Quantum Networking

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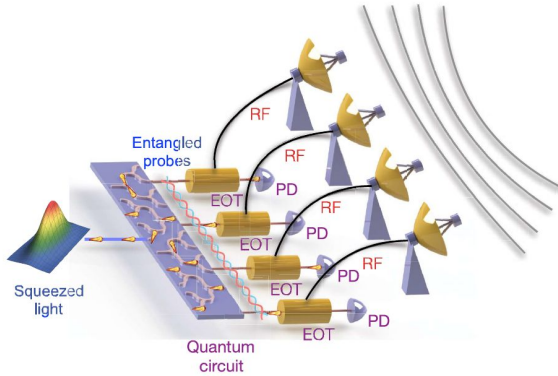Lawrence Berkeley National Lab

INDIS Workshop
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The Quantum Internet is very different than the Classical (Digital) Internet

	Classical Communications	Quantum Communications
Classical Message (bits)	Internet	QKD SuperDense Coding
Quantum Message (qubits)		Quantum Internet

ESnet

Why Quantum Communication?

A completely new set of applications projected to be enabled by implementation of Quantum Networking

Image from *Nat. Phys.* **10**, 582–587 (2014)
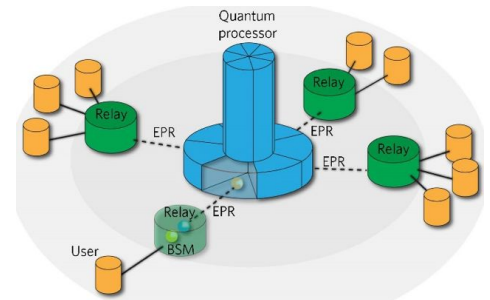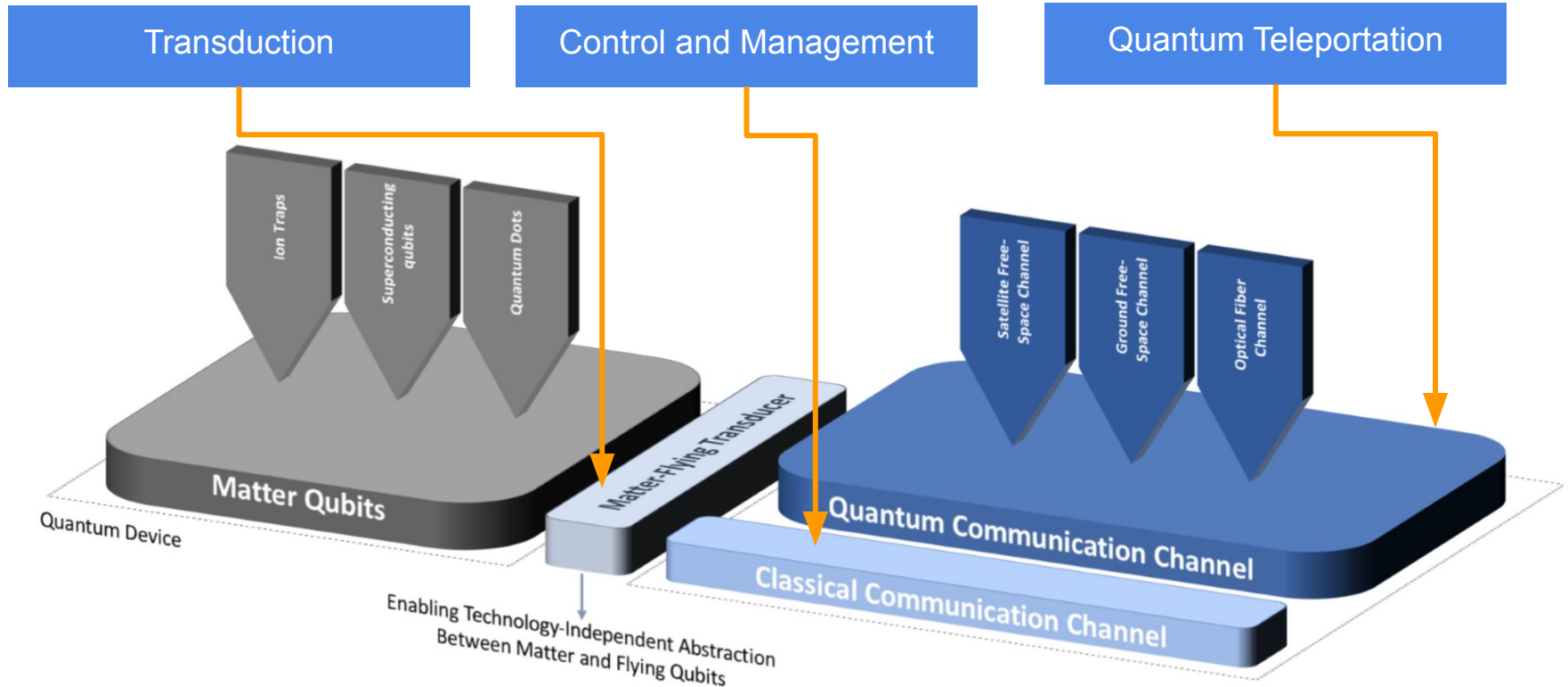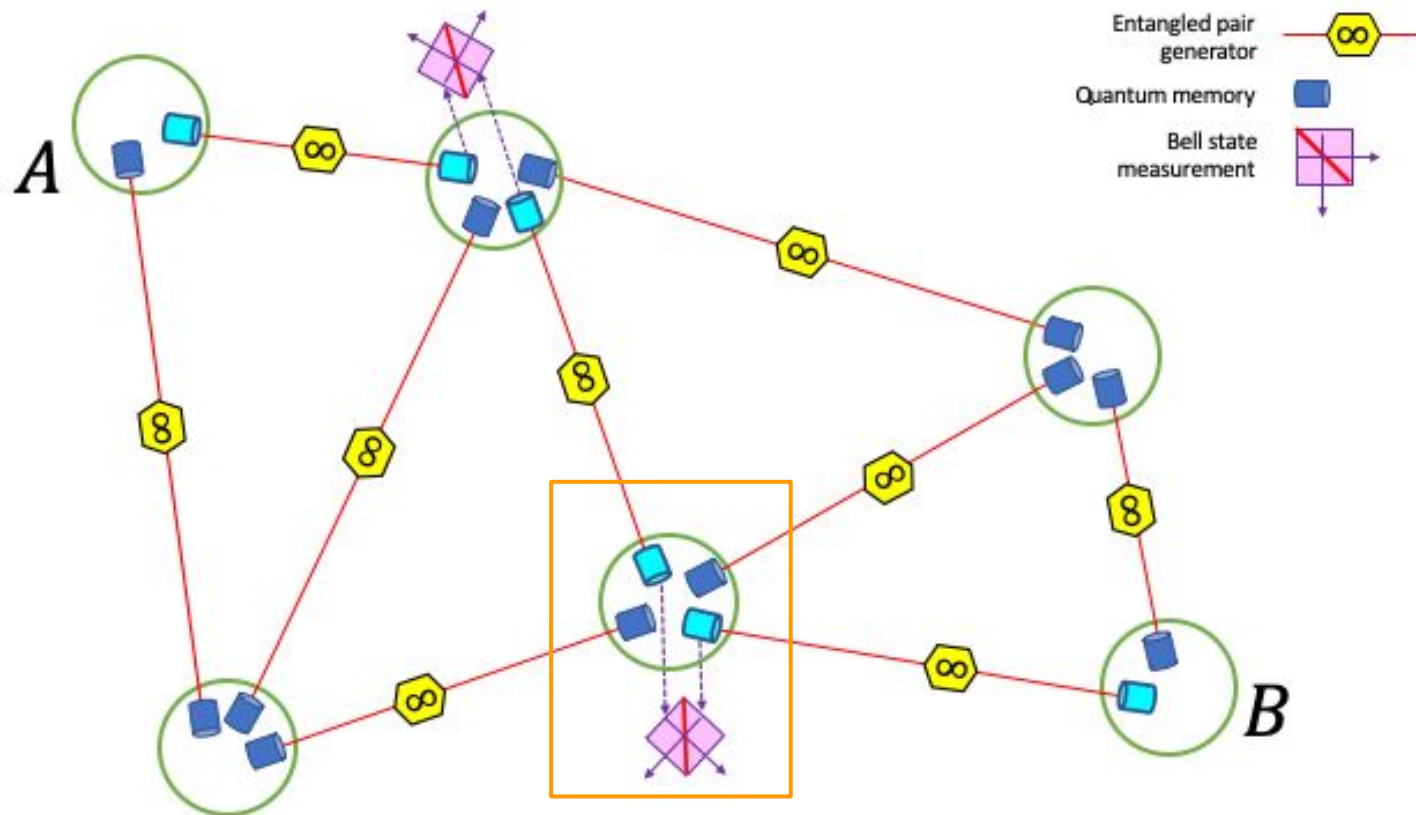
Image from *Nature Photon* **10**, 671–675 (2016).
https://doi.org/10.1038/nphoton.2016.179

Quantum Sensor Networks

Quantum Metrology

Distributed Quantum Computing

Three important elements of Quantum Communication

Transduction

Control and Management

Quantum Teleportation

Ion Traps

Superconducting qubits

Quantum Dots

Matter Qubits

Quantum Device

Matter-Flying Transducer

Enabling Technology-Independent Abstraction Between Matter and Flying Qubits

Satellite Free-Space Channel

Ground Free-Space Channel

Optical Fiber Channel

Quantum Communication Channel

Classical Communication Channel

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https://arxiv.org/pdf/1810.08421v2.pdf

The Quantum Internet: notional view

Entangled pair generator

Quantum memory

Bell state measurement

A

B

**Quantum Repeater:
The grand challenge**

Snet
Thanks to Eden Figueroa

Why now?

