Moonshot R&D International Symposium

Working Group 6 (WG6)

Creating innovative non-traditional sciences and technologies based on quantum and related phenomena

Chair: Yasuhiko Arakawa (The University of Tokyo)

Sub-Chair: Masahiro Kitagawa (Osaka University)

Agenda

1. Introduction
2. Presentation
   - Research trend in hardware
   - Research trend in quantum software
   - Research trend in quantum network
3. Panel Discussion
   - Quantum science and technology policy in US
   - Quantum research trend in US
   - Quantum research trend in EU
   - Discussion
4. Wrap up

Committee Members: Working Group 6

	Name	Affiliation and title
Chair	Yasuhiko Arakawa	Specially Appointed Professor, Institute for Nano Quantum Information Electronics, The University of Tokyo
Sub-chair	Masahiro Kitagawa	Professor, Graduate School of Engineering Science, Osaka University
	Hidemi Ishiuchi	Assistant to General Manager, Technology Innovation Center, KIOXIA Corporation
	Nobuyuki Imoto	Research Professor, Institute for Open and Transdisciplinary Research Initiatives, Osaka University
	Tetsuro Nishino	Professor, Graduate School of Informatics and Engineering, The University of Electro-Communications

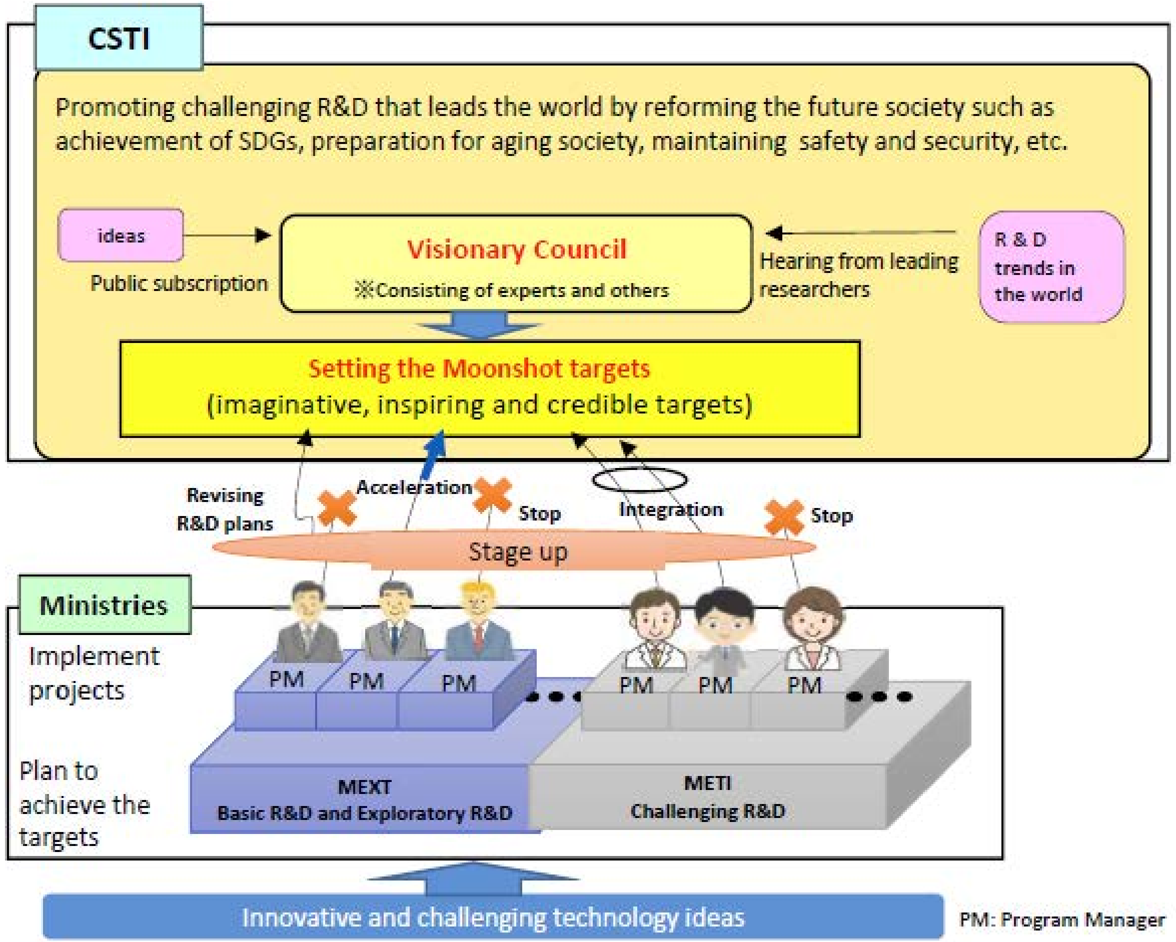
Overview

Objective of the symposium: WG6

- On the basis of the Initiative Report (IR we discuss the proposed Moonshot Goal.

