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Special Feature

Smart House Latest Trends

Toward IoT Smart Homes That Make People Happy

Communication Robotics

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DIY Smart Home for the Elderly: Implement wellness monitoring for parents living elsewhere using IoT

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The ITU Association of Japan (ITU-AJ) was founded on September 1, 1971, to coordinate Japanese activities in the telecommunication and broadcasting sectors with international activities. Today, the principle activities of the ITU-AJ are to cooperate in various activities of international organizations such as the ITU and to disseminate information about them. The Association also aims to help developing countries by supporting technical assistance, as well as by taking part in general international cooperation, mainly through the Asia-Pacific Telecommunity (APT), so as to contribute to the advance of the telecommunications and broadcasting throughout the world.

Toward IoT Smart Homes That Make People Happy

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1. Introduction

Kanagawa Institute of Technology Smart House Research Center is conducting research on "IoT smart homes that make people happy." There are two aspects regarding IoT smart homes as residences. The first is the "smart" aspect, i.e., using energy intelligently (energy savings and conserving electricity). The second is providing residences that promote prosperous lifestyles for people. Both aspects are advancing daily with Internet of Things (IoT) technology. IoT means the use of Internet technologies that connect various devices while creating new value.

This article describes how IoT smart homes will evolve in the future with respect to the latest government policies on residences.

2. New Basic Housing Plan (revised after five years) with "new normal" and "DX promotion" as key words

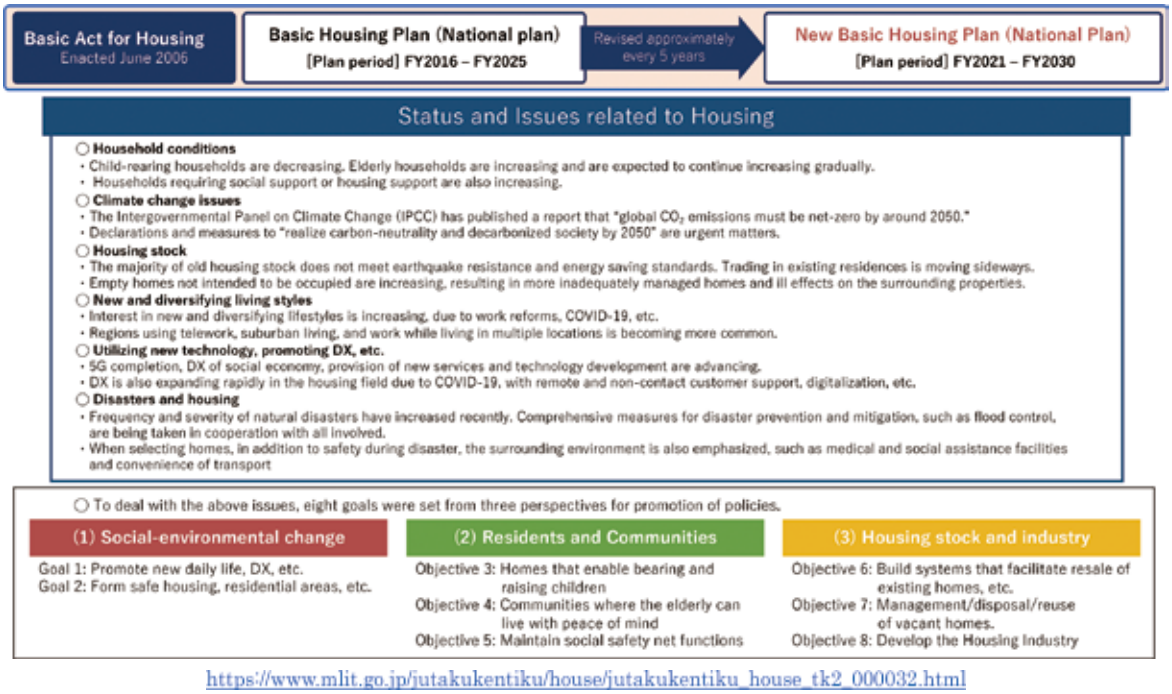
In March 2021, the Basic Housing Plan was revised after five years[1]. This plan is a basic policy on housing to achieve prosperous lives in homes based on a law called the Basic Act for Housing, which was enacted in 2006. It sets housing targets for the next ten years, and is revised every five years. It is referred to as a compass for housing policy for the near future. An outline of the new Basic Housing Plan is shown in Figure 1.

Several new notable themes are shown in Figure 1 regarding the current issues with housing, such as climate change, new lifestyles, and digital transformation (DX) promotion. The new Basic Housing Plan introduced three new goals to address these issues. From the viewpoint of the social-environmental change, goals 1 and 2 were set to indicate policy directions for handling "new normal" and disasters such as heavy rainstorms. From the viewpoint of housing stock and the housing industry, goal 6 was set to indicate policy directions for achieving carbon neutrality by 2050.

For goal 1, which denotes new daily life and DX, the following two directions were devised to achieve new lives in homes.

(1) Promote the diversification of residential styles to meet people's new thoughts on living and the flexibility for

Figure 1: Overview of new Basic Housing Plan



https://www.mlit.go.jp/jutakukentiku/house/jutakukentiku_house_tk2_000032.html

residential location choices according to people's living conditions.

(2) Promote DX of housing contracts and trade processes and of house construction and management processes using new technologies.

