# Project IPv6-First

## A Case Study in Achieving an 80%+ Native IPv6 SOHO Network

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APNIC IPv6 Deployment

# The Objective

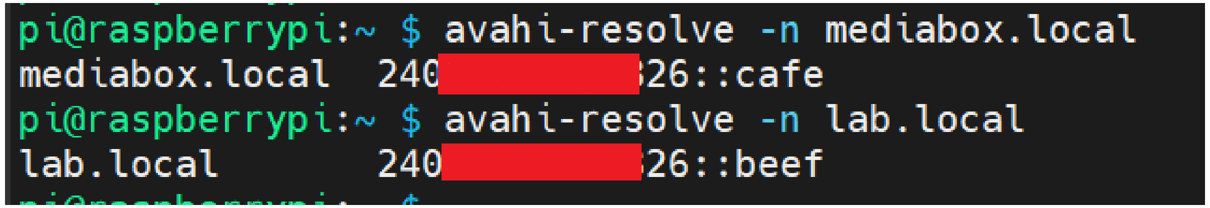
**Is a near-native IPv6-first environment achievable today?**

- **Goal:** Maximize the native IPv6 traffic ratio on a sophisticated SOHO network.
- **Method:** Data-driven analysis using NetFlow (Akvorado).
- **Challenge:** Identify and remediate residual IPv4 traffic sources without using transition technologies like CLAT (yet).

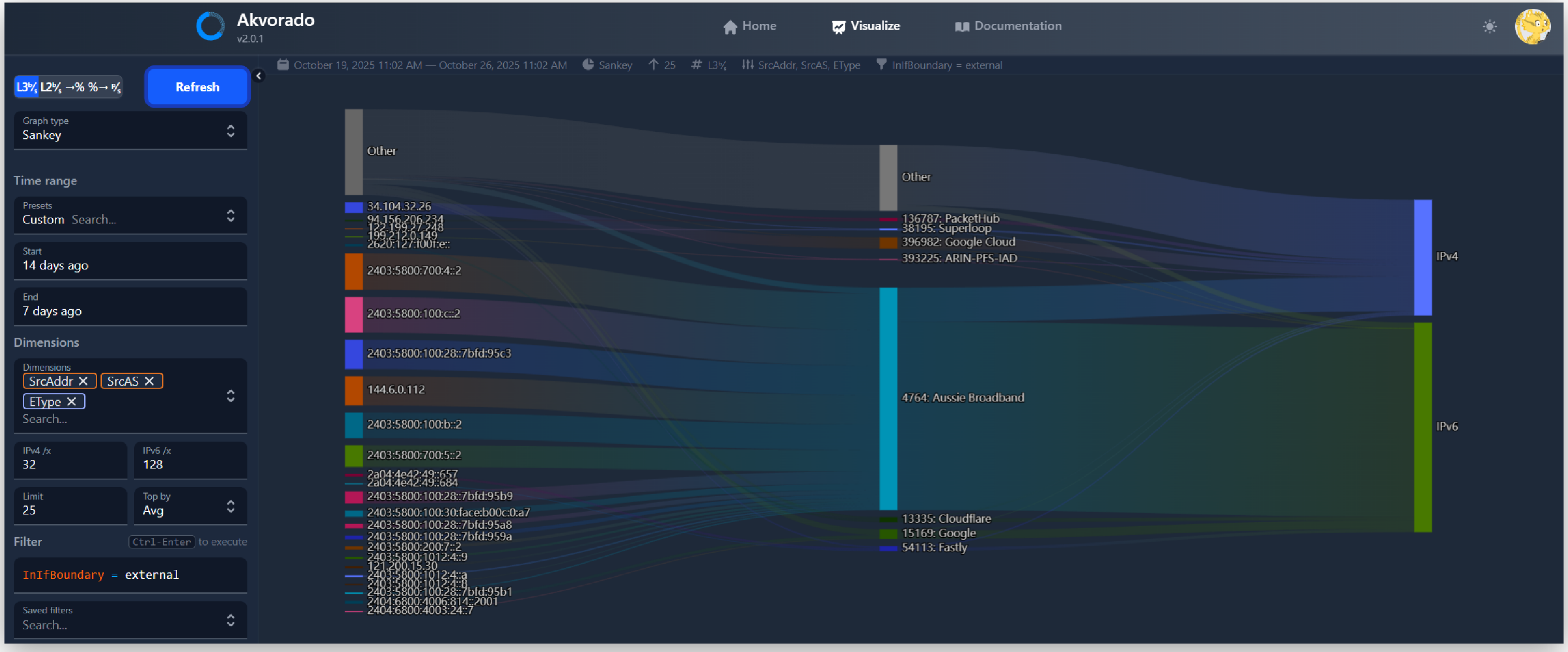
# The Baseline Environment

Starting from a robust dual-stack foundation:

