

PROTOTYPE SYSTEM FOR RADIO PATCHING IN A MOBILE ENVIRONMENT

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Abstract

In order to communicate with various agencies while in their cruisers police officers often need to use multiple radios. We outline an approach that has been developed as a Project54 application supporting the patching of multiple radios in a mobile environment such as a police cruiser. The proposed solution reduces the complexity of operating several radios at the same time by providing a common user interface to all the radios. Preliminary test results show proper system functionality with response times fast enough for operating radio press-to-talk buttons.

1. Introduction

While driving police cruisers, police officers often need to communicate with people from multiple organizations at the same time. For example they may have to talk to other police officers, fire and rescue personnel and federal agents. The much-discussed interoperability problem is that all these organizations do not necessarily use radios that can exchange information with each other. Police officers often solve this interoperability problem by brute force: they use more than one radio at the same time in the cruiser. The officers have the ability to patch multiple radios, meaning they can connect radios so an officer's voice input can be transmitted by more than one radio or that audio received on one radio can be retransmitted on another. However, currently there is no system available that would make radio patching seamless. Using different radio types or radios made by different companies requires significant training as most have different user interfaces and multiple radio parameters may need attention. There is also the issue of driver distraction as it can be difficult to operate the vehicle while the driver is focused on operating one or more of the radios.

A solution to this problem would be a system integrated into the Project54 system [1] that would allow dynamic radio patching under voice control. The Project54 system integrates multiple devices in police cruisers and provides a speech user interface to these devices. Here we describe a prototype PC-based system for radio patching that we integrated into the Project54 system.

2. Prototype System

Figure 1 shows the block diagram of the prototype system. At the center of the system is an audio switch card manufactured by ESI. This card can be controlled by the PC using a USB connection and it has four input and six output channels. The card can be programmed to patch any input channel to any of the output channels. Multiple inputs can be patched to the same output at the same time and one input can be patched to multiple outputs at the same time. This is exactly the functionality that is needed if one wants to patch multiple radios.

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In the prototype system one input/output pair is used to connect the card to the PC microphone (In 4) and speaker (Out 4). One output is also routed back to the PC sound system and the Windows Multimedia drivers (Out 5). Three input/output pairs are used to connect the system to audio sources and sinks. One of these audio source/sinks pairs is a police radio (In 1 is connected to the radio speaker output and Out 1 is connected to the radio microphone input). The radio is connected to the audio switch card through an off-the-shelf radio. This device offers control of the input and output signal levels and also provides an automatic push-to-talk signal and control of its duration. The other two sinks (Out 2 and 3) of the prototype system are connected to speakers. In this prototype we do not have an audio source attached to In 2 and 3.

