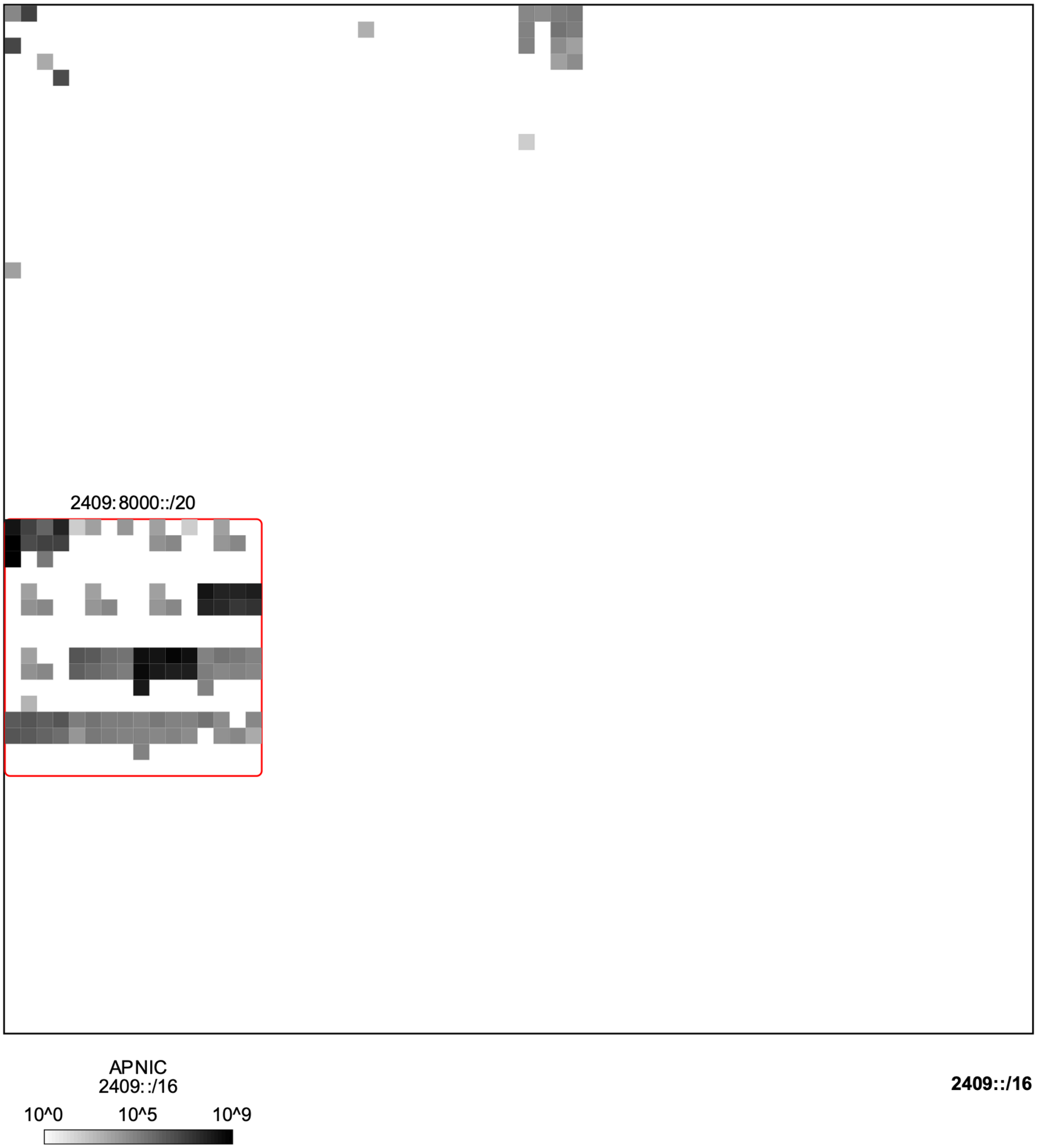
This is a typical /16 with no particularly noteworthy/anomalous subregion(s).

Tier 3, Map 2.2: 2408::/16



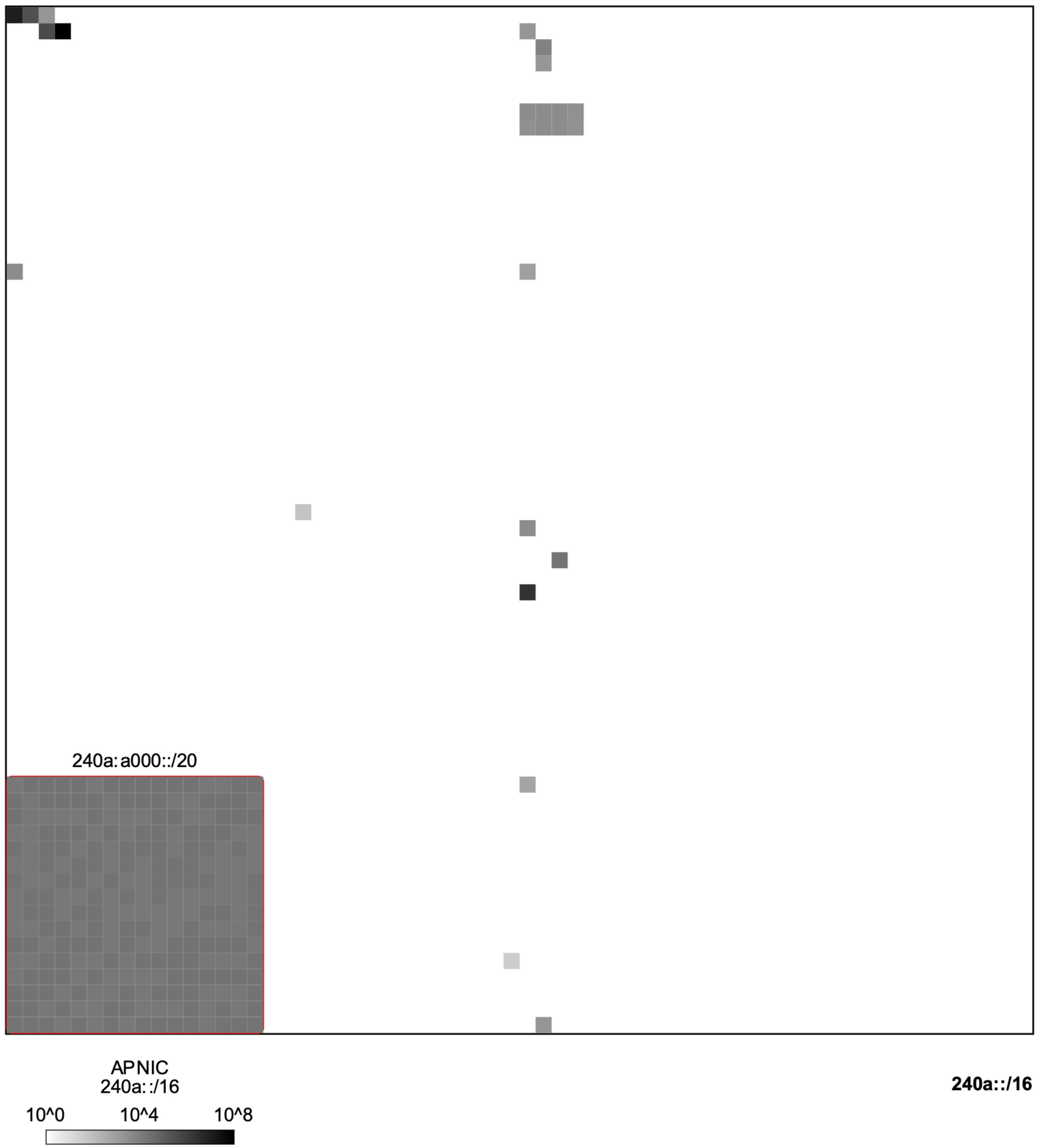
Highlighted region above, 2408:8000::/20 belongs to China Unicom (AS4837).