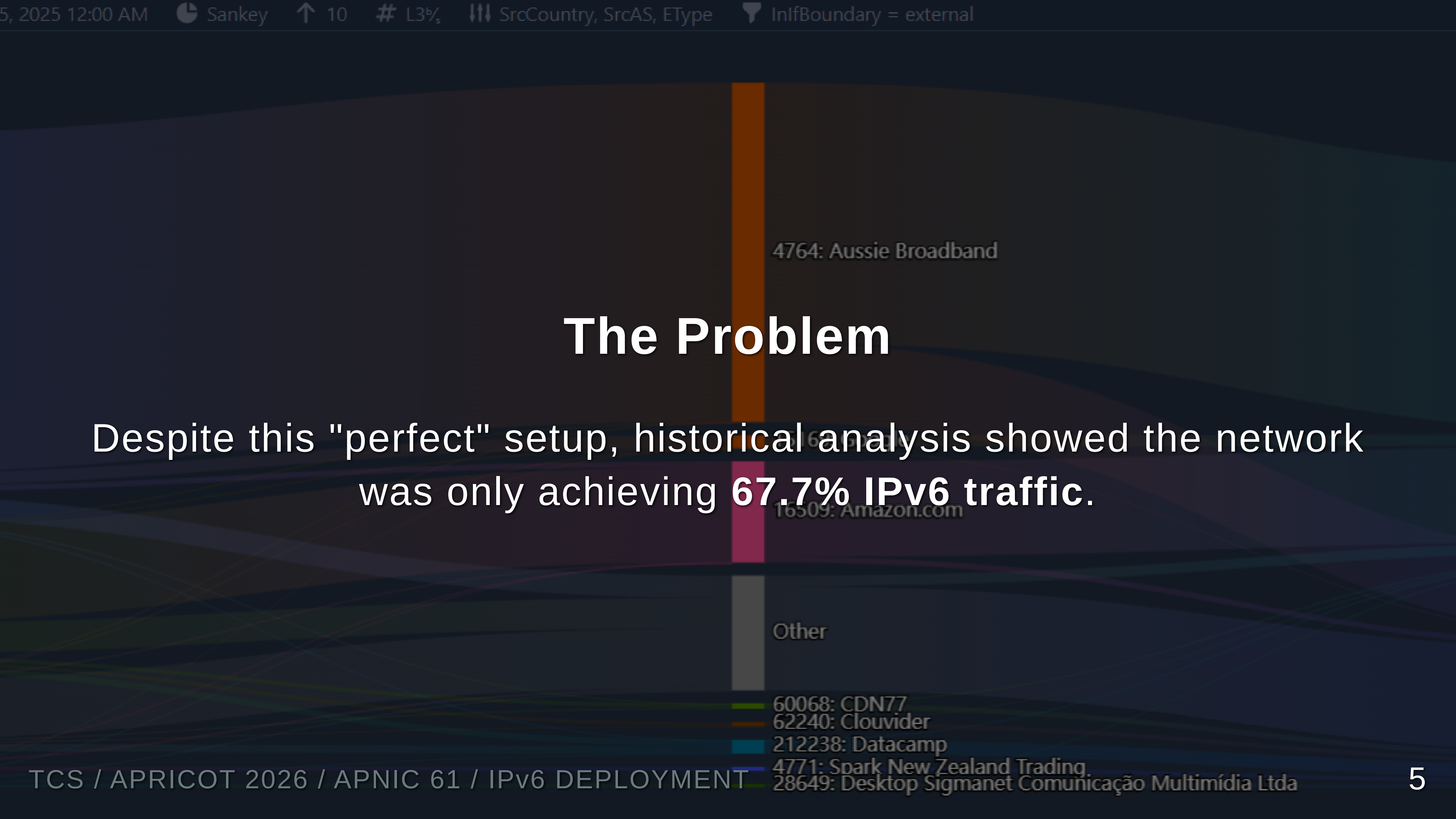
- **ISP:** Aussie Broadband (Native IPv6 /48).
- **Gateway:** MikroTik (RouterOS).
- **DNS:** Public DNS Resolver 1.1.1.1
- **Philosophy:** Local services running on planned IPv6 addresses (e.g., `::cafe`, `::beef`).



