

From allocation to utilization: analyzing the lifecycle of Internet resources

Abstract

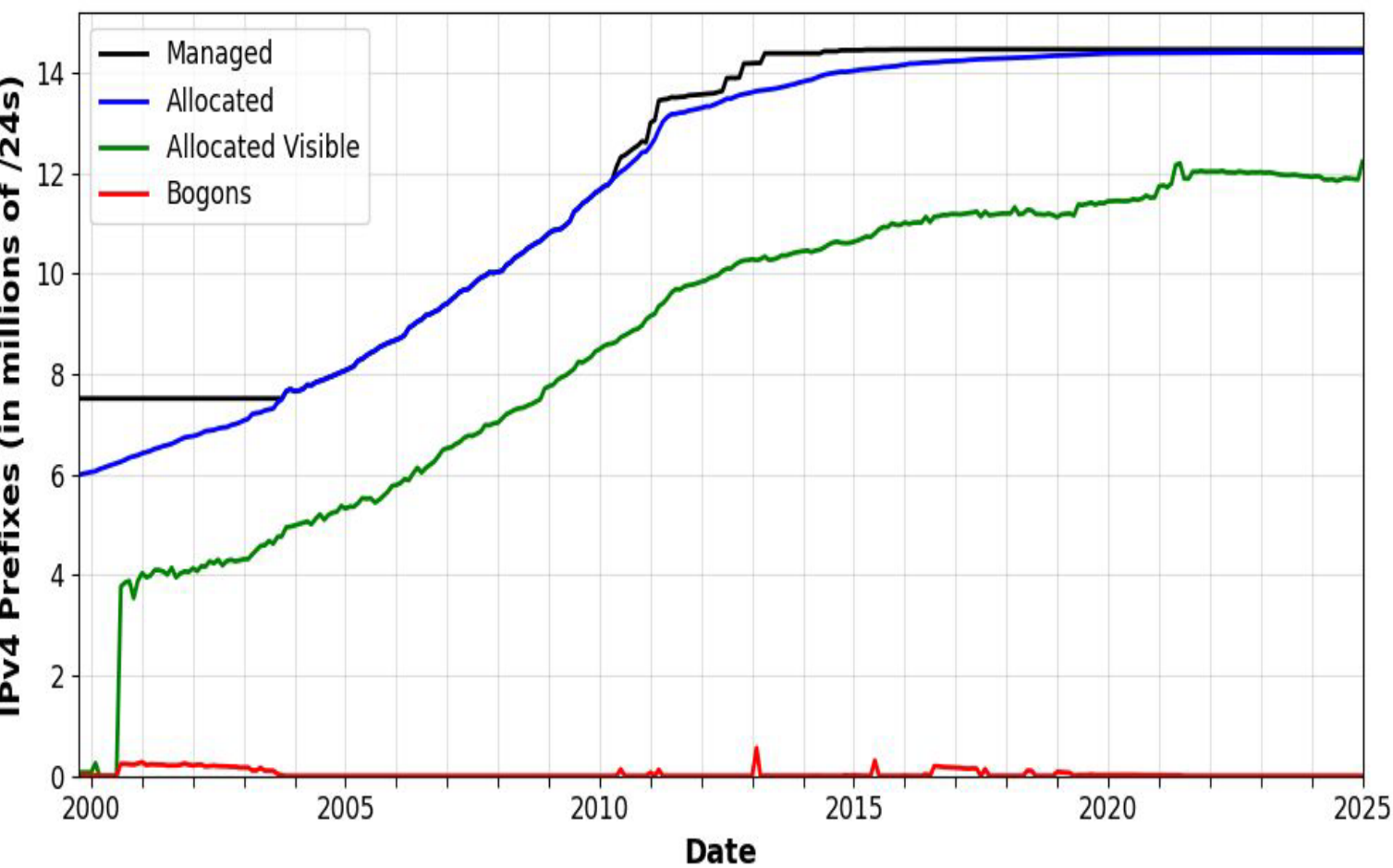
We examine the relationship between the formal allocation and effective use of Internet addressing resources, focusing on IPv4 and IPv6 in global BGP tables over a twenty-five-year period. Using Route Views, RIPE RIS, and PCH feeds cross-referenced with RIR delegation files, we estimate the visibility of allocated prefixes. In January 2025, about 85% of allocated IPv4 /24s appear in public routes, while only 33% of IPv6 /48s are visible. LACNIC shows the highest visibility rates. Additionally, IPv4 transfers between organizations result in rapid gains in visibility, an effect not seen for IPv6. We also measure the time from allocation to first announcement and verify compliance with policies that set such deadlines. In this regard, LACNIC shows explicit rules.

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Background

The Internet consists of a vast infrastructure of interconnected networks, known as Autonomous Systems (ASes), which use IP addresses to communicate with each other. Although RIRs record allocations of these resources, they are not always used or announced in the global Internet. This gap impacts efficiency, governance and security. The current study measures, in a longitudinal and global manner, the visibility of IPv4 and IPv6 addresses, linking it to administrative factors like transfers, regional differences among RIRs, and technical measures (RPKI). By revealing underutilization and anomalies, It provides evidence for improving numbering policies and the operation of the Internet.



Methodology

We build a pipeline that integrates BGP data from Route Views, RIPE RIS, and PCH with daily RIR delegation files. We generate monthly snapshots from 1999 to 2025 and process RIBs using the *bgpscanner* tool. We normalize IPv4 prefixes to /24 and IPv6 prefixes to /48, discarding IPv4 prefixes shorter than /8 or longer than /24, and IPv6 sizes shorter than /16 or longer than /48. We filter bogons and measure visibility by resource and region, along with the time from allocation to first announcement and the impact of inter-organization transfers. Python scripts generate reproducible statistics and figures.

