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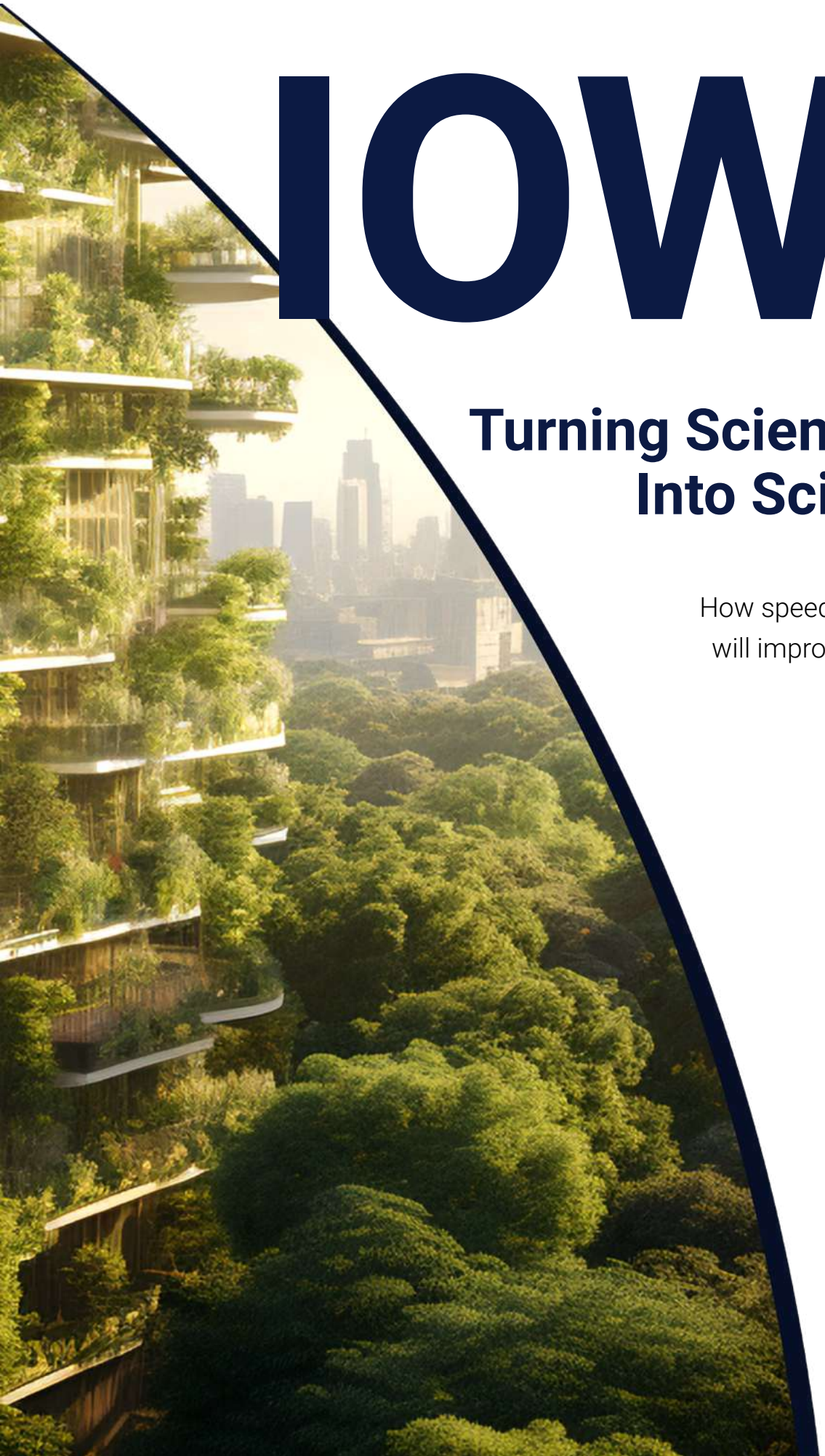


IOWN

Turning Science Fiction Into Science Fact

How speed-of-light technologies will improve daily life, work, and society at large

Introduction

The technology world constantly fills the news with excitement and anticipation about what the digital age might bring. Ten years ago, some called it the "Fourth Industrial Revolution" — one that would reshape personal and societal life and the business world, as with previous industrial revolutions.

But those forecasts have only partially come true.

Take autonomous vehicles, for instance. Futurists predicted that a synchronized flow of self-driving autos would occupy our highways by 2025, reducing and easing our daily commute, then drop us off at our destination and park themselves. We do have assisted driving, and it is an improvement, but it is an incremental one. The majority of us must still drive and park our vehicles.

The business world, likewise, sees a real gap between expectations and reality. Neither factories nor farms operate entirely independently, with little or no human intervention, as imagined. Retailers cannot create immersive virtual environments where customers try on products before purchasing. Digital business meetings continue to occur on screens and in 2-D rather than in entirely virtual and immersive rooms.

Society has yet to see the giant leaps in health care, education, work-life balance, and internet experiences envisioned continuously over recent years.

Most concerning, the widespread pace of technology adoption is pushing our planet and nature to its limits and beyond. The energy consumption of communications and computing technology is surging, and we lack scalable solutions for reducing the impact of technology on climate change.

Humanity possesses the knowledge and, hopefully, the will to resolve these challenges and propel the digital age to the next level while protecting nature and people. We can see a powerful new technological revolution coming based on artificial intelligence and the massive expectations placed on it.

To achieve this new reality, we must revolutionize the underpinnings of the infrastructure and intelligence of our systems. We must meet our expectations as we have in the past by delivering on our new digital promise and doing it without harming the environment more.

We need a new and transformational approach. An approach based on optical technologies is a critical success factor, and NTT's IOWN is our commitment to help get us there.

What is IOWN (Innovative Optical and Wireless Network)?

It's a transformational concept of moving from electronics to photonics for networking and computing based on a set of fundamental technologies, methods, and approaches that together make possible a secure, connected, and immersive future that's also sustainable.

The digital dilemma

At best, doing nothing to change how we transmit and process information today means considerable progress will stall. At worst, staying on the current course accelerates and deepens risks to the future of our environment.

Electricity usage from data centers, artificial intelligence (AI), and crypto mining is forecasted to double by 2026, according to the International Energy Agency.[1] AI alone could consume as much as a medium-sized country like Ireland or Argentina, according to one peer-reviewed study.[2]

Generative AI uses as much energy to make a single image as it takes to charge a cell phone completely, the Massachusetts Institute of Technology reports.[3] At a time when power grids are already experiencing overloads, imagine the effects on our energy supply of millions or billions of GenAI projects per day.