# Data: The Starting Point




*(Ref: Akvorado Sankey Chart)*




# The Problem

Despite this "perfect" setup, historical analysis showed the network was only achieving **67.7% IPv6 traffic**.

# Methodology: The "Find and Fix" Loop

1. **Establish Baseline:** Analyze destination ports and protocols via Akvorado.
2. **Isolate Laggards:** Identify high-bandwidth applications defaulting to IPv4.
3. **Targeted Intervention:** Reconfigure applications to force IPv6 compliance.
4. **Validate:** Measure the "After" state.

# The First Culprit: BitTorrent

**Initial Status:**

BitTorrent was a significant drag on the network, operating at only **44% IPv6**.

**The "Working" Dual-Stack Trap:**

- The client was bound to "Any Interface."
- It accepted IPv4 peer connections from trackers immediately.
- **Result:** It defaulted to a suboptimal IPv4 NAT path rather than waiting for superior IPv6 peers.

# Results: The Shift

## Application Level:

- BitTorrent traffic flipped from 44% to **ALL IPv6**.

## Network Level:

- The structural change lifted the entire network's stable operational average from ~67% to **79.2%**.

> “ How much would an ISP save on NAT444 at a ratio of 80% ipv6 traffic? ”

General | Trackers | **Peers** | HTTP Sources | Content

| Cou… | IP | Port | Con… | Flags | Client | Progress | Down Speed | Up Speed | Downloaded |
|---|---|---|---|---|---|---|---|---|---|
| | 2400:a842:7a31:0:53d7:1556:5d80:cb18 | 30010 | µTP | D X E P | qBittorrent/5.1.4 | 100% | 415.1 KiB/s | | 41.2 MiB |
| | 2405:6e00:494:56dd:1b:8736:e0af:b117 | 30664 | µTP | D ? E P | qBittorrent/5.0.5 | 100% | 273.0 KiB/s | | 17.3 MiB |
| | 2800:484:9b36:4000:a37c:183c:c3df:814a | 51413 | µTP | D ? X E P | Transmission 2.84+ | 100% | 190.1 KiB/s | | 5.2 MiB |
| | 2603:6013:c6f0:85b0:ad20:325:2e08:8c72 | 24778 | µTP | D E P | qBittorrent/5.1.1 | 100% | 168.2 KiB/s | | 4.5 MiB |
| | 2a00:102a:5004:46d2:1:0:c88c:c244 | 45399 | BT | D I X E | libtorrent/1.2.19.0 | 100% | 142.8 KiB/s | | 2.3 MiB |
| | 2407:d000:f:4266:e4b2:e0ff:fea8:9906 | 34060 | µTP | D ? X E P | libtorrent/1.2.2.0 | 100% | 133.9 KiB/s | | 4.5 MiB |
| | 2607:fb91:2630:cb2b:9072:2340:47c8:5c48 | 51413 | µTP | D ? I X E P | Transmission 4.0.5 | 100% | 129.5 KiB/s | | 1.7 MiB |
| | 2804:10f8:457e:e400:bf2a:10d3:27c9:61bf | 9482 | µTP | D E P | qBittorrent/5.1.4 | 100% | 96.8 KiB/s | | 5.1 MiB |
| | 2a01:e0a:9bc:6d00:143f:7bff:fe7e:16de | 35947 | µTP | D ? X E P | libtorrent/1.2.2.0 | 100% | 92.1 KiB/s | | 1.5 MiB |
| | 2001:4454:7f0:8d00:49f:1195:f43:f55c | 6882 | µTP | D ? X E P | libtorrent/1.2.2.0 | 100% | 91.6 KiB/s | | 4.3 MiB |
| | 2a01:36d:1000:8ec8:5571:d50a:96b8:ce35 | 31881 | µTP | D ? S X E P | qBittorrent/4.5.1 | 100% | 88.1 KiB/s | | 3.0 MiB |
| | 2001:4451:84c6:b00:d4e2:ab5:74c:9081 | 22118 | µTP | D ? S X E P | qBittorrent/5.0.0 | 100% | 84.8 KiB/s | | 11.2 MiB |
| | 2a00:23c7:7f9c:7201::ffb | 6881 | µTP | D ? X E P | libtorrent/1.2.2.0 | 100% | 77.7 KiB/s | | 1.7 MiB |

# Local DNS & Happy Eyeballs

The "IPv6-First" success relies on a local DNS stack (Pi-hole + Unbound) that optimizes the **Happy Eyeballs v2 (RFC 8305)** race.