Regarding direction (1), the background on the issues with housing for "new normal" is the increasing interest in new and diversifying ways of living prompted by reforming of working practices and the aftermath of COVID-19. New residential situations, such as the increase in suburban and rural living owing to the increase of telework, or having multiple residences are becoming common. To adapt to these new situations, schemes, such as promoting environmental arrangements, have been set as basic policy to support telework and other new working practices.

Regarding direction (2), the background includes advances in new services and technology on the basis of 5G installation and expanding social and economic DX. It also includes the rapidly expanding DX in the field of housing, such as remote and non-contact customer handling and digitalization prompted due to the aftermath of COVID-19. Schemes, such as AI-assisted designing and all-stage DX, i.e., design, construction, maintenance, management, and disposal, are listed as the basic policy to promote the use of new technologies in housing-contract, trade, construction, and management processes.

Note that in the Basic Housing Plan, DX promotion is described from the perspective of housing suppliers or enterprises. We describe our thoughts on housing DX in later sections.

For goal 2, which denotes establishing safe housing and residential areas and securing houses to people afflicted by increasingly frequent and intense disasters, installation of facilities such as renewable-energy equipment and storage batteries is being promoted by government projects to support energy-saving residences such as net-zero energy houses (ZEHs)[2], which contributes to increasing resilience in housing. Note that the standard equipment for a ZEH is the home energy management system (HEMS), which is the infrastructure for managing energy consumption and controlling home devices, such as appliances. It can also contribute to goal 6 discussed below, with respect to saving energy in the home.

For goal 6 which denotes building house recirculation systems for a decarbonized society and forming good-quality housing stock, the spread of energy-conserving houses such as ZEHs is an important initiative toward achieving carbon-neutrality by 2050.

IoT smart homes will of course be equipped with HEMSs; therefore, we believe that its expansion will contribute to achieving these goals.

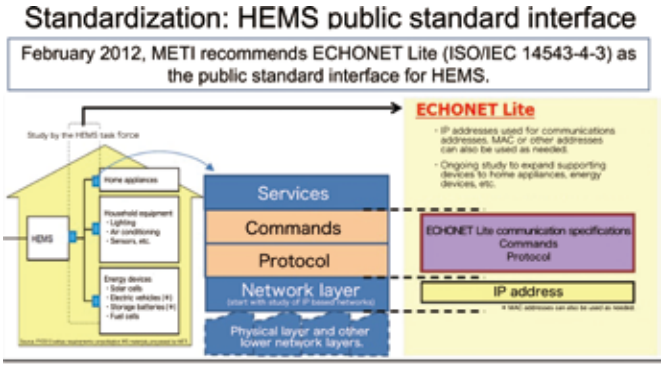
3. What is housing DX?

What is meant by DX? In Japan, the Ministry of Economy, Trade and Industry (METI) has published Digital Governance Code[3], which defines the DX as, "by use of data and digital technology by enterprises in response to intensifying change in business environments, reforming products, services and business models based on the needs of customers and society, and also reforming the business itself: organization, processes, and corporate culture and climate; to establish competitive superiority," indicating that enterprises should take initiatives. However, the historically first definition is attributed to Prof. Erik Stolterman of Umeå University in Sweden, who in 2004 proposed it to mean "improvement in all aspects of people's lives through the permeation of IT[4]". Perhaps housing DX fits this latter definition better. Thus, we assume that promoting housing DX means "'fertilizing' people's lives." We also expect that the use of digital technologies for communication between residents and housing suppliers or providers of residential services on the corporate side will also contribute greatly to DX on the corporate side.

4. ECHONET Lite: key technology for promoting housing DX

A ZEH, as described in the previous section, is equipped with a HEMS. The first objective of introducing HEMSs is to provide visualization of the energy consumption of connected devices to encourage users to actively conserve energy. Therefore, a HEMS requires more devices to be connected to it, so the communication technology used for the interface (language) between devices is a key issue. In November 2011, METI formed the "Smart House Standardization Study Group" to study measures promoting energy saving and conservation of electricity in homes, and this study group recommended ECHONET Lite as the standard communication interface between devices connected to a HEMS in the home and smart meters (Figure 2)[5].

Figure 2: ECHONET Lite: HEMS communication interface



http://www.meti.go.jp/committee/summary/0004668/011_04_02.pdf

Homes have various appliances and other household equipment, and in the past, most manufacturers used different rules for communicating with their products, which resulted in problems such as the inability to manage them centrally and services no longer able to be used if a device was replaced with a product from a different manufacturer. A decision was made to unify and standardize communication rules to resolve such issues. This was a significant decision and became the rationale

for ECHONET Lite as the base communication technology for smart homes and HEMSs. The features of ECHONET Lite are as follows.

1) It is a communication technology based on the Internet Protocol (IP).
2) It is a non-vendor-specific communication technology.
3) It defines detailed control commands at the level of handy remote controllers (defining more than 100 types of devices)
4) It can use various standard transmission media (wired LAN (Ethernet), wireless LAN (Wi-Fi), etc.).
5) It is an international standard (ISO/IEC 14543-4-3).
6) The specifications are open to the public (in Japanese and English).

As stated in 1), ECHONET Lite is based on IP, so connectivity to the Internet is assumed; thus, all ECHONET Lite devices can be called IoT devices. With the ECHONET Lite recommendation as the communication technology for HEMS in Japan, the infrastructure for conversion to IoT has already been built.

