

# The Impact of IP Version on Household Internet Speed: A Comparative Study

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## Abstract

Despite extensive research measuring broadband quality, limited work has considered the interaction between residential Internet throughput and IP protocol. Public speed tests used to determine Internet quality do not, by and large, control for IP version; results, analysis, and recommendations are made using a hybrid of IPv4 and IPv6 data. Given the range of protocol designs, software stacks, and network infrastructure differences between the protocols, combined with the recent significant increase in IPv6 adoption, it is critical to understand what role the IP protocol plays in measuring Internet speeds.

In this work, we systematically compare IPv4 and IPv6 speeds in residential access networks, examining differences in throughput experienced by households depending on IP version. Our findings demonstrate that IPv4 and IPv6 throughput differ in many instances and motivate a large-scale re-evaluation of our assumptions on IP version in future speed test analysis. Specifically, we find that IPv4 and IPv6 speeds differ in a significant number of cases, with up to 18.3% of our measurements differing by over 5%. Our findings indicate that substantial speed differences between IP versions can be driven by provider-specific factors such as speed tiers. Furthermore, we observe differences in IPv4 and IPv6 data depending on the speed-test software and testing infrastructure. Thus, this work guides future research about Internet speeds on how to consider and control for IP version.

## CCS Concepts

• **Networks** → **Network measurement**.

## Keywords

Network measurement; Access networks; Throughput; IP protocol

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## 1 Introduction

Internet access is vital, arguably at the level of a basic human right [7]. Researchers and policy makers alike rely on *speed tests* to understand connectivity quality from the perspective of residential networks [3]. To this end, the United States Federal Communications Commission (FCC) publishes Internet quality measurements via the Measuring Broadband America (MBA) project, which for over 10 years has placed speed test probes in the homes of volunteers in order to evaluate key performance metrics for various Internet Service Providers (ISPs) [5]. This and other speed test datasets have been used to highlight a variety of inequalities by geographic location, service provider, and Customer Premise Equipment (CPE) [12, 17, 23, 25, 26].

Despite extensive and impactful speed test measurements [4], one critical facet that has not been explored in depth is how speeds differ between IP versions. With IPv4 exhaustion, IPv6 deployment has increased dramatically. As of fall 2025, Google estimates that almost half of its traffic is IPv6 [6], with adoption having accelerated significantly since 2020. While IPv6 has allowed the Internet to continue expanding past IPv4 exhaustion [20], the Internet is now a hybrid of IPv4, IPv6, and dual-stack networks. Residential networks are no different and may use IPv4, IPv6, or both, depending on factors such as ISP, hardware, software, or service.

IPv4 and IPv6, while both IP protocols, are inherently incompatible and require translation to interoperate. Moreover, protocols have different software stacks and consumer hardware (e.g., hardware offload [1]). Most notably, IPv4 connections are likely to traverse a Network Address Translation (NAT) technology, implemented to extend the use of the IPv4 address space [21]. Such differences introduce distinct potential for bottlenecks, impacting performance incongruently across IP versions. Differences in performance between IP versions may not be due to the protocol itself, but rather, the infrastructure associated with the protocol and its measurement. However, prior speed test measurement work has not differentiated between the IP versions of measurements, and, thus, has not demonstrated if such variation exists [12, 17, 23–26].

Furthermore, anecdotal evidence indicates that households experience differences across IPv4 and IPv6, with reports of each



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providing faster speeds in different situations [14, 18, 19]. Existing work that compares IPv4 and IPv6 performance focuses on latency [2, 8, 10, 15]. Although measuring network delay is a valuable baseline, throughput measures network capacity and presents another important dimension for understanding performance. However, measuring network speed presents unique challenges due to a lack of availability on client measurement platforms [22] and is more prone to variation based on factors such as subscription tiers [17]. As broadband deployment increases, comparing speeds across IP versions is important to evaluate Internet quality; results have the potential to impact policy decisions that help to narrow the digital divide [5].

We ask how systematic speed test measurements in home Internet connections differ across IP versions. We achieve this by performing repeated systematic IP-version-controlled Ookla [16] and NDT7 [13] speed tests from dual-stack households across multiple US states, ISPs, and CPE using the FLOTO Platform [9].

## 2 Methodology

We briefly provide an overview of our measurement and data collection methods.

**Measurement Infrastructure.** To execute speed tests in households, we use the FLOTO platform [9]. The FLOTO project recruits volunteers who allow network measurements to be conducted within their households. The measurements are executed on Raspberry Pis connected to the home routers via Ethernet. We deploy our measurement software to the devices via Docker containers using the FLOTO platform. At the time of our measurements, the majority of FLOTO volunteers were located in two major US cities across a diverse set of neighborhoods.

**Paired Speed Tests.** We use two speed tests: NDT7 [13] and Ookla [16]. As discussed in prior work [11], these tests differ in their design and, consequently, their results. Based on prior observations that Ookla speed test server has an effect on measurements [11], we experiment with different speed test servers from three ISPs: Comcast, Charter, and AT&T. We choose these speed test servers because they are congruent with the broadband providers for the majority of our households. In each speed test software, we execute paired speed tests in IPv4 and IPv6 tests. These are conducted consecutively, with a brief cool-down period in between. This way, our results are directly comparable but do not interfere with each other.

