



Impact of Network Conditions on Audio Streaming Service Reliability

By Taonga Soko

SELF INTRODUCTION



- Senior originally from Zambia majoring in Computer Science
- Interested in all things tech - specifically AI and Product management
- Hobbies include hiking, ping pong, and working out (only recently)

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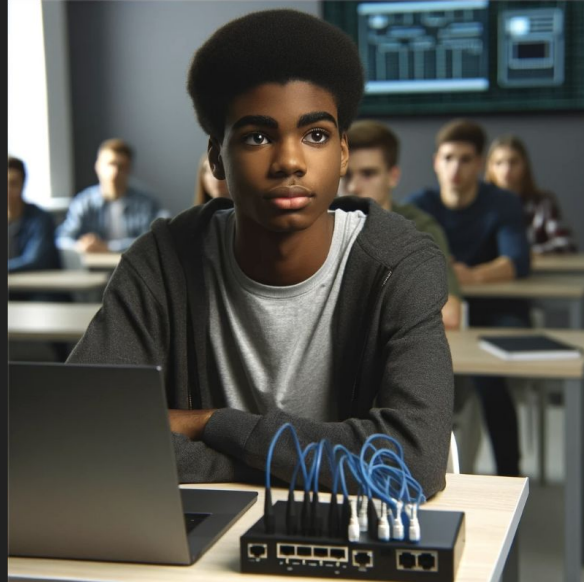
1. BACKGROUND & CONCEPTION
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1. BACKGROUND & CONCEPTION



MUSIC DEBATE →



SYE →



“IDEA!!”

1.1 THE IDEA?

SPOTIFY



APPLE MUSIC

SOUNDCLOUD



2. NETWORK CONDITIONS

DELAY → JITTER → LOSS



2.1 DELAY

Delay, or latency, refers to the amount of time it takes for a packet of data to travel from the source to the destination across a network. This includes the time taken for sending the data, processing at any intermediate nodes, and finally receiving it at the target.

¹ "What Is Latency?" IBM, 21 Mar. 2024, www.ibm.com/topics/latency



2.2 JITTER

Jitter refers to the variation in time between packets arriving, caused by network congestion, timing drift, or route changes. In a stable network, packets arrive at regular intervals. However, with jitter, these intervals vary.



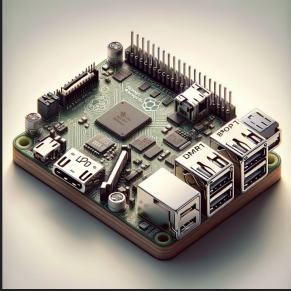
2.3 LOSS

Loss refers to the phenomenon where some packets of data fail to reach their destination. This can happen due to network congestion, faulty routers, or poor signal quality

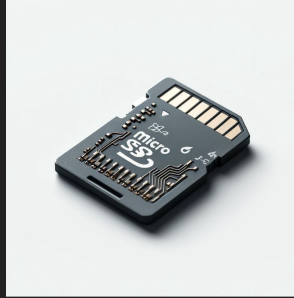


3. Team, IR. "Packet Loss Explained - Causes and Best Solutions." *IR*, www.ir.com/guides/what-is-network-packet-loss#:~:text=
Accessed 11 May 2024.