To what extent have ECHONET Lite devices spread throughout the world? The ECHONET Consortium, which created the ECHONET Lite specifications, has been publishing statistics for shipped devices classified in the major product categories since FY2013 on its web site[6] (Figure 3). In FY2013, there was approximately 4.7 million units shipped, while in FY2022 there was approximately 140 million units shipped. The residential smart meters, that accounts a good portion of the statistics, have been installed in basically all homes in Japan. The consortium has voiced the direction to expand healthcare-related products and will contribute to IoT transformation of homes.

5. State of housing DX expansion

Next we examine the expansion of ZEHs, which are homes

Figure 3: Cumulative numbers of shipped or scheduled ECHONET-Lite-compliant devices

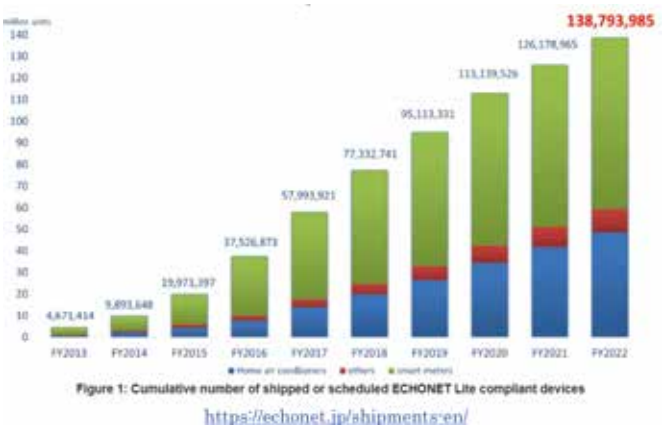
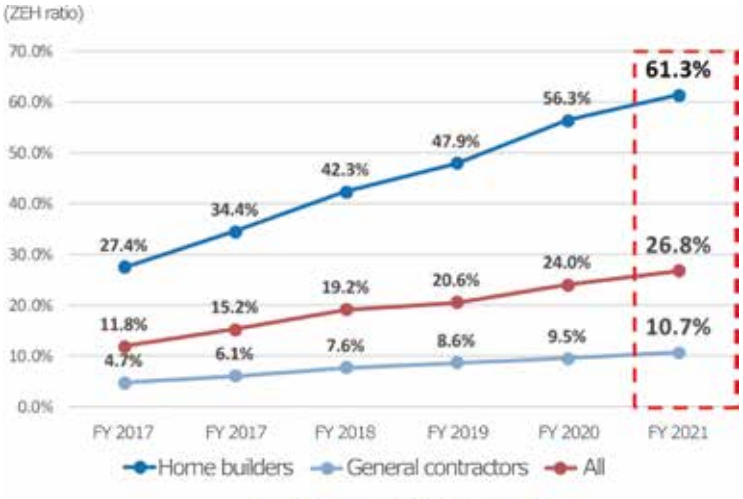


Figure 1: Cumulative number of shipped or scheduled ECHONET Lite compliant devices

https://echonet.jp/shipments-en/

equipped with HEMS and ECHONET Lite devices. Figure 4 shows the year-to-year progress in the percentages of ZEHs among newly built and scheduled homes up to FY2021. The government target for FY2020 for the spread of ZEHs was that 50% or more of newly built or scheduled houses by home builders should be ZEHs, and, as shown in this figure, this target was achieved in FY2020 (56.3%). However, it should be noted that a ZEH is not the same as housing DX. A ZEH only means that a platform for housing DX has been installed, and 70–80% of homes in Japan are still built by local contractors, so the spread of ZEHs is just beginning. However, the government's declaration for carbon neutrality by 2050 is expected to strengthen policy for residential energy saving, and we expect this to promote the spread of ZEHs. COVID-19 has also resulted in trends such as increased telework, so the number of residences with good Internet environments has been increasing steadily, and we expect this will also result in the advance of housing DX.

Figure 4: Percentages of ZEHs as newly built and scheduled homes



https://sii.or.jp/opendata/#prj6

6. Housing also entering “Software First” era

There is a manufacturing approach called “Software First”, in which products are manufactured with the assumption that they will be updated. Familiar examples of devices manufactured with this approach are PCs and smartphones. Both hardware and software (services) had been basically developed together, but by updating software, improvements can be made such as updating the user interface or providing new services, even if using the same hardware. With the development of Internet technologies, the speed of software advances has exceeded that of hardware, which is a major driving factor for the approach. Of course, hardware also needs to be updated periodically, so it still provides value that cannot be improved through software, but the important role software plays in improving the utilization of that hardware is undeniable.

Actually, it seems that this “Software First” concept is gradually entering development in the automobile industry, so perhaps this approach will also become more important in housing in the future (Figure 5). Also in housing policy, themes such as promoting long-term high-quality housing, increasing activity in the used/older/resale housing markets, building long-lasting housing, and utilizing existing housing are becoming important. Considering such conditions, it seems that software development can play an important role in housing, supporting changes in the social environment and lifestyles. Of course, it is important to have ease-of-use so that those not proficient in information technology will not be left behind. Key points include user-friendly design and low-cost, so that anyone can use features easily. For Japan, with its aging population, it is even more important to prepare environments so that all, including both the child-rearing generation and the elderly, can enjoy the benefits.

