COMP 4971C – Independent Studies

Title:

Audio via Bluetooth Implementation on a Raspberry Pi

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1. Motivation

The Raspberry Pi ®, a small development board such as the ones part of the Arduino family, has was released for instructional purposes in 2012 [1].

Since then, the community has built up to a large number online, with many documented projects, or D-I-Y (do it yourself). However, many of these projects only work for the author's specific environment or become obsolete after updates of operating systems, modules or [Linux] packages.

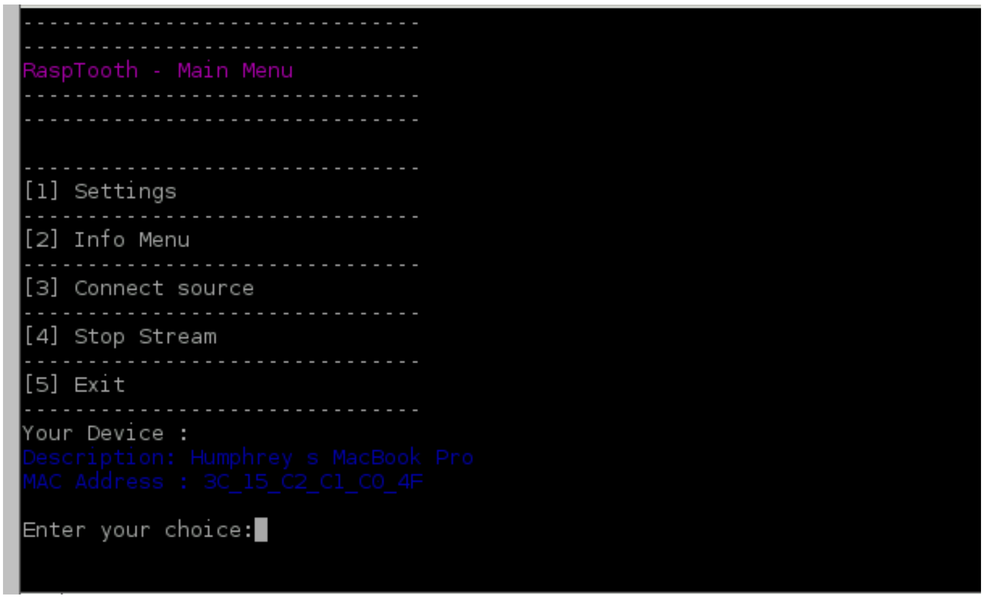
The aims of this project are to explore the Bluetooth® technology when streaming audio from a source device to a Bluetooth-enabled speaker on one hand, and to provide a reliable user interface to simplify the user's interactions with the machine when trying to control audio streams, on the other.

2. Features / End Product

The final product is a “semi-GUI”, in the sense that the graphical user interface appears in the command-line, rather than in a window. It is a simple selection menu that can be navigated with the number keys (1 to 7).
Most actions will output information to the screen.

2.1. Main Menu

The main menu lets a user access the two other menus, namely the Info Menu and the Settings Menu. Furthermore, it enables the user to connect an incoming audio *stream* to the selected output *source*, or to stop a running *stream* from playing.



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-------------------------------
RaspTooth - Main Menu
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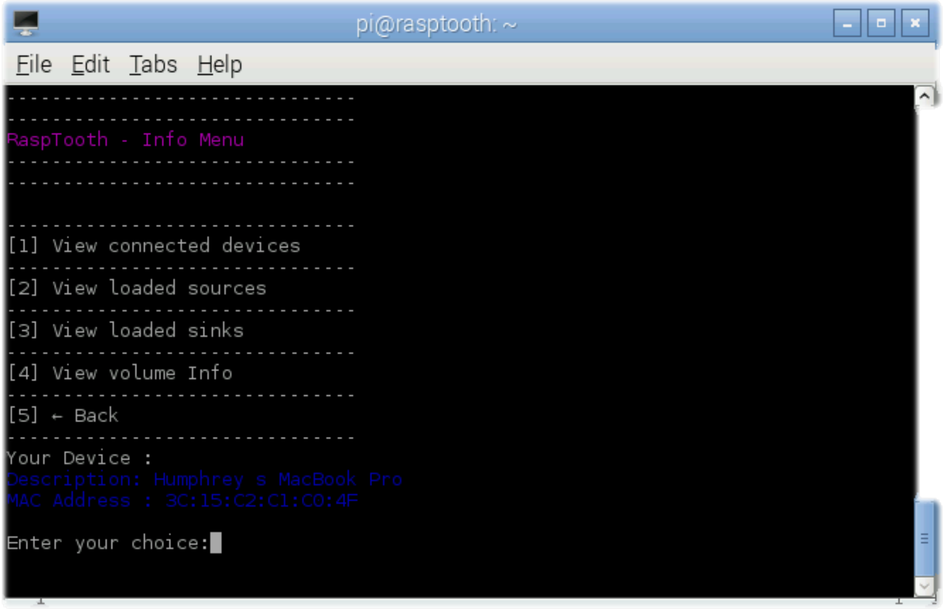
-------------------------------
[1] Settings
-------------------------------
[2] Info Menu
-------------------------------
[3] Connect source
-------------------------------
[4] Stop Stream
-------------------------------
[5] Exit
-------------------------------
Your Device :
Description: Humphrey s MacBook Pro
MAC Address : 3C_15_C2_C1_C0_4F