Tier 3, Map 2.3: 2409::/16



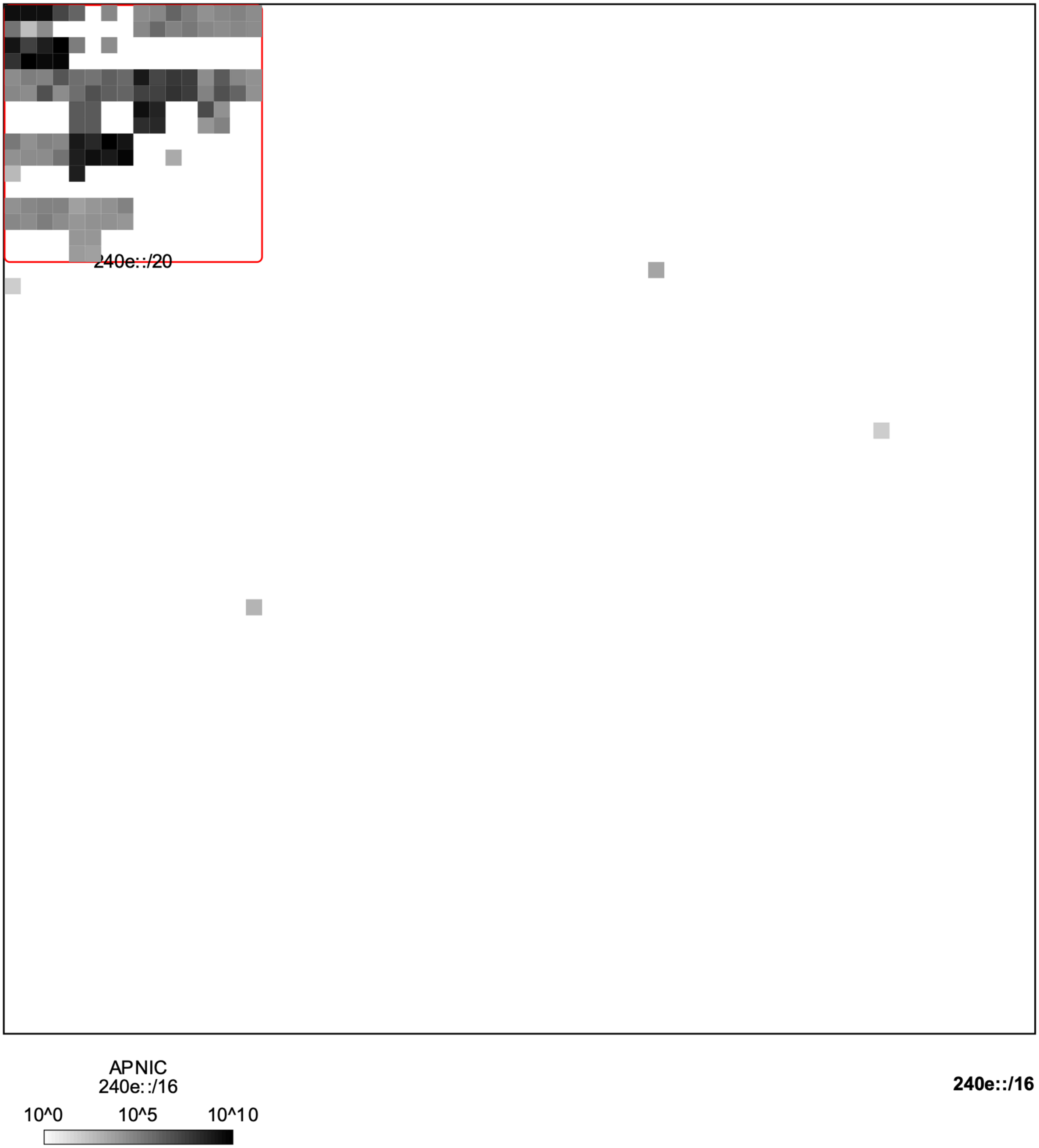
The highlighted block above, 2409:8000::/20, belongs to China Mobile Communications Corporation (AS9808).

Tier 3, Map 2.4: 240a::/16



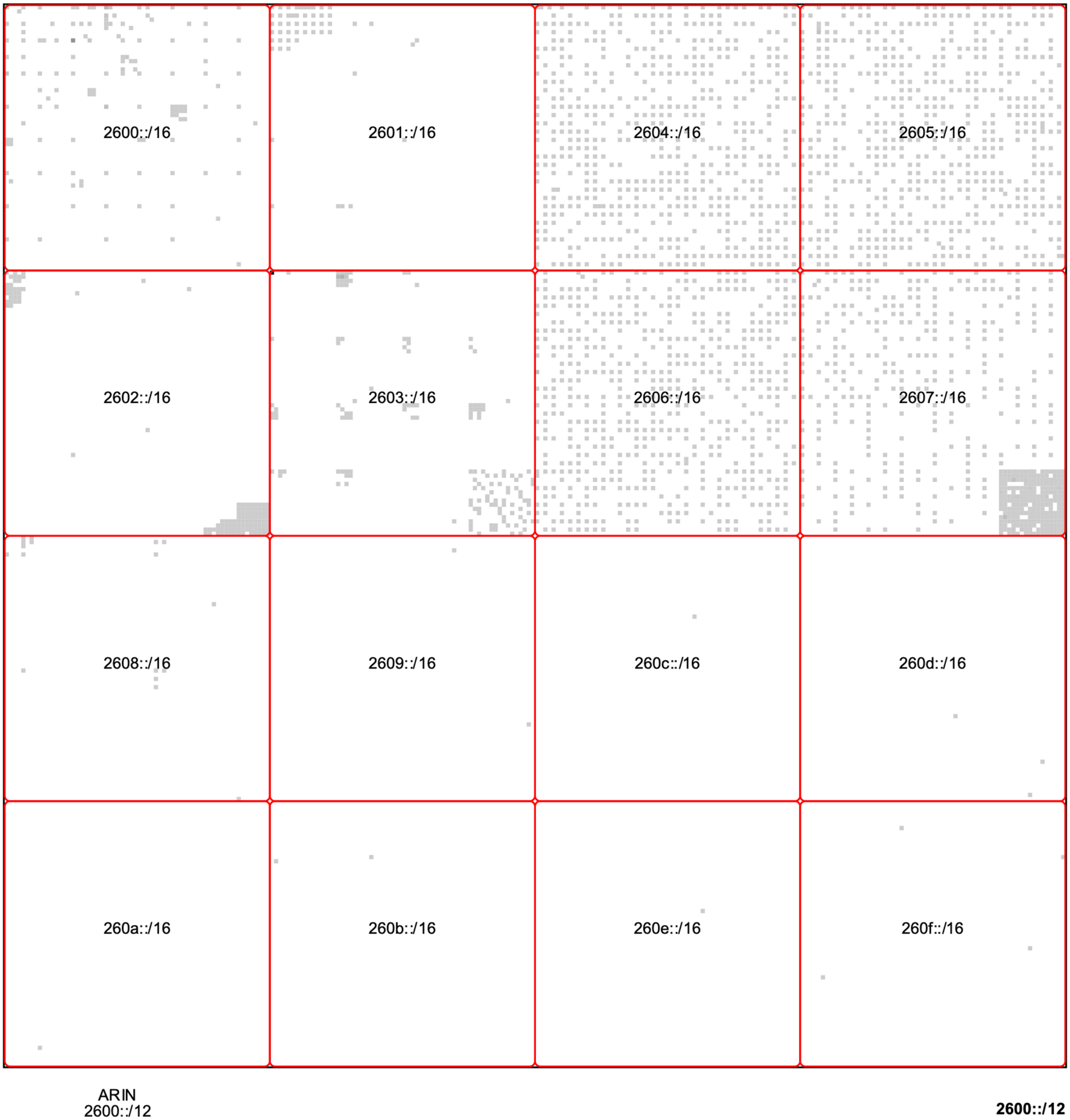
The highlighted block above, 240a:a000::/20, belongs to "China Education and Research Network (CERNET)".