Moreover, the proliferation of connected home appliances, devices, consoles, vehicles, sensors, wearables, servers, and storage also elevates energy consumption.

Electronics

Beyond energy consumption concerns, these new technology innovations are being limited by the laws of physics. The inherent latency (response time) involved in moving electronic data across today's networks limits what is possible with virtual reality, autonomous vehicles, global storm-watch sensors, remote medical procedures, and other innovations we hope to implement. We have a vision for future innovation. However, the reality of physics is limiting our advancement.

To find solutions to these limits, we need technologies for networks and computing that are both fast and sustainable.

Getting there will require solving the problem at the root of the digital dilemma: electrons.

IOWN is vital to avoid digital limitations and environmental harm, propelling us into a thrilling new era.

The electron in the room

Today's **digital infrastructure** has limits that will prevent future innovation.

Modern digital technologies and infrastructure are electronics-based, meaning they use electrons to send information across networks and for computing in servers and devices. However, electrons generate heat and are not as fast as photons (light), limiting our ability to create the **immersive and responsive world** we keep promising. Electrons require energy to transmit and process data and create heat, which then requires more energy to cool the servers, devices, or data centers.

In short, electronics limit the pace of innovation of new technologies that will solve our most pressing problems and deliver on our most significant opportunities. However, photonics can remove that limitation.

Photon-based optical networks and computing rely on light particles to transmit information. They travel distances at the speed of light, need very little energy, and generate no heat.

The photonics research and development conducted by NTT and its partners produces revolutionary technologies and solutions that transmit and process information at the speed of light while using exponentially less energy.

The results we are seeing are turning science fiction into science fact.

The IOWN concept

For NTT, IOWN comprises three core components:

The All-Photonics Network (APN), built on optical, light-based technology.

Digital Twin Computing for instant interaction between digital twins themselves.

The Cognitive Foundation operates and coordinates the resources required.

Together, these components comprise many technologies and methodologies that contribute to profound improvements in ultra-low data latency, significantly less energy consumption, and increased speed and capacity.

The All-Photonics Network will work with other existing and new infrastructure components such as 6G cellular service (estimated at 20 times faster than 5G), satellites, fiber optics, and wireless communication to deliver on its full promise.

And our creative partners and developers will undoubtedly produce IOWN-powered solutions, devices, technologies, and platforms to transform how we live, work, play, and thrive.

Moving into the future at the speed of light

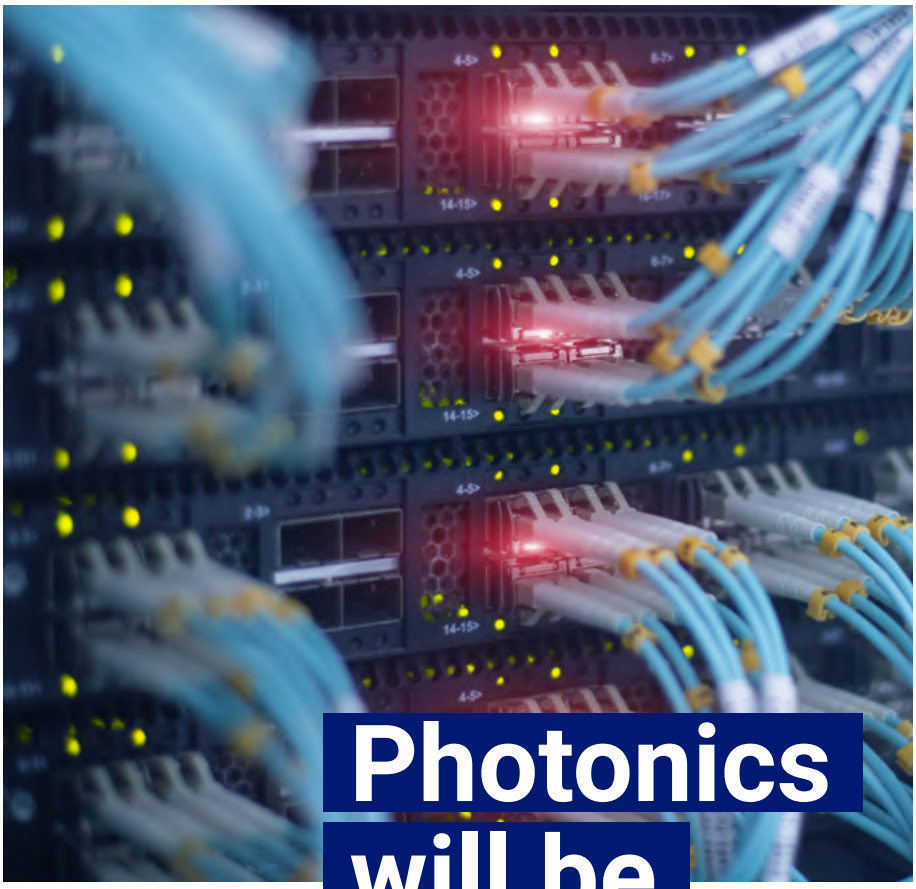
Technology is accelerating in a variety of areas that could transform our world, including:

Completely immersive digital worlds, also known as "metaverses," where we can work, shop, play, and interact in virtual environments.

Quantum computing and security as a new way of computing (already in development) that uses photonics-based technologies to instantly process massive amounts of data with greater security than we have today.

AI (artificial intelligence) that learns and evolves like the human brain to solve big problems and deliver on new opportunities.

Medical technologies to help us live healthier, longer, and more fulfilling lives.