3. HARDWARE + SETUP



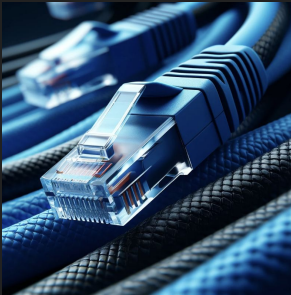
Raspberry pi



Micro SD Card



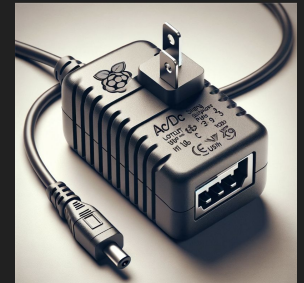
Laptop/macbook



Ethernet

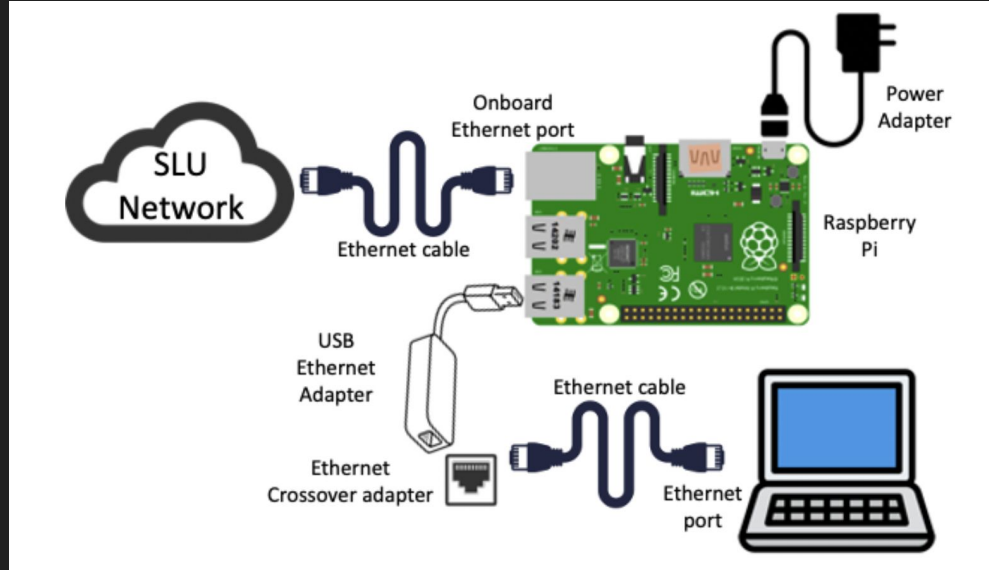


Adapters



Power supply

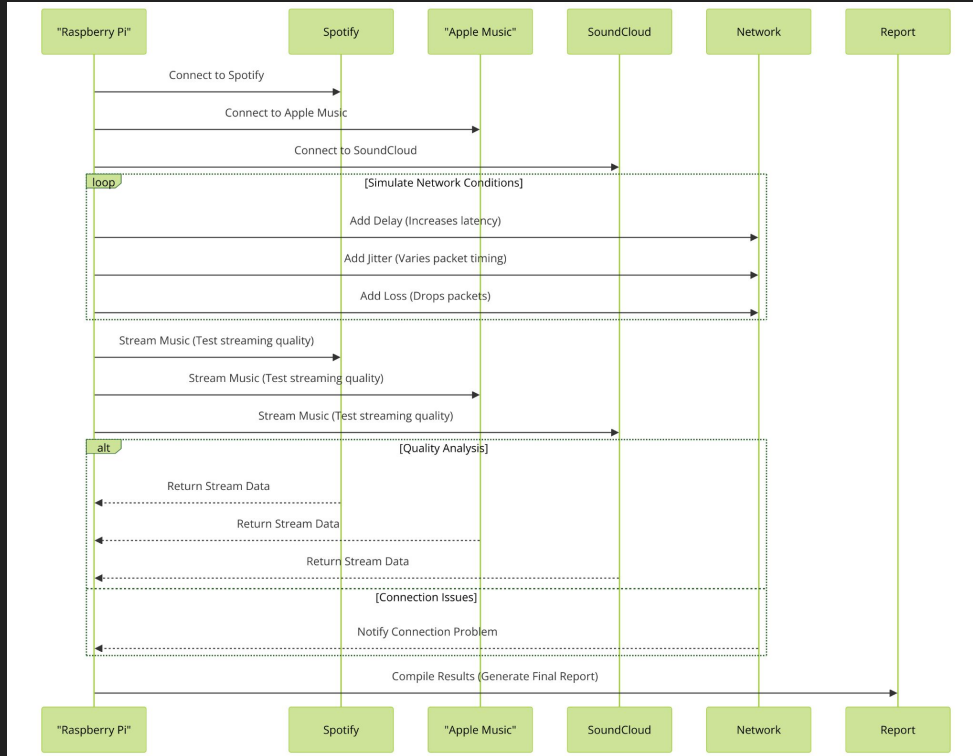
3.1 CONNECTION



```
STUDY_PRACTICE_24 --zsh -- 79x24

MyDataStructures      Project4
  eclipse
DSA Practice           IdeaProjects
  OneDrive - St. Lawrence University Public
  eclipse-workspace
Desktop               Indexer
  Pictures             PycharmProjects
  logisim-evolution-3.8.0-all.jar
Documents             Lab7
  Postman              RecursionExamples
Downloads             repos
  Project0             Library
  soko                 STUDY_PRACTICE_24
Examples              Movies
  Project1             Stock_Market
taongasoko@Taongas-MacBook-Air ~ % cd STUDY_PRACTICE_24/
taongasoko@Taongas-MacBook-Air STUDY_PRACTICE_24 % ls
CSS      CodePath      DOM_MANIPULATION      Day_2
        Economics      Forms                  Ramp
Client.py server.py    DAY_1                 Day8                  Day_6
        Express        Grid                  public
taongasoko@Taongas-MacBook-Air STUDY_PRACTICE_24 %
```

