

Analysing the Impact of DNS propagation delays on website availability and user experience.

Zandile Ndlovu, ICT Coordinator – Namespace Development, ZA Domain Name Authority, Johannesburg, South Africa (Author)

Advocate Lerato Seema, Executive Manager, Compliance and Regulations–Namespace Development, ZA Domain Name Authority, Johannesburg, South Africa (Reviewer)

1. Abstract

This study will focus on analysing the impact of DNS propagation delays on website availability and user experience. Delays in Domain Name System (DNS) propagation are a notable yet frequently ignored factor that impacts website availability and, as a result, user experiences. This study examines the complexities of DNS propagation delays, investigating their origins and assessing their effects on website performance and user satisfaction. By conducting this analysis, the concept of DNS propagation will be explored while highlighting its significance within the framework of the internet.

2. Introduction

The Domain Name System (DNS) serves as the underlying framework that transforms user-friendly domain names into IP addresses, allowing browsers to retrieve websites and a plethora of online services. As web applications and internet resources proliferate, so does the need for a robust and reliable mechanism to ensure that domain names resolve accurately and swiftly. It translates domain names, which are

easy for humans to remember, into IP addresses that computers use to identify each other on the network. Although DNS is an essential service that enables users to locate web resources efficiently, one of its inherent characteristics is propagation delay, which can significantly impact website availability and user experience. This research explores the complexities associated with DNS propagation delays, examining their origins, repercussions, and strategies to mitigate their effects.¹

3. DNS Propagation

DNS propagation refers to the period during which updates to DNS records spread across the global network of DNS servers after a domain name's settings are changed. When a change is made to a domain's DNS records, such as updating an IP address, this information does not instantaneously update across all servers. Instead, it takes time for the new information to be fetched and stored by DNS servers worldwide—hence the term “propagation.” Typically, this process can take anywhere from a few minutes to 48 hours; in some cases, it may take

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even longer, depending on several influencing factors².

4. The Mechanics of DNS Propagation

The architecture of DNS is decentralised, consisting of multiple servers, each containing parts of the DNS information, usually organised hierarchically. When a user attempts to access a domain, their authoritative server for updated information³.

5. Methodology

A desktop approach was adopted in the study, zooming into the various elements contributing to DNS propagation and the mitigation adopted to address it.

6. Factors Influencing DNS Propagation

6.1. Global Distribution of DNS Servers

A significant aspect of DNS propagation is the geographic distribution of DNS servers. Each locality may have different caching strategies, and DNS changes may be retrieved at varying rates contingent upon regional infrastructure and specific server configurations⁴.

6.2. Network Congestion

High traffic levels on a network can lead to delays as data packets are queued for transmission. When numerous users are attempting to access a website simultaneously, server

response times may lag, leading to frustrating experiences for users.

6.3. Routing and Switching Delays

The journey that data takes from one point to another is rarely direct. Data often traverses multiple routers and switches, each introducing its own latency due to processing times. Each device in the path must inspect, queue, and forward packets, further compounding delays.

6.4. Quality of Service (QoS) Policies

Internet Service Providers (ISPs) may implement Quality of Service (QoS) policies that prioritise certain types of traffic over others. This can result in increased propagation delays for lower-priority packets, affecting the overall user experience⁵.

6.5. Geographical Factors

The location of servers relative to user bases can greatly impact propagation delays. For instance, a website hosted on a server located halfway around the world will inherently experience longer propagation delays for users accessing it than one hosted locally⁶. Propagation delays influence website availability in numerous ways.

A key aspect of availability is the time it takes for a website to load fully. When propagation delays are substantial, users may experience increased loading times, resulting in a higher probability of abandoning the site before it fully takes longer than three

² <https://www.whatsmydns.net/>

³ <https://hostafrica.co.za/blog/domains/dns/what-is-dns-propagation/common-dns-propagation-issues-and-how-to-fix-them>

⁴ <https://www.ibm.com/topics/dns-propagation>

⁵ <https://blog.j2sw.com/xisp/quality-of-service-qos-for-internet-service-providers-isps/>

⁶ <https://techgdpr.com/blog/server-location-gdpr/Impact on Website Availability>

seconds to load⁷. Hence, even minor propagation delays can lead to significant decreases in user retention and satisfaction⁸.