1. **The "Resolution Delay" (50ms):**
   - **Standard:** RFC 6724 sees to it that all `AAAA` records are ranked first.
   - **Local Edge:** Unbound resolves in **microseconds**. The `AAAA` record never arrives "late," so the browser never defaults to IPv4 during lookup.
2. **The "Connection Head Start" (~250ms):**
   - Because the IPv6 address is available instantly, the OS starts the IPv6 connection immediately.
   - It waits **~250ms** before attempting IPv4.
   - **Result:** IPv6 runs unopposed for a quarter of a second.

**Key Takeaway:** Local DNS resolution removes any "latency penalty" from the race, ensuring IPv6 is not just **preferred**, but mathematically **destined** to win.

# Update: Breaking the 90% Barrier

Recent SQL analysis (Dec 7 – Dec 22, 2025) shows continued optimization has pushed the network even further.

| Metric | Long Term (Oct-Dec) | Short Term (Dec 7-22) |
|---|---|---|
| Total Flows | 3.3M | 28.1M |
| **IPv6 Bytes %** | 81.19% | **90.74%** |

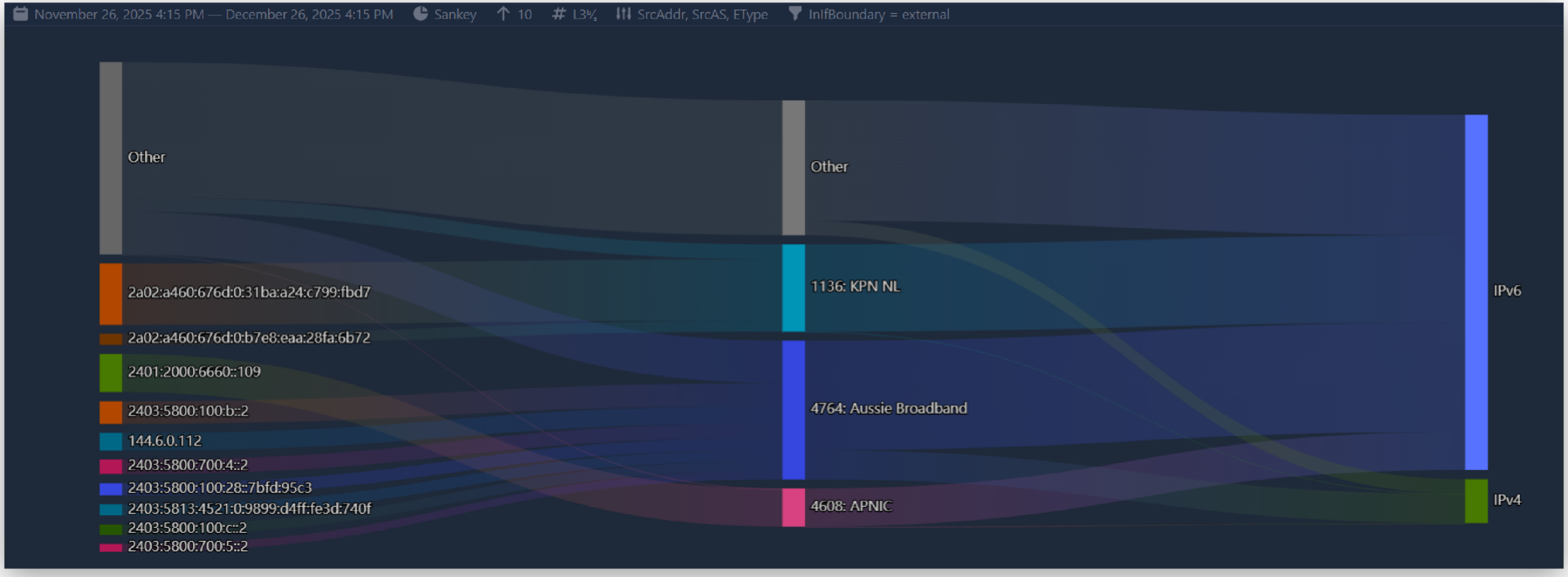
> “ The network is now operating as an effectively IPv6-Native environment. ”