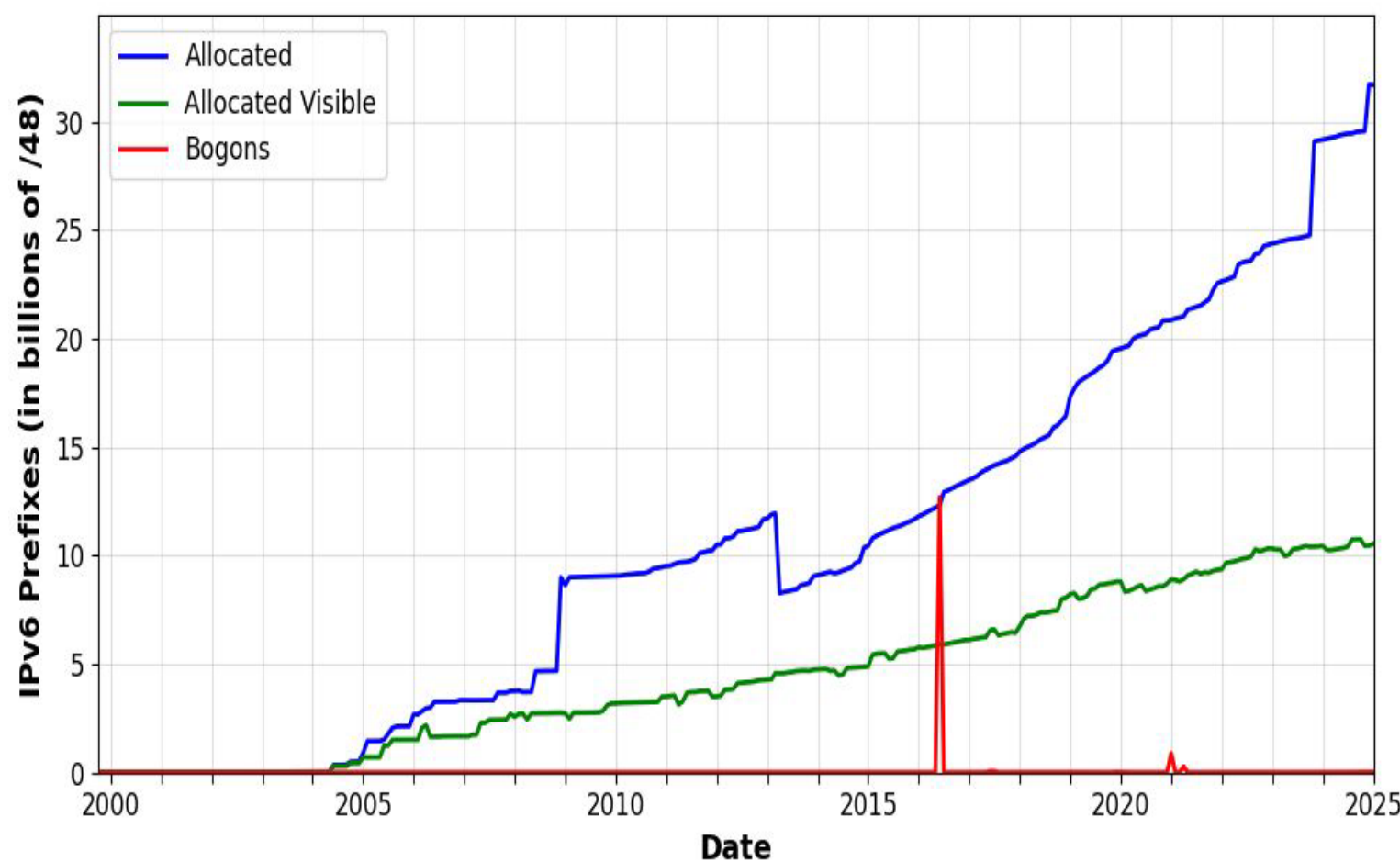
Main Results

From 1999 to 2025, monthly snapshots show steady growth in IPv4 and IPv6 visibility, with signs of stabilization. In January 2025, about 85% of allocated IPv4 /24s are visible in BGP tables, while IPv6 /48s reach only 33%. In this regard, LACNIC leads in visibility. Formal inter-organization transfers significantly increase IPv4 visibility and modestly improve IPv6 visibility. Figures show the temporal evolution of IPv4 and IPv6 visibility over time.

Potential Use and Application

The results support both technical and policy decisions. For network operators, visibility metrics help monitor the effective use of IPv4 and IPv6 blocks and track their evolution in global BGP tables. For RIRs, long-term measurements provide input for policies aimed at recovering unused resources and setting realistic deadlines between allocation and first announcement, with distinctions between IPv4 and IPv6.

The findings also serve the community to avoid in IPv6 practices seen in the early days of IPv4, such as allocating excessively large blocks to a few organizations. Similar patterns are already visible. These early signals can guide policies and actions to ensure balanced and sustainable IPv6 utilization, helping to align operational practices with long-term growth and address allocation equity concerns.



Future Work and Conclusions

Several research paths remain open for future work. One promising direction is the analysis of resource visibility during outage or instability events, assessing whether temporary interruptions affect the persistence of announcements. Another is the study of the visibility of IPv4 addresses obtained through wait lists maintained by RIRs after the exhaustion of available space, as well as the visibility of address blocks involved in leasing arrangements, which may present distinct propagation patterns.

Ultimately, the results reinforce that allocating a resource does not ensure its efficient use. Public visibility, observable via BGP, remains a fundamental indicator for evaluating whether blocks are effectively operating in the global Internet. These findings provide a foundation for future studies and for the development of policies that promote sustainable and equitable utilization of Internet number resources, with particular attention to improving IPv6 adoption.

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