7. Conclusion

With the aftermath of COVID-19, advancing DX has become a target of housing policy, and we expect various residential services to emerge through the Internet in the future. We also expect this to become a design assumption for the “hardware” of housing. Through the promotion of energy-saving housing, many household appliances and residential equipment and devices have become IoT compliant. Houses are used over many years and change gradually over long periods, but the environment for building “Software First” housing seems to be falling into place. In the future, enterprises supplying housing and residential service providers are expected to promote housing DX. We hope to also be able to contribute to this effort through collaborative research with enterprises. We hope that housing DX will lead to home-building initiatives that bring happiness to everyone.

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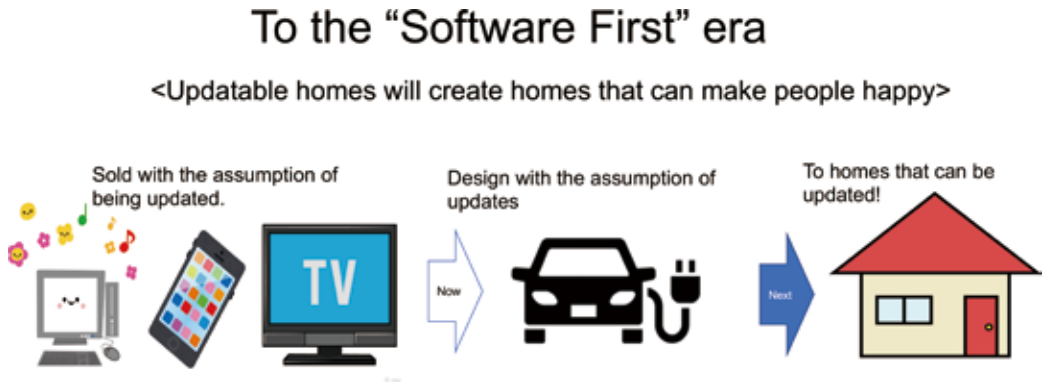
Figure 5: Updatable homes



Communication Robotics

— *Life technologies to catch, communicate and connect* —

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1. Introduction

With the spread of AI and IoT, homes and other living environments are advancing daily, and the government has designated its vision for Japanese society in the future as "Society 5.0." In the government's 2016 5th Science and Technology Basic Plan, Society 5.0 is advocated as, "A human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace (virtual space) and physical (real) space"[1]. In the 2021 6th Science, Technology and Innovation Basic Plan, the image of society for Society 5.0 was revised to reflect rapid changes in Japan and internationally, and to emphasize the diversity in how people pursue happiness, as: "Build sustainability and resilience for the threats faced by society and uncertain conditions yet to come, to ensure safety and security for citizens and a society where people can achieve well-being in their own diverse ways" [2].

To realize this, people must be able to receive meticulous services anywhere in society, accommodating their needs, whatever the situation. This will require technologies that enrich daily life in society, connecting people with systems, with places and with each other. ICT, AI, IoT, virtual reality (VR), and also human interface technologies will play a central role in this. The author is from the Department of Home Electronics, Faculty of Creative Engineering at Kanagawa Institute of Technology, where he conducts R&D in the Life Tech field. This field connects various issues faced by people in life and work with engineering, with three core elements of livelihood, social environment and education. This article describes technologies that the Communication Robotics Laboratory is working on, as examples of research to realize richer lifestyles for people, in three themes: "Catch" technologies that help systems understand people, "Communicate" technologies that help robots show emotion and intentions to people, and "Connect" technologies that help people connect with each other through use of robots. We also include examples of collaboration with enterprise on these technologies. Examples of applications in these three themes, "Catch," "Communicate," and "Connect" are shown in Figure 1.

Figure 1: Catch, Communicate and Connect technologies and applications

2. Life Tech Communication Robotics

As ICT, AI and IoT systems advance and spread, robots are anticipated to serve as interfaces to these systems. In order for such robots will coexist with people in our living spaces, direct communication such as speaking will be important, but so will familiarity and non-verbal behaviors, and as we have with ordinary communication, common rules for these will be needed[3]. Communication Robotics is a field of research on common forms of behavior and expression for robots in contact with humans, so they can convey information to humans. The Communication Robotics Laboratory is developing technologies for robotic movement, representations and systems to convey information to humans in a casual manner, through development of robotic systems focused on expressing emotion and other forms of non-verbal expression.

In this research, we have selected three technical issues discussed below, as elemental technologies for realizing rich lifestyles for people. The first issue is information technology that will enable systems to handle emotion and other human ambiguities. General purpose technology for recognizing an individual's emotions already exists and in the future, frameworks and technologies to determine conditions using data from multiple people will be needed. The second is how to present information to people. Considering the smart-house example, when a system works with a person to control an appliance automatically, the system must present the actions it is planning to the person casually, in a way that does not seem troublesome. The third issue is technology to connect people to others and to spaces through the network. The entire living environment will be connected to the network, providing communication experiences beyond video calling and email, so that new lifestyles and experiences can be provided through the internet.

The following sections of this article present technologies

being developed to solve the problems described above on three themes, which are "Catch" technologies that help systems that can understand people, "Communicate" technologies that help robots show emotion and intention to people and "Connect" technologies that use robots to help people connect with other people. In recent years AI technology has also spread rapidly, and basic technologies that have been accumulating are starting to be implemented in real living spaces, so that cases of trial research with enterprise are increasing. Some of these will also be introduced.

3. "Catch" technologies that help systems understand people

With the spread of IoT, residences are also being converted to smart houses rapidly, with living-space sensors and home appliances being connected to networks, enabling them to use each other. In such an environment, each appliance can be considered as an actuator able to control the living environment, influencing not only superficial physical aspects such as temperature and humidity, but also psychological features such as the moods of people in the space. To do so, information technology to enable systems to handle the ambiguity of people, as well as know-how to apply it in real environments will be essential. This section introduces an "atmosphere" recognition technology that is able to understand people and conditions within a residence.