Tier 3, Map 2.5: 240e::/16

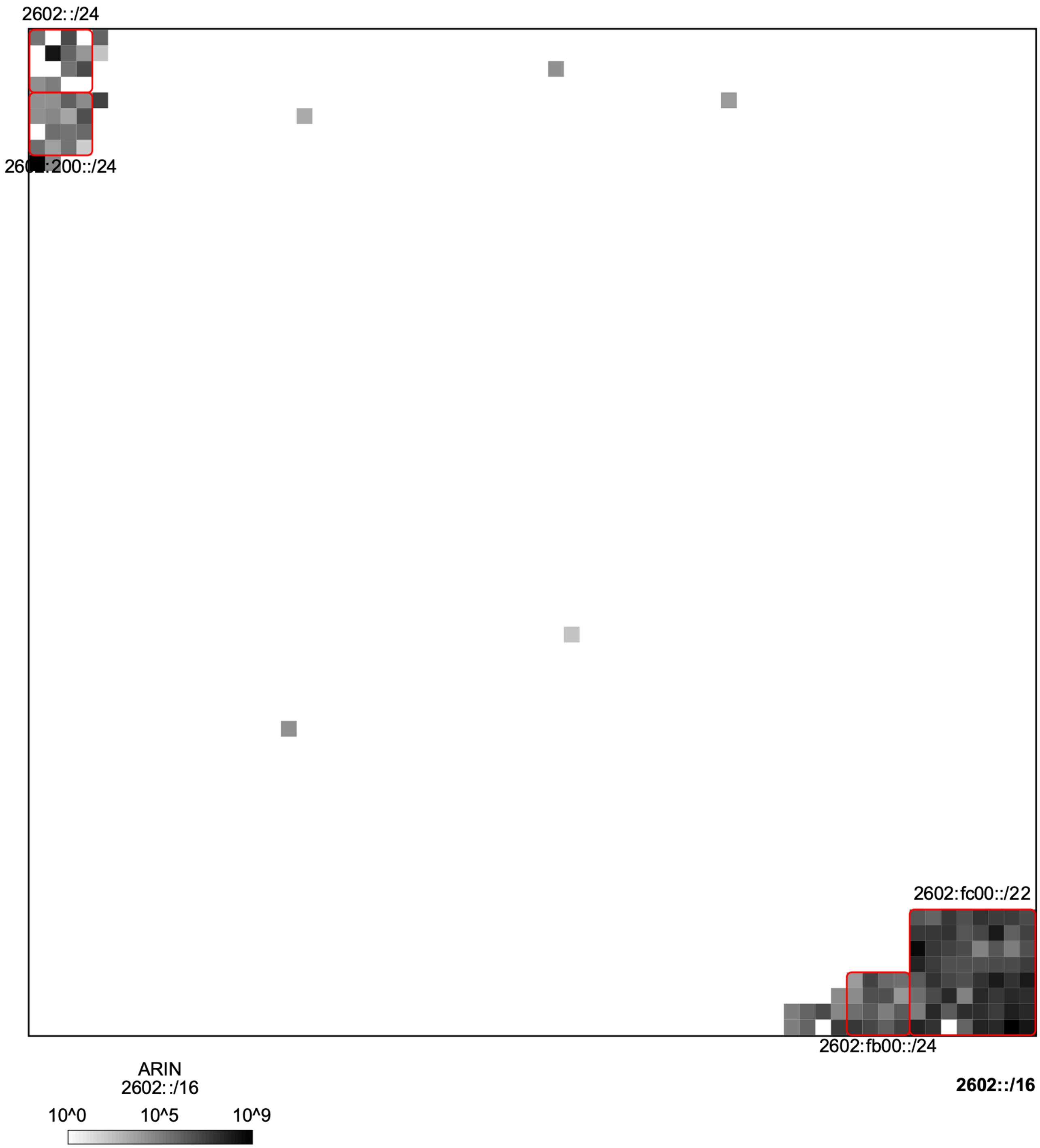


The highlighted block above, 240e:0000::/20, belongs to China Telecom/Chinanet (AS4134)

Tier 2, Map 3: 2600::/12 (ARIN)

