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Assessing the influence of USB-C and USB-A Local Area Network (LAN) Cable Connector Adapters on Internet Latency Performance

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ABSTRACT

Abstract This research investigates the potential influence of USB-C and USB-A Local Area Network (LAN) cable connector adapters on internet latency performance. With the growing prevalence of USBC ports on modern devices, the use of adapters to connect them to traditional RJ45 Ethernet cables is becoming increasingly common. This study aims to determine if these adapters introduce any significant latency overhead compared to direct RJ45 connections. The research will explore the technical specifications of USB-C and USB-A protocols in relation to data transfer speeds and potential bottlenecks introduced by adapters. Real-world testing will be conducted to measure and compare latency experienced with both USB-C and USB-A adapter configurations against a direct RJ45 connection. The findings of this research will be valuable for users seeking to understand the potential impact of USB-C and USB-A LAN adapters on their internet experience. It will shed light on whether the convenience of using these adapters comes at the cost of increased latency, a critical factor for applications sensitive to real-time data exchange.

Keywords – **LAN RJ-45, Latency, Universal Serial Bus, USB Type-A, USB Type-C.**

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1. INTRODUCTION

This research paper embarks on an in-depth investigation into a highly relevant and timely topic: the influence of USB-C and USB-A Local Area Network (LAN) cable connector adapters on internet latency performance. As the digital age progresses, the prevalence of USB-C ports on modern devices is growing rapidly. This has led to an increased reliance on adapters to connect these devices to traditional RJ45 Ethernet cables, which are still widely used for wired internet connections. The primary aim of this study is to determine whether the use of these adapters introduces any significant latency overhead compared to direct RJ45 connections. Latency, defined as the delay before a transfer of data begins following an instruction for its transfer, is a critical factor in the performance of internet connections. High latency can lead to a laggy or unresponsive internet experience, which can be particularly detrimental for real-time applications such as video conferencing or online gaming. The research will delve into the technical specifications of USB-C and USB-A protocols, focusing on their data transfer speeds and potential bottlenecks introduced by adapters. It will also involve real-world testing to measure and compare the latency experienced with both USB-C and USB-A adapter configurations against a direct RJ45 connection. The findings of this research will be valuable for users seeking to understand the potential impact of USB-C and USB-A LAN adapters on their internet experience. It aims to shed light on whether the convenience of using these adapters comes at the cost of increased latency, a critical factor for applications sensitive to real-time data exchange. By providing a thorough and detailed analysis of this topic, this research aims to contribute to a better understanding of the implications of using USB-C and USB-A LAN adapters, thereby aiding users in making informed decisions about their internet connectivity options.

2. METHODOLOGY

Methodology for this study will be divided into two primary phases: theoretical exploration and empirical testing. The theoretical exploration phase will involve a comprehensive

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review of existing specification of USB A and USB C. This review will identify key concepts, theories, and frameworks that underpin the research question. Once the theoretical foundation is established, the empirical testing phase will commence. This phase will involve the collection and analysis of quantitative or qualitative data to test the hypotheses or research questions derived from the theoretical exploration. The specific methods employed in the empirical testing phase will depend on the nature of the research question and the available data.

2.1 Theorical Exploration

First, Technical Specifications. The Universal Serial Bus Type-C connector, spearheaded by a collaborative effort between USB-IF and major tech companies, has revolutionized the way we connect devices. Introduced in 2014, this sleek and versatile interface boasts a multitude of capabilities, making it a true powerhouse of connectivity.

2.1.1 USB Type C Technical Specifications

No	Version	Code Name	Transfer Speeds	Connectors
1	1.0/1.1	-	12 Mb/s	Type C
2	2.0	Hi-Speed	480 Mb/s	Type C
3	3.0/3.1 Gen 1	Super Speed 5	5 Gb/s	Type C
4	3.1 Gen 2	Super Speed 10	10 Gb/s	Type C
5	3.2	Super Speed 20	20 Gb/s	Type C
6	USB 4	-	20-40 Gb/s	Type C
7	USB 4 Version 2	-	80 Gbs	Type C