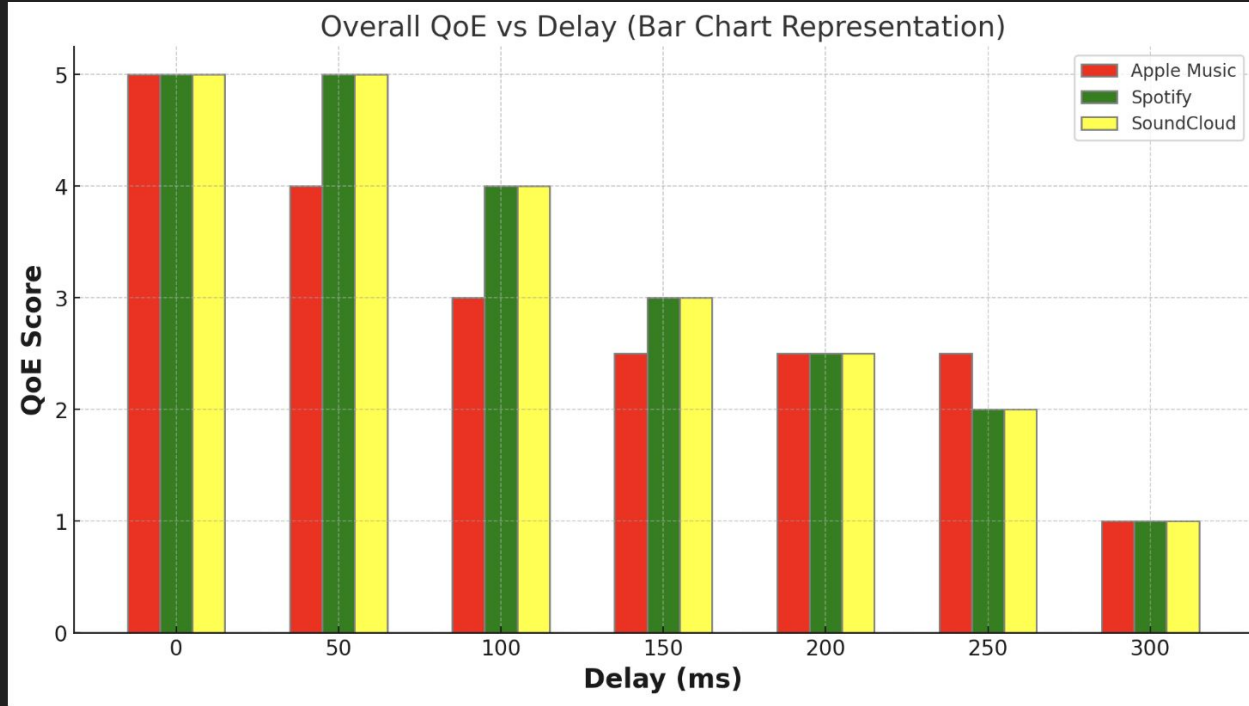
3.2 EXPERIMENT



```
sudo tc qdisc add dev eth0 root netem delay 300ms
```