Enter your choice:
```

2.2. Info Menu

The information menu gives useful information on –simply put- what cannot be seen.

The user may see which devices are connected to the Bluetooth® dongle, which devices are connected to the Pulseaudio® module (this nuance will be explained later), as well as the available sinks.



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RaspTooth - Info Menu
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-------------------------------
[1] View connected devices
-------------------------------
[2] View loaded sources
-------------------------------
[3] View loaded sinks
-------------------------------
[4] View volume Info
-------------------------------
[5] ← Back
-------------------------------
Your Device :
Description: Humphrey s MacBook Pro
MAC Address : 3C:15:C2:C1:C0:4F

Enter your choice:
```

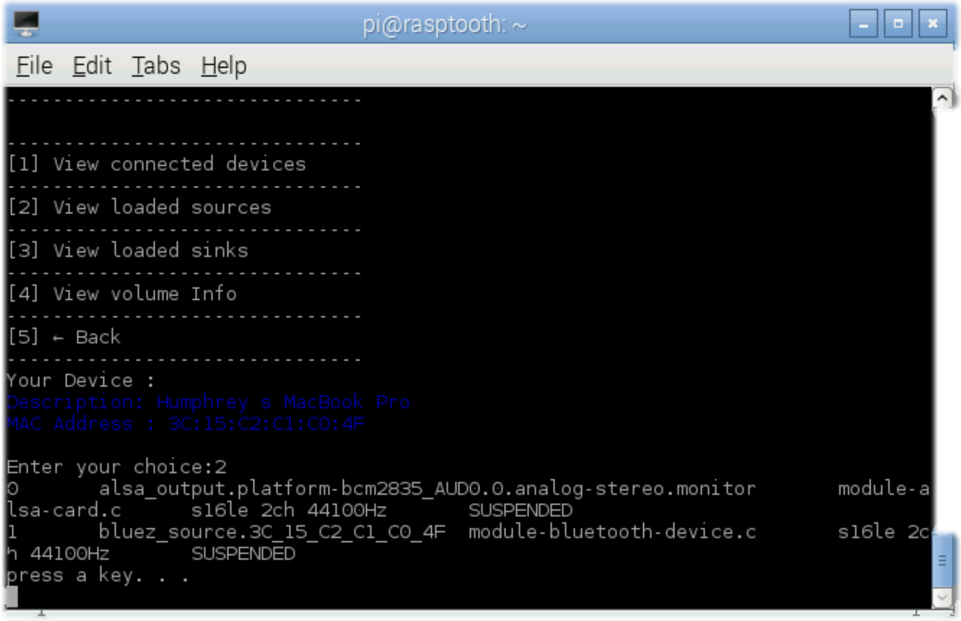

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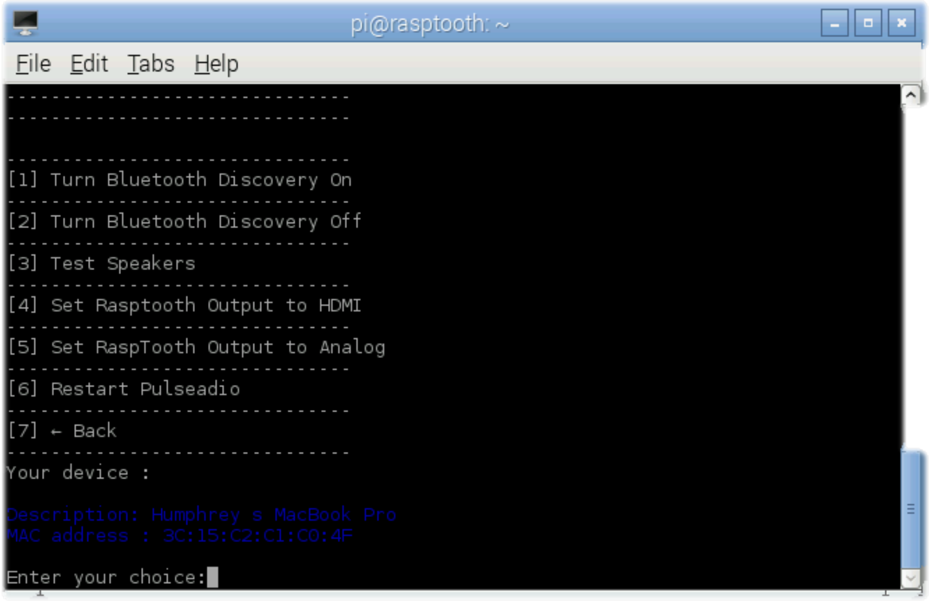
-------------------------------
[1] View connected devices
-------------------------------
[2] View loaded sources
-------------------------------
[3] View loaded sinks
-------------------------------
[4] View volume Info
-------------------------------
[5] ← Back
-------------------------------
Your Device :
Description: Humphrey s MacBook Pro
MAC Address : 3C:15:C2:C1:C0:4F