# Visualizing the Data

```
acbd9d624098 :) select * from report_short_term;

SELECT *
FROM report_short_term

Query id: 71553fb0-9273-4850-8404-e744f2397fba

   ┌─protocol─┬─total_flows─┬─────────inbound_gb─┬─flow_percent─┬─bytes_percent─┬──────────first_seen─┬───────────last_seen─┐
1. │ IPv4     │     1646522 │  41.80382528807968 │         6.99 │            16 │ 2026-01-15 16:48:07 │ 2026-01-30 22:27:35 │
2. │ IPv6     │    21902546 │ 219.47984801977873 │        93.01 │            84 │ 2026-01-15 16:48:00 │ 2026-01-30 22:27:35 │
   └──────────┴─────────────┴────────────────────┴──────────────┴───────────────┴─────────────────────┴─────────────────────┘
   ┌─protocol─┬─total_flows─┬────────inbound_gb─┬─flow_percent─┬─bytes_percent─┬──────────first_seen─┬───────────last_seen─┐
3. │ TOTAL    │    23549068 │ 261.2836733078584 │          100 │           100 │ 2026-01-15 16:48:00 │ 2026-01-30 22:27:35 │
   └──────────┴─────────────┴───────────────────┴──────────────┴───────────────┴─────────────────────┴─────────────────────┘

3 rows in set. Elapsed: 0.301 sec. Processed 96.38 million rows, 1.44 GB (319.75 million rows/s., 4.79 GB/s.)
Peak memory usage: 18.38 MiB.

acbd9d624098 :) select * from report_long_term;

SELECT *
FROM report_long_term

Query id: b6bb621a-0f28-4efc-819c-cd51f4db65d7

   ┌─protocol─┬─total_flows─┬────────inbound_gb─┬─flow_percent─┬─bytes_percent─┬──────────first_seen─┬───────────last_seen─┐
1. │ IPv4     │     1356057 │  790.951160935685 │        27.34 │         18.01 │ 2025-10-11 02:00:00 │ 2026-01-30 22:00:00 │
2. │ IPv6     │     3604284 │ 3601.858009760268 │        72.66 │         81.99 │ 2025-10-11 02:00:00 │ 2026-01-30 22:00:00 │
3. │ TOTAL    │     4960341 │ 4392.809170695953 │          100 │           100 │ 2025-10-11 02:00:00 │ 2026-01-30 22:00:00 │
   └──────────┴─────────────┴───────────────────┴──────────────┴───────────────┴─────────────────────┴─────────────────────┘

3 rows in set. Elapsed: 0.145 sec. Processed 20.01 million rows, 300.09 MB (137.84 million rows/s., 2.07 GB/s.)
Peak memory usage: 9.48 MiB.

acbd9d624098 :)
```

*(Ref: Clickhouse SQL Analysis confirming >90% IPv6 byte ratio)*

# Visualizing the Data




*(Ref: Akvorado Sankay Charts)*

# Macro vs. Micro: Validating the Data

My SOHO network mirrors global adoption curves, suggesting that **~80%** is the current "natural limit" for standard dual-stack implementation.

| Context | IPv6 Ratio | Status |
|---|---|---|
| **Germany** (National) | **66.67%** | Strong legacy infrastructure drag |
| **My Network** (Baseline) | **67.70%** | Default configs favoring IPv4 |
| **India** (National) | **78.90%** | Mobile-first / Greenfields architecture |
| **France** (National) | **79.23%** | Aggressive ISP migration |
| **My Network** (Optimized) | **79.20%** | Active deprecation of IPv4 paths |
| **My Network** (Dec '25) | **90.74%** | **The "IPv6-Native" Frontier** |

**Key Insight:**

*We can manually achieve today what the global internet would naturally reach in ~5 years.*

# Defining the "IPv4 Floor"

The remaining ~10% of IPv4 traffic is irreducible without CLAT/NAT64. It consists of:

1. **Legacy IoT:** Ring cameras (IPv4-only video upload).
2. **Legacy Web Services:**
   - Amazon.com (Main retail site).
   - GitHub.com (Main site, though assets are v6).
3. **ISP Infrastructure:** Aussie Broadband caching/accelerators.

> “ Or we can wait for these services to deploy ipv6 … ”

# DNS-Aware Dynamic EAM "The Idea"

Standard 464XLAT double-translates traffic (IPv4 → IPv6 → IPv4).
For the "Ring Camera" problem (IPv4 device → IPv6 API), we can do better.