Structures of the program

- 100billion Japanese Yen in the second supplementary budget of 2018FY
- 7 Working Groups discuss the Moonshot Goals.



Background

- The progress of semiconductor technology has been the driving force behind the today's rapidly growing information society. Toward the realization of Society 5.0, the demand for the computers will increase explosively. However, computer progress in such a conventional style will soon come to a limit.
- A number of important computational tasks are known to be difficult or impossible to perform using current style supercomputers. Many of such difficult tasks are expected to be efficiently calculated by using a large-scale "fault-tolerant universal quantum computer".

Proposal of the MS Goal

The WG6 reviewed and discussed candidates of the MS goals from various perspectives, considering societal demands toward developing quantum computers, global trends in research and technical challenges, such that the MS goal will be accepted by many as a viable goal achievable by 2050.

Finally, WG6 proposed the following MS Goal:

Realizing a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050

Initiative Report of WG6

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

2050

[Moonshot Goal candidate]

Realization of fault-tolerant universal quantum computers

2040

Demonstration of distributed NISQ computer & Calculation of useful tasks under quantum error correction

2030

Development of NISQ computers of a certain scale & Effectiveness demonstration of quantum error correction

Network

Development of quantum memory, establishment quantum interface technology between photons and quantum memory.

- Photon source & detector
- Quantum memory
- Quantum interface technology

Hardware

System design and implementation of quantum error correction, establishment of quantum bit and gate platforms.

- Super-conducting qubits

Stage gate
Identify suitable & feasible physical system.

- Photons
- Trapped-ions
- Silicon quantum dots

Software

Development of low overhead quantum error correction code and quantum algorithms, development of measurement and control software.

- Quantum error correction theory
- Middleware, compiler
- Algorithms, applications

Related Quantum Technology

- Quantum sensors
- Quantum materials
- Basic and Fundamental Research

Initiative Report (IR) of WG6

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

The milestone by 2030

Development of NISQ computers of a certain scale, and effectiveness demonstration of quantum error correction

- Hardware: Design and implementation of quantum error correction systems, and establishment of quantum bit and gate platforms, etc.
- Software: Low overhead quantum error correction code, quantum algorithms, and measurement/control software, etc.
- Network: Quantum memory and quantum interface technology, etc.

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Initiative Report (IR) of WG6

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

The milestone by 2040

Demonstration of distributed NISQ computer and calculation of useful tasks under quantum error correction

2-1) Demonstration of distributed NISQ computer

●Hardware: Design and implementation of quantum information processing units and interfaces

●Software: Distributed quantum algorithm and communication protocols

●Network: Quantum repeater system and quantum state transfer technology

(2-2) Useful task calculation under quantum error correction

●Hardware: Design and implementation of large-scale system architecture

●Software: Large-scale quantum error correction execution software, useful calculation tasks and algorithms

●Network: Large-scale three-dimensional assembly and packaging

Initiative Report (IR) of WG6

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

The milestone by 2050s

Realization of large-scale/fault-tolerance

- Hardware: Design and production of large-scale systems
- Software: Tools (compilers) for gate decomposition/quantum circuit optimization/verification
- Network: High-speed and large-capacity communication

Today’s discussion

On the basis of the Initiative Report, the followings are discussed at this session.

- The proposed Moonshot Goal
- Strategy and milestone toward the Moonshot Goal candidate
- Expectations to Japan

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Presentation

Topics and presentators
"Research trend in hardware" Yasunobu Nakamura Professor, Research Center for Advanced Science and Technology, The University of Tokyo
"Research trend in quantum software" Keisuke Fujii Professor, Graduate School of Engineering Science, Osaka University
"Research trend in quantum network" Hideo Kosaka Professor, Faculty of Engineering, Yokohama National University

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Panel discussion

Panelists
“Quantum Science and Technology Policy in US” Jake Taylor Assistant Director, Quantum Information Science at White House Office of Science and Technology Policy, USA
“Quantum science and technology policy and research trend in EU” Tommaso Calarco, Director, Institute of Quantum Control, Peter Grünberg Institute Forschungszentrum Jülich, Germany
“Quantum research trend in US” Alexander D. Cronin, Senior Quantum Coordinator, White House Office of Science and Technology Policy, USA