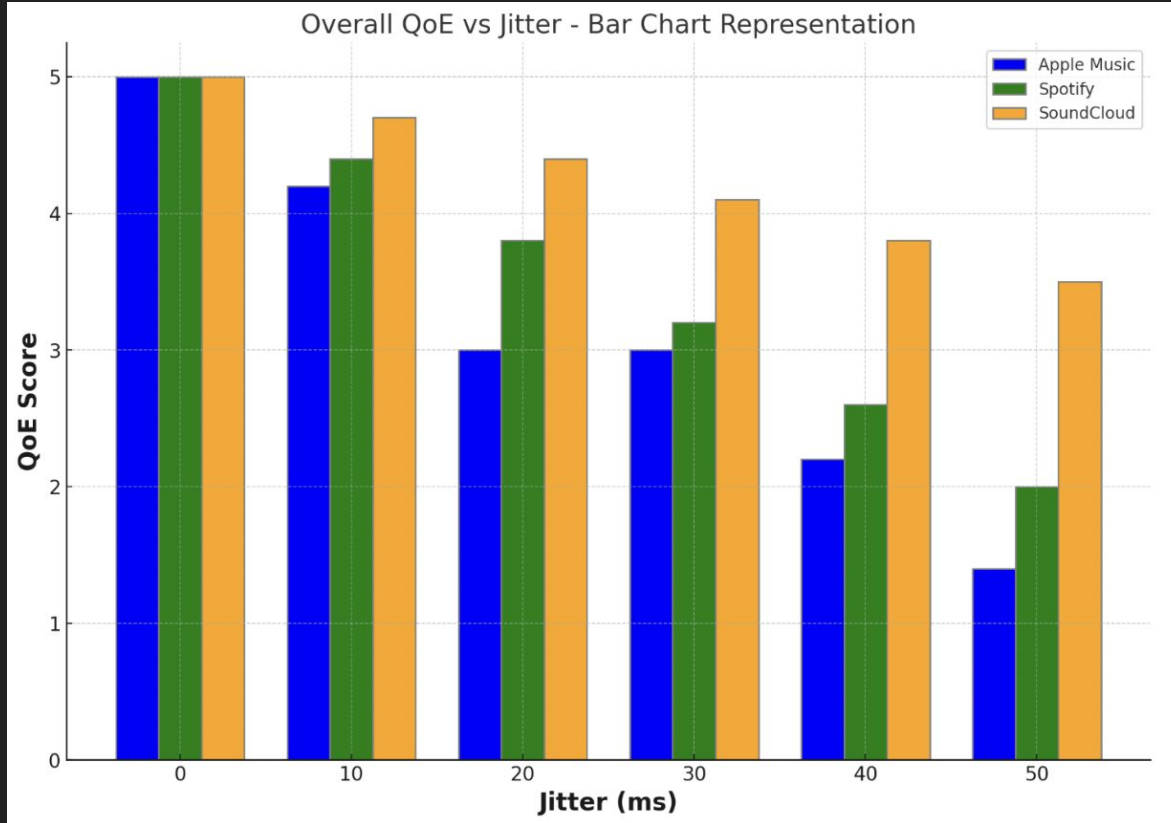
```
sudo tc qdisc add dev eth0 root netem loss 10.0% 25%
```