Enter your choice:2
0       alsa_output.platform-bcm2835_AUD0.0.analog-stereo.monitor       module-a
lsa-card.c      s16le 2ch 44100Hz       SUSPENDED
1       bluez_source.3C_15_C2_C1_C0_4F  module-bluetooth-device.c       s16le 2c
h 44100Hz       SUSPENDED
press a key. . .
```

2.3. Settings

The settings menu provides useful debugging options for the user. He/she may toggle Bluetooth® visibility of the device, get information on the volume, choose to output sound to the HDMI or Analog output.



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-------------------------------
[1] Turn Bluetooth Discovery On
-------------------------------
[2] Turn Bluetooth Discovery Off
-------------------------------
[3] Test Speakers
-------------------------------
[4] Set Rasptooth Output to HDMI
-------------------------------
[5] Set RaspTooth Output to Analog
-------------------------------
[6] Restart Pulseadio
-------------------------------
[7] ← Back
-------------------------------
Your device :

Description: Humphrey s MacBook Pro
MAC address : 3C:15:C2:C1:C0:4F

Enter your choice:
```

3. Implementation and Environment

3.1 Raspbian Wheezy

Raspbian Wheezy is the most common Operating System available for the Raspberry Pi. It is an unofficial port of Debian, the Linux Operating system. [2]

3.2 ALSA

The Advanced Linux Sound Architecture (ALSA) is what communicates with the Linux kernel and thus, the hardware. It provides an API for software to manage audio streams. It is responsible for combining sounds from several applications (i.e. listening to music and playing a video game simultaneously), something that was not supported in Linux audio before its introduction. [3]

3.3 Pulseaudio

Being so close to hardware, the ALSA framework is not practical for the end user. The Pulseaudio module comes in here. When manipulating several streams, Pulseaudio provides more control over the various inputs and outputs. Noticeably, it adds features to manipulate streams from and to the network. This includes the Bluetooth® Advanced Audio Distribution Profile (A2DP).

3.4 UNIX Scripting

In order to provide a functioning application for a user, the semi-GUI offers a smooth, simple way of managing the various modules. This relieves the user of knowing how to operate these audio modules and debugging it. To achieve this, scripts constitute a powerful tool enabling a candid user to achieve audio manipulation.

4. Limitations & Improvements

There are several ways this project can be improved, that will be discussed in the following sections: Hardware, Features and Software.

4.1 Hardware

With its 512 MB of RAM and 700 MHz clock speed, the Raspberry Pi is essentially a general-purpose, low cost development board. Linking this to streaming audio via Bluetooth®, it results in a considerable quality loss when more than one stream is playing. Upgrading the development board to one with higher specifications (especially RAM) could solve this. Ideally, the system could run on a tailored-made development board, which would include only the essential packages and modules for the audio functionalities.

4.2 Features

Currently, the application only supports Bluetooth® streaming. However, Pulseaudio also supports retrieving source devices and routing their outputs on the network. Adding this feature would allow Rasptooth to wirelessly stream audio with two main improvements:
Firstly, there would be no issue regarding the range within which the source device must be.
Secondly, the compression happening when using the A2DP profile would not occur, due to a much greater bandwidth Wi-Fi provides (Bluetooth bandwidth: 721 kB/s; Wi-Fi bandwidth: several MB/s), granted a good connection is already established. As a result, this will allow greater quality; therefore allowing lossless audio files to keep their superior quality [4].

4.3 Software

Finally, to offer an enhanced user experience, a real GUI can be implemented. For example, if it appears on a touchscreen, the user would enjoy a pleasant, colorful experience.

5. References

[1] D Cooper, “Raspberry Pi Boards Begin Shipping Today”, April 2012; http://www.engadget.com/2012/04/16/raspberry-pi-begins-shipping/

[2] “Raspbian FAQ”; http://www.raspbian.org/RaspbianFAQ#I.27m_new_to_Raspberry_Pi_and_Raspbian.__What_should_I_know.3F

[3] April 2010; http://tuxradar.com/content/how-it-works-linux-audio-explained

[4] S. Smirnoff, “Audio Quality of Bluetooth aptX”, September 2014; http://soundexpert.org/news/-/blogs/audio-quality-of-bluetooth-aptx