**Document Title:** Software Radio for School Safety

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## Accomplishments

Vanu, Inc has developed a transceiver handheld, with multiple waveforms in the UHF and VHF bands and a user interface that can be easily configured for non-technical users. The system can be used for approximately an hour on the current battery configuration, given a 80/10/10 standby/receive/transmit usage.

The handheld software radio development involved development of many different subsystems. Vanu Inc worked with third-party RF contractors to specify the RF transceiver, and the mechanical, electrical and data and control interfaces to the RF system. We designed and fabricated the interface board between the RF system and the iPAQ. We wrote the FPGA code providing control to the board, the RF system, and the data registers between the RF system and iPAQ. We installed Linux on the iPAQ, and wrote a driver for the interface hardware. In parallel, we developed waveforms and the graphical user interfaces to allow non-technical personnel to easily launch different radios. We ported those applications to the iPAQ StrongARM processor.

Many people in the software radio community were impressed to see APCO 25 on a low power StrongARM processor. Our work to implement the vocoder algorithm efficiently in fixed point from the beginning paid off. Because of our software architecture, it was easily ported from the desktop processor where it was initially implemented to the StrongARM.

In recognition for our accomplishments, our paper detailing the software design and implementation on the handheld ["A handheld software radio based on the iPaq PDA: Software (Jessica Forbess, Andrew Chiu)" ] was presented at the SDR Forum 2003, and won Best Paper of the Forum.

## Software

The software radio applications targeted in this project were public safety two way radio waveforms, both analog and digital, and mobile-side implementations of cellular waveforms with bendwidths low enough to be processed on a low power handheld processor, specifically TDMA and AMPS. The Vanu Inc middleware and libraries provided a good base from which to start. The digital APCO 25 waveform was straightforward to port, as it had been implemented using fixed point algorithms initially. We adapted some of the previously existing cell monitoring software for the receive chain physical layer processing, and implemented Layer 2 with our in-house expertise. To move from a standard desktop processor to the low power StrongARM it was necessary to substitute some fixed point algorithms for the floating point algorithms.

We were able to test the receive chain with realtime data on our desktop receive-only system, and we were able to test both the receive and transmit chains by piping the data into and out of files, which were easily verified with external toolchains like octave, an open source numerical computation tool.

The graphical user interface was written with gtk, a standard Linux graphical toolkit. The waveform applications may be selected by the specific waveform, or the waveform may be linked to a particular public safety service, such as police, fire, or another specific organization. The various configurations were left to be explored and optimized when a complete prototype, including cell waveforms, was available.

## Hardware

The processing hardware consisted of an iPAQ consumer handheld, based around a StrongARM 206 MHz RISC processor. This processor and the specific iPAQ line are well supported by the Linux community and Compaq/HP. The iPAQ provides a expandable interface port which we needed to access the data from the RF hardware. Because RF hardware is not designed to use the iPAQ interface or any other standard handheld interface, we designed an FPGA interface card to sit between the RF transceiver and the iPAQ. The FPGA provided a reprogrammable control system that allowed us to interface with multiple RF transceivers.

## RF

The original RF transceiver was specified to cover all of the spectrum from 20 MHz to 2.5 GHz. It would provide a selectable sampling rate, to match the relevant bandwidths for various waveforms, from the narrow two way FM radio to the wider APCO 25, to the even wider GSM band.

The RF transceiver we used for the prototype demonstration was provided by General Dynamics Decision Systems from their PRC-112 military radio. It provided frequencies in the UHF and VHF bands, but did not reach to the cellular band.

## Failures

The transceiver does not operate in the cell bands. This severely limits the usefulness to school safety personnel who were looking to use this device to incorporate both civilian and public safety communication methods.

## Conclusions

A widely-tunable, handheld RF system is difficult to design, manufacture and verify. We greatly underestimated our difficulty in acquiring one when proposing this project. We attempted to correct our mistake by applying for a new grant focused on the development of an automated testing system for a handheld, widely-tunable RF transceiver. We were awarded grant 2002-RD-CX-R004 to continue this work. Unfortunately, the RF contractor we were working with was unable to deliver a working system after many delays, and was unable to schedule any time to work with us to debug the semi-working system he did deliver. We were able to demonstrate a proof-of-concept system at the NIJ Project Review Conference in May of 2003 in Greensboro, North Carolina, using a handheld software radio with a different prototype RF transceiver to provide an analog two-way FM radio and a digital APCO 25 radio. This configurable prototype is a step to bridging the gap between civilian communication standards and public safety communication standards, but it does not bring the power of cell technology to the mix, limiting the number of user scenarios that we are able to explore and test.

Future handheld projects will need to address the problem of a widely-tunable portable RF transceiver. They should also pay attention to the rising bandwidth of modern cell waveforms, and not overlook the problem of moving data at higher sample rates between the RF transceiver and a standard consumer handheld with limited data rate interfaces.