Table 2.1 usb type-c technical specifications

While USB Type-C steals the spotlight with its sleek design and cutting-edge features, its predecessor, the USB Type-A connector, remains a workhorse in the world of connectivity. Introduced in the mid-1990s, USB Type-A has become ubiquitous, appearing on countless computers, peripherals, and chargers

2.1.2 USB Type A Technical Specifications

No	Version	Code Name	Transfer Speeds	Connectors
1	1.0/1.1	-	12 Mb/s	Type - A
2	2.0	Hi-Speed	480 Mb/s	Type - A
3	3.0/3.1 Gen 1	Super Speed	5 Gb/s	Type - A
4	3/1 Gen 2	Super Speed 10	10Gb/s	Type - A

Table 2.2 usb type-a technical specifications

In summary, both USB-C and USB-A have their unique specifications and have evolved over time to support higher data transfer speeds. While USB-C offers more versatility and higher speeds, USB-A remains a reliable and compatible choice for many devices. Seconds, Potential Bottlenecks. When assessing the influence of USB-C and USB-A Local Area Network (LAN) cable connector adapters on internet latency performance, several potential bottlenecks could impact the results. The quality of the adapter is a significant factor, as poorly manufactured adapters may not meet the technical specifications of the USB-C or USB-A protocols, leading to increased latency. Similarly, the quality of the LAN cable used can also affect the latency. Damaged or low-quality cables can cause data loss or require retransmission of data, increasing latency. Not all devices fully support the capabilities of USB-C or USB-A. Older devices may not be able to fully utilize the speed capabilities of these protocols, leading to increased latency. The software drivers used by the operating system to interface with the USB-C or USB-A adapters can also impact latency. Outdated or poorly optimized drivers can reduce performance. External factors such as network congestion, physical distance from the server, and the quality of the network infrastructure can also influence latency. Lastly, USB-C and USB-A adapters require power to operate. If the device they are connected to cannot provide sufficient power, their performance may be throttled, leading to increased latency. These potential bottlenecks should be considered when assessing the influence of USB-C and USB-A LAN cable connector adapters on internet latency performance.

2.2 Empirical Testing

To evaluate the impact of USB-C and USB-A LAN cable connector adapters on internet latency, this study will conduct real-world testing under various conditions to measure and compare their performance against a direct RJ45 connection. First, test setup. Real-world testing will be conducted to measure and compare the latency experienced with both USBC and USB-A adapter configurations against a direct RJ45 connection. These tests will be carried out under a variety of conditions and with different types of internet traffic to ensure a comprehensive assessment. Seconds, data collection. Latency data will be collected using network diagnostic tools. The data will be recorded and analyzed to determine the impact of using USB-C and USB-A LAN adapters on internet latency performance. And third, data analysis. The collected data will be statistically analyzed to draw conclusions about the influence of these adapters on internet latency performance. This will involve the use of statistical software and techniques to ensure the validity and reliability of the findings. This methodology is designed to provide a thorough and rigorous assessment of the influence of USB-C and USB-A LAN cable connector adapters on internet latency performance. By combining theoretical exploration with empirical testing, the research aims to provide a comprehensive understanding of this topic.

3. RESULTS

3.1 Direct LAN Cable (RJ-45) Connection

No	Result	Status
1	16ms	-
2	16ms	-
3	17ms	Increased by 1 millisecond
4	17ms	-
5	16ms	Decreased by 1 millisecond
6	16ms	-
7	16ms	-
8	16ms	-

Table 3.1 local area network test results

The direct LAN cable connection exhibits the most stable and consistent performance among the three configurations tested. The latency values predominantly stay at 16 ms, with only minor variations observed. A slight increase to 17 ms occurs intwo instances, and a corresponding decrease back to 16 ms follows. These variations are minimal, amounting to just a 1 mschange, indicating a very stable connection. The direct LAN cable's performance is superior due to the inherent reliability and high bandwidth capability of wired connections, which areless prone to interference compared to wireless or adapted connections.