7. Findings on the Impact of DNS Propagation Delays on Website Availability and User Experience

The availability and speed of websites are paramount for both users and businesses. Propagation delays, often overlooked in discussions about network performance, can significantly affect website availability and user experience. Understanding the implications of these delays is essential for web developers, network engineers, and business owners aiming to optimise their online presence⁹. Propagation delay refers to the time taken for packets of data to travel from the source to the destination across a network. This time is primarily influenced by the physical distance between the two points and the medium through which data travels.

Generally measured in milliseconds, propagation delays can be the result of various factors, including network congestion, routing inefficiencies, and the nature of the physical infrastructure itself¹⁰.

7.1. Impact on User Experience

The user experience encompassing optimal engagement, satisfaction, and ease of use can be severely hindered

⁷ <https://www.thinkwithgoogle.com/consumer-insights/consumer-trends/mobile-site-load-time-statistics/>

⁸ <https://chemicloud.com/blog/dns-propagation/>

⁹ (Kurose, Ross, 2017, p. 127,129)

¹⁰

<https://www.techtarget.com/searchnetworking/definition/propagation-delay>

by propagation delays. A website that loads slowly frustrates them and detracts from web design's aesthetic and functional elements. For instance, animations, videos, and other rich media that enhance interactions may fail to load altogether or lag, leading to a disjointed user journey. Research conducted by Akamai suggests that a two-second delay in web page load times can increase bounce rates by 103%¹¹. Moreover, user expectations regarding website performance have evolved in tandem with technological advancements. Today's users anticipate instant gratification; businesses can keep customers engaged by creating seamless, fast online experiences. A delay of even a few seconds can shift user perception unfavourably, potentially branding a website as untrustworthy or inefficient.

7.2. The Impact on Website Availability

Website availability refers to the accessibility of a website for end users, and propagation delays can heavily influence this. For instance, if a user attempts to access a website hosted on a server located far away, the propagation delay can lead to slow loading times. This delay can frustrate users and lead them to abandon the website altogether¹². A study conducted by Google revealed that "53% of mobile users will abandon a website if it takes longer than three seconds to load"¹³

¹¹<https://www.researchgate.net/publication/361717406>

¹² <https://www.uptimia.com/learn/what-is-website-availability>

¹³ <https://www.vallettasoftware.com/website-audit.html>

Propagation delays are an inherent aspect of network communication due to physical distance, network congestion, and transmission mediums. The speed of light in fibre optic cables, for instance, is about two-thirds of its speed in a vacuum, which leads to unavoidable delays in data transfer¹⁴.

Consequently, as the geographic distance between users and data centres increases, so does the propagation delay, directly affecting the availability of websites and the responsiveness of services.

In practical terms, propagation delays manifest as latency, the time a data packet takes to traverse from the source to the destination. Latency is influenced not only by propagation delays but also by queuing delays, processing delays, and transmission delays, making it a multifaceted issue. Understanding these delays is critical for both web developers and users as even minor delays can accumulate to result in a significant hindrance to the user experience ¹⁵.

7.3. TTL Settings

TTL plays a critical role in propagation. A shorter TTL can lead to faster updates but may increase the number of requests made to the DNS server, leading to potential server load issues. Conversely, longer TTL values can be advantageous for improving load times but may delay reflecting updates. Understanding the balance between these implications is vital for webmasters when planning changes to

their DNS records¹⁶. If the TTL is set to a high value, changes will take longer to propagate¹⁷.

7.4. ISP Policies

Rather than getting new information from your DNS server, ISP caches DNS records by storing the information locally. This may slow the propagation time but also speeds up online browsing and lowers traffic. Some ISPs only update their cached records every two to three days, ignoring TTL settings. The speed at which DNS changes reach end users is influenced by the caching policies that Internet service providers (ISPs) may employ in addition to maintaining their own DNS servers. ISPs occasionally keep records in their caches for longer than the suggested TTL values. This suggests that end consumers using specific ISPs might not notice updates immediately, even if they might be visible on authoritative servers¹⁸. ISP's cache DNS records and some users may still be directed to the old IP address even after the DNS records have been updated¹⁹.