- Recent proof-of-concept demonstrations
- International interest
- Opportunities and threats
  - Scientific leadership
  - National security
- DOE support

"The construction of the nation's first Quantum Internet will open new possibilities in science, strengthen our national security, and open a world of opportunities in communications, innovation, and technology."

– Secretary Dan Brouillette

⚡ ENERGY.GOV

Report of the DOE Quantum Internet Blueprint Workshop

From Long-distance Entanglement to Building a Nationwide Quantum Internet

February 5-6, 2020
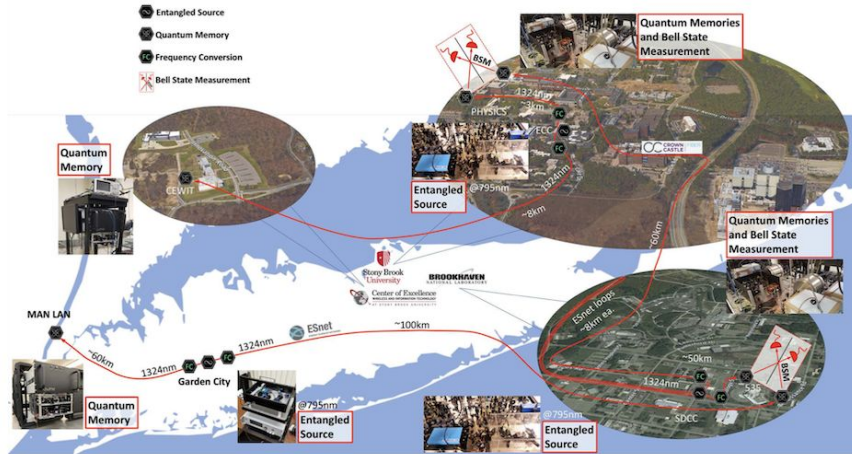
Current testbeds focused on QR Grand Challenge

Figure 3:3. Long Island quantum network extended to New York City. The network will use a chain of quantum repeaters, extended across Long Island via three entangled sources, six quantum memories, and two entanglement swapping stations. Using ESnet's existing fiber infrastructure, the network will connect SBU to New York City via Brookhaven Lab with intermediate stations on the two campuses and in Garden City, N.Y. This is expected to be the first quantum repeater network of its kind in the world.

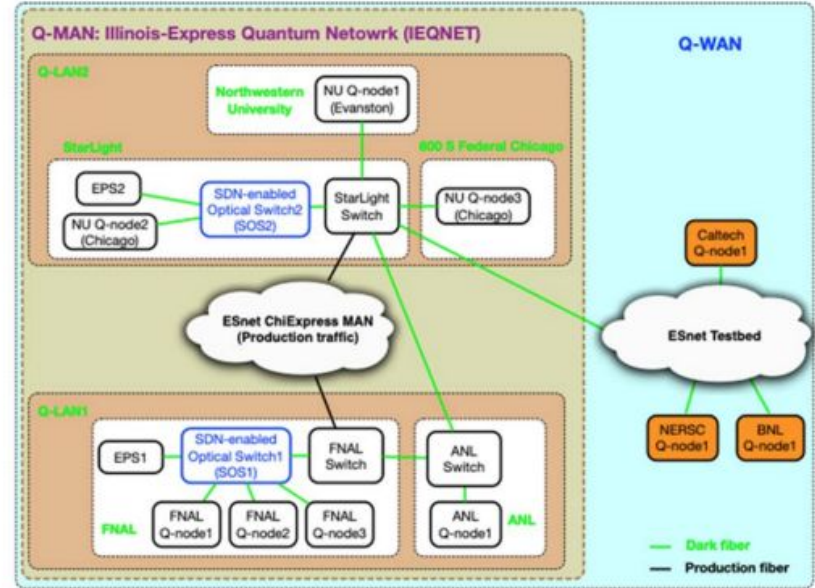*BNL/Stonybrook/ORNL/LANL quantum network testbed*

Figure 3:2. IEQNET Topology

Quantum Testbeds in Chicago/Caltech, some parts are planned

Testbeds also in **Boston Area (MIT/Harvard/BBN/Sandia)**, **Caltech/JPL**, **Univ. of Arizona** among others

Questions?

Contact imonga@es.net for more information