Senior Design Proposal- Bluetooth WiFi Speaker Hub

1   Introduction

The aim of this design project is for senior engineering students Ben Colfer, Mia Gorman, Callie King, Deirdre Sheridan, and TJ Sims to apply their knowledge of electrical engineering principles to design a high-quality, flexible, and portable speaker configuration. Each member of the group is either currently or has taken the Audio Technology course offered by the University and will apply this knowledge to the project as well.

2   Problem Description

Portable speakers have become an integral part of every person's day-to-day life. They're used socially on the beach, on bike rides, and at picnics. They come in all different shapes and sizes. But they lack the sound quality that other non-portable speakers provide. They also lack the surround sound experience that makes music and other media forms so enjoyable.

The problem that this project aims to solve is simple: portable speakers cannot truly fill larger spaces with high-quality audio. Often, when choosing the portable option for a speaker, the consumer has to sacrifice high-quality audio. Speakers are plagued with audio distortion, limited loudness, popping or humming sounds, and so enjoyment of the media is lessened. When having an outdoor party, having one portable speaker means that only a small subset of the audience gets to enjoy the music.

3   Proposed Solution

The goal of the Bluetooth WiFi Speaker Hub team is to design a speaker configuration that provides high-quality sound on the go for its users. The speaker design will be composed of smaller speaker units that will be flexible in their orientation. They can function as one large speaker or be broken up and distributed to create a more surround sound experience and allow music to be synced at various parts of a larger space. We will need to utilize rechargeable batteries and Bluetooth-enabled chips for each speaker that we have onboard memory.

4   Demonstrated Features

Portability: The speaker system will be chargeable and the parts will be able to move freely.

Surround sound capability: Having the drivers connect to each other via Bluetooth will allow the customer to enjoy a surround sound experience as they will all be placed in specific areas. Regardless of the space, there will be surround sound with this proposal.

High-quality sound: The speaker system will produce high-quality sound.

Bluetooth dual topology (multi-connection Bluetooth): A multi-node Bluetooth network with one node (the main hub) having both master and slave capability.

Connection stability and time synchronization: The system will distribute audio data to each speaker and, after a delay to ensure that all connections are stable and that each speaker has received sufficient data, begin audio playback through all speakers at the same time.

5   Available Technologies

The main available technologies that we will be working with include Bluetooth, 3D printing, and high-quality speaker components. We will use Bluetooth to connect to a cellphone or other device that supports Bluetooth. We will have to do more research on bluetooth protocol to understand if our multi-connection device will work over bluetooth. The hope is for one bluetooth chip (possibly the ESP-32) in the hub to act as both the slave to a user's device as well as a master to the peripheral speakers (additionally purchased chips). Briefly looking into Silicon Labs' Blue Gecko Bluetooth stack, it appears this should be possible with dual topology:
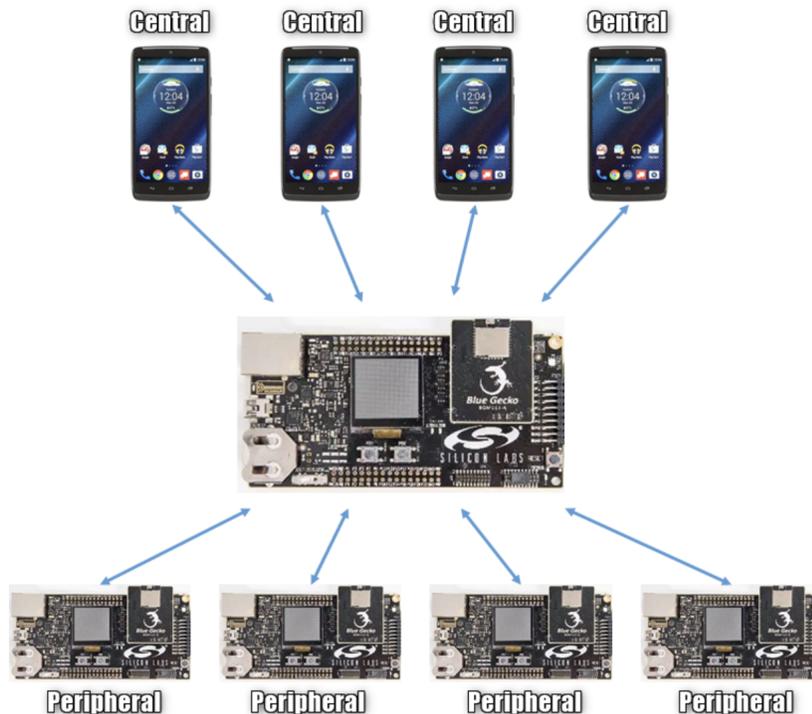
Bluetooth Dual Topology

We will use 3D printing to create the protective casing of the speaker in a way that we can configure separate pieces together and fit the components we choose. We will research to determine which speaker components, like drivers and subwoofers, best fit our budget as well as standards for quality. We plan to use a rechargeable lithium battery to power our speaker configuration. We will use Eagle to design a chip using the ESP32 microprocessor, and other available board components to create boards for the subwoofer and one for each speaker.

