Researchers patent enabling technology for spread-spectrum systems

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If you've ever gotten the dreaded "network busy" message while trying to make a cell phone call, you've experienced the complication of sharing a single network with numerous other users.

What may be a mere annoyance for civilian cell phone users is a more serious problem for soldiers and other military personnel who depend on reliable communication for effective operation. While multi-user interference is an important challenge to address, military operations typically involve the use of multi-beam radars and satellite links that may also need to operate in the presence of interference.

That's why a pair of engineers at Kansas State University developed and patented an algorithm that enables next generation smart adaptive radios and makes radars more effective by customizing the coding used in transmitting their signals. Although military applications provide an obvious stage to employ the technology, can the algorithm be used in other arenas?

"Definitely," said Bala Natarajan, K-State associate professor of electrical and computer engineering and one of the inventors. "The cool thing is that the core idea can be applied to any system that employs some form of spread spectrum technique with spreading codes. That includes cellular, satellite and wireless systems like local area networks. The algorithm can be used to design effective pulse compression codes for multi-beam radar systems employed in both defense and meteorological applications."

In September, he and former K-State student Justin Dyer received a patent for the algorithm. The patent can be viewed online at http://ow.ly/BaF4

When the engineers began the project, Dyer was still an undergraduate student in electrical engineering. He earned a bachelor's degree in May 2004 and a master's degree in May 2006. Dyer's research also helped him receive the National Science Foundation graduate fellowship in 2006. Dyer now is a doctoral candidate in the department of statistics at Stanford University.

In code division multiple access systems — known as CDMA systems — users transmit their signals at the same time and frequency but use a different spreading code to encode their information. Natarajan said there are two primary issues that affect performance of CDMA based multiple user systems.

First, every signal experiences interference from other users' signals. Second, a user's signal can experience interference with delayed copies of itself caused by multi-path propagation effects like echoes.

"Because you're talking about a wireless environment, the performance declines with the more users you add," Natarajan said. "The autocorrelation and cross correlation properties of the codes determine the quality of service that is experienced by the user."

Additionally, the length of the codes used impacts the system capacity and bandwidth occupancy.

"Many of the traditionally used code sets are binary code sets that have stringent restrictions on the length of the code," Natarajan said. "And once I fix the length, that means I also have restrictions on how many codes I can generate of that length, and so it limits how many users you can support on a network."

Because there are fundamental results that illustrate that it is not possible to design codes that minimize both self interference and inter-user interference, the researchers at K-State went on a search for flexible-length code sets that offer the optimal tradeoff.

Dyer and Natarajan developed an algorithm that can be used to generate complex-valued code sets of any length and can be optimized for various performance measures like interference. Their approach involves the use of a specific type of algorithm, an asymptotically optimal decoding algorithm like a Viterbi algorithm. This algorithm allows a systematic search over the phase space to determine the best set of complex-valued code elements that satisfy a desired performance measure.

"Our algorithm can provide customized code sets that give you to the best possible tradeoff," Natarajan said. "Many families of code already exist, but our algorithm can design a customized code set of any length for the performance you want on a specific technology. No other approach can give you that level of flexibility in design."

The beneficiaries of this algorithm are technologies vital to defense, such as radar and smart radios. For instance, when radars emit multiple beams at the same time, specialized pulse compression coding schemes based on the algorithm developed at K-State can ensure that the beams don't interfere with each other.

Cognitive radios, also called smart radios, benefit from this algorithm-derived coding because they need to adapt to changes in the environment, Natarajan said. For instance, military personnel may rely on a smart radio's ability to find out which band is open for communication and keep up with a changing bandwidth.

"So when you're talking about a highly programmable and adaptive radio, having the ability to design spreading codes that are actually adaptive is important," Natarajan said. "Our algorithm will give you an updated code that will help you adapt to changing situations."

Since 2005, Dyer and Natarajan's work on the algorithm has appeared in academic journals like *IEEE Transactions on Wireless Communications* and *IEEE Communications Letters*. It has been presented at several conferences, including the IEEE 62nd Vehicular Technology Conference, the IEEE International Symposium on Wireless Pervasive computing and the IEEE 40th International Conference on Communications.

Source: Kansas State University (news : web)

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