BY LYNNETTE LUNA

Professor might have solved SDR

Using open-source software makes price right for public safety

Charles Bostian, a professor at Virginia Tech University in Blackburn, Va., is leading a team in developing software-defined radios, or SDRs, based on an open-source software platform, which could bring about an SDR-enabled handset in 2008 at a $500 price tag—significantly below the $38,000 estimated for military-grade SDRs.

Public safety has been clamoring for SDR and cognitive radio capabilities, especially in light of radio incompatibility issues during major man-made and natural disasters such as the terrorist attacks on the World Trade Center in New York on Sept. 11, 2001, and the devastating Hurricane Katrina last year (*MRT*, March 2004, page 76; *MRT*, November 2005, page 40). Grants from the National Institute of Justice (NIJ) and the National Science Foundation (NSF) are funding Bostian's work, which aims to support the onslaught of first responders who arrive at the scene of a natural disaster with radios that sport their own frequencies, waveforms and wireless standards.

"We are developing a public-safety cognitive radio," Bostian said. "The first responder will turn the radio on, scan commonly used public-safety bands and tell the operator what networks it sees. The operator in principle can click on one of those and configure it properly, and a cognitive engine is capable of recognizing those waveforms and configuring [the radio] to transmit and receive the correct waveform."

Cognitive radio takes an SDR and adds what Bostian calls a cognitive engine that combines artificial intelligence and SDR technology to create a transceiver that is aware of its RF environment, its own capabilities, policies that define legal operation and its user's needs and operating privileges. The Virginia Tech team has developed a proprietary engine based on genetic algorithms developed for an earlier NSF disaster communications project. The algorithms incorporate logic, readiness and adaptive memory.

"In principle, it can do things its designer didn't anticipate," he said.

The ability to create new waveforms is the Holy Grail public safety has sought for many years, but the effort has met myriad technical and political obstacles. Chief among them is the sputtering effort of the Department of Defense—via its Joint Tactical Radio Systems (JTRS) program—to develop a common architecture, known as Software Communications Architecture (SCA), to decrease the form factor and cost of SDR handsets for the military that would trickle down to domestic first responders. The JTRS subsequently went over budget and fell behind schedule, but even if it gets back on track, the fundamental problem with the SCA is that the military's requirements aren't shared by public safety, which results in form factors and price points that place SDRs beyond the reach of first responders.

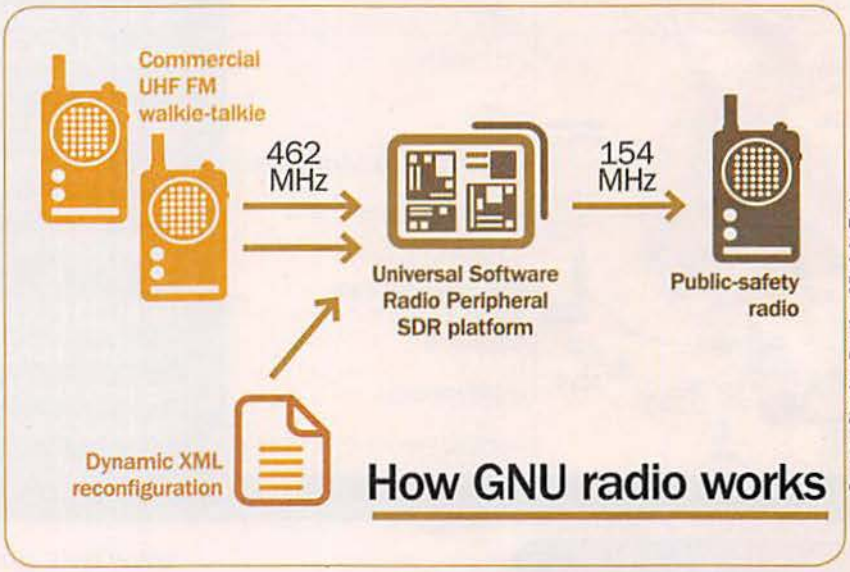
This is where Bostian's team comes in. Rather than building an SDR based on SCA, they developed a device based on GNU, an open-source software platform, using off-the-shelf components.

"The military SDRs are based on systems communications architecture that is an overkill and overly complex," Bostian said. "Most of the computations done on the GNU platform are done with general-purpose platforms."

