Physicists take steps toward delivering quantum information to the home

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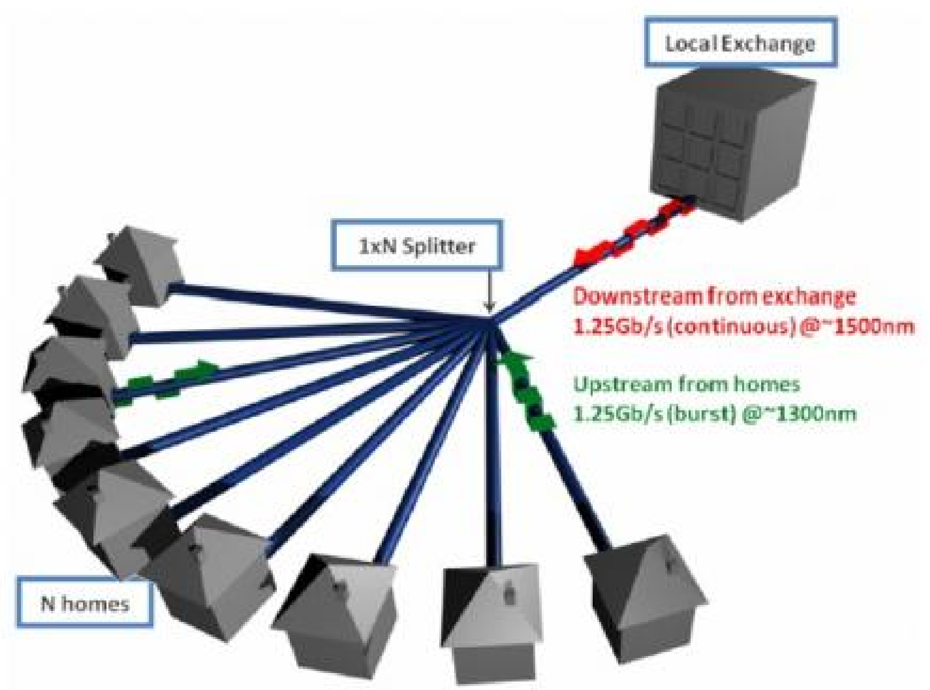

A tree network is often used to distribute classical data to homes via fiber optics. Researchers are working on co-propagating quantum information with the classical data to improve security. Image copyright: Iris Choi, et al. ©2011 IOP Publishing Ltd and Deutsche Physikalische Gesellschaft

(PhysOrg.com) -- Today, fiber optics technology transports information in the form of classical data to homes and businesses. But researchers are currently working on ways to combine quantum data with the classical data in fiber optics networks in order to increase security. In a new study, scientists have shown how quantum and classical data can be interlaced in a real-world fiber optics network, taking a step toward distributing quantum information to the home, and with it a quantum internet.

The physicists, Iris Choi, Robert J. Young, and Paul D. Townsend, from the Tyndall National Institute at the University College Cork in Cork, Ireland, have published their study on combining quantum and classical signals in a recent issue of the New Journal of Physics. While the feasibility of transferring qubits on modern fiber-to-the-home (FTTH) networks has previously been demonstrated, this is the first time that researchers have investigated how the operation would work in a real-world network.

“I believe that our work constitutes the first really hard-nosed, pragmatic attempt to address the question of whether quantum key distribution (QKD) can work on a real fiber-to-the-home (FTTH) network,” Townsend told *PhysOrg.com*. “The new scheme that we have developed and tested demonstrates that the answer is ‘yes it can.’ I say pragmatic and hard-nosed because we have taken a widely deployed classical FTTH system and have adapted QKD to interwork with it, leaving the design of the classical part of the system essentially unchanged. The alternative approach, sometimes taken in QKD research, is to leave out the classical system completely or to adapt it to work with the QKD. In our view this is not very practical for cost reasons.”

The biggest challenge in transferring qubits in real-world networks is overcoming the crosstalk between the classical and quantum channels. Crosstalk is induced by spontaneous Raman scattering of photons in the optical fiber. Since the classical channels involve strong laser pulses while the quantum information is carried by single photons, the crosstalk primarily affects the quantum channel, making the error rate so high that the quantum channel is unable to operate.

Previous research has shown that the Raman noise level can be reduced by optical filtering, although this technique is too expensive for practical use. So Choi, Young, and Townsend have developed and demonstrated a novel noise suppression scheme that involves creating gaps in the scattering, and sending quantum data in these gaps.

First, the researchers chose a configuration that used two different wavelengths for transmitting the quantum and classical channels. In this configuration, only the Raman-scattered light in the "upstream" channel (going away from a user's house) can generate crosstalk for that user. Then, the researchers identified quiet periods between the bursts of noise generated by Raman scattering in the upstream channel. Using a time and wavelength-multiplexing scheme, the researchers demonstrated that quantum data generated by a quantum key distribution (QKD) scheme can be transmitted during these quiet periods with high fidelity.

While building a purely quantum network could avoid the problem of crosstalk altogether, the researchers explain that combining quantum channels with classical channels is by far the more practical option.

"I see this as an absolute requirement – a 'must have,' Townsend said. "That's because optical fiber network infrastructure is enormously expensive to deploy, so it must last for a long time – perhaps 25 years or more – and be able to support a wide range of current and future, yet to be defined, systems and services. So it is extremely unlikely that an operator would ever deploy a network, or even dedicate fibers within an existing network, purely for quantum communications – it's just too expensive to do so. Consequently, we have to develop techniques that enable classical and quantum channels to work together on the same network if we want quantum communication systems to become a practical reality."

By demonstrating that both quantum and classical information can be transmitted on a single optical fiber network in a way that satisfies real-world requirements, the researchers hope to bring quantum information technology one step closer to commercial applications.

"As we have demonstrated, in principle the technology to do this is available now," Townsend. "However, in reality further research is likely to be required to reduce the cost and improve the performance of certain key parts of the system such as the single photon detectors, before widespread applications emerge. In general, the 'value proposition' for QKD on FTTH and other networks is under intensive discussion today, but at the moment no clear consensus has emerged concerning if and when it might be adopted to replace classical encryption techniques. However, as demonstrated by this research, the QKD field is not standing still and systems are continuing to evolve to become more practical, improving the potential for adoption of the technology in the future."

More information: Iris Choi, et al. "Quantum information to the home." *New Journal of Physics* 13 (2011) 063039
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