Photonics will be a game-changer

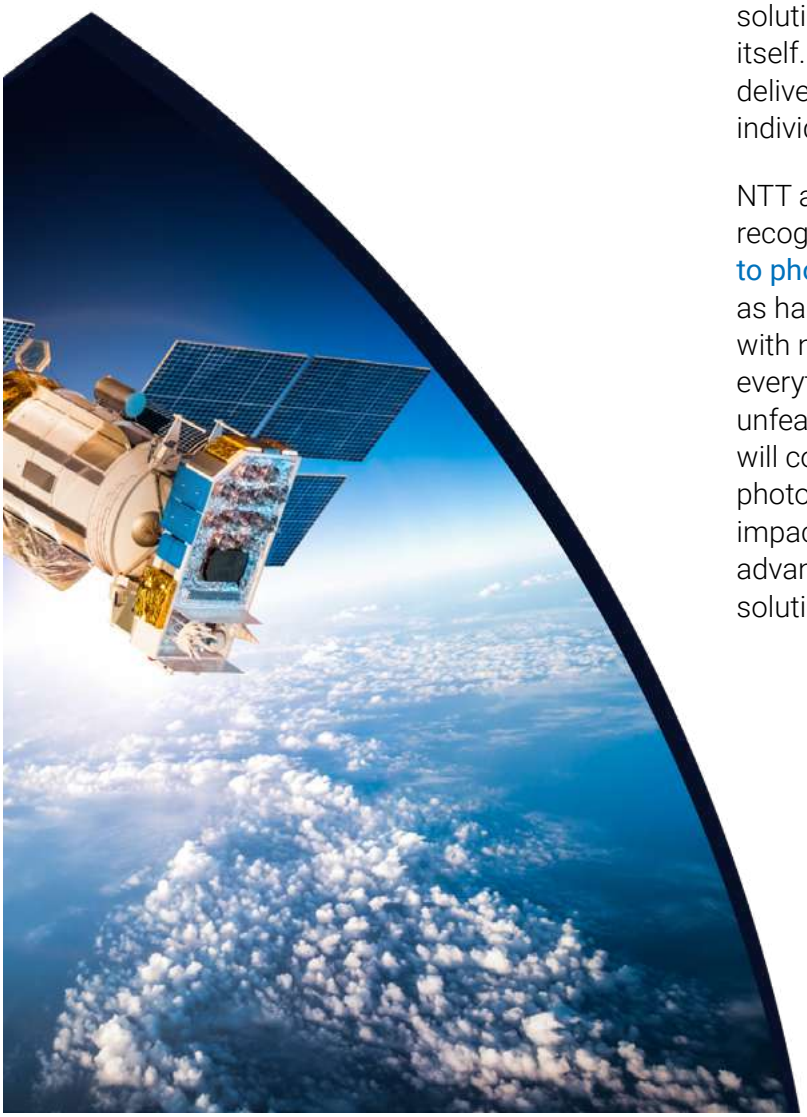
These projects and others will need help with current digital technologies. And in today's world, we need to progress at an accelerated rate to capture the benefits of human ingenuity.

The possibilities are immense if we move towards photons replacing electrons in our devices and across all our networks. We will communicate, respond, act exponentially faster, and use much less energy.

Photonics will be a game changer. It is a technology that promises to reduce technology energy consumption while increasing computing power and responsiveness.

The **IOWN** Global Forum aims for a shift to photons, bringing transformative impacts to individuals, businesses, and society.

Introducing the IOWN Global Forum



The IOWN Global Forum is a consortium of 130+ companies worldwide and is growing, including founding members NTT, Sony, and Intel. Partners include (alphabetically) Ericsson, Fujitsu, Microsoft, Nokia, Nvidia, Orange, Qualcomm, and Red Hat, among many others.

The IOWN project began as an open collaboration of companies with a concern about the impact of technology on the sustainability of the planet and the belief that we can find solutions to that through technology itself. These solutions would also deliver many other benefits for individuals, businesses, and society.

NTT and the IOWN Global Forum recognize that the shift from electrons to photons will happen gradually as hardware and software develop with new functionality. Replacing everything all at once would be unfeasible and costly. Photonics will complement electronics, and photonics will eventually scale up to impact both sustainability and the advancement of digital technology solutions.

Technology

The IOWN Global Forum's vision is to enable the transition from electronics to photonics to provide better services in a highly data-driven world, deliver greater security through technology, and support sustainable growth and, notably, do this through a global coordinated effort of industry leaders. Current use cases and proof of concepts increasingly indicate what is achievable and imminent with the contributions from many individuals and organizations committed to the IOWN Global Forum's goals.

This coalition continues to broaden participation in this vital work through shared research and development and exchanging ideas and expertise.

To illustrate the opportunity and inspire more people and organizations to get involved, this paper presents three areas of benefits that IOWN might bring to daily life, businesses, institutions, society, and the planet as a whole.

While some of these concepts may appear ambitious, ambition is usually the starting point of achieving significant breakthroughs. Although some of these advancements may happen without IOWN technologies, a faster transition to photonics-based networking and computing may allow them to accelerate their development and do so with a long-term sustainable approach.

The Personal Promise of IOWN

Life and leisure at the speed of light

Dramatically improved communication and processing speed, with reduced energy consumption, benefits each of us. The personal benefits of IOWN come from how they deliver the promises predicted for years. Examples include:

Enhanced human connection. Gathering with family and friends in a virtual, immersive environment with almost no perceptible lag time feels realistic.

Instant, low-cost, virtual travel. The possibilities for virtual reality travel are limitless. Amid the vineyards in Spain's Rioja wine region? On top of Mount Kilimanjaro? Or the shrines of Kyoto?

While personal physical travel will never be replaced entirely, virtual travel allows more people to see and understand the world around them. Using virtual and augmented reality, you will someday visit your city or countryside and walk the streets, visit museums, hike the trails, and smell the cherry blossoms without leaving home. In an immersive metaverse, you can even interact with others.

There is no need to learn the language wherever you go – virtually or in person. A digital translator turns your speech into any language you choose while speaking, and it feels instantaneous.

Lower energy bills. Technology consumes a lot of energy. One study estimates that the technology industry currently accounts for up to four percent of all energy usage, and that is predicted to rise to 14 percent by 2040.[4] In another study, just the internet infrastructure alone could account for five percent of global power use by 2050.[5,6] This does not include phones, tablets, laptops, wearables, or other digital devices.

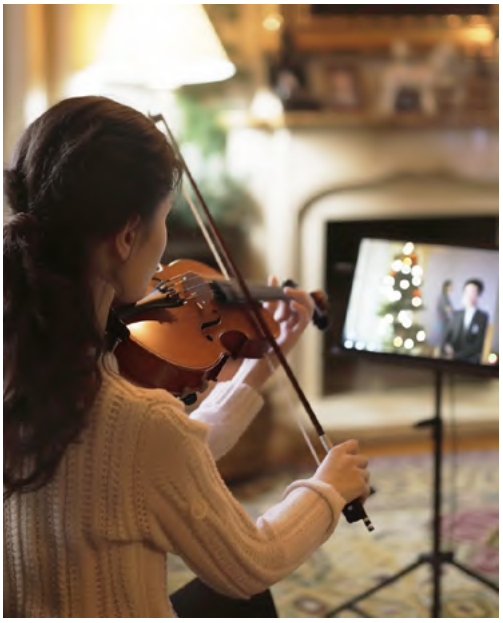
Photonics is a game changer on the sustainability front. Photons, or optical-based technologies, need far less energy to transmit information farther and faster than electrons. And they produce minimal heat, so cooling becomes less necessary. An example of how it can have an enormous impact is that IOWN technologies will reduce NTT's carbon emissions by 45 percent in Japan (180,000+ employees) by 2040.