3.2 With Type-C Adaptor

No	Result	Status
1	18ms	-
2	21ms	Increased by 3 milliseconds
3	18ms	Decreased by 3 milliseconds
4	21ms	Increased by 3 milliseconds
5	18ms	Decreased by 3 milliseconds
6	19ms	Increased by 1 millisecond
7	21ms	Increased by 2 milliseconds
8	18ms	Decreased by 3 milliseconds

Table 3.2 usb type-c test results

Using a Type-C adaptor introduces greater variability in latencycompared to the direct LAN connection. The results fluctuate between 18 ms and 21 ms, with notable increases and decreases of 3 ms occurring multiple times. The average latency is higherthan the direct LAN connection, and the frequent changes suggest a less stable connection. The fluctuations can be attributed to the additional processing required by the adaptor to convert signals from one format to another. Type-C adaptors are commonly used for their versatility and ability to connect various devices, but they may introduce overhead that affects performance. The slight increases and decreases in latencymight also be influenced by the adaptor's handling of data packets, potentially causing brief delays.

3.3 With Type-A Adaptor

No	Result	Status
1	18ms	-
2	21ms	Increased by 3 milliseconds
3	18ms	Decreased by 3 milliseconds
4	21ms	Increased by 3 milliseconds
5	18ms	Decreased by 3 milliseconds
6	20ms	Increased by 2 milliseconds
7	19ms	Decreased by 1 millisecond
8	23ms	Increased by 4 milliseconds

Table 3.3 usb type a test results

The Type-A adaptor exhibits the highest variability and overalllatency among the three configurations. The latency values range from 18 ms to 23 ms, with frequent and significant fluctuations. The increases of 3 ms and 4 ms, as well as decreases of 3 ms, are indicative of a more unstable connection. The Type-A adaptor, like the Type-C, adds an extra layer of processing which impacts performance. However, the Type-A adaptors may be less efficient in handling network data compared to Type-C adaptors, leading to higher latency. This is evidenced by the more significant peak of 23 ms observed inone of the tests. The additional delay and inconsistency make the Type-A adaptor less suitable for applications requiring stable and low-latency connections. From the data collected, itis evident that the direct LAN cable (RJ-45) connection provides the most consistent and lowest latency performance. The stability of the results, with most measurements at 16ms and only minor variations, highlights the efficiency and reliability of wired connections. Wired connections are generally preferred in environments where high performance and low latency are critical, such as data centers, gaming setups,and professional workspaces. In contrast, both the Type-C and Type-A adaptors introduce higher and more variable latency. The Type-C adaptor, although versatile and commonly used for its multifunctional capabilities, shows a range of 18 ms to 21 ms with frequent fluctuations. This indicates that while it is relatively efficient, itstill cannot match the stability of a direct LAN connection. The Type-A adaptor performs the worst among the three, with the highest latency readings and the most variability, ranging from18 ms to 23 ms. This makes it the least desirable option for latency-sensitive applications. The performance differences can be attributed to several factors, including the inherent limitations of adaptors, additional processing overhead, and potential interference or inefficiencies in data conversion. Adaptors, by design, introduce an extra step in the data transmission process, which can cause slight delays. The more stable performance of the direct LAN connection is a direct result of its straightforward, unimpeded path for data transmission, minimizing potential sources of delay.

3.4 Analytics

To provide a comprehensive analysis of the network latency test results, we will examine the average latency, range of latency values, and overall stability for each of the three connection configurations. A direct LAN cable (RJ-45), Type-C adaptor, and Type-A adaptor.

3.4.1 Direct LAN Cable (RJ-45) Connection

Data Recorded	Average
16,16,17,17,16,16,16,16	16.25

Table 3.5 avarage lan

Range of Latency: 17 ms - 16 ms = 1 ms

3.4.2 With Type-C Adaptor

Data Recorded	Average
18,21,18,21,18,19,21,18	19.25

Table 3.6 avarage type-c

Range of Latency: 21 ms - 18 ms = 3 ms

3.4.3 With Type-A Adaptor

Data Recorded	Average
18,21,18,21,18,20,19,23	19.75

Table 3.7 avarage type a

Range of Latency: 23 ms - 18 ms = 5 ms

3.5 Comparison and Interpretation

3.5.1 Average Latency

Direct LAN Cable	16.25ms
Type- C Adaptor	19.25
Type- A Adaptor	19.75

Table 3.8 avarage latency

The direct LAN cable has the lowest average latency, indicating the fastest and most efficient data transmission. Both adaptors increase the average latency by about 3-4 ms.