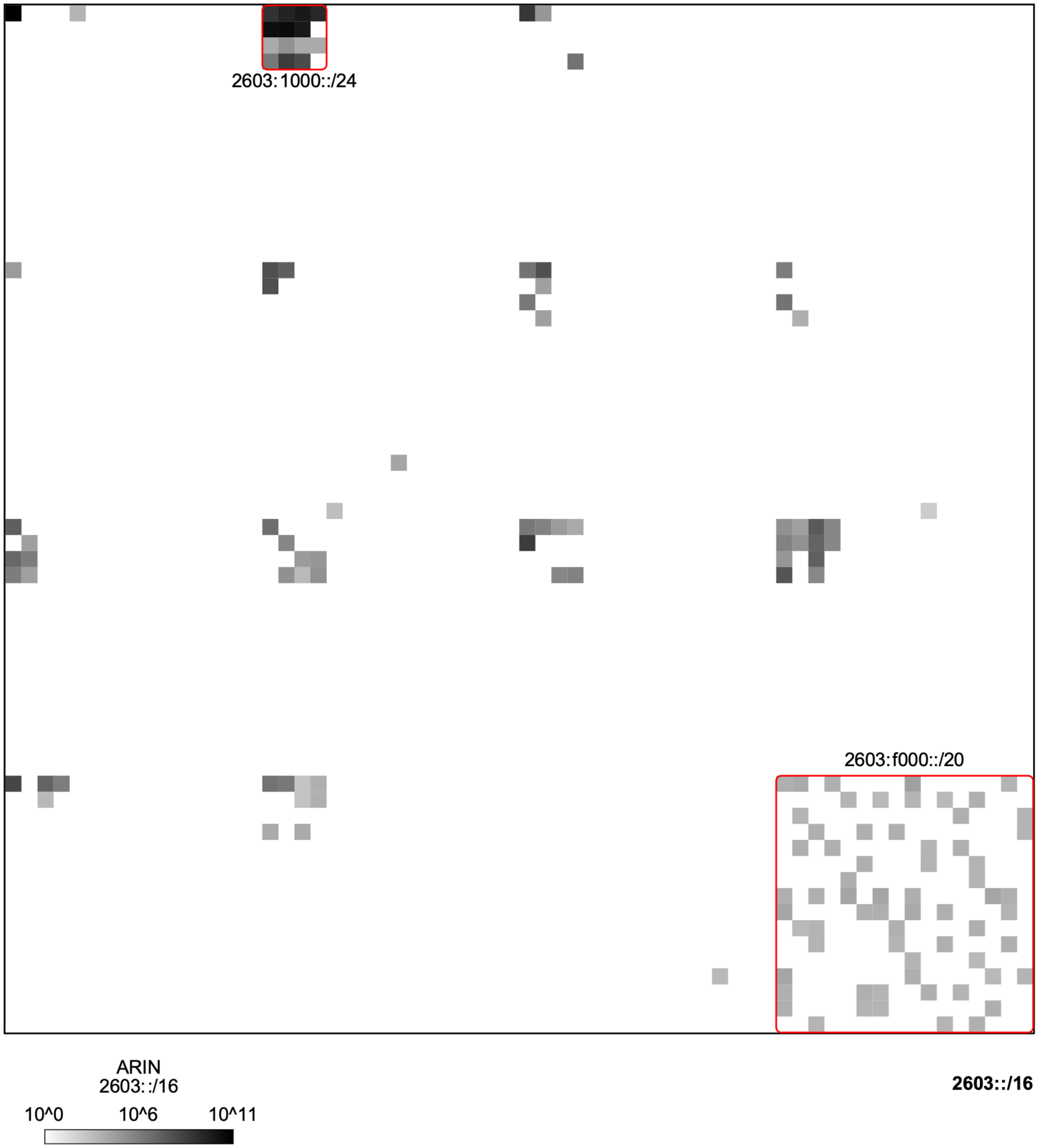


Tier 3, Map 3.1: 2602::/16



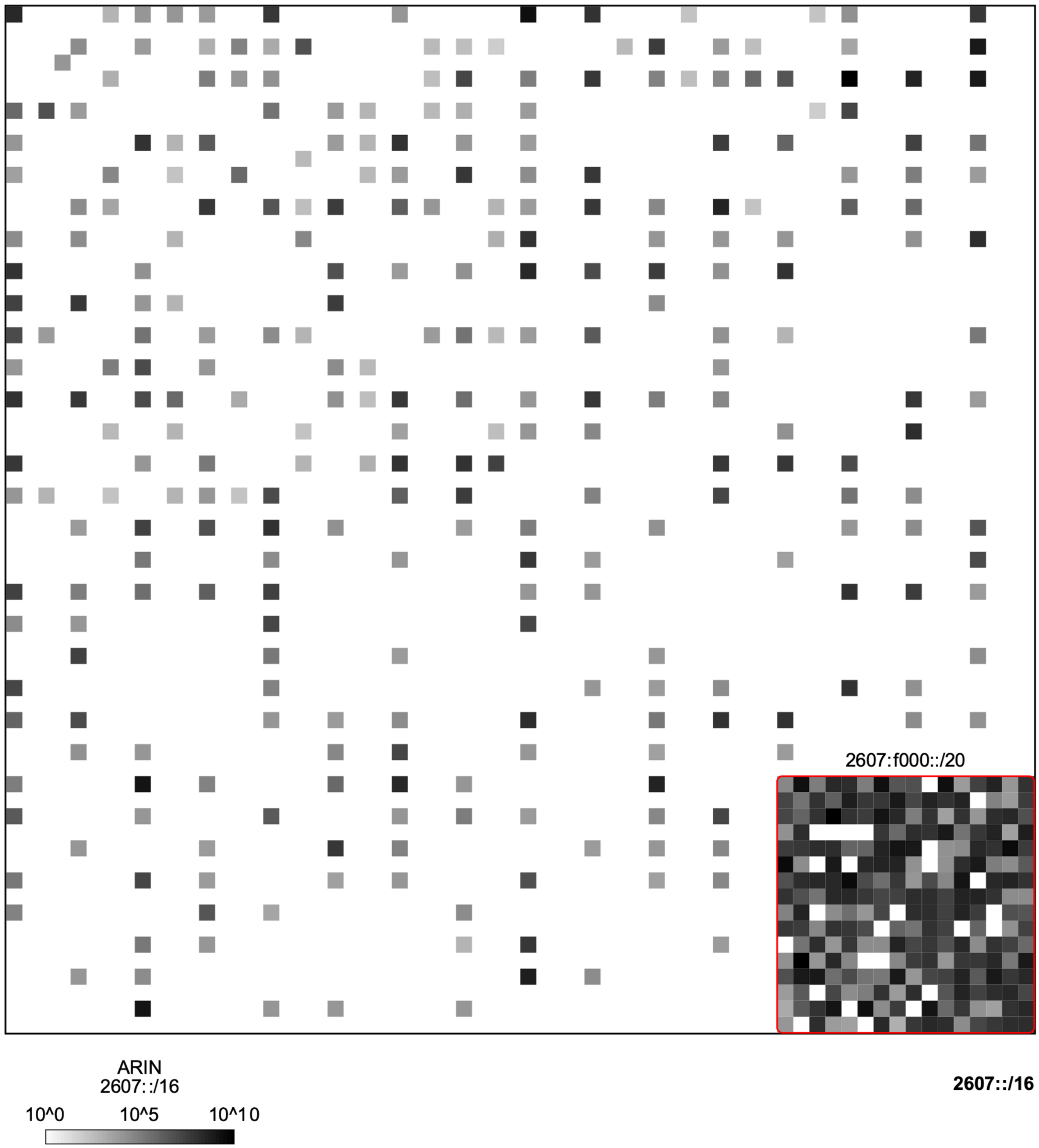
The highlighted regions appear to contain IPv6 /32 or IPv /36 assignments to various ISPs, made rather densely.

Tier 3, Map 3.2: 2603::/16



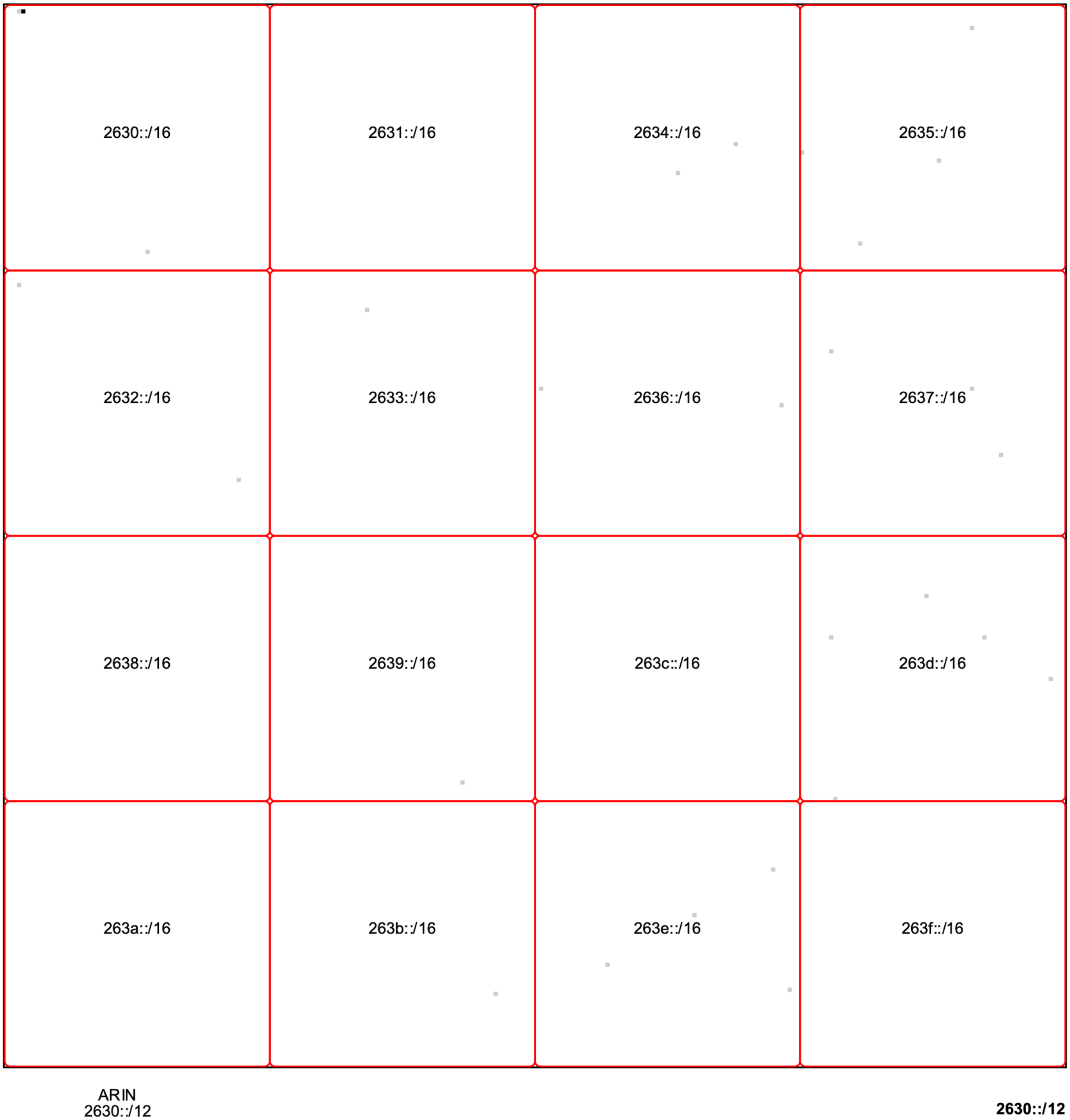
The small upper highlighted region, 2603:1000::/24, belongs to Microsoft (AS8075). The larger lower highlighted region, 2603:f000::/20, belongs to EpicUp Holdings Inc, of Cheyenne WY (AS397165).