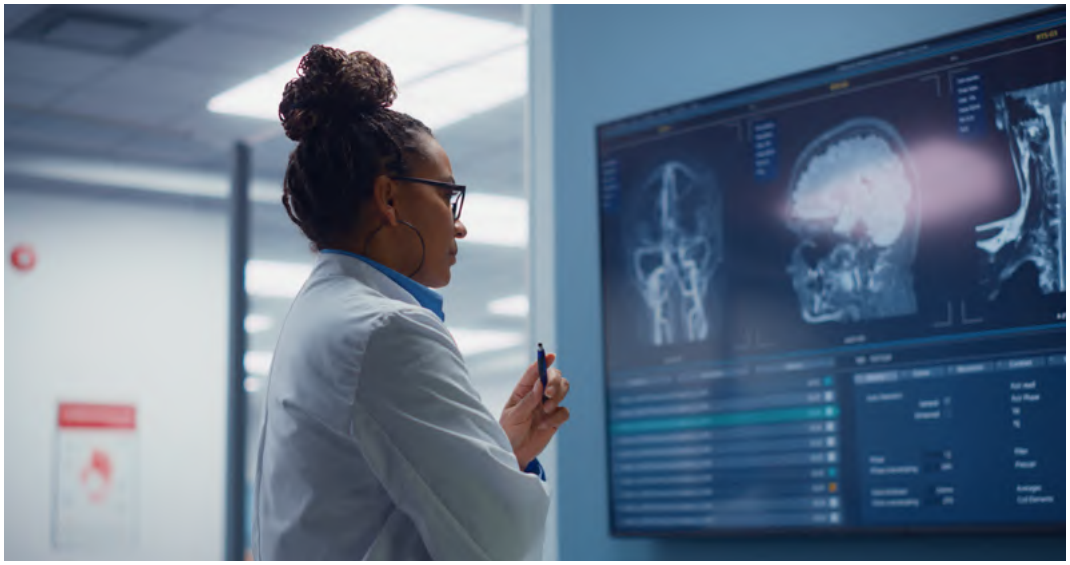
Less expensive, more convenient, and greater accessibility for more people to attend theater, concerts, sports games, and other live entertainment events. NTT is already a research leader in virtual entertainment dreams.

Through photonics technologies, NTT can create events on stage or online with performers in various locations with no visible or audible lag time. For example, performing a Kabuki play or a comedy routine on stage, with physical or virtual performers interacting with other virtual performers.

Easier creative and artistic collaboration. Musicians have tried performing live concerts via online technologies, but they fail because the lag time is too noticeable by the human ear.

With All-Photonics Networks, an entire symphony of musicians worldwide can play together with no perceivable lag in sound. NTT has already proven this in a concert in Japan with players in multiple locations. Dancers can interact long-distance as if they were in the same room, even sharing a virtual rehearsal space and stage.





Better physical and mental health and health care services. Self-diagnostic tools providing instant results that can be shared with physicians in real time give a new opportunity for health care access.

The long-time promise of remote surgery that surgeons can perform in a place different from patients may become a reality. Removing the barrier of distance provides more people with access to more doctors.

Prescribing medicines becomes an act of precision rather than an educated guess. Physicians can first test the drugs on biomedical “digital twin” prototypes that mirror our bodies and genetic makeup, then properly prescribe the ideal drugs and doses. Using optical-based sensors, this bio-digital twin can become a reality.

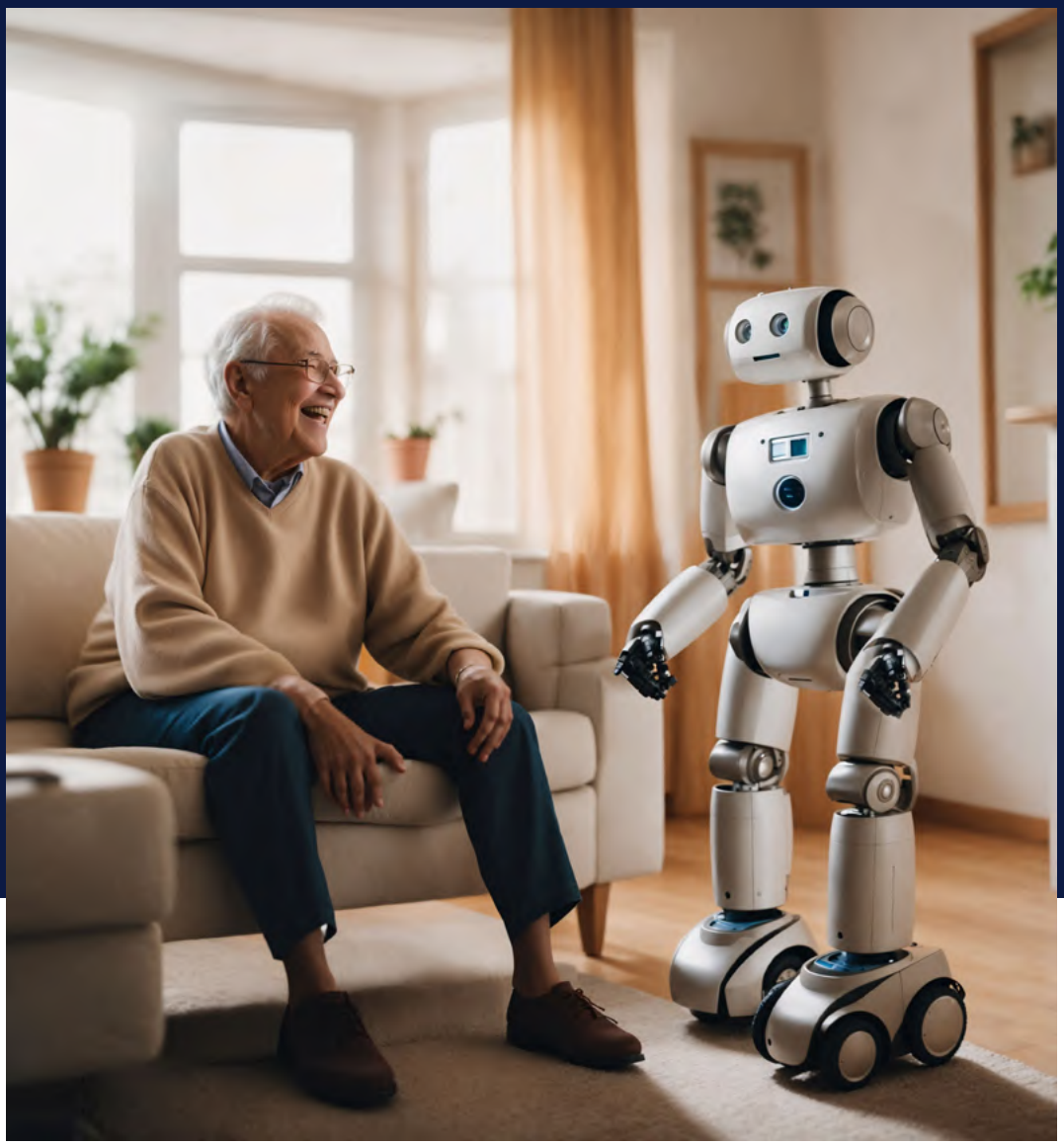
People with disabilities have greater mobility as signals travel instantly from the brain, eye, or muscle movements to prosthetics or paralyzed limbs. Today, one DJ with ALS can dance and perform virtually through his avatar with sensors that read his eye and muscle movements and turn them into actions.[7] Imagine what speed-of-light processing and transmission might enable.