6   Engineering Content

Bluetooth Topology
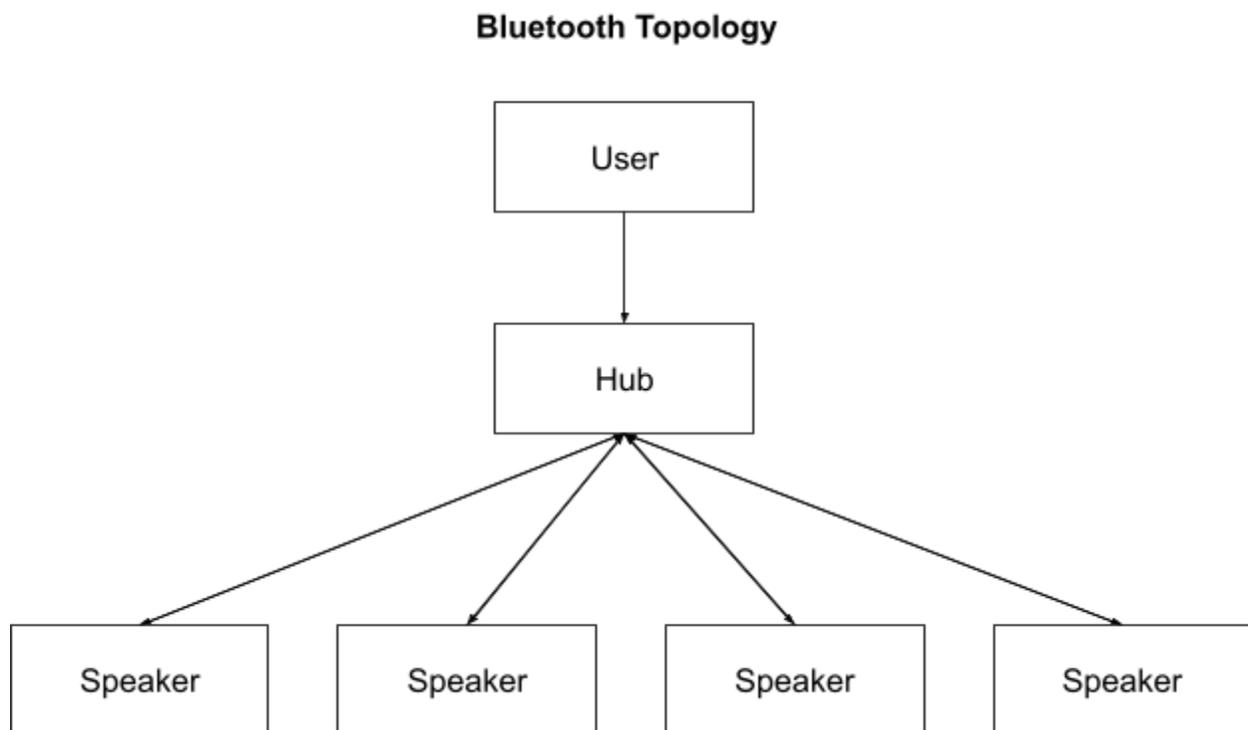
There are three main components to the engineering content of our project: power and charging, audio systems, and wireless communication. First, we will need to design rechargeable battery-based power circuits for the hub and each detachable speaker. We will need to consider things such as power requirements for each audio system/drivers, voltage/current regulation, and recharging the speakers within the hub.

As for the audio systems, we will need to design full systems from data reception through output to the driver. Ideally, we will be able to use pre-designed, Bluetooth-enabled chips at the receiving end. We will have to consider both

amplification and filtering. Amplification will most likely be done through hardware and filtering through software. Filtering could be done through hardware crossover networks, but we will have to decide which approach will be best for the project.

Finally, the wireless communication aspect of the project will be the main engineering challenge. As it stands, we are unaware of any existing communication protocol for connecting multiple audio systems for synchronized playback. It may be possible to use dual topology Bluetooth capable chips in the speakers and a microprocessor program in the hub to manage data transfer playback synchronization. If not, we may have to explore designing our own communication protocol over the Bluetooth band from the bitstream up in C++ or python. Either way, we will need to do more research and some of our own testing with Bluetooth dual topology first.

7   Conclusions

As of now, there's no product on the market that gives customers the ability to create surround sound from anywhere. The 4-6 rechargeable speakers connected via Bluetooth to the main hub (that will double as a subwoofer) will solve this problem. Since the speakers and hub are rechargeable they will be extremely portable. The customer will connect their phone or any other Bluetooth-enabled device to the main hub which all the speakers will be connected to. This will elevate the portable speaker market as current portable speakers they're either not loud enough or too loud.