Is quantum Internet search on the way?

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In classical computing, random access memory (RAM) is needed to make things "work." But it is subject to a certain level of energy loss. But what if you could create low-energy quantum access memory (QRAM) that would not only work in terms of quantum computing, but that could also be applied to classical computing?

Seth Lloyd, a researcher at MIT, believes that a new architecture for QRAM could be used to not only reduce the energy wasted by RAM, but also be used for completely anonymous Internet search. "My colleagues and I were interested in protocols for quantum Internet search," he tells *PhysOrg.com*. "And we were also interested in what we could do with even a rudimentary quantum Internet. But first you have to develop this quantum RAM."

Lloyd worked with Vittorio Giovannetti at the NEST-CNR-INFM in Pisa, Italy, and with Lorenzo Maccone at the University of Pavia, in Pavia, Italy, to put together a system that would work as QRAM. They even called researchers and developers at Texas Instruments to see if their idea is feasible. The results of their efforts are published in *Physical Review Letters*: "Quantum Random Access Memory."

"Our design is based on a bucket brigade sort of design," Lloyd says. He explains that the design came about when he and his colleagues were trying to figure out how to make QRAM work based of classical RAM design. "There is just too much decoherence in classical RAM architecture. Too much for the quantum states to remain intact."

Lloyd explains how classical RAM works: “Lets say you have a gigabyte of RAM. That means you have one billion memory slots, each with an address. When you wan to access one, an address is given, let’s say it is about 30 bits long. The first bit will throw two switches, the next will throw four, and so on until a billion switches are thrown at once.”

“The conventional design is incredibly wasteful. And it is susceptible to noise and interference. We saw that this wasn’t going to work at all in terms of quantum RAM,” Lloyd continues. He and his colleagues set to work on their bucket brigade design.

“It is a sneakier way to access RAM,” he explains. “In the same gigabyte RAM, we send the first bit of the address along a path. Once the first layer is accessed, the next bit comes, following the path of the first bit, until it reaches the second layer. The third bit then traces the two paths before it. In this way, all the bits of the address only interact with two switches.”

There are problems with this set-up, however. Even though the experts at Texas Instruments agree that it would work, they point out that the energy saved using QRAM would not offset the larger energy problems associated with classical computing. Besides, Lloyd admits, the QRAM set-up is a little slower than the RAM. “You’d have to be willing to make that trade-off.”

That brings Lloyd back to the idea of quantum Internet search. “If you had a quantum Internet, then this would be useful,” he points out. “This offers a huge decrease in energy used and an increase in robustness.” The other interesting aspect is the possibility of completely anonymous Internet search. Not even your service provider would know who you are or what you search for.

This all sounds very nice, but is it something that could be implemented in the near future? Lloyd sees the potential, since immediate implementation isn’t possible. “We’re working on setting up an experiment with optics to show how this would work.” But the real issue is setting up an infrastructure that could support a quantum Internet.

“For a quantum Internet to work,” Lloyd explains, “we need what is called dark fiber. In some places, this is already being used for classical communications. But we would need more of it, and the necessary quantum switching structure is only just now being developed.”

If Lloyd is right, the next few years could be very interesting in terms of quantum technology and communications.

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