7.5. Browser and Operating System Caching

When ISPs ignore TTL values and keep records in the cache after the records have expired, propagation can slow significantly. Additionally, end-users' devices may cache DNS information. Browsers maintain their cache, which can further delay the visibility of

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<https://www.techtarget.com/searchnetworking/definition/propagation-delay>

¹⁵ <https://www.geeksforgeeks.org/delays-in-computer-network/>

¹⁶ <https://www.ibm.com/topics/dns-propagation>
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¹⁷ <https://www.ibm.com/topics/dns-propagation>

¹⁸ <https://www.godaddy.com/en-ph/help/what-factors-affect-dns-propagation-time-1746>

¹⁹ <https://hostafrica.co.za/blog/domains/dns/what-is-dns-propagation/>

changes. Users may need to clear their browser cache or perform a flush DNS command on their operating systems to ensure they are accessing the latest information²⁰.

7.6. Domain Name's Registry

When changes are made to a domain name's nameserver, the change request might get to the registry within a few minutes. The registry will, in turn, publish the new nameserver record to their root zone. Most registries will make the update promptly. However, to protect root nameservers from overuse, some registries might set their TTL to as high as 48 hours or more²¹.

7.7. User Experience and Latency

User experience is a broad concept that encompasses all aspects of a user's interaction with a website, including ease of navigation, speed, and overall satisfaction. Latency, heavily influenced by propagation delays, plays a central role in shaping user experiences. A website with high latency can result in poor user perceptions, which can adversely affect brand loyalty²². Websites rely heavily on quick response times to enhance user experience. A study examining user behaviour found that "nearly 70% of consumers cited page speed as a primary factor in overall satisfaction, implying that latency

could cause potential customers to visit competitor sites instead". Thus, when users encounter slow-loading pages due to high propagation delays, their likelihood of completing a purchase diminishes, leading to lost revenue for businesses²³.

Furthermore, the psychological aspect of waiting plays a significant role in online interactions. According to research published in the Journal of Experimental Psychology, users perceive longer wait times as a result of poor site performance. This perception can induce frustration and lead to negative emotional responses (Ariely, 2008). Users expect instantaneous information, and even minor increases in load times can shift their perceptions of a website's quality and reliability²⁴.

8. Mitigating Propagation Delays

Given the potentially adverse impacts of propagation delays on website availability and user experience, various strategies can be employed to mitigate these delays. This include:

8.1. Content Delivery Networks (CDNs): By employing CDNs, businesses can store cached versions of their content in various geographical locations, reducing the distance between users and servers. This can significantly minimise propagation delays and enhance website load times²⁵.

²⁰ <https://jvns.ca/blog/2021/12/06/dns-doesn-t-propagate/>

²¹ <https://www.scalahosting.com/kb/what-factors-affect-dns-propagation-time/>

²² <https://codeconspirators.com/importance-of-user-experience-of-a-website/>

²³

https://www.researchgate.net/publication/277967995_The_effects_of_online_service_quality_of_e

[commerce_Websites_on_user_satisfaction/link/5b90ef86299bf114b7fea57c/download?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19](https://www.researchgate.net/publication/338336943_Perceived_Waiting_Time_and_Waiting_Satisfaction_a_Systematic_Literature_Review)

²⁴https://www.researchgate.net/publication/338336943_Perceived_Waiting_Time_and_Waiting_Satisfaction_a_Systematic_Literature_Review

²⁵

<https://www.cloudflare.com/learning/cdn/what-is-a-cdn/>

- 8.2. Optimising Content: Streamlined and optimised websites can load faster. Techniques such as image compression, minimising HTTP requests, and leveraging browser caching can reduce the size of the data packets being transmitted, resulting in quicker loading times²⁶.
- 8.3. Selecting Appropriate Hosting Solutions: Companies must strategically choose hosting solutions that suit their user demographics. Hosting a website close to the target audience, or opting for a distributed hosting solution, can decrease propagation delays²⁷.
- 8.4. Implementing DNS Prefetching: This technique can help minimise delays related to domain name resolution (the process by which domain names are translated into IP addresses). By prefetching DNS information, users experience quicker loading times, as the browser can resolve domain names more rapidly²⁸. Propagation delays undoubtedly have a significant impact on website availability and user experience. As the digital landscape evolves, the expectation for fast and reliable web experiences continues to grow. Businesses must adapt their strategies to address the challenges posed by these delays, ensuring they maintain a

competitive edge in a crowded marketplace. By implementing effective measures to mitigate propagation delays, organisations can enhance both the performance of their websites and the satisfaction of their users. A robust understanding of propagation delays and their implications is fundamental for web developers and businesses alike, steering them toward a more proficient and user-centric approach to online engagement²⁹.