Technology that recognizes an individual's emotion is already common; utilizing language and also various other approaches, such as speech rhythm, images and bodily information. However, to combine such emotional information from multiple people and quantify the atmosphere in a space requires a different theoretical framework. The method for quantifying atmosphere described in this article uses existing technologies for recognizing emotion and adopts a bottom-up approach to compute the atmosphere of a space from the emotional information of multiple people. To model an individual's emotion, an affinity-pleasure-arousal space[4] is used, and we use a method from Onishi et al.[5] to transform emotional information from several people to an atmosphere space with three axes indicating friendliness, liveliness, and casualness. An overview of the living-room atmosphere-recognition system is shown in Figure 2. When fitting ordinary emotion information into an emotion model, it must be formulated according to the state of the environment, which will be original know-how.

This technology is being applied in development of a smart living room that uses a game device as a sensor and links with home appliances to perform child care[6], in smart appliances that calm the atmosphere when watching a TV program, and in development of smart robots[7][8]. It can also be applied to connect people in distant locations, to develop atmosphere-sharing systems that connect people for telework, online lessons or other applications (Figure 3).

Figure 2: Living-room atmosphere-recognition system using emotion information from individuals

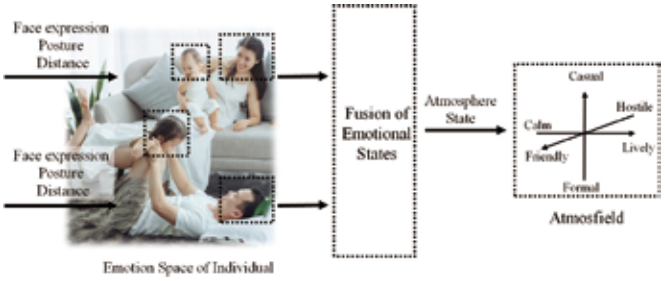
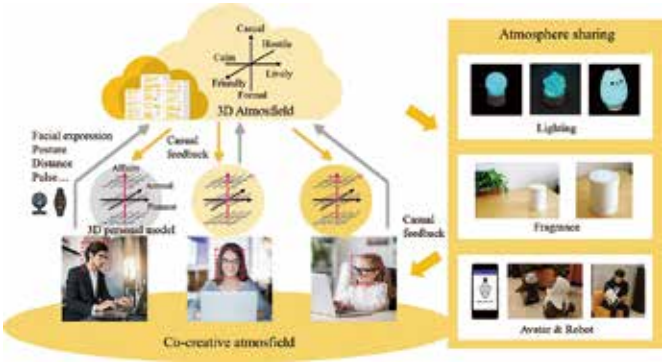


Figure 3: Co-creative atmosfield and remote atmosphere sharing for telework or online learning



4. Casual, non-verbal expression technologies that "Communicate" to people

To implement services suited to people and conditions as required for Society 5.0 will require presentation of detailed information. On the other hand, conveying an excess of information could seem annoying and troublesome to people. To solve this problem requires careful examination and presentation of the minimal necessary information, and the information must be presented in a casual and familiar way so that it does not feel troublesome. This section introduces examples of casual information presentation, focusing on non-verbal expression technology for familiar information presentation.

4.1 Familiar information presentation

Familiarity is an important element in systems that present information to people. This is more than showing the information concisely, and giving it familiarity can have effects including increasing a person's understanding and recall of the information[9]. For familiarity, emotional elements are particularly important. This section introduces a home robot called AHOBO, which provides on-going frailty care to the elderly in their homes for everyday lives (Figure 4)[10].

Frailty refers to various changes in faculties and loss of ability with advancing age, and prevention of frailty in the elderly, or

Figure 4: Recognition training (left) and health support (right) given by AHOBO

frailty care, contributes to preventing illness and accidents in the home. Frailty care requires continuous support in everyday life, and the AHOBO robot was developed to provide such support. AHOBO is a table-top communication robot that shows emotion with its antennas and eyes, and implements two types of system to support daily life of the elderly, for physical health and to prevent dementia. For physical health frailty care, AHOBO supports measurement of blood pressure, and for psychological frailty care, it has a recreational function that provides cognitive training.

4.2 Casual information presentation

When too much information is presented to people at once, they tend to feel it is troublesome, so it is necessary to present the minimal amount of information in a casual way. In particular, while walking, driving or otherwise moving, it can be dangerous to present too much information, so a safe means to convey information is needed. This section introduces a method of presenting information when traveling that is not troublesome, using a device called "FUN'IKI Ambient Glasses."

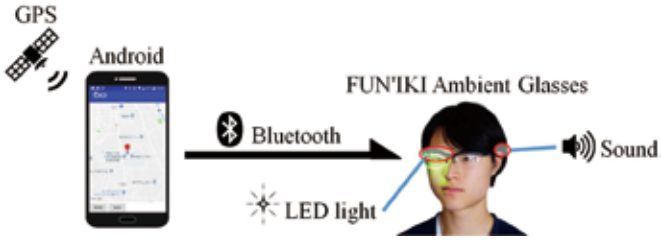
FUN'IKI Ambient Glasses are an information device developed by Namae Megane Inc., that are glasses incorporating full-color LEDs and a compact speaker. They are able to present information linked to a smartphone in an intuitive way, using sounds and LED lights that switch on and off [11]. An example of FUN'IKI Ambient Glasses emitting light is shown in Figure 5. By turning on LEDs in the frame of the glasses, the entire lens glows, and this can be used to convey information.