Tier 3, Map 3.3: 2607::/16

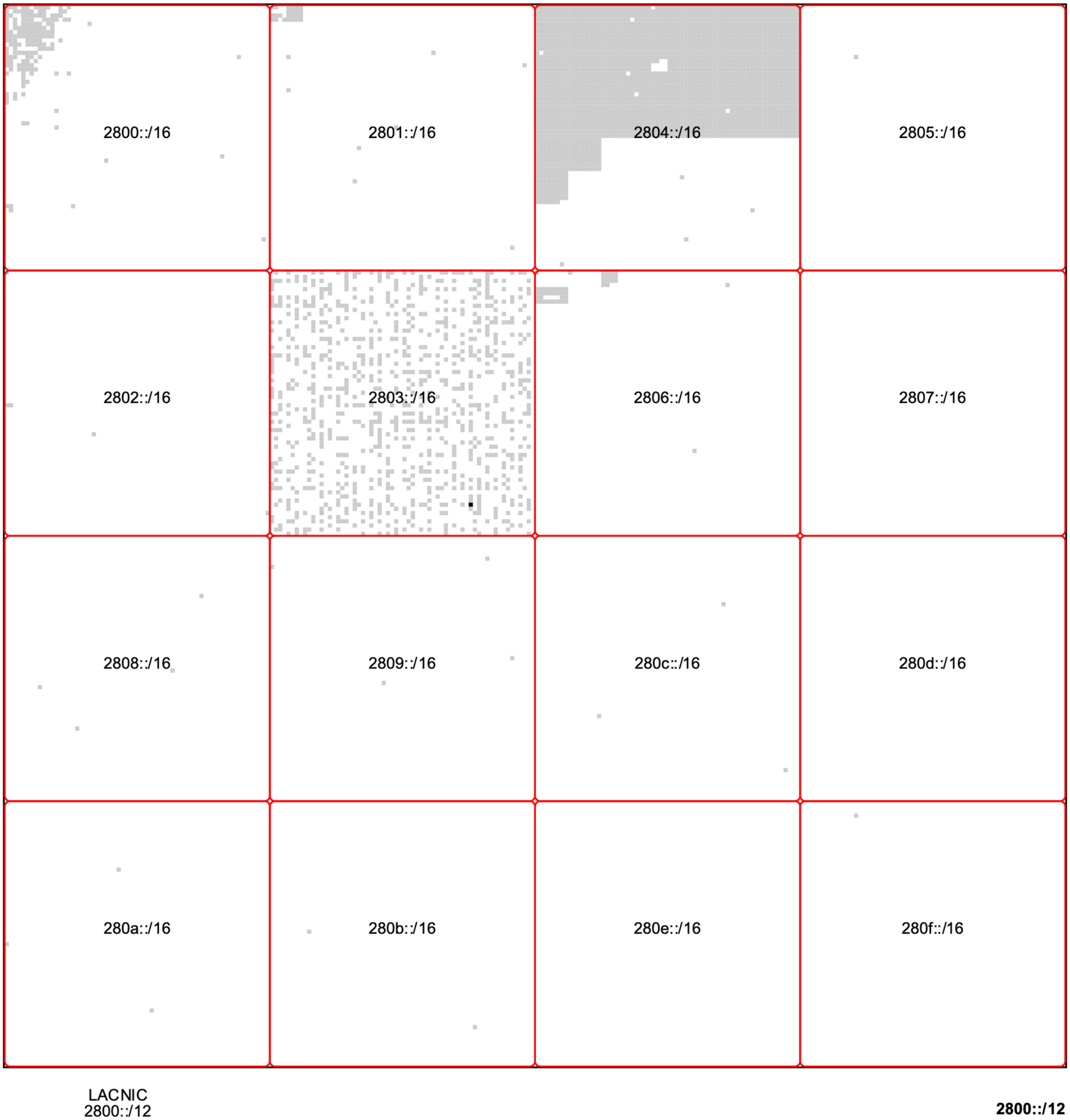


The highlighted region in the bottom right corner appears to contain diverse /32 allocations (check 2607:F000::, 2607:F100::/32, 2607:F100::/32, …, 2607:FF00::/32) made to various ISPs rather densely.

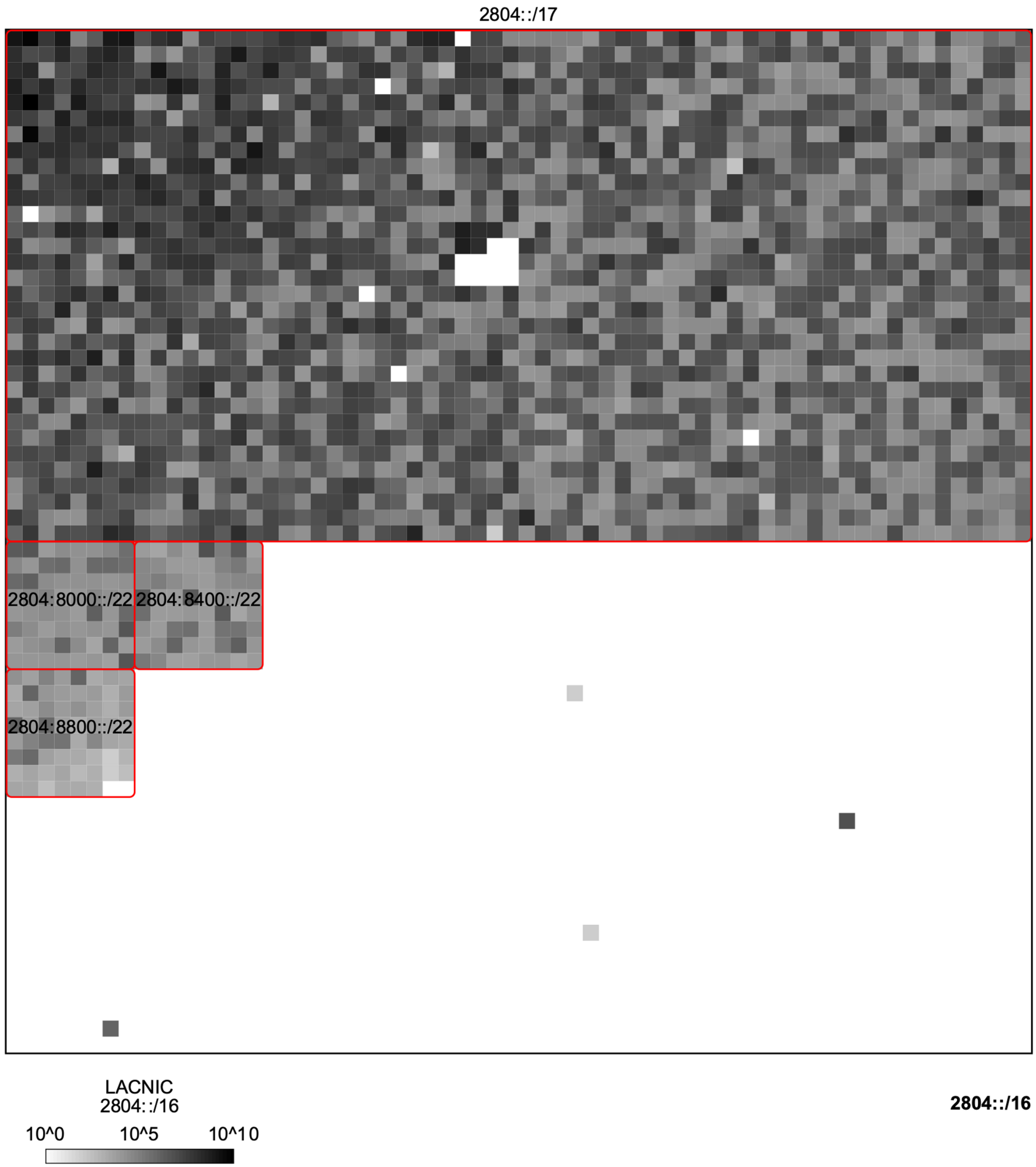
Tier 2, Map 4: 2630::/12 (ARIN)



Tier 2, Map 5: 2800::/12 (LACNIC)