**The Prototype: Unbound + Jool (SIIT)**
I am proposing a dynamic extension to **RFC 7757 (EAM)**:

1. **Detect:** Daemon monitors local DNS (Unbound) for `A` + `AAAA` pairs.
2. **Map:** Dynamically populates the SIIT translator table.
3. **Result:** Legacy IPv4 devices connect **directly** to IPv6 APIs.

> **Impact:** This removes the "Vendor Negligence" traffic (e.g., Ring) from the IPv4 floor without waiting for firmware updates.

# A Call to Action

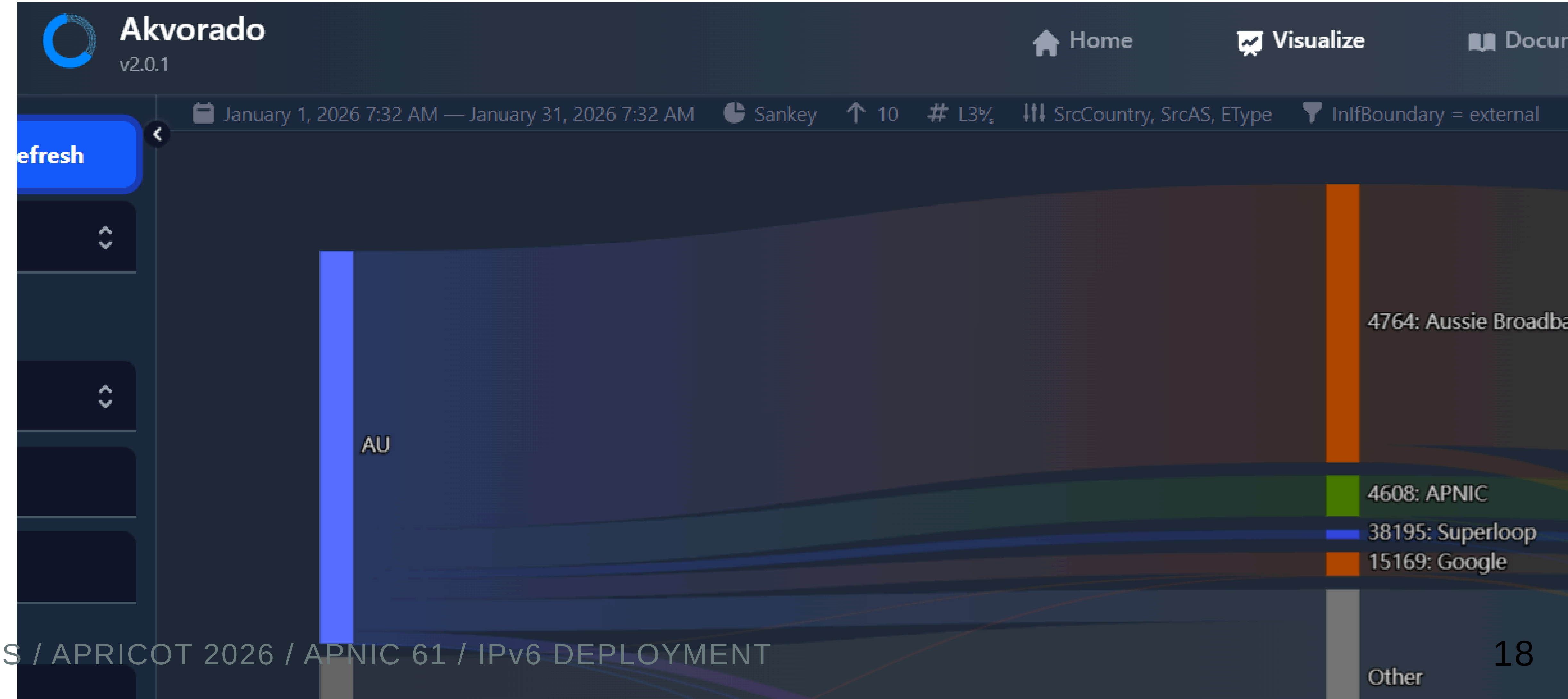
We need 464XLAT on more platforms, including PLAT and CLAT on Mikrotik.

## 📢 We Need Your Voice

Support Feature Request **#263487** to bring native 464XLAT to RouterOS.

**forum.mikrotik.com/t/feature-request-464xlat/263487**

# January 2026 Data



“ So, yes, we can live without ipv4 ... ”

https://bit.ly/3L4clnw