The benefits of FUN'IKI Ambient Glasses include: (1) information can be checked while working, without looking away from the work, (2) the information presented does not obstruct the field of view, (3) information can be presented intuitively, with

Figure 5: FUN'IKI Ambient Glasses

Figure 6: Presenting bicycle riding conditions using FUN'IKI Ambient Glasses

Figure 7: Navigation system using FUN'IKI Ambient Glasses



low cognitive load, using color and sound, and (4) it is possible to present information to the surroundings at the same time as presenting information to the wearer. This could be suitable for types of mobility that require a certain amount of attention, such as walking or driving, because it requires less cognitive load than smart glasses that display text. The FUN'IKI Ambient Glasses have been used in applications such as visualizing conditions when riding a bicycle[12], or providing map guidance when walking or running[13].

5. Technologies that "Connect" people with people

Entire living environments will become connected to networks, creating environments with communication experiences beyond video calling and email, making new lifestyles and experiences possible through the internet. We are aiming to create disruptive innovation initiated in Japan, and to implement a cybernetic avatar platform that will enable anyone to participate in various social activities, as part of goal 1 of the "Moon-shot research and development program" being promoted: "To realize a society in which people are freed of constraints of body, mind, space and time, by 2050" [14]. More specifically, we aim to expand the opportunities and potential for social activity by remotely operating cybernetic avatars, which includes robots and virtual

avatars, as "additional bodies for the user." This will require technologies that connect people with other people, and people with spaces, as discussed in Section 2. The technology introduced in Section 3 for sharing atmosphere for telework or online learning is an example. This section describes trials of another example of a "Connect" technology, doing remote work and avatar work at the Avatar Robot Café, using avatar robots that OryLab is promoting in collaboration with the authors.

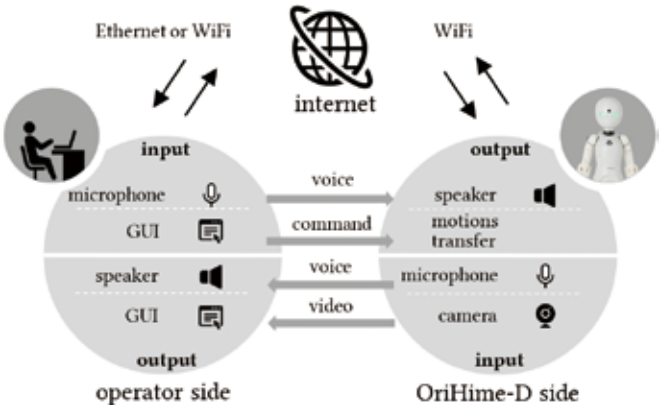
Robots that operate from a remote location through the internet in place of a person are called telepresence robots. Various types of telepresence robot are being developed, such as the newme (avatarin Inc.)[15], which emphasizes communication and combines a mobile robot with a display, and humanoid robots that emphasize a sense of presence.

Telepresence robots enable lifestyles in which people can be transported instantly, overcoming constraints of space, but they also have potential to extend a person's bodily capabilities. This is very significant, particularly for persons with disability. OryLab Inc. has set its mission to eliminate loneliness through technology, and is developing avatar robots that enable people who have given up on communication due to disability, to go out and communicate with people through the internet[16]. There are two types of avatar robot: a table-top model called OriHime (Figure 8) and a mobile model called OriHime-D (Figure 9). Both types of OriHime are equipped with a camera, microphone and speaker and can be operated through the internet using a PC, tablet or smartphone application (Figure 10). In addition to input using a mouse or tablet, line-of-sight input using an intention-communication device (OriHime eye+Switch) is also available. Providing OriHime at schools or companies can enable those with disabilities that make it difficult to go out, to participate in society, attending school or work while they are at home or in the hospital.

OryLab has proposed Avatar work as a system that can enable those with difficulty going out to perform remote work using OriHime from home or hospital, and is operating a café space for

Figure 9: OriHime-D

Figure 10: OriHime-D operating system



avatar work called "Avatar Robot Café DAWN Ver. β," as a trial social implementation[17]. A concept image of Avatar Robot Café DAWN Ver. β is shown in Figure 11.

Avatar Robot Café DAWN Ver. β was opened as a time-limited-trial shop in November 2018, and after trials in various regions, a permanent trial shop was opened in Nihonbashi, Tokyo

Figure 8: OriHime

Figure 11: Avatar Robot Cafe concept image

in June 2021.

To work at Avatar Robot Café, operators (pilots) that have difficulty leaving home provide service by operating OriHime and OriHime-D robots remotely. OriHime are used to provide customer services such as taking orders, and OriHime-D are used to perform service tasks that require physical movement, such as bringing drinks to the table.

One of the important benefits of avatar robots is the ability to share the experience of a place with others using a physical robot. By sharing an experience with the person in front of the avatar robot through the robot, a person can get a real sense of actually being in the place, even from a remote location. In research so far, working at the Avatar Robot Café has been shown to be mentally fulfilling for pilots and has been suitable for many disabled people desiring participation in society[18]. As with Avatar Robot Café, by using avatar robots that expand bodily capabilities of people with disabilities and by creating a society where avatar robots are ubiquitous, we believe we could realize a society in which people can participate in various activities, even if they are bedridden, for example.

