In the last week, I interacted with my friends on a laptop through an application called Discord whilst playing a video game together. By using the Discord application's voice call function, I was able to communicate with my friends during the video game without any delays. This interaction required the use of digital audio data as well as the peripherals to collect the data, the hardware such as the Central Processing Unit within the laptop and the software such as Discord installed on the laptops. Alongside the Internet, these computing technologies were needed to allow for this interaction to be possible.

## COMPUTER ARCHITECTURE
The laptops we used to play video games and interact with each other had a Central Processing Units(CPUs), Random-Access Memory(RAM) sticks and a Graphics Processing Units(GPUs) built into them. With peripherals such as a microphone and a mouse, these hardware allowed for a seamless experience for me and my friends to play a video game together whilst communicating with each other on a Discord voice call.

The CPU which functions as the brain of the computer handled the processing of the digital audio data that was being taken in using the microphone as the input device. The CPU handled the encoding and decoding of the digital audio files being transferred and received to allow for seamless communication between me and my friends. It also handled the resources, sending the required instructions to the various parts of the laptops such as the RAM and the GPU so as to run the video game and the Discord application smoothly. The RAM provided quick access to the digital audio data and temporary storage of essential information, aiding in establishing a smooth and uninterrupted exchange of audio data between me and my friends. These two components allowed for the video game and the Discord application to run smoothly and without any problems on our laptops. The GPU allowed for smooth rendering of the graphics on the laptop screen, allowing for a smooth gaming experience, in turn improving the user experience by allowing for a smoother overall visual experience such as seeing graphics in higher definition or the smoother visuals when using the laptop.

The peripherals we used such as a microphone and a mouse helped in improving the user experience. The microphone helped to capture the voice data in an easy manner without any audio issues. The mouse helps in improving the user experience by allowing an easier movement of the pointer on the laptop monitor, allowing users to easily click on applications that they wish to open or to control the character or the character's viewpoint in a video game. The speakers built into the laptop or the headphones plugged in allowed for the audio from the game or the voices from my friends in Discord to be able to be heard.

As such, the peripherals and the laptop components work together all at once to allow for a seamless real-time conversation with my friends while gaming.

## DATA REPRESENTATION
Data such as digital audio files are used to allow for real-time conversations between my friends on Discord. Digital audio files follow an audio coding standard to allow for the storage or transmission of digital audio. Most commonly used digital audio formats are MP3, WAV and AAC, each having its own use case in the audio industry. Audio formats such as the MP3 are mostly used by the public as a way to share audio files on the Internet as their file size is smaller as compared to an audio compression format like WAV which is shared in its

original state without any file compression. The WAV audio format is used instead by professionals as there is no loss in the audio quality or audio data, making it suitable for professional use cases such as in audio engineering.

In my interactions with my friend, Discord uses the microphone that was plugged into the laptop to collect the audio data of our voices. This audio data that was collected by the microphone is converted into the Opus audio format via the built-in Opus codec within Discord. The codec is able to convert the analogue audio signals into digital audio format whilst optimizing the digital audio files for the bandwidth of the network connection that the laptop is currently using through either constant or variable bitrate encoding. The converted audio files are then sent to the Discord servers and members within the voice call can have the audio files decoded by the Opus codec to be played through their headphones or speakers for them to be heard in real-time. The Opus audio format which follows the audio coding standard codes speech and general audio into a single format that is low-latency, thus enabling real-time communication while being low-complexity enough for low-end processors to be able to process smoothly.

## AUDIO COMPRESSION
There are two different ways of data compression: lossy compression and lossless compression. While both do the same thing of reducing the file size of the data, the usage case for the different compression is different. Lossy compression is used when the file can afford to lose some data or storage space is a concern while lossless compression is used when none of the data being stored can be lost. This means lossless compression is mostly used in professional occupations where every bit of data within the files are important while lossy compression is used when quality is not of utmost importance or when storage space is limited. As such Discord makes use of the Opus audio format that is a lossy audio coding format, which means that while the audio will be degraded as information is lost during the compression, it results in a smaller file size. This alongside the fact that the Opus audio format is tuned towards human speech means that the file means that by using a lossy audio coding format, the file size being sent to Discord servers is much smaller as compared to using a lossless audio coding format and the data being lost is not substantial enough to affect the voice call. Coupling with the fact that everyone's bandwidth is different means that by making use of a lossy audio coding format, everyone is able to receive the audio data without any problems, allowing for seamless real-time conversation on the Discord voice call. If Discord was using a lossless audio coding format, Discord will not be able to handle the Discord voice calls at the scale that it does as with such an audio coding format, as the amount of data storage required by Discord would be so high that it would not be financially viable. With the fact that some devices might have poor bandwidth which results in slower transmissions of the audio data means that the real-time conversations that Discord currently has would not be possible.

## OPERATING SYSTEMS
The main functions of an operating system is to manage the computer's resources such as the CPU, to establish a Graphical User Interface(GUI) and execute and provide services for application software. Without the operating system, applications like Discord would not have access to the network framework that operating systems have to function as intended or be able to display the application as intended on the display. The Windows Operating System installed on our laptops as such provided a GUI for us to select applications like Discord

easily and display them whilst it handles the resources required to launch the applications. The operating system handles the requests given and sends the appropriate requests and/or information to the different parts of the laptop such as the CPU, GPU or RAM. The Windows Operating System also supports Application Programming Interfaces(APIs) that Discord uses to be able to communicate with the hardware on the laptops to be given the resources the application needs to run efficiently. These APIs that were supported by the operating systems allows Discord to be able to maintain compatibility across different devices whilst optimizing performance. The operating system provided the necessary framework for Discord to manage the data inputs from peripherals such as our voices and to send it to the relevant servers on the Internet by connecting the laptop to the Internet.

**CONCLUSION**

Thus, this interaction required a multitude of computational technologies such as the Opus codec within the Discord application to be able to convert the analogue signals collected by the microphone into a digital file format that can be sent to a Discord server via the Internet such that it can be shared across a multitude of devices that can then decode the audio file and play it through a speaker or a headphone such that the user can hear it in real-time without any delay. The Windows Operating System made it easy for me and my friends to select the applications that we wanted to open as well as provide the necessary frameworks and APIs for the applications that we use to function. The hardware within our laptops allowed the operating system and the application to be able to run as the CPU handled the tasks it was given and allocated them effectively, providing us with a pleasant user experience during the interaction.

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