3.6 Range of Latency

Direct LAN Cable	1ms
Type- C Adaptor	3ms
Type- A Adaptor	5ms

Table 3.9 range of latency

The direct LAN cable connection also has the lowest range of latency, this means LAN cable connections is the most stable data transmissions

3.7 Standard Deviation

Direct LAN Cable	0.433ms
Type- C Adaptor	1.391ms
Type- A Adaptor	1.741ms

Table 3.10 standard deviation

The direct LAN cable shows the smallest range, highlighting itsstable performance. The adaptors, especially the Type-A, show a wider range, indicating less consistency in performance. The standard deviation values reinforce the findings from the rangeanalysis. The direct LAN cable has the lowest standard deviation, pointing to the least variability. The Type-C adaptorhas moderate variability, while the Type-A adaptor has the highest variability, making it the least reliable for consistent performance. The detailed analytics of the network latency testsconfirm that the direct LAN cable (RJ-45) connection provides the most stable and lowest latency performance. It is the preferred option for applications requiring real-time data transmission and minimal delay. The Type-C adaptor, while introducing some additional latency and variability, remains a viable option for general use where the highest performance isnot critical. The Type-A adaptor shows the most variability and highest latency, making it the least desirable choice for performance-sensitive applications. In summary, for optimal network performance, particularly in latency-sensitive scenarios, the direct LAN cable is the best choice, followed bythe Type-C adaptor, with the Type-A adaptor being the least favorable option.

4. CONCLUSION

In the realm of network systems, latency is a critical factor that determines the quality of a network connection. It refers to the time delay experienced when data is transmitted from one point to another. This delay is typically measured in milliseconds (ms). Lower latency is generally preferred as it signifies a faster and more efficient data transfer process, which is crucial for real-time applications such as online gaming, video conferencing, and live streaming. The test results above providea comparative analysis of the latency performance under three different connection methods: a direct LAN cable (RJ-45) connection, a connection with a Type-C adapter, and a connection with a Type-A adapter. The direct LAN cable (RJ- 45) connection emerged as the clear winner in this test, exhibiting the most stable and consistent performance. The latency values primarily remained at a low 16 milliseconds, with only minor variations observed. This highlights the inherent reliability and high bandwidth capability of wired connections, which are less prone to interference compared to wireless or adapter-based connections. Wired connections, suchas a direct LAN cable connection, offer a straightforward and unimpeded path for data transmission, minimizing potential sources of delay and ensuring a stable and consistent network performance. In contrast, both USB-C and USB-A adapters introduced higher and more variable latency. The USB-C adapter displayed results ranging from 18 milliseconds to 21 milliseconds, with occasional increases and decreases of 3milliseconds. This indicates that while the USB-C adapter is relatively efficient, it cannot match the stability of a direct LANconnection. The use of adapters inherently introduces an extra step in data transmission, leading to slight delays. Additionally,the signal conversion required by the adapters can contribute tolatency, affecting the overall network performance. The USB- A adapter performed the worst among the three, with the highest overall latency and the most significant variability, ranging from 18 milliseconds to 23 milliseconds. These frequent and substantial fluctuations make it a less suitable option for applications requiring stable and low-latency connections. The performance differences between the USB-Cand USB-A adapters can be attributed to several factors, including the quality of the adapters and the complexity of the signal conversion process. In conclusion, for optimal internet performance, particularly in latency-sensitive scenarios, a direct LAN cable connection is the undisputed champion. If portability necessitates an adapter, the USB-C option proves tobe a preferable choice compared to the USB-A adapter. This research provides valuable insights for users seeking to understand the impact of USB-C and USB-A LAN adapters ontheir internet experience, ultimately empowering them to make informed decisions for their connectivity needs. However, it’s important to note that these results might vary based on other factors such as network traffic, the quality of the network infrastructure, and the specific hardware and software configurations of the devices involved. Therefore, while these results provide a general guideline, users should consider their specific use cases and requirements when choosing between different connection methods.

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