

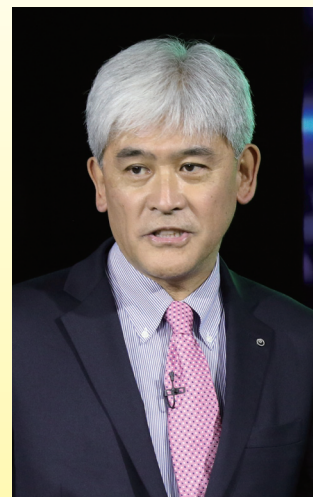
## Upgrade Reality—Reality in IOWN Concept

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### Abstract

This article introduces the vision of NTT Research, Inc., which began its operations in July 2019 with the three laboratories. This article is based on the special session for NTT Research, Inc. at the NTT R&D Forum 2019, which was held on November 14 and 15, 2019.

*Keywords: advanced basic research, IOWN, Upgrade Reality*



### 1. The current situation of ICT sector and launch of NTT Research, Inc.

Looking at the recent trends in the information and communication technology (ICT) market, we see new innovations making good progress in the areas of Internet of Things (IoT), big data, artificial intelligence (AI), and automation. Many technologies to support such trends are now affordably available, which triggered digital transformation (DX) in many business sectors, which has created tremendous positive impact on the way we do business and live our lives. However, there are several limiting factors on the horizon that could impede this evolution. These factors are ICT energy consumption, saturated Moore's Law, and security (or privacy) (**Fig. 1**).

To sustain DX for over a long period, we see the need of having some kind of "game changer," rather than incremental improvements. That is exactly how NTT research and development (R&D) laboratories view the Innovative Optical and Wireless Network (IOWN) initiative. IOWN is a reflection of NTT R&D's focus on long-term solutions.

NTT Research, Inc. was founded in July 2019 to conduct basic research activities related to the key components of the IOWN initiative. This company is based in the area outside of San Francisco, California,

in the United States known as Silicon Valley. The key advantage of this setting is this is where many of the major global talent and global research partners are located; therefore, collaborations with them are easily facilitated. Also, by having this footprint in Silicon Valley, NTT R&D as a whole becomes a part of such communities. The vision of NTT Research, Inc. is to further enhance the research activities that NTT has been engaged in for a long time through such collaborations (**Fig. 2**).

### 2. The activities of each laboratory

NTT Research, Inc. is currently organized into three research areas, as shown in **Fig. 3**. These are the Physics & Informatics Laboratories (NTT PHI Labs), the Cryptography & Information Security Laboratories (NTT CIS Labs), and the Medical & Health Informatics Laboratories (NTT MEI Labs).

#### 2.1 NTT PHI Labs

PHI Labs studies completely novel optical computers called coherent Ising machines (CIMs), which are designed to solve combinatorial optimization problems efficiently. An example of a combinatorial optimization problem is the traveling salesman problem, which is to find the shortest overall route covering all

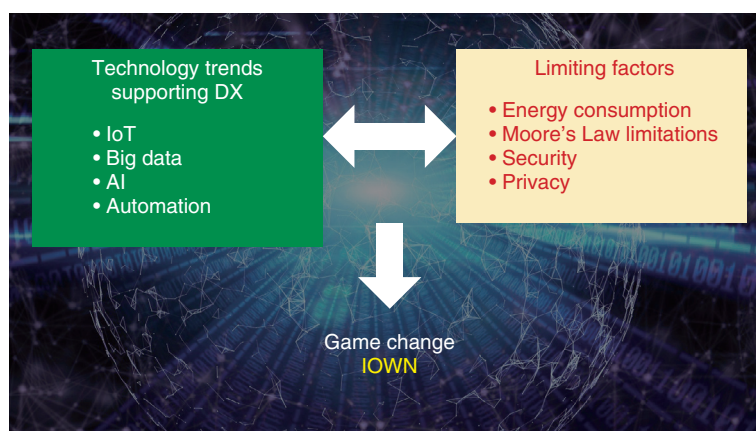


Fig. 1. Technology trends and limiting factors.

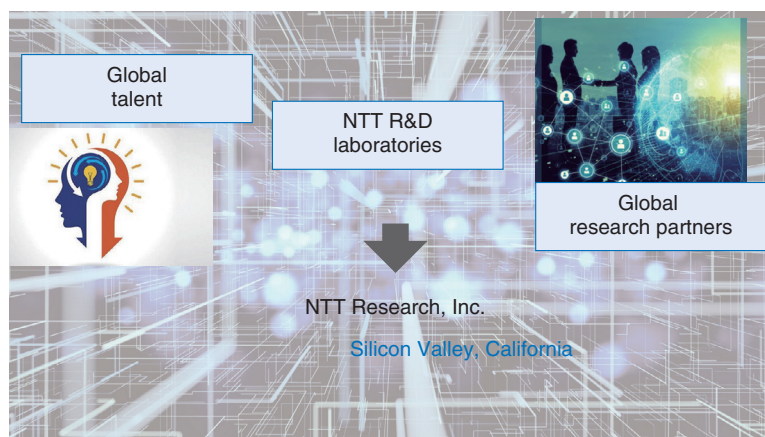


Fig. 2. Why NTT Research, Inc. was established in Silicon Valley.