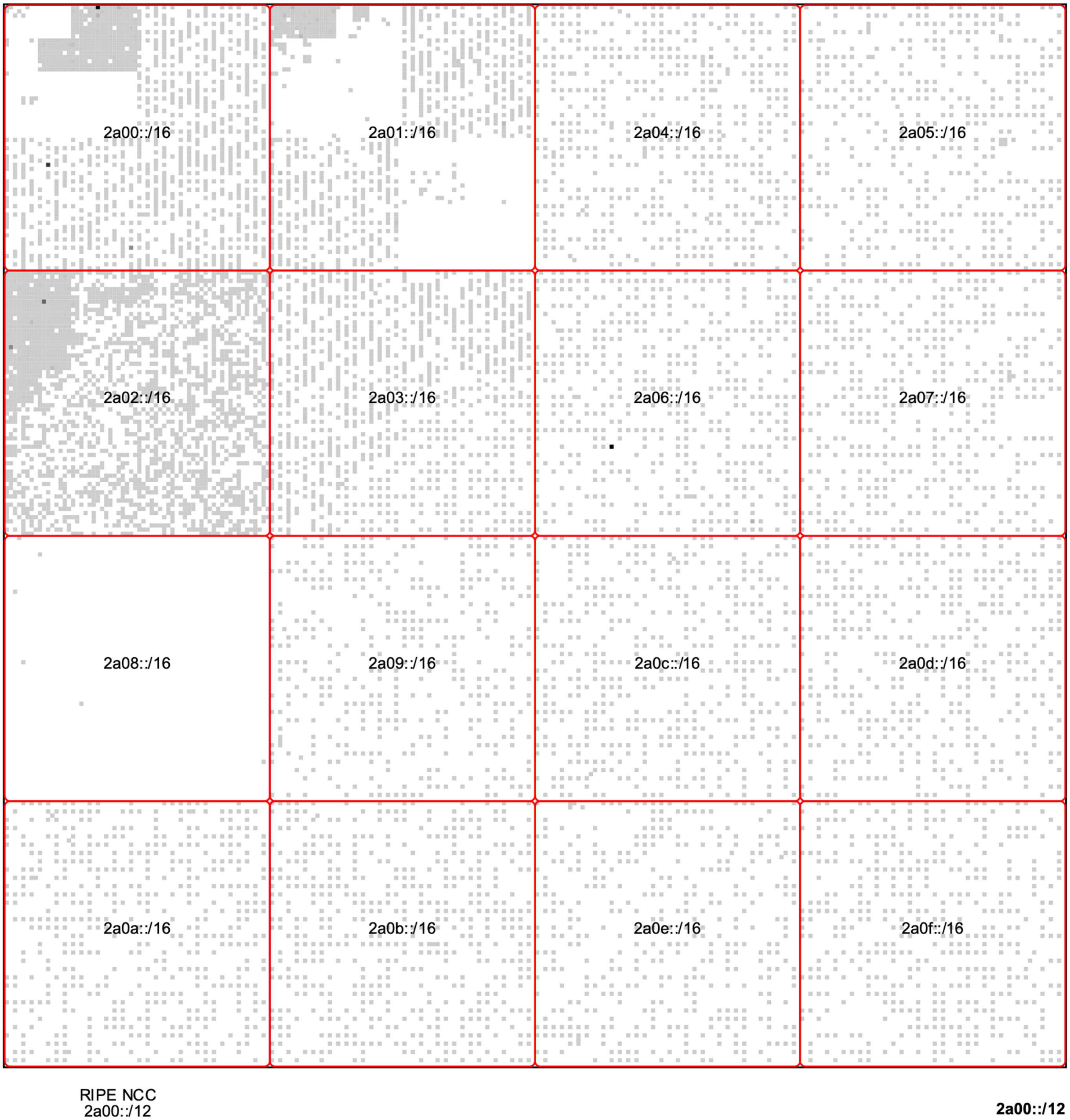


Tier 3, Map 5.1: 2804::/16



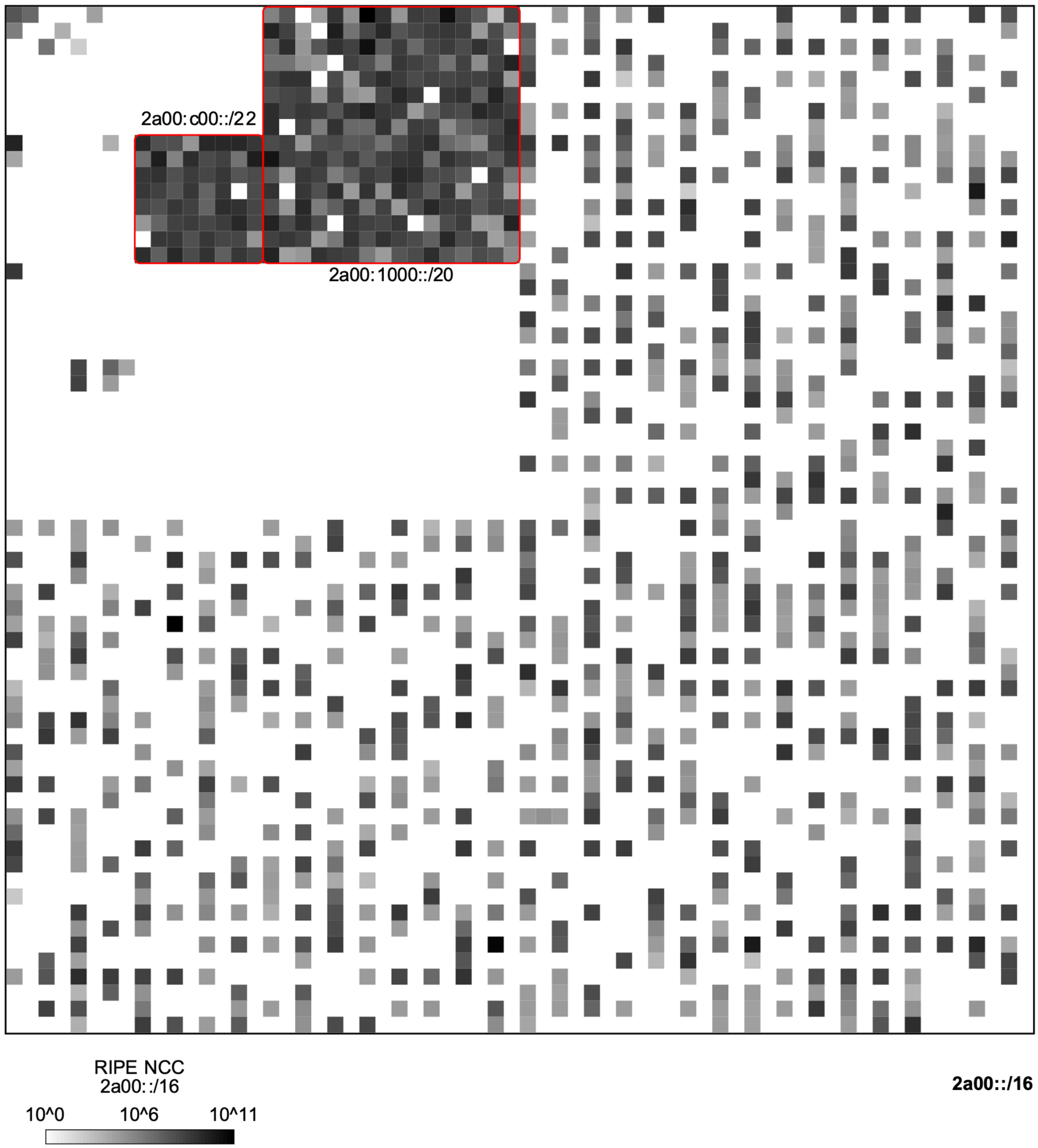
The highlighted regions appear to have /32's allocated (rather densely!) to various ISPs.

Tier 2, Map 6: 2a00::/12 (RIPE NCC)