4. RESULTS → DELAY



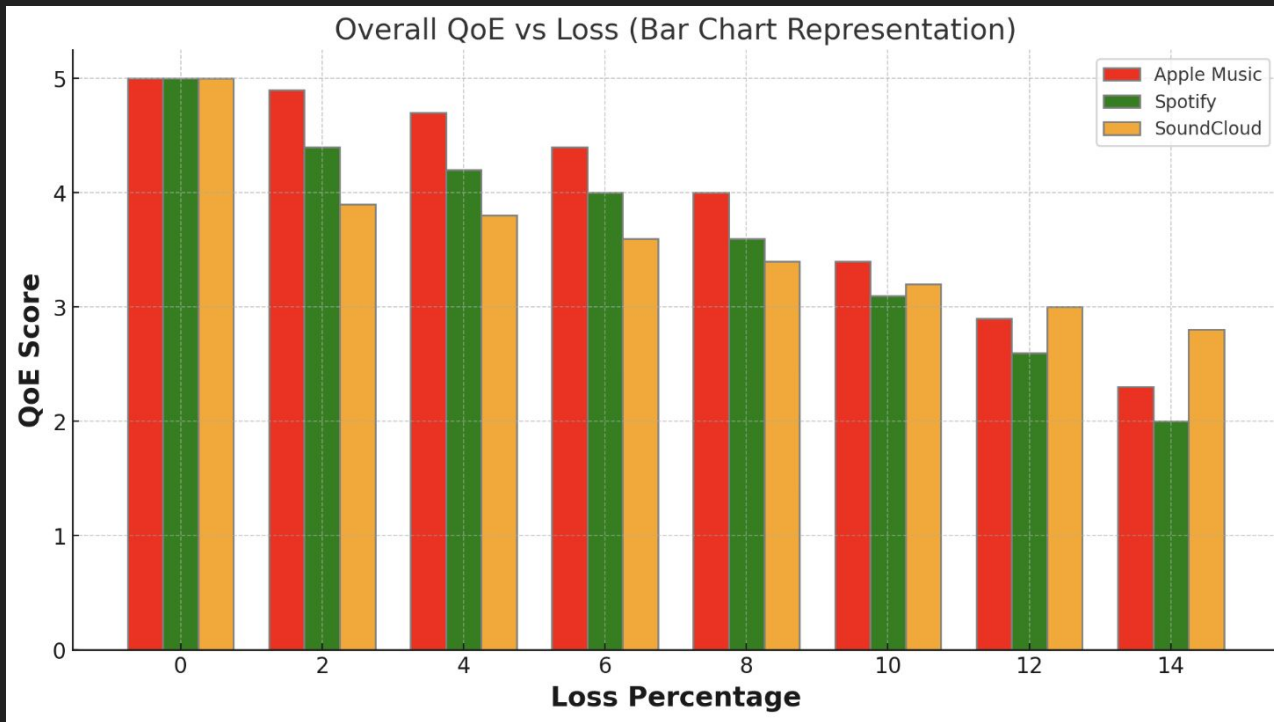
SPOTIFY
STREAMING
PROTOCOL (SPS)?

4.1 RESULTS → JITTER



SOUNDCLOUD'S
HTTP SLS?