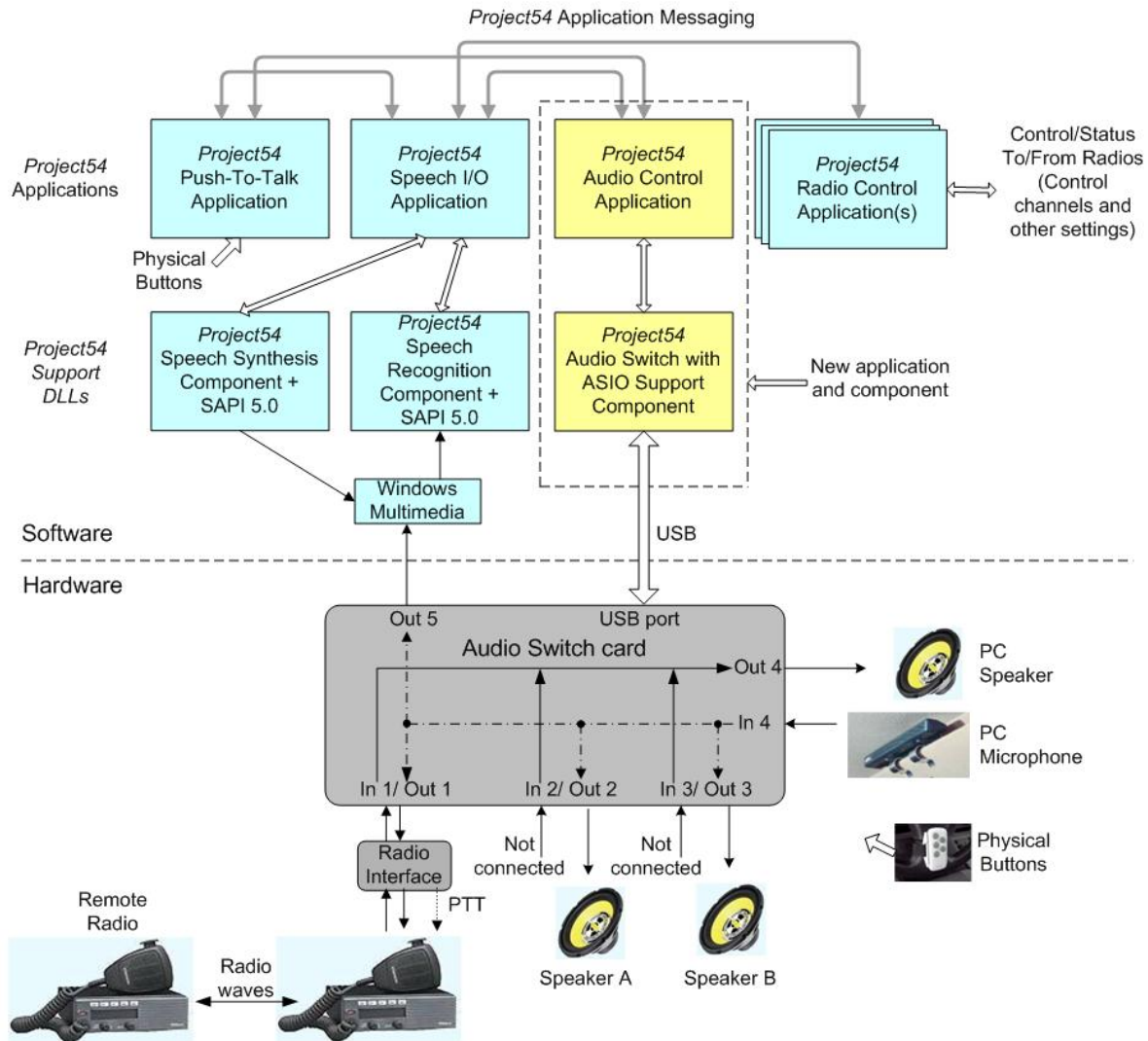


Figure 1 – Block diagram of the prototype system

The Project54 software consists of components called applications which can communicate with each other using text messages routed through a core piece of software. Most applications control a piece of hardware. Thus, in Figure 1 the Radio Control Application controls radio settings (e.g. channel and volume settings) for a given radio. We have implemented different Radio Control

Applications for different police radios. The Push-To-Talk Application interacts with the AirClick remote device. The AirClick is used as the push-to-talk button for radio transmission, as well as for signaling the beginning and end of a speech command to Project54 (two different AirClick buttons are used for these two functions). Speech is handled by the Speech I/O Application. The Speech I/O Application interacts with the speech synthesis and speech recognition components.

For our prototype, we created the Audio Switch with ASIO Support component (ASwAS) and the Audio Control Application. The ASwAS component is based on the work of Bouin and Lengrand [2]. It implements a set of functions to allow the controlling of the audio switch card. The functions from the ASwAS call functions from the ASIO API level which in turn is an abstraction of the hardware architecture and calls functions from the ASIO driver. The specifications for the ASIO API level functions can be found in the Steinberg SDK [3].

The Audio Control Application provides a GUI and a speech user interface for controlling the audio switch card. In our prototype the Audio Control Application only allows connecting In 4 (PC microphone) to one or more of the outputs and it hardwires In 1 (radio) to Out 4 (PC speaker).

3. Testing

The system was tested using the lab setup shown in Figure 2. A radio (Figure 2- item 1) is connected to the audio switch card (item 8) through the radio interface (item 9). Another radio (item 2) is connected to the first radio via radio waves and is included for proof-of-concept to show the signal is properly transmitted and the PTT signal functions. Two speakers (item 3 and item 4) are used as audio sinks (connected to the audio switch outputs denoted as Out 2 and 3 in Figure 1). The user interface for system testing consists of the PC speaker (item 5, connected to Out 4), PC microphone (item 6, connected to In 4), and the AirClick device (item 7).

