Quantum Computing Use Cases

Biosafety simulation



Promotion of SDGs with Quantum Technology

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New Energy and Industrial Technology Development Organization (NEDO)

生体保全シミュレーション
Biosafety simulation



ユースケース概要 **Use Case Overview**	生態系のバランスに大きな影響を与える品種などをシミュレーションで特定 Identify species that have a significant impact on the balance of ecosystems through simulation.
解決できる課題と効果 **Issues to be addressed and their effects**	絶滅危惧種などを効率的に救出するために、試行錯誤の生態系維持活動を洗練 Refine the trial-and-error ecosystem maintenance activities to efficiently rescue endangered species and others.
量子技術の貢献 **Contributions of quantum technology**	各種生物の絶滅リスクや過剰繁殖リスクを予測するシミュレーション Simulation to predict the extinction risks and overpopulation risks of various species.

実現予想時期 **Expected realization period**	(Year)2040～2050
産業分類 **Industry classification**	情報・金融・その他サービス Information・Financial・Other services
関連するQRAMI階層 **Related QRAMI layers**	事業層 Business layer
関連する量子技術 **Related quantum technologies**	量子コンピュータ(FTQC) Quantum Computer(FTQC)

新規性 **Novelty**	軽微な改良 Minor improvements
達成難易度 **Difficulty of achievement**	非常に困難 Very Difficult
社会貢献度 **Social contribution level**	社会全体に貢献 Contributions to society as a whole
市場規模 **Market size**	見積困難 Difficult to estimate

Detail

Biosafety simulation

- Optimal ecological simulations and ecological, conservation, and technological innovations will enable people to continue their economic activities while coexisting with the ecosystem.



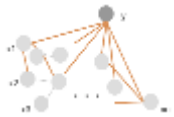
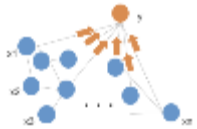
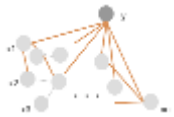
8,878 species
Endangered species that can be rescued every year

Currently, activities aimed at ecosystem conservation are carried out by trial and error, so their effect is limited. By using precise simulations of ecosystems, it will be possible to identify species that have significant effects on the eco-balance and save them effectively.

Potential contribution of computational technology	Feasible ultimate world	Supportable SDG goals
Ecosystem simulation Predicting by simulation the risk of extinction and overpopulation of various organisms Simulating mid- to long-term effects and risks of human and corporate activities on the ecosphere Extracting important indicators for ecological conservation Proposing optimal solutions for ecological conditions	The ecosystem will be maintained. It will become possible to quantitatively and horizontally compare the impact of human and corporate activities on the ecosphere, and efforts to conserve living organisms will thus become more proactive.	14 海の豊かさを守ろう 15 陸の豊かさも守ろう 12 つくる責任 つかう責任