Backed by the university community and government agencies, GNU radio is a free software toolkit for learning about, building and deploying software radios that it comes with complete source code. In addition to support for broadcast and narrowband FM radios, GNU radio has a complete implementation of a digital high-definition TV transmitter and receiver.

As with all SDR systems, reconfigurability is the key feature. Instead of purchasing multiple expensive radios, a single, more generic, radio is purchased, which feeds into powerful signal processing software—in this case, the GNU radio. If one understands the math of a radio transmission system, one can reconfigure GNU radio to receive a desired signal.

According to Bostian, who is an



"In principle, [the cognitive engine] can do things its designer didn't anticipate."
—CHARLES BOSTIAN, UNIVERSITY OF VIRGINIA

IEEE fellow, the GNU radio code runs on a universal software radio peripheral (USRP) a low-cost, high-speed USB-based board for making software radios. The USRP is intended to be a relatively inexpensive hardware device that facilitates the construction of a software radio with an open design and the schematics, drivers and free software needed to integrate with a GNU radio.

One significant feat that Bostian and his team accomplished on the GNU platform is the ability to configure and reconfigure the platform in less than a second. Military SDRs have been criticized for their slow configuration capabilities.

The team has been working since August to develop a cognitive radio for public safety that can operate with other radios or serve as a bridge for older radios that don't have software capability. Funded by a $420,000 grant from the NIJ, the analog prototype will run on an SDR—the size of a laptop—being built by Innovative Wireless Technologies beginning in the second quarter of 2007.

By 2008, the team hopes to see a commercial analog radio. It has yet to address the Project 25 Phase 1 standard, but the team has committed to identifying four of the most common waveforms used by public safety—P25 and analog voice in various flavors.

Certainly Bostian's research couldn't come at a better time for public safety. A recent survey from Venture Development Corp. of some 300 first responders revealed that 46% of respondents expect to be equipped with SDRs by 2010. However, VDC couldn't identify any suppliers with a strong interest in SDRs. Nor could the firm pinpoint anyone making SDRs for the public-safety market.

Bostian said the research his team has done using GNU radio means radio manufacturers could come to market quickly with SDRs. "We have made a quick way of controlling the SDR platform using USRP," Bostian said. The fear has been that SDR's entrance into the public-safety arena could lag behind the commercial sector for business reasons, as public safety has no single large buying presence.

Still, developing an SDR in a lab is the easiest part. "A GNU radio is a very desirable concept, but there are a lot of specifics that need to be addressed before it becomes a commercial reality," said Jim Gunn, an independent communications consultant that works with the SDR Forum on a regular basis. "It could substantially reduce the costs of radios, but we have to test the reliability and ensure regulatory concerns aren't violated."

Indeed, Bostian and team will have to obtain the first-ever FCC certification for a cognitive radio while developing a user interface that is easy to use for the first responder in the field.

And developing an SDR that is compliant with P25—with its various phases and proprietary implementations—will be tricky. Bostian's team will begin studying P25 Phase 1 next year, but everyone associated with SDR continues to struggle with the ability to develop a radio whose entire functionality can be programmed to support multiple bands and modulation platforms. The problem is exacerbated by the P25 standard, which has had various proprietary implementations tacked on by Motorola and other vendors.

Indeed, the SDR Forum's recent public-safety report identifies several obstacles that must be cleared for such capability, including the question of whether an intra-device interface standard should be developed to standardize SDR components.

It's a problem also faced in the commercial world. "Everyone is doing SDR in the baseband, but we can't do the RF and throughput-intensity stuff," Gunn said. "We need special hardware, and we need to make it configurable to be able to change elements such as error coding."

Early next year, commercial SDR silicon maker BitWave will be sampling its True Software radio transceiver chips, which integrate an SDR receiver and transmitter. The beauty of the product is its promise to offer a multimode transceiver that can be produced at the same cost as a single-mode transceiver, without using more power.

But, "before you can get to cognitive radio, the first thing you need is a device that's actually tunable because it can't be cognitive until you know what's out there," said Russ Cyr, BitWave's chief marketing officer and cofounder. "We're that underlying technology that will make cognitive radio a reality."

Cyr said both commercial and public-safety safety vendors will be sampling the chips early next year. With the average cost of a transceiver in a public-safety radio costing $2000, Cyr said BitWave could make a significant impact on cost, given that its silicon could drive the transceiver cost down to $10 per device. ■

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