6. Conclusion

This article has introduced examples of communication robotics research to enrich the lives of people in the three themes of "Catch" technologies, which help systems understand people; "Communicate" technologies, which help robots express intention to people in familiar and casual ways; and "Connect" technologies, which help people connect with others through use of robots, including examples of collaboration with enterprise. These technologies will contribute to creating the society that Japan is aiming for, in which each and every person can realize their own version of well-being.

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Cover Art

Yōrō Waterfall (Yōrō no taki), Mino Province, from Famous Views of the 60 Provinces

Utagawa Hiroshige (1797-1858)

Source: National Diet Library, NDL Image Bank (https://rnavi.ndl.go.jp/imagebank/)

Sekisui Heim Smart Houses: Latest technology trends

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1. Introduction

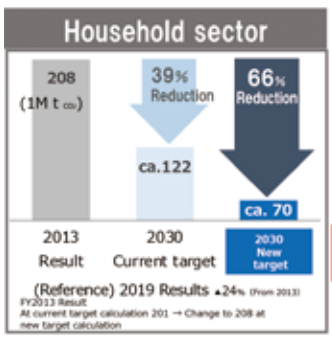
As of November 9, 2021, 144 countries, including Japan, have pledged to achieve carbon neutrality by 2050. In April 2021, Japan declared that it would aim to "reduce its greenhouse gas emissions by 46% in 2030 compared to the level in 2013 and continue its efforts to meet the lofty goal of cutting its emission by 50%" at the meeting of Japan's Global Warming Prevention Headquarters, as well as at the 2021 Leaders' Summit on Climate. In particular, the target set for the household sector is the highest among all sectors at about 66% (Figure 1). Energy-saving measures in the household sector include improving insulation performance, improving the efficiency of equipment through the Top Runner Program, and providing information on energy-saving equipment and energy-saving measures. Japan is also promoting the construction of net zero energy buildings (ZEB) and net zero energy houses (ZEH), which are designed to reduce the annual primary energy consumption to net zero through the use of solar power and other renewable energy sources. In addition to energy conservation through solar power generation and high thermal insulation, the government is also urging captive consumption through the introduction of storage batteries, electric vehicles (EVs), and heat pump water heaters to improve grid stability and resilience for renewable energy, which fluctuates depending on the weather, and provide added value to residents (according to the Sixth Strategic Energy Plan (Draft) announced on July 21, 2021).

2. Sekisui Heim Deployment Achievements

Given this situation, Sekisui Chemical has placed priority on the resolution of environmental and other social issues and the establishment of a solid management foundation as the drivers of future business growth through its Sekisui Heim brand of houses, promoting ESG management by balancing customer value and business value. To achieve a balance between economic efficiency and environmental friendliness, the company has been proactively proposing the use of photovoltaic power generation systems (hereafter referred to as "PV") in its houses since 1997. In 2012, it launched the "Smart Heim" house equipped with PV, home energy management system (HEMS), and household storage battery. Further, in 2018, it adopted the ZEH standard as the standard specification for its houses. In particular, 『ZEH』 (ZEH with square brackets), which ranks highest in terms of environmental contribution among its ZEH lineup, has been the most popular among house owners (Figure 2).

Sekisui Chemical has been promoting the use of renewable energy in detached houses for 25 years, providing a total of more than 229,000 PV houses*1 since 1997 (Figure 3). The total installed PV capacity has reached more than 1.25 M kW*2, with a total annual power generation equivalent to the annual electrical energy consumption*3 of municipalities with a population of 500,000 (e.g., Tottori Prefecture and Hachioji City, Tokyo). This has resulted to reduction in CO_2 emissions by approximately

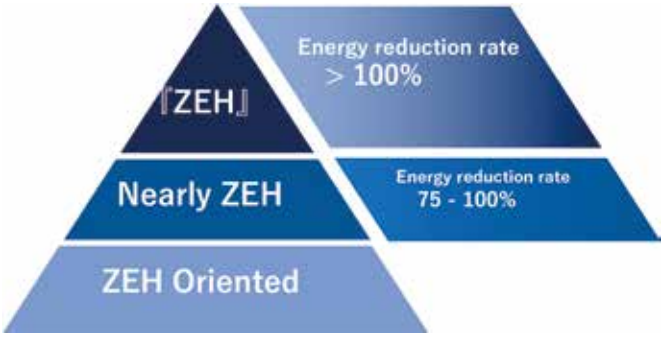
Figure 1: CO_2 reduction targets in the household sector
Reference: "Plan for Global Warming Countermeasures" (Draft) published July 26, 2021



(Reference) Sectoral CO_2 emissions reduction targets

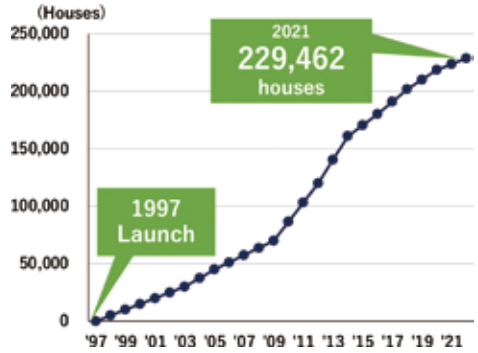
Unit [1M t CO2]	FY2013 Results	FY2030 Targets	Reduction rate
Industrial sector	463	ca. 290	ca. 37%
Service sector	238	ca. 120	ca. 50%
Household sector	208	ca. 70	ca. 66%
Transport sector	224	ca. 140	ca. 38%