Virtual reality, already proving beneficial for mental health issues, including post-traumatic stress disorder, can be even more effective when it is fully immersive and available anytime, anywhere.

And even today's telehealth can finally become more ubiquitous and available in areas that digital technologies still cannot reach.

More years living at home for elders. Sensors tracking seniors' movements send alerts if they fall, forget to take medication (or take the wrong amount), or need help in some other way.

AI assistants provide care and companionship; virtual visits allow elders to connect more easily with family members and friends and vice versa. Haptic clothing provides them with the experience of physical touch, as well. For everyday companionship, they can have a robot dog or cat that never needs feeding, exercise, or clean-up.

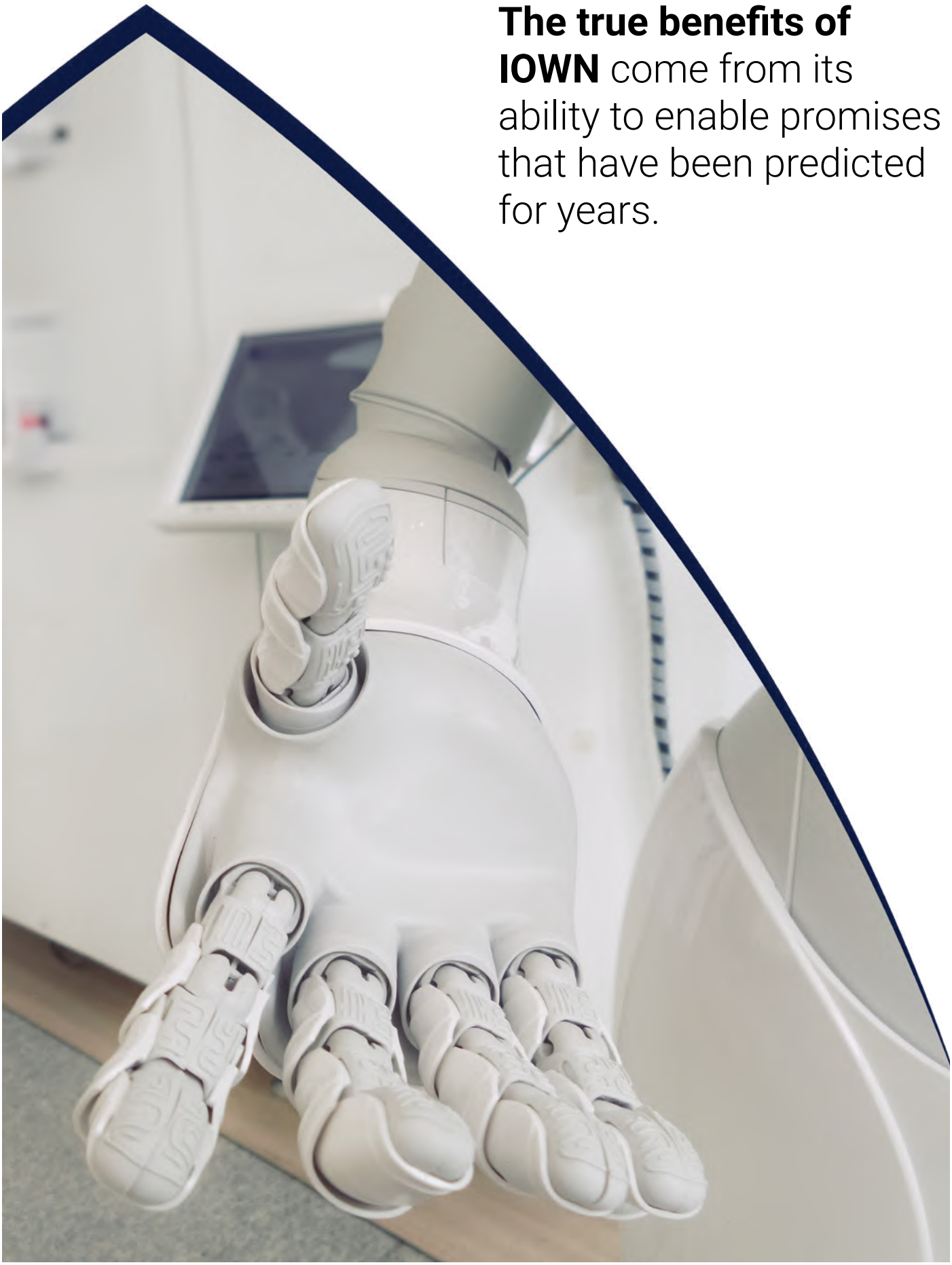


Better, more enjoyable education. Personalized lessons tailored to unique learning styles and preferences – and available for all – willl one day make school more enjoyable and effective, so children (and adults) learn more.

Students work with expensive equipment they would not otherwise have access to. They learn new skills using virtual reality and haptic gloves that respond in real-time to activities in another distant location.

They can study with teachers and students worldwide in virtual classrooms and take field trips in metaverses.

The true benefits of IOWN come from its ability to enable promises that have been predicted for years.



The Business Promise of IOWN

Working at the speed of light

Already, generative AI is enhancing business processes and performing tasks much more quickly and with fewer errors than humans. An All-Photonics Network will allow incredibly complex communications much faster with greater bandwidth, which means AI can be even more effective.