Roadmap

Biosafety simulation

Process		Necessary R&D and business development	Quantum-computer scope of contribution and future development issues	
Optimal ecological simulation	Establishing ecosystem model	■ Establishing ecological mathematical models. Specifically, factors that affect the amount and distribution of biological species are identified from a huge amount of actual measurement data and formulated as linear functions. → Mathematical models already exist, but the correlation between parameters in existing models is unclear, so efforts to refine them (e.g., taking into account the evolutionary history of various organisms) are necessary.		■ Expanding the scope of quantum computing for statistical analysis, e.g., linear-regression analysis (i.e., developing methods with a wider range of applications than current algorithms)
	Establishing methods for acquiring necessary information	■ Improving the accuracy and speed of the environmental DNA method for estimating biomass. Establishing technology for decoding fragmented DNA sequences quickly ■ Developing technology to obtain biological ecological information in extreme environments such as the deep sea	-	■ None in particular
	Establishing calculation technology	■ Establishing simulations to predict the extinction and overpopulation risks of various species ■ Establishing simulations of the mid- to long-term effects/risks of human/business activities on the biosphere (e.g., verifying the environmental friendliness of business activities/products, loss of habitats due to construction and deforestation, spread of infectious diseases in wild fish due to escaped farmed fish, and eradication of wild animals through genome editing of organisms)	Solve forward problems in causal models 	■ Within those models, identify computational tasks difficult to solve by a classical approach ■ Developing algorithms to efficiently solve the tasks
Innovation in ecological-conservation technology	Determining indicators for ecological conservation	■ Establishing a calculation technique to determine indicators for biodiversity evaluation based on the ecological mathematical models. Specifically, extracting parameters important for ecological conservation from a large data set ■ Proposing optimal solutions for ecological conditions based on the ecological mathematical models and important parameters for ecological conservation (optimal solutions within ethically acceptable limits)		● Expanding the scope of quantum computing for statistical analysis, e.g., linear-regression analysis (i.e., developing methods with a wider range of applications than current algorithms)
	Establishing ecological-protection technology	■ Providing medical solutions—based on biological models and pharmacological function models—to assist in the recovery and propagation of species in need of protection ■ Developing technology to assist in the recovery and propagation of species in need of protection by editing genomes of organisms and artificially introducing and crossbreeding individuals with dominant genes ■ Establishing techniques for simulating for the effects of introducing the above solutions and technologies on the ecology and verifying the validity of artificial manipulation (e.g., crossbreeding leads to a further decline in fitness and extinction and adverse effects on other species)	-	■ None in particular

Roadmap

Biosafety simulation

Process		Necessary steps	2024	2025-2030	2030-2040	Beyond 2040
Optimal ecological simulation	Establishing ecosystem model	■ Collecting information on existing ecological models and food chains, and refining the parameter interactions				
		■ Collecting past measurements of biological species and environmental data				
		■ Expanding the scope for application of quantum computers to statistical analysis, e.g., linear-regression analysis				
		■ Identifying factors that affect the amount and distribution of biological species from collected data, formulating them into linear functions, and building models				
	Establishing methods for acquiring necessary information	■ Establishing an algorithm for decoding environmental DNA sequences and quantum computing				
		■ Developing technology to obtain biological ecological information in extreme environments such as the deep sea				
	Establish computational technology	■ Within those models, identify computational tasks difficult to solve by a classical approach				
		■ Verifying the possibility and business feasibility of accelerating calculations with quantum computers				
		■ Establishing quantum algorithms for predicting extinction risk and overpopulation risk of various organisms				
		■ Establishing quantum algorithms for predicting the medium- to long-term effects of human/corporate activities on the ecosphere				
Innovation in ecological-conservation technology	Determining indicators for ecological conservation	■ Using the ecological model to extract important parameters and important protected objects in ecological conservation				
		■ Establishing international consensus and public-private cooperation schemes considering the above important parameters and important protected objects in ecological conservation				
		■ Establishing a quantum algorithm for proposing strategies to promote the recovery and reproduction of important protected species				
	Establishing ecological-protection technology	■ Establishing technology based on biological and pharmacological models—for assisting the recovery and reproduction of species in need of protection				
		■ Establishing technology to optimize technologies to assist the recovery and reproduction of species in need of protection (processes/optimal genome sequences, etc.)				
		■ Establishing technology for predicting the effects of the introduction of these human technologies on the natural world				

Items related to quantum computers

More use cases are available on our website. We invite you to explore them.
https://www.quantum-computing-use-cases.nedo.go.jp/english/

More Use Cases

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This collection of use cases was obtained as a result of the work commissioned by the New Energy and Industrial Technology Development Organization (NEDO) "Cyber-Physical Development Business of Quantum/Classical Hybrid Technology/Study of Use Case of Quantum Technology" and the “Post-5G Information and Communications System Infrastructure Reinforcement R & D Project (Quantum Industrialization)/Comprehensive Study for Promoting the Industrialization of Quantum Computers ”.