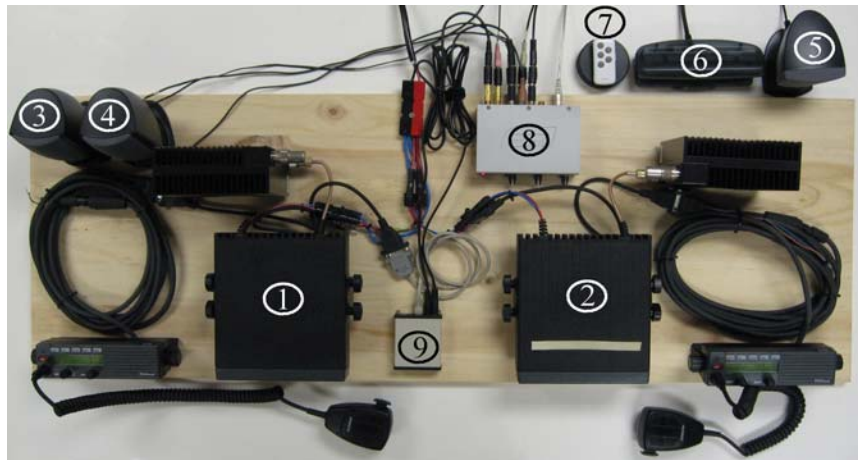


Figure 2 – Lab setup for testing the prototype system

As shown with the solid and dotted lines in the audio switch card in Figure 1, in our prototype system only a limited number of input/output connections were allowed. In 4, which brought in the PC microphone, could be connected to any combination of Out 1, 2, 3 and 5. In 1, which brought in the audio from the radio was always connected to Out 4 (PC speaker). In 2 and 3 were also routed to Out 4 (PC speaker), however they were not used in testing.

We successfully tested the operation of the system and confirmed that the audio connections could be controlled according to the specifications in the previous paragraph. We also measured the audio signal path delay time (latency) from the microphone input of the audio switch (In 4) to the first output of the audio switch (Out 1), just prior to entering the radio interface. The system shows a low latency time of only 23.5 ms, which allows operating the radio press-to-talk button without cutting off parts of the audio transmission.

4. Conclusion and Future Work

The cheapest and quickest solution to the interoperability problem in police cruisers is radio patching. However, this solution brings a multitude of new electronic devices into the cruiser, namely police radios, each with its own user interface. This brute force solution can therefore be both distracting and extremely taxing on officers as they drive and perform other necessary tasks.

Our prototype integrates all of the radios under the Project54 system. This allows the officer's attention to be focused on only a single, common user interface (a microphone, speaker, and push-to-talk button) while still operating up to three different radios. The result is a system that should not only be less confusing but less distracting to officers as they carry out their assigned tasks within the police cruisers.

Additional testing will need to be performed to examine the effects of mixing signals from different sources at the same time. This includes a more thorough look at the normalization option used to keep all signals at the same level and its impact on the level of noise. Once this has been done software can be developed to support full-blown signal patching, removing any limitations on what is routed where and how it is mixed. This will permit the mapping of audio from one radio directly into any other(s) in true patching fashion.

We will also examine the impact that the system has on the police officer's driving and task completion through driving simulator studies. Finally we will deploy the system in a real-world scenario to test its operation. This will require setup in an actual police cruiser with at least two radio systems.

5. Acknowledgements

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6. References

- [1] Kun, A. L., Miller, W. T. and Lenharth, W. H., Computers in Police Cruisers, IEEE Pervasive Computing, Volume 3, Issue 4, Pages: 34 - 41, October-December 2004
- [2] Bouin, A., Lengrand, B., Audio Switch, Technical report ECE.P54.2006.6, Electrical and Computer Engineering Department, University of New Hampshire, 2006
- [3] Steinberg, Steinberg Audio Streaming Input Output Specification: Development Kit 2.2, Steinberg Soft - und Hardware GmbH 2005.
- [4] MacMillan, K., Droettboom, M., Fujinaga, I., Audio Latency Measurements of Desktop Operating Systems, Proceedings of the International Computer Music Conference, 2001.