The business benefits are numerous, and they differ from industry to industry. Some examples of realistic possibilities, categorized by sector, include:

Agriculture

Automation and AI work together to drive tractors, bale hay, plant and harvest crops, and perform other tasks. Drones survey fields, send photos showing diseases, pests, and other problems, and even create digital maps of the entire operation. Soil, air, and water quality sensors send data, as well.

"Precision farming" takes on a new meaning when IOWN digital twin technologies will allow farmers to plant in virtual fields to determine the effects of varying conditions on crop yields, test out new varieties, decide what to plant where and when, and more. Sustainability and health problems resulting from over-watering, over-fertilization, and over-application of pesticides could diminish or disappear.

Meanwhile, AI can make decisions: bots will pick only the ripe fruits and vegetables and feed animals what they need when they need it and in precise amounts.

Harper Adams University's "Hands-Free Hectare farm" in England became, after a few years, the "Hands-Free Farm," a 35-hectare project that plants, cares for, and harvests crops with no human presence on the land.

IOWN's ubiquitous sensing and communications, light-speed photonics transmission and processing, and digital twin computing could propel this project and others into the next generation, allowing the scale necessary to meet demand. And the low energy requirements will help farmers save on power bills.

Automotive

Autonomous vehicles

While they are still in development, the need for high-speed and low-latency communications is a prerequisite to achieving autonomous vehicle transportation. IOWN technologies will enable fast information processing so AI in vehicles can make better decisions more rapidly than humans. This will be critical as autonomous vehicles permeate our cities and streets, ensuring a safer environment.

Function

With accurate autonomous driving, cars can become conference rooms on wheels, entertainment centers, mobile gyms, and even bedrooms for long-distance trips.

Sales

Automotive showrooms can be virtual and immersive: customers will walk around and even sit inside a vehicle they might want to buy without leaving home, customize color and interior choices, and take a test drive.

Service

Mechanics could work remotely, making repairs and performing tune-ups using robot arms or haptic gloves to adjust from afar.

Insurance

Blockchain technologies will allow for instant contracts with varying terms – by the hour, for instance, for travel to various places with different risks.

Trucking

Self-driving trucks are a work in progress. Semi-autonomous vehicles are already on the road. Ridesharing, platooning, or grouping trucks in a coordinated traffic stream, on-demand services, and fuel efficiency can reduce energy use considerably.

Technology

Ambient computing, with optical-based devices on your person and surrounding you, allows for information display and processing anywhere. Handheld devices can project images onto any surface or allow images to free-float in the air. Personal devices are more than just smart devices; they are AI devices. Phones, laptops, consoles, and other devices based on photonics will require much less time to charge. Imagine only having to charge your phone monthly or even just once a year.

Computing power in your hand increases exponentially through photonics in phones, laptops, or other devices. An all-photonics wireless network can instantly move information to and from data centers when needed.

Data centers can be broadly dispersed and less centralized, while devices on the “edge” of the network can do processing previously done in data centers. This distribution of computing and networking will allow data centers to be placed closer to renewable energy sources. Computing peaks can be distributed wherever the capacity exists for greater load balancing of processing, reducing energy usage through greater utilization of all computing capacity.

AI-enhanced development systems based on this faster, lower latency infrastructure allow developers to become designers and dreamers, their software tested instantly, and flaws and security vulnerabilities eliminated in real time.

Energy

Electricity becomes dependable even during peak demand and inclement weather; a truly smart grid based on AI manages supply and demand instantaneously as fluctuations occur. This grid connects power from various sources, including solar and wind.

Digital twins simplify the management of these complex systems without downtime, as engineers can troubleshoot problems before they occur. Likewise, drones work with AI to monitor turbines and transmission equipment to see when they need repairs and to make those repairs quickly and safely.

Problems can be solved before they occur

Financial services

Near-zero lag time enables nearly instantaneous trading, a tangible benefit when a microsecond's delay can cost enormous amounts of money. Blockchain technologies can process the billions of daily transactions in financial systems with greater speed, accuracy, and functionality.

Manufacturing

In an industrial metaverse, a digital twin of reality can be connected and communicate via an All-Photonics Network powered by AI. Intelligent systems can predict when machines need maintenance or are in danger of breaking down, and then they order parts, supplies, and equipment and make repairs.

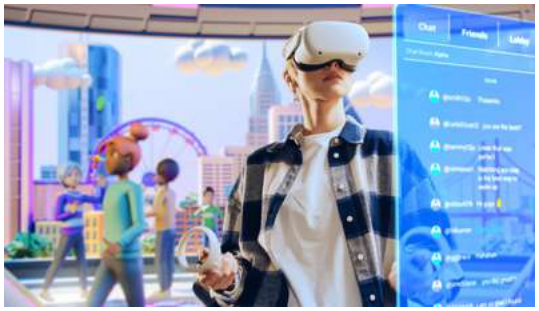
When humans are needed for repairs, they can perform them remotely using virtual and augmented reality and an optical-based AI robot that can act like a human at the point of repair.

Digital twins based on photonic networks and systems make new business models possible for manufacturing companies – instantly scaling production up or down depending on demand. They also contribute to a more effective supply chain model of complex global logistics based on blockchain systems with extremely low latency communications.

Retail

Shopping at home can become a completely immersive experience, with virtual salesclerks helping customers find their item or size, making suggestions if desired, and speeding them through checkout. Drones deliver purchased items within the hour.

When the customer wants to return something, their digital personal assistant can notify the retailer, which deploys a drone to collect the item.



Using virtual reality with optical-based sensors can be beneficial even in physical stores, allowing the consumer a physical and virtual experience. This can be something as simple as searching for style, size, or type of product without having to roam the whole store.

Public services

Sensors and drones, based on photonics, need very little energy for extended periods and can be placed in locations where they can aid in search and rescue. This is an urgent need as weather events become more severe and life-threatening. These sensors and drones can also create the urban center's digital twin to help predict and detect issues. For example, in significant public events, they can direct the traffic of people and cars. Or they can be used for preventative maintenance of city utilities and parks. Public safety, too, benefits through an increased number of optical-based sensors that can be managed to prevent privacy issues and used to track crime and criminals.