- 8.5. Employing edge computing can further help reduce latency. By processing data closer to the source (i.e., the user), edge computing minimizes the distance that data must travel, thus reducing propagation delays. As highlighted in a report by the International Data Corporation (IDC), “edge computing can significantly enhance response times by enabling real-time data processing, ideal for applications requiring low latency” (IDC, 2021).
- 8.6. The Future of Web Performance: As technology continues to advance, the expectations regarding website performance will likely increase. Emerging technologies such as 5G networks promise to reduce propagation delays drastically, while

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<https://developers.google.com/solutions/content-driven/hosting/optimizations>

²⁷ <https://hostafrica.co.za/blog/marketing/web-hosting-success-strategies/>

²⁸ <https://www.geeksforgeeks.org/what-is-dns-prefetch/>

²⁹

<https://www.sciencedirect.com/science/article/pii/S2772503024000021>

innovations in web architecture and design will enhance the overall user experience. The evolution of web technologies, including protocols like HTTP/3, which uses QUIC (Quick UDP Internet Connections) to reduce latency, further supports the need for organisations to adapt to the changing landscape of web performance (Dohm, 2023).

businesses mindful of their online reputations³¹. If organisations streamline DNS propagation and reduce delays, it can enhance overall user satisfaction, thereby engendering a sense of trust and reliability in web services.

9. Recommendation

To safeguard against the adverse effects of DNS propagation delays, organisations can adopt various strategies, including:

- 9.1. **Increased Security Awareness:** The performance of websites is paramount for users and businesses alike. Among the factors influencing website availability and user experience, DNS (Domain Name System) propagation delays emerge as a critical bottleneck. Understanding DNS propagation and its delays not only aids in enhancing technical performance but also bolsters user engagement, customer retention, and, ultimately, revenue growth³⁰.
- 9.2. **Effects on User Experience:** DNS propagation delays can considerably impair user experience. Whether or not a user can access a website is only the starting point; the subsequent latency and delays can lead to user frustrations, increased bounce rates, and ultimately, a diminutive return on investment for

- 9.3. **Redundancy:** Incorporating multiple DNS servers can alleviate bottlenecks when changes are made. This strategy ensures that updates are disseminated more efficiently and equitably across geographical regions³².
- 9.4. **Regular Performance Audits:** By establishing a routine for monitoring DNS performance³³, ZADNA can pinpoint discrepancies and inefficiencies, effectively responding to delays before they adversely impact users.
- 9.5. **Stakeholder Education:** ZADNA can play an integral role in educating stakeholders—be they businesses or individual domain owners—on the implications of TTL settings and timely propagation. This knowledge can promote more judicious management of DNS records.
- 9.6. **Advanced DNS Solutions:** Investing in advanced DNS technologies, such as Anycast DNS, allows for faster responses to user requests by routing traffic to the closest

³⁰ <https://www.ibm.com/topics/dns-propagation>

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<https://hostafrica.co.za/blog/domains/dns/what-is-dns-propagation/>
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³² <https://www.wallarm.com/what/dns-load-balancing-and-failover>

³³ <https://www.dotcom-monitor.com/learn/glossary/dns-monitoring/>
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operational server, thereby minimising unnecessary delays³⁴.

9.7. Transparent Communication: Maintaining open lines of communication around expected propagation times can also manage user expectations. The knowledge that updates may take up to 48 hours can prevent frustration and confusion during crucial periods.

10. Conclusion

DNS propagation delays pose significant challenges to website availability and user experience, especially for organisations that aim to foster a stable and user-friendly online environment. The multifaceted nature of these delays – from economic implications to the erosion of user trust – requires comprehensive strategies to address them effectively. By reducing TTL values, leveraging caching mechanisms, and employing robust monitoring solutions, organisations can position themselves to counteract some of the adverse impacts of DNS delays. Further, user education and redundancy measures are key components of a well-rounded approach. Through these efforts, organisations can not only enhance website availability but also bolster user experience, ensuring a more reliable and robust online ecosystem for all users.

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