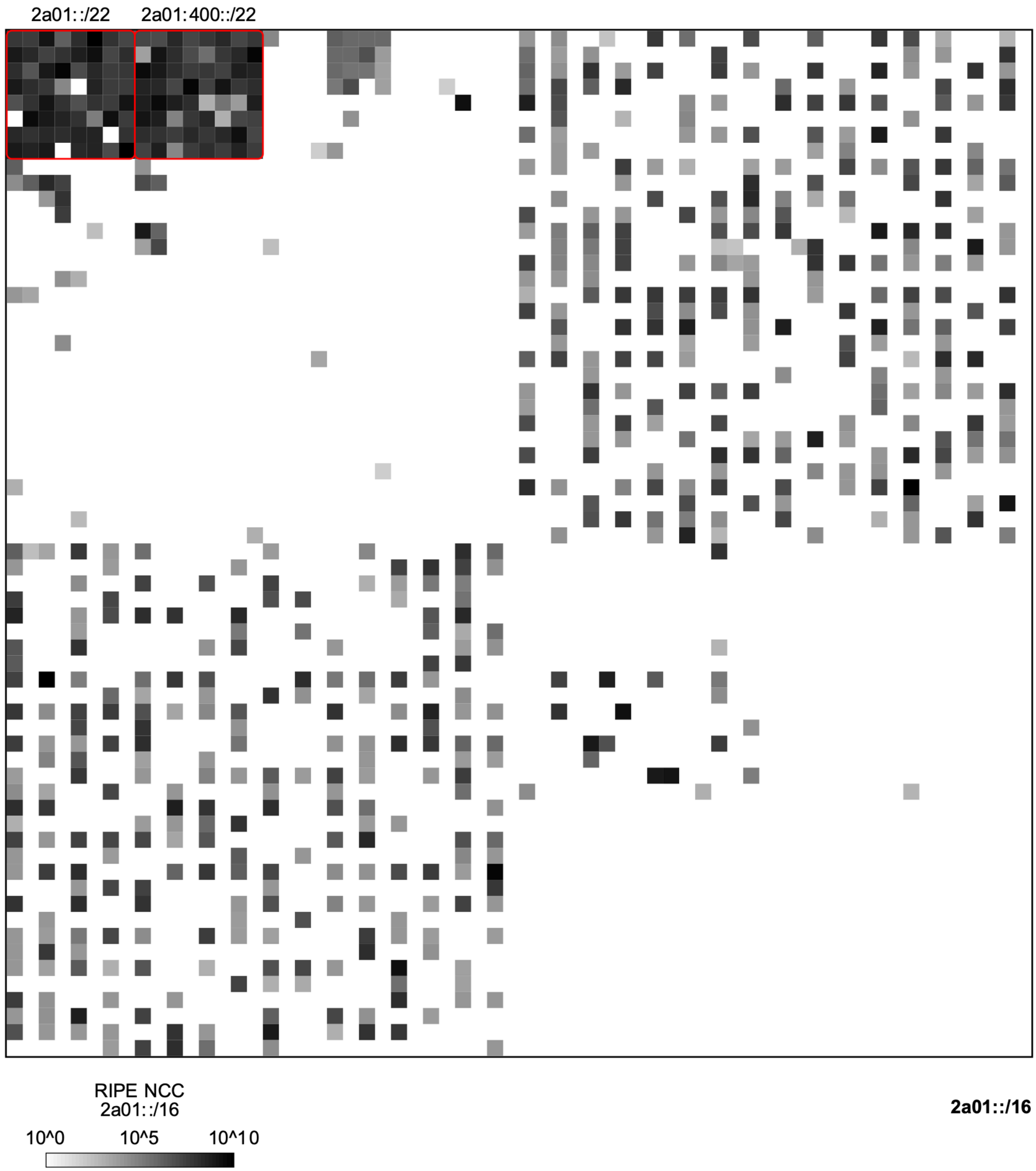
RIPE's overall allocation strategy can be seen visually here, allowing space for contiguous growth of current allocations. We also can see why RIPE has a second allocation.

Tier 3, Map 6.1: 2a00::/16



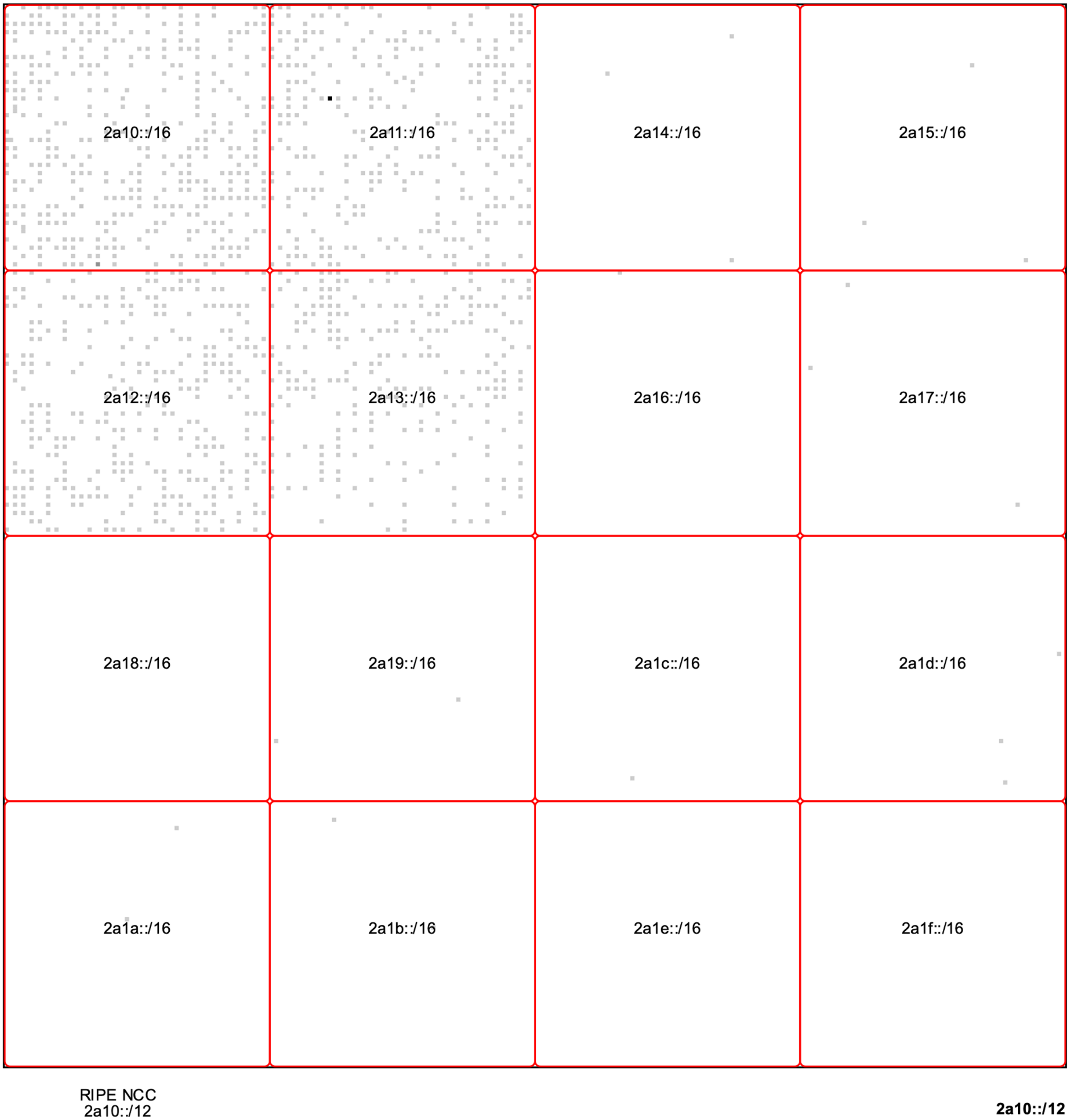
The highlighted regions appear to have /32's allocated rather densely to various ISPs.