04

The Government & Societal Promise of IOWN

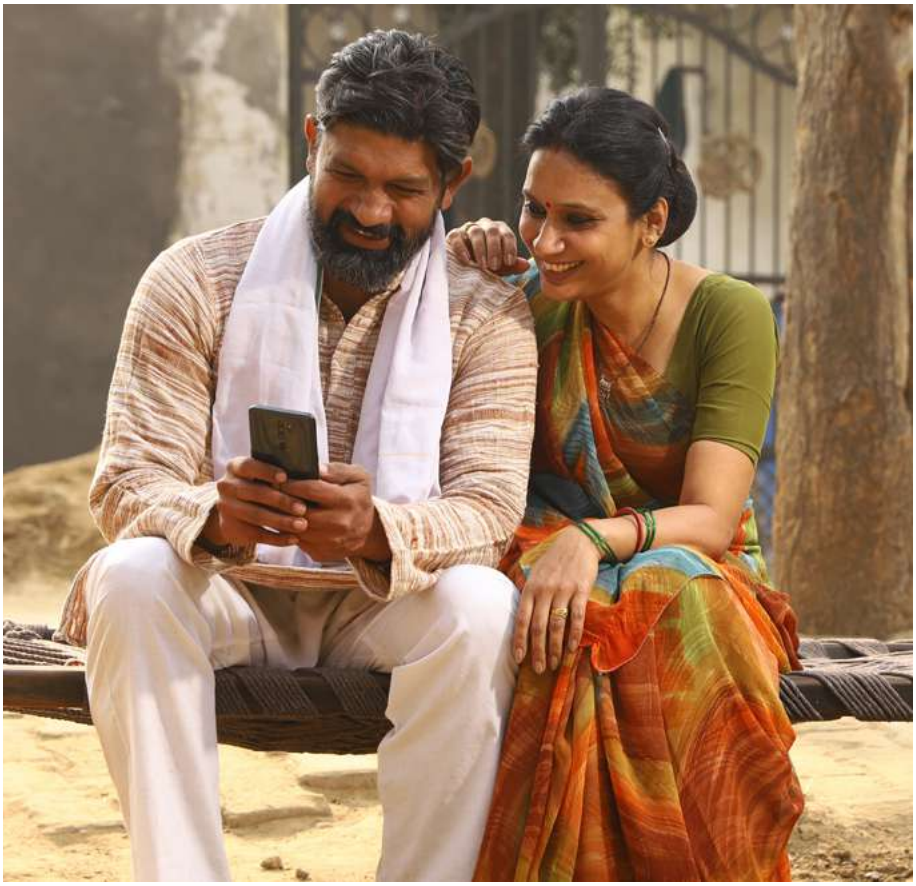
A world transformed at the speed of light

NTT and the IOWN Global forum recognize technology's incredible progress in humanity and societies.

Specific problems – hunger, healthcare, water, education, conflict – have challenged humanity, and humans have sought solutions. Technology has made it possible to improve many things, like helping to feed the world, eradicating many illnesses and diseases, traveling long distances quickly, increasing educational standards, and enhancing global communications. But much more is needed.

With an All-Photonics Network and computing infrastructure, we can envision an environment where data can flow to distributed data centers for rapid processing and analysis, providing ubiquitous access to services and better decisions about every aspect of society. This is the central premise of the Japanese government's Society 5.0 model.[8]

Many organizations have articulated ideals for a better future – visions that the IOWN Global Forum shares. Inspirations include the United Nations 2030 Agenda for Sustainable Development.[9]



IOWN applications and technologies could make fulfilling many facets of this vision possible, including:

A more equitable world

Although 95 percent of the world has access to broadband communications, according to the UN, some areas remain underserved. Optical and photonic technologies could bring digital communications to the world's farthest corners.

Sensors become inexpensive to produce and require almost no energy, so they can quickly run on solar power. Placed even in remote rural areas, they – as well as fiber optic cables and satellites — can bring services, including autonomous vehicles, wireless internet, and emergency response.

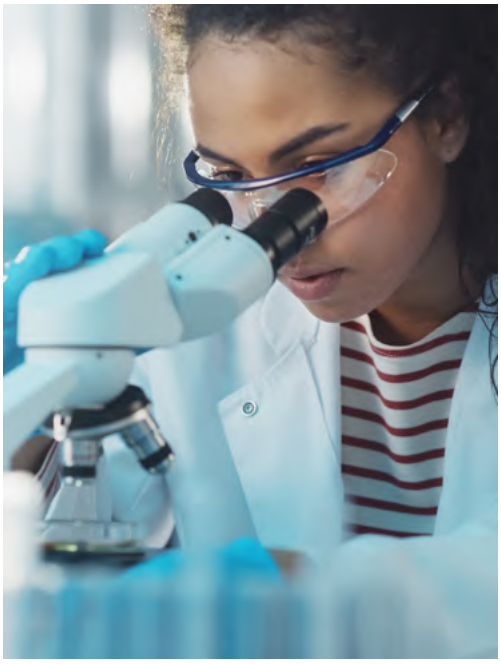
Ubiquitous computing can act as an equalizer, bringing education, work opportunities, healthcare, and enhanced quality of life to all.

Digital twin computing can also help eradicate poverty. Scientists can create twins of entire societies to find the best redistribution of wealth and resources and how to implement it.

A world without hunger

Advances in agricultural technologies have done much to increase the food supply. Yet the Food and Agriculture Organization of the United Nations found that 2.3 billion people worldwide were moderately or severely food insecure in 2021.[10]

Innovations such as seaweed farming, vertical farming or farming in layers (often indoors), drones, robots, AI, and data intelligence can improve food production by using less energy and with much less waste.



Longer, healthier life

With fast, powerful diagnostic and monitoring tools, including digital biomedical twins, caregivers and individuals could find and correct global health crises before they become pandemics.

Quality education

Lessons become available in all languages and to all students of all ages worldwide. Illiteracy could be eradicated, and skills could be taught to anyone who wants to learn them.

Photonics-enabled virtual reality technologies could allow apprenticing welders, plumbers, electricians, builders, surgeons, pilots, chefs, and others in training to see and manipulate equipment and controls from wherever they are.