Physics and Informatics (PHI Labs)  
 Cryptography and Information Security (CIS Labs)  
 Medical and Health Informatics (MEI Labs)

Fig. 3. Laboratories in NTT Research, Inc.

the customers. The number of possible routes increases exponentially as the numbers of customers and possible paths increase. This problem can take years to solve on conventional computers when dealing with practical cases. The concept of the traveling salesman problem can be applied in many similar

real-life problems such as optimal traffic control to minimize congestion in a large city and wavelength allocation in mobile phone services.

Over the years, NTT R&D has been working on optical versions of the CIM, which combine the principles of quantum information processing with those of brain information processing. NTT Research, Inc. announced in November the start of a research collaboration with eight external partners in the United States, Canada, and Australia (five US-based universities, one Australian university, NASA, and one software startup) to enhance the research activities around CIMs. Together with these partners, PHI Labs studies the theoretical aspects of these machines, conducts related experiments, and explores applications for which these machines would solve their

issues effectively and efficiently.

## 2.2 NTT CIS Labs

CIS Labs conducts research on cryptography. To build a smart world and connected society, we need to be ever-more attentive on the issues around privacy and security. Crypto systems are developed to protect security and privacy; however, the implementation of such systems tends to make information sharing more difficult. In other words, easy information sharing and protection of privacy/security are trade-offs in many cases. CIS Labs is researching new cryptographic techniques that enhance the flexibility in information exchange while maintaining security and privacy. Another topic that this group is tackling is post-quantum cryptography, addressing the concern that most current crypto systems would be broken when quantum computers are in place.

CIS Labs is also working on the topic of blockchain security. Blockchain has been implemented in several applications such as crypto currencies and fintech applications. However, there has not been much research into its security implications and scalability issues. One of CIS Labs' focus areas is the proofs of blockchain security, for example, to answer the question, "under what conditions can a blockchain be broken."

We will continue to assemble a dream team of top experts and talent. Currently, the team consists of researchers and scientists who came from the faculties of top level universities in this field such as the University of Texas, Northeastern University, Princeton University, and Cornell University.

## 2.3 NTT MEI Labs

MEI Labs' field of research is medical and health sciences. This is closely related to Digital Twin Computing (DTC), an important component of the IOWN initiative. Medical practice is always looking for the best solution *along with* the next best. With this in mind, to have your digital twin (alter ego) in the cyber world and administer treatments to it would create a huge advantage for medical care in the future. If a particular treatment, tested on the digital twin, does not work, we can try another approach without risking the patient's health. Furthermore, if you have a precisely simulated model of your body or part of your body (i.e. organs), it would create a revolution in the world of medical practice. Today, with significant progress in bio-sensing technologies, a vast amount of medical information is becoming available. Together with the innovations in AI, big data, and

robotics, precise human-body simulation and medical treatment based on it will be the next step we need to pursue. In the past, medical records, and even test and imaging results, existed solely within the handwritten analog world, but now these data are all digitally stored. We envision that, by leveraging the output from advanced crypto technologies, such data will be effectively exchanged among bio-medical/data-analytic experts to study and create simulated human-body models while maintaining patients' privacy.

Many experts have been pointing out that medical and health sciences need to collaborate in a more robust manner with math, science, and engineering disciplines. In this new era where information technologies are progressing rapidly, we can expect medical and health sciences to leverage a variety of these innovations. However, such an approach should be ethically sound. The fundamentals of human community needs to be preserved while developing cutting edge medical and life-science technologies. One of the conditions for achieving this is the integrity of the members engaged in the research activities.

In Silicon Valley, such collaborations are normal between industries, academia, medical facilities, and startups, each of which brings its own strengths. We see many young people in their 20s and 30s proving their mettle in the competitive environment of Silicon Valley. MEI Labs offers an attractive workplace for highly motivated researchers in the fields of medicine, data science, and material science.

## 3. Researchers at NTT Research, Inc.

We have recruited over 20 researchers and scientists thus far, all of whom have doctorates and 10 hold professorships. They have variety of backgrounds in terms of where they are from. Just under ten are from North America, one is from Europe, and just under ten are from Asia.

We also formalized numerous research collaborations, mostly with universities in the United States (**Fig. 4**). These partnerships effectively enhance the talent and resources engaged in our research activities, expand the horizon of our thinking process, and strengthen our ties to research networks. We are envisioning to further enhance these partnerships moving forward.

These basic research NTT Research, Inc. is engaged in is in line with the IOWN initiative. Our activities are also to support further development of NTT's global businesses from innovation perspectives along with two other companies, NTT Disruption and



Fig. 4. Research partners.

NTT Venture Capital. NTT Disruption will be showcasing what can be done in the near future using the latest DX technologies. It will unearth concrete solutions tailored to various verticals such as healthcare, financial, autonomous driving, sports, and entertainment. NTT Venture Capital will take responsibility for the medium term by identifying and investing in promising startups. NTT Research, Inc. is ideally placed to take charge in addressing longer-term innovation by envisioning “beyond Internet,” which the

IOWN initiative is targeting.

#### 4. Conclusion

The motto of NTT Research, Inc. is *Upgrade Reality*. By “reality” we mean so-called accepted norms that define what we think of as the real world. Our focus will always be on fundamental improvements to the status quo.

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#### Kazuhiro Gomi

President & CEO, NTT Research, Inc.

He joined NTT in 1985. Before taking up his current post in April 2019, he served as vice president (VP) of the Global Business Department of NTT Communications from 2001 to 2004, after which he served as VP of the Global IP Network Business Unit of NTT America (2004 to 2009), chief operating officer of NTT America (2009 to 2010), and president and chief executive officer of NTT America (2010 to 2019).

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