Tier 3, Map 6.2: 2a01::/16

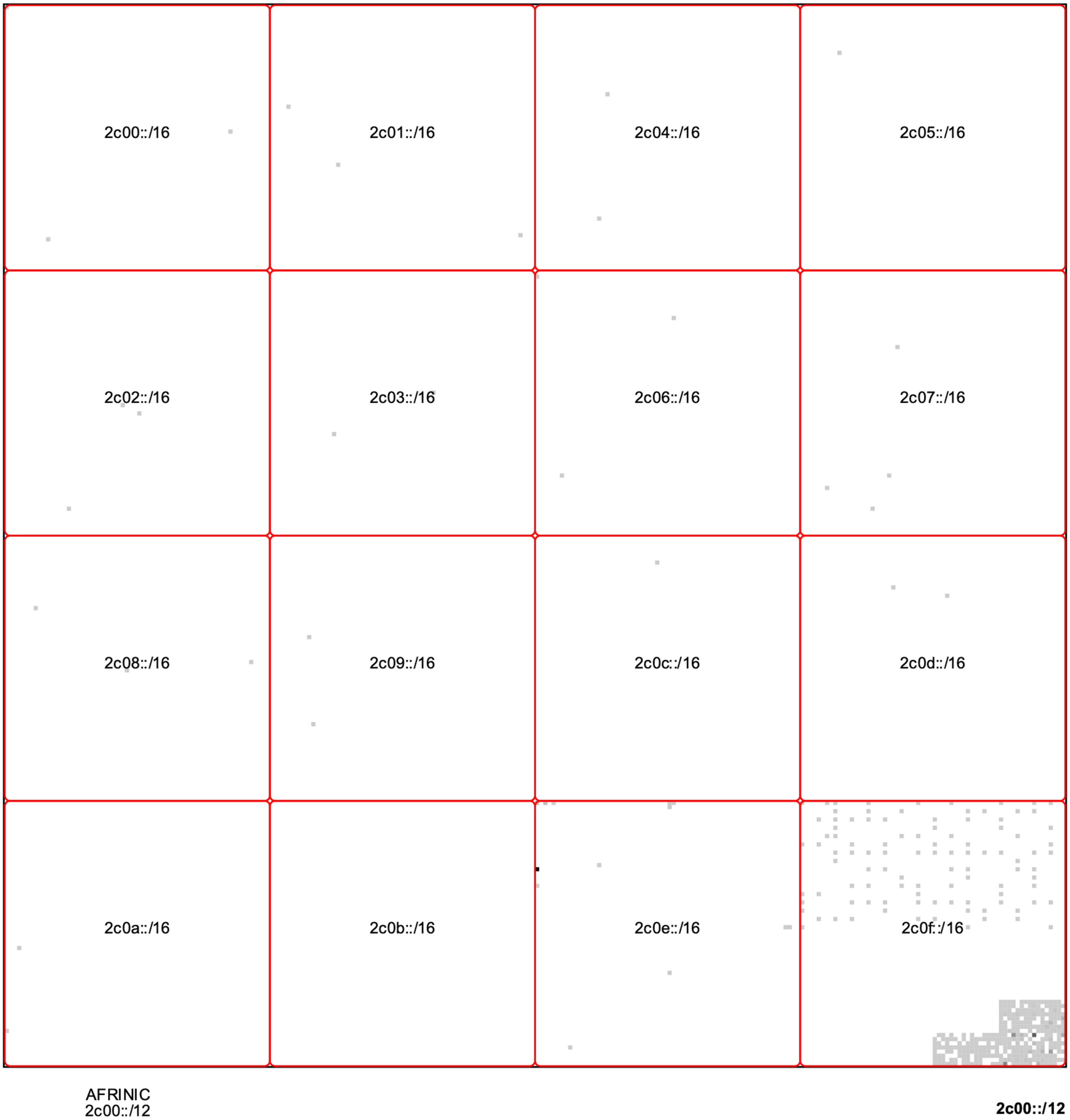


The two highlighted blocks above appear to have /32's allocated rather densely to various ISPs.

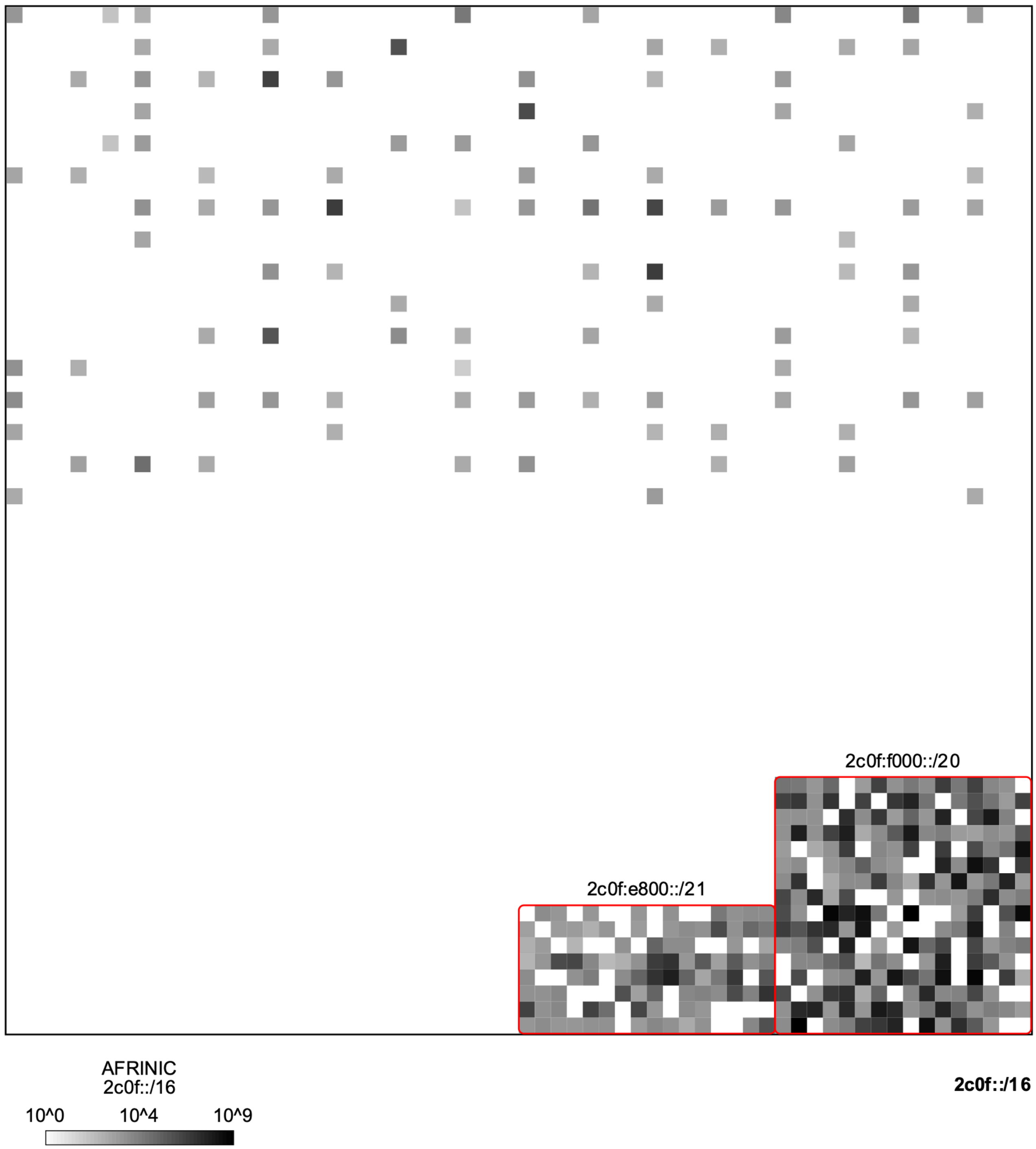
Tier 2, Map 7: 2a10::/12 (RIPE NCC)



Tier 2, Map 8: 2c00::/12 (AFRINIC)



Tier 3, Map 8.1: 2c0f::/16



The highlighted regions appear to have /32's allocated rather densely to various ISPs.

XII. Conclusion

After previously reporting on the Internet's use of IPv4 address space from the perspective of Farsight DNSDB passive DNS data for a 90 day period, we wanted to do the same for IPv6. This report delivers similar insights for IPv6 counts and unique RRsets over a 90 day period based on DNSDB data.

Creating this report presented some challenges, largely driven by the immense size of the IPv6 address space, even though only a tiny fraction of the total available space is currently being used. Leveraging DNSDB API's ability to perform IPv6 CIDR queries, and taking advantage of dnsdbq's ability to process -V summarize queries at scale, we made just under half a million IPv6 /28 queries to get the data we needed.

As you've now seen, we looked at two different measures for each of eight IPv6 /28 prefix:

- Aggregate Count Data Per IPv6 /28 Prefix: We summarized aggregate count data at the IPv6 /28 level for the eight allocated IPv6 /12-equivalents. We considered three different approaches to considering those distributions:

    - Simple summary statistics,
    - Grouped cumulative distribution plots, and
    - Aa grouped violin plot.

    We then report on excerpts from the top two dozen prefixes with the highest aggregate cache miss counts, so those curious about the IPv6 prefixes that get the most queries can get some sense of the underlying activity.

- Unique RRsets Per IPv6 /28 Prefix: Our DNSDB API -V summarizes queries returned counts, but also returns the total number of unique RRsets. This is another intriguing metric summarizing per-prefix IPv6 activity. We produced the same set of three distribution statistics we used to consider the aggregate count data.

    As we did for "top count" prefixes, we also provided excerpts for the top two dozen prefixes for those who might be curious about these "top RRset" prefixes.

- IPv6 Count Data "Maps:" We also visualized our IPv6 count data as a way of summarizing what we've found using three hierarchical tiers of graphs:

    - We started with a top level "overview" map considering all of 2003::/4, covering the global unicast IPv6 space that's currently in use.

        - We then "drilled down" through a set of eight IPv6 /12 prefix maps, with each of those showing one of the eight allocated IPv6 /12's in more detail.

            - We then concluded with a small set of select individual IPv6 /16 maps that allow us to "zoom in" for a closer look at some regions that exhibited atypical macroscopic patterns when viewed at the previous IPv6 /12 level of detail.

We believe this report represents a unique contribution when it comes to describing current IPv6 deployment practices as seen in passive DNS data, and we hope others will replicate and deepen its coverage in the future.

Beethoven's Appassionata Piano Sonata
No 23 in F minor Op 57 movement 3
performed by Anastasia Huppmann

https://www.youtube.com/watch?v=VHUxgEHrUS8
192,418 views