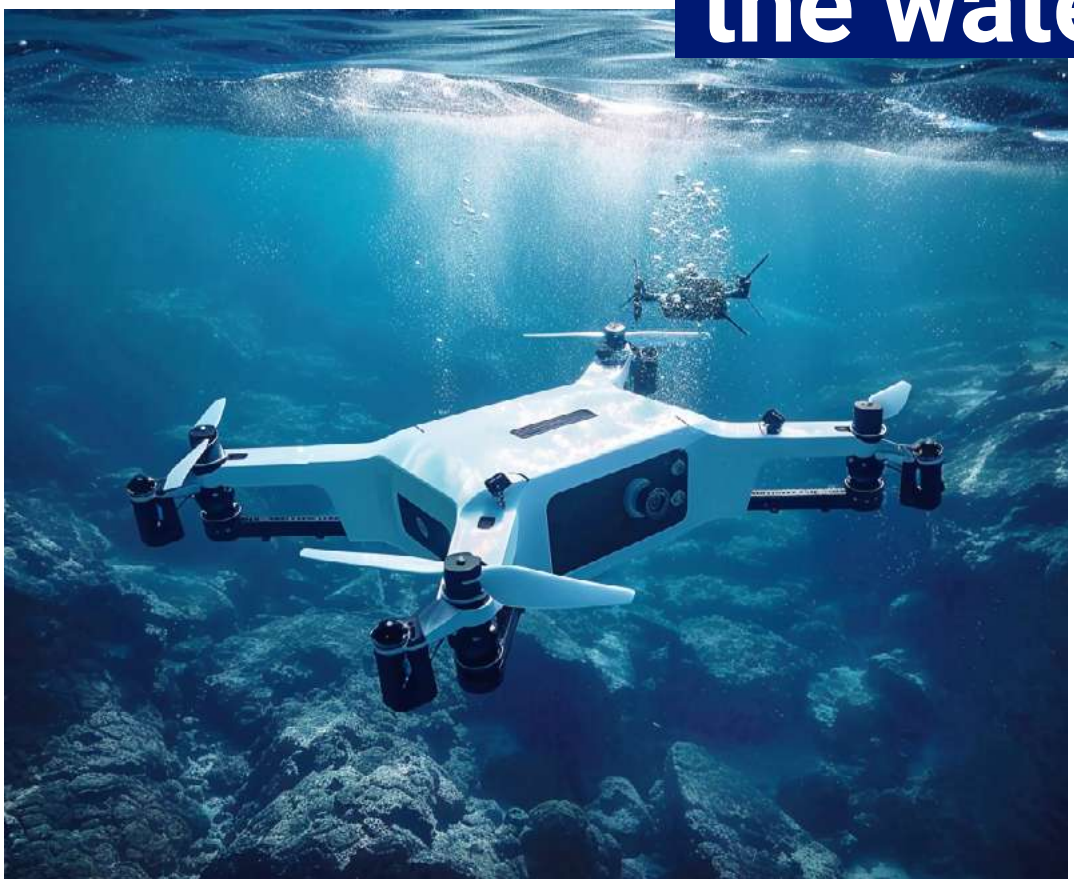
Clean water and sanitation

Scientists are researching and developing ways to clean our oceans of pollution.

Aquatic drones help to find and clean up spills, shipwrecks, and garbage. Solar-powered water filtration, nanotechnology, and desalinization to make saltwater potable, bio-augmentation (adding microbes to water to clean it), and other techniques are all proving effective.

Photonic technologies can help accelerate this development to benefit clean water and water conservation as this precious resource becomes even more scarce.

Aquatic drones help clean the water



Affordable, clean energy

Renewables power nearly 30 percent of the world's electricity but only about 10 percent of its heating and four percent of transportation, according to the UN. To meet 2030 sustainability goals, energy efficiency improvements must double their pace.[11]

According to the International Energy Agency, digital data centers and data transmission networks accounted for some 330 megatons of carbon dioxide emissions in 2020, about one percent of energy-related greenhouse gas emissions.[12]

Photonics uses much less energy than electronics, reducing greenhouse gas emissions. In an all-photonics world, computing devices will rarely need charging, and server farms that make up the cloud would require fewer machines because each can process more data than today's servers.

This solves a huge problem: data centers have become so large and require so much energy that they must be built closer to power plants. Disaggregated computing eliminates the need for these mega server centers, with many smaller, globally connected servers acting as one – a benefit of IOWN and optical technologies.

Blockchain, AI, and yet-to-be-developed technologies would also require less power for significantly more capacity. Allowing for more significant benefits of future technologies will still allow nations and enterprises to meet carbon footprint goals.

IOWN technologies could aid clean energy efforts in other ways, as well. By using exponentially faster networks and computing to support AI environmental solutions, results can be achieved quicker and more effectively.

A safer world

A world wracked by tornadoes, earthquakes, tsunamis, and other natural disasters demands ubiquitous early warning systems – something that digital twin technologies based on faster networks and computing will make possible.

During an emergency, alerts and signals can send people to shelter, directing them along the way, and sensors, wearables, and sophisticated detection tools can help rescuers locate people. Drones can airlift people and pets away, saving their lives.

Devices and equipment under the ocean can transmit data with a near-instant response, including warnings when they sense impending weather disasters such as tsunamis and earthquakes.

This feature becomes increasingly important as global warming makes dire weather events the norm. Response and rescue coordination, including modeling to predict a storm's path, will become spontaneous and practical, regardless of scale.

Sustainable cities and communities

"Densely populated" does not have to mean "crowded": smart cities can be designed for livability and sustainability.

With the sensors, autonomous vehicles, AI, and digital twin computing that all-photonics infrastructure enables, city administrators can make better, faster, smarter decisions in real-time that keep city life humming along – at a lower cost and using less energy than cities today.

People will not need to drive or even own automobiles, as public transportation can be incredibly efficient and effective. The technologies that run it all, powered by photonics, will use only a tiny fraction of the energy that electronics use today.

What is it going to take?

Moving forward – together – at the speed of light

Although only a few years old, the IOWN Global Forum has quickly grown. This organization comprises more than 130 leading global technology providers and users with clear ambitions.

But it still needs to be completed. It needs partners in technology, security, business, non-profit, government – every sector.

The IOWN Global Forum is actively searching for ideas, additional talent, creativity, ingenuity, and support to help revolutionize our digital society from our current electronics-powered model to one that transmits, receives, and processes information via photonics.

Placing a photonics infrastructure alongside current electronics – the necessary first step – will undoubtedly prove challenging. But this can and will happen. Early supporters and adopters will be well-positioned to contribute and capitalize.

Taking this leap into the future requires coordination, collaboration, and cooperation. It will also need clear standards and governance to ensure that more people and businesses will use technologies IOWN makes possible for the good of humanity and our planet.

We encourage you to work with us!

Innovating The Future

IOWN:
Turning Science Fiction Into Science Fact

How speed-of-light technologies will improve daily life, work, and society at large

SPECIAL THANKS: This paper was made possible through collaborative contributions from several IOWN Global Forum partners. A special thanks go to all those who participated and contributed directly and indirectly. We want to thank the following organizations who participated alongside a team of stakeholders at NTT (alphabetically): Accenture, Fujitsu, Intel, NEC, Nokia, Red Hat, and Sony.

Citations:

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