UCSD-led team hopes to turn utter 'chaos' into the next generation of wireless communication

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UCSD-LED TEAM HOPES TO TURN UTTER 'CHAOS' INTO THE NEXT GENERATION OF WIRELESS COMMUNICATION

In a move that researchers hope will usher in a new era of wireless communication, a multi-university team led by the University of California, San Diego has received an award worth up to $4.5 million from the Department of Defense's Army Research Office to build a communications system based on the principles of "chaos."

The award, granted to UCSD's Institute for Nonlinear Science under the Multidisciplinary University Research Initiative (MURI), provides $2.7 million to the project for three years and an option for $1.8 million for the following two years. Lawrence Larson, the Communication Industry Professor endowed chair at the Irwin and Joan Jacobs School of Engineering at UCSD, is the principle investigator for the project.

Webster's defines chaos as "a state of utter confusion." However scientists from three universities, backed with support from several corporations, are giving it a new definition. The team will develop a communication system at UCSD that not only harnesses chaotic signals, but uses them as the backbone of what they hope will become a wireless network that is simpler and more secure than today's telecommunication standards. The project will team researchers from UCSD's Institute for Nonlinear Science and the Jacobs School of Engineering, UCLA and Stanford University. Industry partners include Qualcomm, Hughes Electronics, Scientific Atlanta, Ariel Systems, Jaycor, Lockheed Martin and Recording Physics.

"It's our hope that this system will have important long-term benefit to the wireless communications industry here in San Diego and worldwide," said Larson, a faculty member in UCSD's Center for Wireless Communications. "There's a possibility of a whole new way of communicating in a secure and very power efficient way that will come out of this research."

Communication systems have traditionally been designed to be as linear as possible. In a perfect world, a linear signal originates from a transmitter, keeps its linearity during transmission and arrives at a receiver in standard linear format. But these signals, when pushed to their maximum power limits, become distorted as "nonlinear" noise. Precious power must be allocated to dampen this noisy effect and keep the signal on a linear path.

Under chaotic principles, most recently documented in an upcoming issue of Physical Review Letters by Henry Abarbanel, professor of physics at UCSD and a member of the MURI project, and Matthew Kennel of the Institute for Nonlinear Science, chaotic signals are used as the main ingredient in transmitting the communication signals. Here's how it works: The sender puts the message onto a chaotic signal, which sounds like static, and then transmits the combined chaos and message. The receiver, which is synchronized perfectly to just the chaotic part, subtracts the chaos and is left with the message. The transmitter and receiver are connected in a synchronized manner so that the information is sent out and received with no distortion.

The tagging and decoding principles are the same as those used in standard AM (amplitude modulation) and FM (frequency modulation) radio, but instead of amplitude or frequency, the chaotic carrier cannot be defined by one characteristic. Instead, it is unpredictable over long periods of transmission. Thus the new system not only frees up power formerly dedicated to keeping the signal linear, but also increases security due to the chaotic nature of the transmission.

"If an eavesdropper tries to pick up the signal, what he sees is just noise," said co-principal investigator Lev Tsimring, an associate research scientist at the Institute for Nonlinear Science. "Code-breakers are based upon the principle that you pick up certain amounts of information and you wait until they repeat. In chaotic systems, there is no repetition and that's what makes this type of signal virtually unbreakable."

How to increase bandwidth and use it more effectively has been a constant struggle for the telecommunications industry.

"I personally believe that we'll be able to send many, many more signals and therefore use the bandwidth much more efficiently now it's our job to prove that," said Abarbanel, director of the Institute for Nonlinear Science.

The proposed prototype resulting from the project, the Digital Chaotic Communications Demonstration (DCCD), will consist of a base station with wireless and optical transceivers; approximately five hand-held wireless mobile units; and nearly five remote units connected by optical fiber to the base station.

The project also proposes to explore a chaos-based version of code division multiple access (CDMA) technology, which was developed by San Diego-based Qualcomm Inc.

In addition to Larson, Tsimring and Abarbanel, other members of the project include Jiaming Liu of UCLA, who will address lasers and optical communication; William Dally of Stanford, who will investigate circuit systems; and Russell Impagliazzo of UCSD, who will address computer science and security issues. Nikolai Rulkov of UCSD and Kung Yao of UCLA also will take part in the project. Part of the award will be used to support roughly a dozen postdoctoral and graduate student researchers at UCSD, UCLA and Stanford.

The MURI project's industrial partners will assist in field testing the DCCD and engage in quarterly meetings to assess new design strategies for the device. The companies also will address new ideas in chaotic communication and work with the university researchers in training students and post-doctoral researchers.

The MURI project also provides funding for an annual Winter School at UCSD featuring leading authorities in chaos and nonlinear dynamics. The week-long programs will include national and international speakers who will discuss and disseminate research advances in the field. The first Winter School is planned for January 1999. Scholarships for students from around the world are included in the grant.

The field of chaos and nonlinear dynamics has evolved in recent years as a science that spans not only communication engineering, but chemistry, cardiology and psychiatry. Researchers have sought a greater understanding of chaotic situations, found in areas as diverse as chemical reactions inside power plants, weather patterns in the atmosphere and the ocean and even how dolphins are able to slice through the seas by vibrating their skin.

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