A STRATEGIC VISION FOR AMERICA'S QUANTUM NETWORKS

Product of

THE WHITE HOUSE

NATIONAL QUANTUM COORDINATION OFFICE

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INTRODUCTION

The Trump Administration is committed to American leadership in quantum information science (QIS), and to unleashing its incredible potential for U.S. economic growth, technological advancement, and national security. To coordinate a national research effort encompassing Federal agencies, the academic community, and industry leaders already underway, The White House National Quantum Coordination Office has released *A Strategic Vision for America's Quantum Networks*.

Exploring how to build the quantum internet—a vast network of quantum computers and other quantum devices—will catalyze new technologies that accelerate today's internet, improve the security of our communications, and allow dramatic advances in computing. By leading the way in quantum networking, America is poised to revolutionize national and financial security, patient privacy, drug discovery, and the design and manufacturing of new materials, while increasing our scientific understanding of the universe.

Quantum computing and networking technologies are still at an early stage of research and development (R&D). The strategic vision focuses America's R&D efforts to advance the development of foundations for the quantum internet. It establishes QIS community goals for quantum networking, and recommends six specific technical areas for focused research activity.

This strategic vision is driven by the National Quantum Initiative Act (NQIA), signed into law by President Trump in December 2018, to accelerate QIS R&D through increased federal investment and coordination. The strategy was developed through the NQIA's coordinating bodies, the National Quantum Coordination Office (NQCO) and the National Science and Technology Council's Subcommittee on Quantum Information Science (SCQIS) and reflects deep community input from SCQIS request for information responses of 2018-2019 and from recent workshops hosted by Federal agencies[1,2].

Over the past year, as called for by the NQIA, The White House established the National Quantum Coordination Office to unify Federal R&D activities across government, and the National Quantum Initiative Advisory Committee to ensure perspectives from the quantum community inform Federal efforts. Additionally, to implement the NQIA, the National Science Foundation announced the Quantum Leap Challenge Institutes[3] solicitation to explore foundational quantum science and technology, and the Department of Energy (DOE) announced funding for the creation of new QIS research centers[4] where researchers from DOE's National Labs will join with experts from academia and the private sector to advance R&D. This builds upon the robust QIS research programs, centers and consortia at other agencies including National Institute for Standards and Technology, the Department of Defense, the National Security Agency, and NASA.

In 1969, the Department of Defense's Advanced Research Projects Agency demonstrated the first network (ARPANET) that led to the internet we know today. Back then, one could hardly imagine that it would become the world's most powerful driver for economic growth and quality of life.

As demonstrated once by ARPANET and now by *A Strategic Vision for America's Quantum Networks* and the NQIA, the Federal government has a critical role to play in driving early-stage QIS research and providing direction to national R&D efforts. Under the Trump Administration's leadership, the United States will pioneer the quantum internet and ensure QIS discovery and innovation that benefits all Americans.

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[1] 2019 NSF workshop on quantum Interconnects, https://arxiv.org/abs/1912.06642
[2] 2018 DOE workshop on quantum networks, https://info.ornl.gov/sites/publications/Files/Pub124247.pdf
[3] NSF Quantum Leap Institutes: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505634
[4] DOE Quantum Centers https://www.energy.gov/articles/department-energy-announces-625-million-new-quantum-centers

BUILDING THE FOUNDATIONS FOR NETWORKING QUANTUM DEVICES

Quantum networking uses the quantum properties of light and information to enable secure communication, new sensing modalities, and enhanced quantum computation. Research in this area will ensure continued advances in fundamental science and enable innovative applications of quantum devices to improve the Nation's economy and security. Long-term prospects for quantum networks hinge on our ability to pioneer platforms that reliably link together quantum devices, and to develop applications that leverage quantum-enabled security, sensing, and computation modalities. By making a concerted and sustained effort to develop these prospects, the foundations for a quantum internet will be in place to enhance America's future.

Two specific goals will focus efforts in this direction:

- Over the next five years, companies and laboratories in the United States will demonstrate the foundational science and key technologies to enable quantum networks, from quantum interconnects, quantum repeaters, and quantum memories to high-throughput quantum channels and exploration of space-based entanglement distribution across intercontinental distances. At the same time, the potential impact and improved applications of such systems will be identified for commercial, scientific, health and national security benefits.
- Over the next twenty years, quantum internet links will leverage networked quantum devices to enable new capabilities not possible with classical technology, while advancing our understanding of the role entanglement plays.

While pursuing these goals, key opportunities for new directions and spin-off applications will be encouraged by strong coordination and future-looking leadership under the auspices of the National Quantum Initiative's coordination mechanisms. This includes both the strong support of federal agencies performing the research and development and also a dedication to using the new technologies and scientific discoveries to enhance the execution of agency missions.

Accordingly, the National Science and Technology Council Subcommittee on Quantum Information Science recommends pursuing the following activities, commensurate with our growing understanding of their relevance to useful quantum networking and other quantum technology:

- Technology and platform development for key components including classical sources, quantum-limited detectors, ultra-low loss interconnects, space-to-ground connections, and classical networking and cybersecurity protocols and scaling costs;
- Transduction of quantum sources and signals from optical and telecom regimes to quantum computer-relevant domains, including microwaves;
- Entanglement and hyper-entangled state generation, and transmission, control, and measurement of quantum states;
- Development of quantum memories and small-scale quantum computers that are compatible with photon-based quantum bits in the optical or telecom wavelengths;
- Exploration of novel algorithms and applications for long-range entanglement between small-scale and large-scale quantum processors, including quantum error correction, quantum cloud computing protocols, and new quantum sensing modalities; and
- Exploration of techniques for both terrestrial and space-based entanglement distribution.

ABOUT THE WHITE HOUSE NATIONAL QUANTUM COORDINATION OFFICE

Established by the National Quantum Initiative Act of 2018 to reside within the White House Office of Science and Technology Policy, the National Quantum Coordination Office coordinates quantum information science research and development across the Federal Government. Providing a central point of contact for stakeholders working in the field, the NQCO supports the various interagency groups and coordination mechanisms to ensure a cohesive and sustained approach for American leadership in quantum information science.

ABOUT THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is to ensure science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at http://www.whitehouse.gov/ostp/nstc.

ABOUT THE NSTC SUBCOMMITTEE ON QUANTUM INFORMATION SCIENCE

The NSTC Subcommittee on Quantum Information Science (SCQIS) coordinates Federal research and development (R&D) in quantum information science and related technologies under the auspices of the NSTC's Committee on Science. This coordinated R&D aims to ensure that U.S. leadership in quantum information science and its applications is maintained and expanded over the next decade. The SCQIS is co-chaired by the Department of Energy, the National Institute of Standards and Technology, the National Science Foundation, and the White House Office of Science and Technology Policy. Additional members include the Department of Defense, National Aeronautics and Space Administration, National Security Agency, Office of the Director of National Intelligence, Office of Management and Budget, United States Patent and Trademark Office, and the Department of State.

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