Engineers using quantum nature of light to boost Internet security

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Michael Vasilyev's goals in his research are simply stated: increase by tenfold the amount of information that can be securely transmitted via the Internet and the distance over which that data can be transmitted.

Vasilyev, a UT Arlington associate professor of electrical engineering, is participating in an $8 million research project funded by the Defense Advanced Research Project Agency that enlists five universities and three companies to study advanced quantum communications.

Conventional or classical communication transmits information by "bits" that take values of either one or zero. In contrast to that, quantum communication uses quantum bits, or "qubits," which, in addition to being one or zero can also be in a "superposition" state, which is both one and zero simultaneously.

The qubits are represented by quantum-mechanical objects, such as single photons, that can provide a much higher level of protection from eavesdropping than classical communication signals.

"There are all kinds of personal information – both among private citizens and public governments – that require the utmost security," Vasilyev said. "Quantum communication offers the most rigorous solution for security because it employs the fundamental laws of quantum mechanics to enforce the exclusive linkage between the sender and the receiver, with no chance of other people eavesdropping."

Jean-Pierre Bardet, dean of the UT Arlington College of Engineering, said Vasilyev's work is essential to expanding the data information superhighway.

"Transmission speed, storage and security are crucial elements as our information-based society continues to grow and mature," Bardet said. "Dr. Vasilyev's work demonstrates the important role UT Arlington engineers are playing as we investigate these critical issues in shaping network security and capacity for the future."

Vasilyev said one of the challenges in current technology is that today's secure quantum communications can be done at any meaningful speed only over short distances, about 100 kilometers before the signal breaks down.

Longer distances can only be used at the expense of a dramatic reduction in the transmission capacity. Qubits cannot go through optical amplifiers, commonly used in classical communications, without losing their quantum-mechanical security advantages, he said.

"It opens the possibility of hackers intercepting a message that must be made secure," Vasilyev said.

Vasilyev's lab will encode information in spatial features or pixels of the photons that are sent through multimode fiber-optic lines to dramatically increase the amount of received data without jeopardizing its security protected by quantum mechanics.

"We will transmit multi-pixel spatial patterns to encode more and more information into single photons," said Vasilyev, who noted that Northwestern University is the prime contractor for the nationwide project. Vasilyev's portion of the larger grant is $675,000 over four years.

Other participants in the project will contribute technologies such as quantum frequency conversion, quantum repeaters, arbitrary waveform generation and advanced coding schemes to further increase the capacity and distance of the secure information transmission. Other participants include: the University of California, Davis;

University of Calgary, Canada; Montana State University; Raytheon BBN Technologies, Cambridge, Mass.; Advanced Communication Sciences, Piscataway, N.J.; and NuCrypt LLC, Evanston, Ill.

Vasilyev added that the technology developed will be useful for classical communications as well.

"The Internet is facing a capacity crisis," Vasilyev said. "If the current rates of network traffic growth continue, we could be out of bandwidth by 2020, unless we start harnessing the spatial degrees of freedom of photons in a fiber."

Vasilyev's recent research focused on dramatically reducing the cost of transporting data over the Internet backbone. His group, in collaboration with the University of Vermont, has developed regeneration technology that restores the quality of optical signals at multiple wavelengths simultaneously, without ever converting them to electrical signals.

"The power of optics is in its capability to process many independent high-speed data streams in parallel," Vasilyev said. "So far, we have been applying this power to multiple wavelengths. With all possible wavelengths exhausted, we're now turning to multiple spatial pixels to keep the capacity growing."

Provided by University of Texas at Arlington

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