4. 2 RESULTS → LOSS



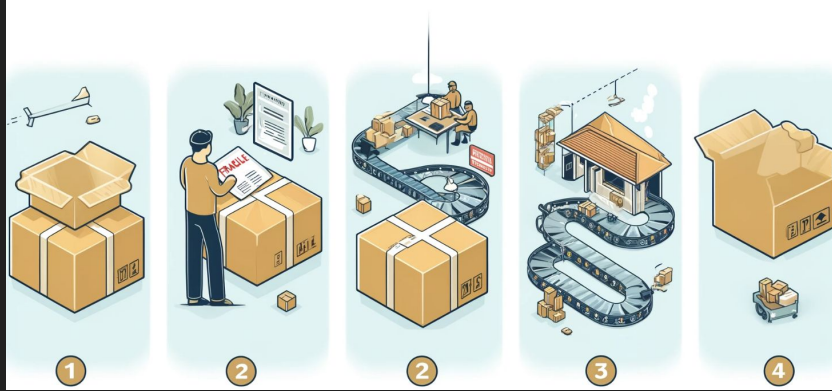
APPLE'S LOSSLESS
AAC?

5. PERFORMANCE + PROTOCOLS

TCP is a connection-oriented protocol, which means it establishes a connection between sender and receiver before data is sent. TCP ensures that data is delivered accurately and in the same order it was sent by using acknowledgments, retransmissions of lost packets, and sequence numbers to assemble packets in the correct order. This makes TCP more reliable but generally slower than UDP due to its overhead.

- **Web Browsing:** When you visit websites using HTTP/HTTPS, TCP is used to ensure all the web page content is loaded correctly and in order, including text, images, and other media.
- **Email (SMTP):** Email transmission protocols use TCP to ensure that all parts of your emails are sent and received without errors.
- **File Transfers (FTP):** TCP is used for file transfer protocols to ensure that files are completely and accurately transferred over the network.

5.1 REAL WORLD EXAMPLE



Imagine you're sending a valuable package through a courier service. Before the package is sent, you call the recipient to tell them it's coming. As the package moves, you get updates: when it's dispatched, when it arrives at a sorting facility, and finally, when it's delivered. TCP is similar in this structured, reliable approach.

5.2 PERFORMANCE + PROTOCOLS

UDP is a connectionless protocol, meaning it does not establish a connection before sending data. It sends data as packets (called datagrams) directly to the recipient without verifying whether the recipient is ready to receive the data or whether the data is received correctly. This makes UDP faster and more efficient for certain types of applications, but less reliable because it does not guarantee delivery, order, or error-free communication.

- **Online Gaming:** Speed is crucial in gaming, and UDP allows the fast transmission of game states, such as player positions and actions, without the overhead of ensuring every packet arrives.
- **Live Streaming and Voice over IP (VoIP):** For live audio and video streaming, including services like Skype or Zoom, UDP is used because it minimizes delays, and missing a few packets (which might cause a minor glitch in the stream) is preferable to waiting for delayed data.

5.3 REAL WORLD EXAMPLE



Imagine an announcer at a football game. There is no guarantee that what he has announced or said has been received by the people in the stands. There is no confirmation that comes back to him.

5.4 INDIVIDUAL PROTOCOLS

SPS (Spotify Streaming Protocol): Spotify uses a proprietary protocol known as Spotify Streaming Protocol (SPS), which is optimized for efficient transmission of music streams over the internet. The details of SPS are not extensively publicized as it's proprietary; however, it is designed to be highly resilient and efficient, enabling fast streaming and quick track changes with minimal buffering.

AAC (Advanced Audio Codec): Apple Music primarily uses the AAC format for streaming music. AAC is known for its efficiency and superior sound quality at similar or even lower bit rates compared to MP3. This codec is part of the MPEG-4 standard and is favored for its efficiency in bandwidth usage and its performance across a wide spectrum of sound frequencies.

CONTINUED.....

HTTP Live Streaming (HLS): SoundCloud uses HTTP Live Streaming for delivering content. HLS is an adaptive streaming communications protocol developed by Apple. Works by breaking the overall stream into a sequence of small HTTP-based file downloads, each downloading one short chunk of an overall potentially unbounded transport stream. As the stream is played, the client can adjust the quality of the stream according to the current network conditions.