## 3 Key Contributions

We find that the IP version used in a speed test affects its result. We identify that this impact is correlated with several factors, such as speed test software and the ISP. Although our measurements do not represent a generalized view of the Internet at large, they provide evidence that IP version reliably affects speed test results, and motivate a need to consider IP version as a primary factor in future explorations of home Internet performance. More specifically, from our measurement vantage, we identify several conditions where IPv4 and IPv6 speed results are similar or different. We highlight these trends in our results to illustrate *systematic* differences in IPv4 and IPv6 throughput.

**Similarities.** We find that IPv4 and IPv6 speeds differ by low margins in 81.7–91.5% of speed tests, depending on speed test parameters (software and the target server). We summarize these trends across the different facets we measure from our vantage points:

- We characterize a *steady-state* behavior for speed comparisons between IP versions. Across all data, IPv4 is most likely to be slightly (up to 2.5%) faster than IPv6. This slight difference is likely due to minor optimizations present in IPv4 that do not exist in IPv6.
- Because this steady-state behavior is relatively constant, we find that the consistency and individual household speed range are not affected by the IP version of the test. We find rare exceptions in high speed tiers (>600 Mbps in download speeds, >400 Mbps in upload speeds).

**Differences.** We find that speed tests differ significantly in a non-negligible fraction of cases (8.5–18.3%), disproportionately influenced by several factors, including speed test software and ISP.

- We find systematic differences in testing infrastructure. NDT7 tests are more likely to be faster in IPv4, while we found one Ookla speed test server that is more likely to report low speeds in IPv4. Some of these differences have a substantial impact on the interpretation of the results.
- The IP version of the speed tests has a significant effect on the overall speed test distribution in almost all households. Although significant differences (>5%) are less common, we demonstrate cases where they occur in conditions specific to the ISP. This includes specific cases that indicate a household's speed tier may play a role in which IP version is faster.
- We find that individual households are occasionally more prone to be significantly faster in one IP version. Although this is the minority of cases, this prompts us to hypothesize that local household-specific factors (such as local network conditions) affect which IP version is faster.

We additionally release our speed test data to encourage future work in understanding the role of IP version in measured Internet throughput [27]. We redact data that may compromise user privacy, such as full client IP addresses.

Our work calls for revisiting the impact of IP protocol on Internet speeds. We show that future research on broadband quality should consider IP version as a factor that can affect Internet performance. From these findings, we make several recommendations for future work measuring Internet speed using speed test software. As these measurements have consequences, such as when used to ground policies [4, 5], we emphasize the importance of understanding IP version in conjunction with coverage and quality. We hope that future work can leverage our findings to make Internet quality analysis more accurate and impactful.

## 4 Recommendation for Future Work

Based on our findings, we make several recommendations for future work that measures Internet quality. We hope subsequent work can expand our measurements to more vantage points, including households with more router vendors and different broadband providers. With more conditions represented in our dataset, we hypothesize that we could identify other bottlenecks unique to each IP version.

Based on our observations, our foremost recommendation is to consider the IP version of the test in analysis by testing in both IP versions or separating results by IP version. When possible, it is important to understand the IP versions available to the client one measures from, and control for IP version in the speed test software. Failing to measure in one IP version may paint an incomplete picture of the client's network or other factors affecting performance.

Aligning with prior work [11], we encourage future work to use different types of speed test software and be conscious of the unique differences that may emerge in each based on the IP version of the connection. For example, if a lower speed is observed in tests, we encourage researchers to investigate whether this occurs in only one IP version and, if possible, repeat the test in the other IP version. As other works have shown that factors such as Wifi [23] and subscription tier [17] can affect measurement results, we hope that future work will add IP version to the factors that they consider in analysis.

**4.0.1 Speed Test Software.** We find that NDT7 speed test results are more likely to be faster in IPv4 compared to Ookla speed tests. The cause of this result could be due to several differences between the two types of speed tests, including both the testing software itself and the infrastructure. Aligning with prior work [11], we emphasize that the results from each software are not *right* or *wrong*; rather, they model different types of connections. As they both help us learn different things about the network, we encourage future work to use different types of speed test software and be conscious of the unique differences that may emerge in each based on the connection's IP version.

**4.0.2 Speed Test Servers.** We additionally identify an Ookla speed test server that tends to report lower IPv4 download speeds compared to other servers. Prior work [11] additionally identifies inconsistencies in results related to specific Ookla servers. We similarly identify anomalies related to the consistency of tests using the AT&T Ookla server. We contacted Macmillan et al. and confirmed that they did not control for IP version; therefore, they have a mix of IPv4 and IPv6 results in their analysis. We hypothesize that their finding that some Ookla servers under-report speed may only have existed in one IP version. Thus, we recommend that future work consider results from multiple Ookla test servers.

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