QUANTUM INFRASTRUCTURE HITS THE ENCRYPTION MARKET

Toshiba is releasing its FIRST COMMERCIAL QUANTUM KEY DISTRIBUTION SYSTEM, capable of supporting city- and national-scale quantum-secured communication.

The code-cracking potential of future, powerful quantum computers poses a threat to data security, and governments and companies are installing infrastructure to try to shore up their defences, says Taro Shimada, CEO of Toshiba, in Tokyo, Japan. Tech giants Google and IBM, alongside a raft of start-ups, are all promising to roll out rudimentary quantum computers within the next few years.

Quantum technologies also provide a potential solution in the form of quantum key distribution (QKD) encryption, notes Shimada. Already Toshiba, which has been leading research on quantum encryption systems for many years, has QKD products that are ready for market adoption.

▲ **A Toshiba researcher inspects a quantum key distribution chip under the microscope.**

ENCODED IN PHOTONS

While there are various forms of QKD, in essence they all rely on the fact that if an encryption key is encoded into the quantum state of photons of light, any attempts to intercept the key disturbs the photons, alerting users.

But given that QKD only operates with either single photons or very weak signals of light, the big challenge over the years has been developing the necessary light sources and detectors to support key transmission over useful distances and at sufficiently fast data rates, while also being cost effective and practical.

Toshiba has spent the past few years optimizing and testing its QKD technology, in particular low-noise, efficient photodiode detectors — semiconductor devices that convert photons into electrical current on the receiving end of communications — as well as transmission fibre cable stabilization during communication. And after some successful proof of concept trials using genomic, financial and telecommunication data, among others, the company has now decided that it's ready for commercial deployment, says Shimada.

Toshiba's first commercial offerings will support several kilobytes of key material over standard optical fibres exceeding 150km and several megabytes over metropolitan scale (<40km) links. Toshiba's engineers are also conducting commercial field trials in London to explore the potential for new services with United Kingdom telecoms operator, BT Group. The company is now signing up its first customers, including the financial firm Ernst and Young.

▲ **Toshiba's quantum key distribution systems distribute secret keys over optical fibre networks (top). Andrew Shields (bottom left) is head of the Quantum Technology Division of Toshiba Europe based in Cambridge in the United Kingdom. Taro Shimada (bottom right) is CEO of Toshiba in Tokyo, Japan.**

"There is definitely increasing demand and now widespread recognition of the threat to information security posed by quantum computers, and that the era of large-scale quantum computers is not so far away," says Andrew Shields, head of the Quantum Technology Division of Toshiba Europe in Cambridge, UK. "People working in information security would like to prepare now and QKD provides them security for the quantum age."

Their commercial systems work with completely standard optical fibre, and the key rate and transmission distance has been improving with time, explains Shields. "With our standard QKD product we can offer a QKD link across more than 150 km and that's significant because it starts to reach the distances needed for national networks in many countries, including the UK. I think deployment will evolve quickly. There are many proposals around the world in places like China and Europe for putting in national quantum networks."

GREATER SCALABILITY

Toshiba has long been a leader of research into QKD at its research centre for quantum technology in the city of Cambridge. Over that the past 30 years Toshiba has accomplished many world firsts, including the first LED capable of emitting single photons in 2002 and a high-speed gigahertz photon detector in 2010.

The team are still hard at work on increasing the distances possible. In 2018, Shields' team demonstrated a quantum signal transmission architecture called twin-field QKD[1], which supports transmission distances of up to 550km at viable data transfer rates. This test was done using standard optical fibre and improved upon distances achieved previously using conventional transmission fibres. In 2021, the team also demonstrated a more manageable and versatile stabilization scheme for their twin-field QKD signals, called dual-band stabilization scheme[2].

Shields says that another very important area will be photonic integration and the emergence of QKD systems on a chip. "The ordinary optical communications industry was totally transformed by the ability to put an optical system on a chip, and we're seeing the same things in quantum communication," explains Shields. "In 2021, we published on a prototype QKD system on a chip and that could be transformative as it allows us to cost effectively manufacture systems in much larger volumes, and in new forms that are smaller and use less power, which will help drive deployment[3]."

Eventually scalability will open up a whole range of opportunities, he adds. For example, "you could even think about a set-top box and quantum communications for the home, when the price becomes sufficiently low".

The business potential and long-term vision for quantum technologies is also very much on Shimada's mind. "Our approach is to create a QKD service with a plug and play approach, so that it's very easy for end users to utilize it in many ways. The real beauty is in the future scalability, as right now everybody needs or wants protection."

10 MILLION USERS

Last year, Q-STAR, a Japanese industrial consortium on quantum technologies was established. To date, there are 60 companies involved. Toshiba is playing a leading role as chair of the steering committee.

Significantly, more than half of the companies which are members are potential end users from the chemistry, automotive, financial and healthcare sectors, that are interested in and exploring how quantum technology can be used within their businesses, says Shimada.

"I was asked to help on a working group for the Japanese government's roadmap for quantum technology," he says. "I proposed that within five years, 10 million people in Japan should be using quantum technology, perhaps without necessarily even knowing it. This was adopted as the basis for future plans."

Why 10 million people? "Because this is roughly 10% of the Japanese population and once you achieve that it will take off as an ecosystem," says Shimada. ■

REFERENCES

1. Lucamarini, M., *et al. Nat.* **557,** 2018
2. Pittalugo, M., *et al. Nat. Photonics* **15,** 2021
3. Paraïso, T., K., *et al. Nat. Photonics* **15,** 2021

TOSHIBA

www.global.toshiba/ww/products-solutions/security-ict/qkd

Advertiser retains sole responsibility for content