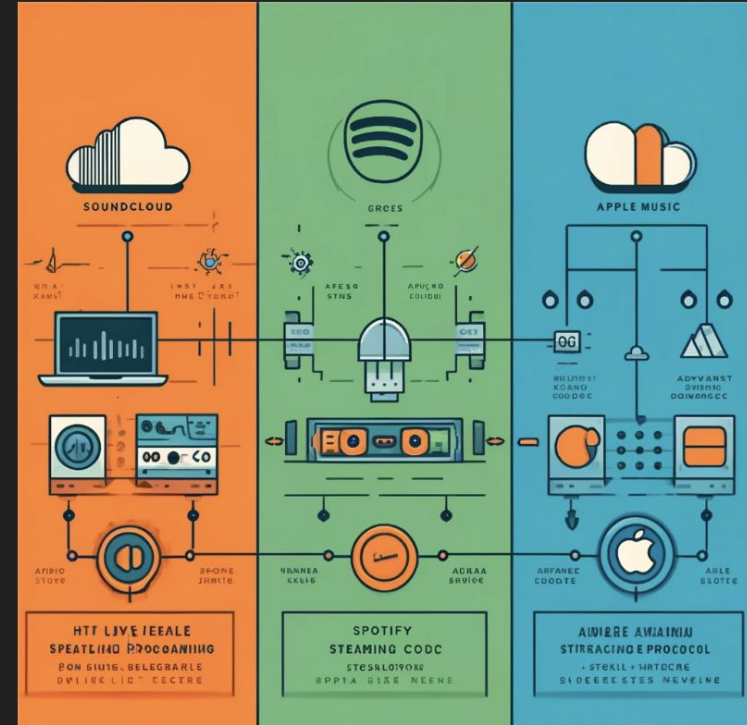
6. FUTURE RESEARCH

For my future research, I plan to delve into the streaming protocols and adaptive technologies utilized by major music streaming services such as SoundCloud, Spotify, and Apple Music.

I intend to explore SoundCloud's use of HTTP Live Streaming (HLS). Additionally, I aim to investigate Spotify's proprietary Spotify Streaming Protocol (SPS), which prioritizes efficient music transmission and quick track changes with minimal buffering.

Finally, my research will include a thorough analysis of Apple Music's use of the Advanced Audio Codec (AAC), focusing on its efficiency and superior sound quality. By comparing these technologies, I hope to gain insights into their operational efficiencies, potential areas for improvement, and their overall impact on user experience.

This comparative study will contribute to a broader understanding of how adaptive streaming technologies can enhance music streaming services in varying network environments.



7. WORKS CITED

1. Professor Choong-Soo Lee (*St. Lawrence University, Department of Mathematics, Statistics and Computer Science*)
2. SoundCloud. “Playback on Web at SoundCloud.” *SoundCloud Backstage Blog*, developers.soundcloud.com/blog/playback-on-web-at-soundcloud. Accessed 9 May 2024.
3. “Media Delivery Api.” *Media Delivery API | Spotify for Developers*, developer.spotify.com/documentation/commercial-hardware/implementation/guides/media-delivery. Accessed 9 May 2024.
4. “About Lossless Audio in Apple Music.” *Apple Support*, support.apple.com/en-us/118295#:~:text=Apple%20Music%20delivers%20an%20unparalleled,from%20the%20original%20studio%20recording. Accessed 9 May 2024.

ILLUSTRATIONS USED

4. *Chatbot App - Ai Image Generator Powered by Dall-E 3 and Stable Diffusion XL*, chatbotapp.ai/imagegeneration?utm_source=GoogleAds&utm_medium=cpc&utm_campaign=%7Bcampaign%7D&utm_id=21141503886&utm_term=157311759821&utm_content=695317756006&gad_source=1&gclid=CjwKCAjwrvyxBhAbEiwAEG_Kgjdpx-J149NVta0apHCXccQiQF_r4XceeVVlv0PE4-UZgRiMbs4ZRoC3IMQAvD_BwE. Accessed 9 May 2024.