Figure 2: ZEH categories

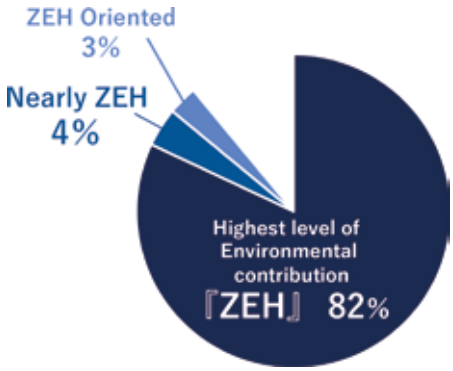


*1 Number of PV houses sold, including new and renovated units, as of the end of March 2022 (based on our research).
*2 Total installed PV capacity for all PV contracts, including new and renovated units, up to FY2021 (based on our research).
*3 Electrical energy consumption was calculated from the national average in the "Household Energy Consumption (FY17)" report by the Ministry of the Environment. (Energy consumption does not include gas or kerosene usage.)

■ Figure 3: Cumulative number of Sekisui Heim houses equipped with PV



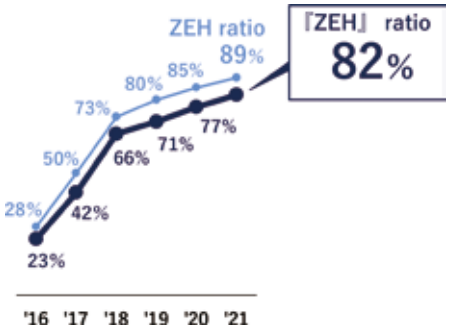
■ Figure 5: Sekisui Heim ZEH deployment record (FY2021)



386,000 tons per year*4, which is equivalent to CO_2 absorption by approximately 27 million cedar trees*5 and to afforestation of more than 31,000 hectares of land, an area similar to the artificial forest area in Tokyo (ca. 35,000 hectares)*6.

Along with the uptake of PV, early on, we have focused on the spread and promotion of ZEH. Performance equivalent to the highest rating (ZEH level) for the thermal insulation performance rating and primary energy consumption rating, which were newly established in April 2022 under the Housing Performance Indication System, has been incorporated as part of the standard specifications of Sekisui Heim houses in 2018*7. Recognizing at the outset the growing need for energy conservation in the future, we have continued to propose ZEH to our customers. In particular, we are focusing on the promotion of 『ZEH』, which ranks highest in the ZEH series in terms of environmental contribution, setting a record high of 82%*8 deployment ratio for 『ZEH』 in FY2021. The overall deployment ratio for ZEH*9 was 89% (Figures 4 and 5).

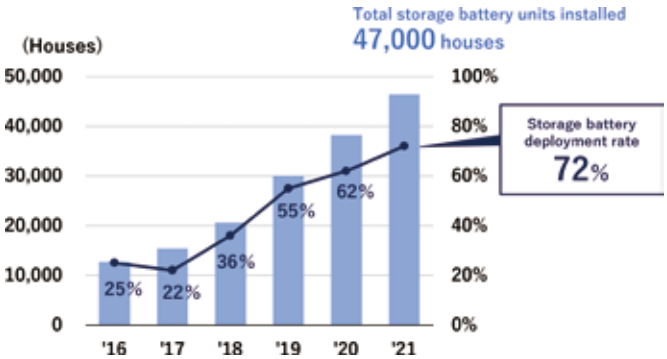
■ Figure 4: Trends in Sekisui Heim ZEH deployment ratios



『ZEH』 is designed to reduce primary energy consumption by 100% or higher than the standard primary energy consumption*7, in addition to use of PV and other renewable energy sources, whereas "Nearly ZEH" is designed to reduce primary energy consumption by 75% or higher, and "ZEH Oriented" by 20% or higher, excluding use of renewable energy.

Also, we are actively working to develop and popularize "energy self-sufficient houses"*10 equipped with storage batteries in response to rising energy prices and supply instability, as well as to enable resilience against frequent natural disasters. The storage battery deployment ratio in sales of newly built detached houses increased for the fourth consecutive year, reaching 72% in fiscal 2021 at 47,000 houses in total*11 (Figure 6). Going forward, we will continue to promote the uptake of "energy self-sufficient houses" along with 『ZEH』.

■ Figure 6: Trends in storage battery deployment ratio and total installed units



*4 Our calculation was based on the installed PV capacity for all PV contracts, including new and renovated units, up to FY2021.
*5 Our calculation for cedar tree conversion was based on data from the Kanto Regional Forest Office.
*6 The artificial forest area in Tokyo was based on the Natural and Artificial Forest Ratios by Prefecture (as of March 31, 2017) published by the Forestry Agency (MAFF).
*7 Standard specifications were refined to meet the national ZEH external standard UA value of 0.6 or less (Regions 4 to 7). Depending on the plan, this may not be achieved if the openings are too large.
*8 『ZEH』 deployment ratio was aggregated based on the ZEH Builder reporting method.
*9 In addition to 『ZEH』, ZEH includes Nearly ZEH and ZEH Oriented models. ZEH deployment ratio was aggregated based on ZEH Builder reporting method.
*10 Not all the electricity can be supplied. There is still a need to purchase power from a utility company.
*11 This deployment ratio represents the contract-based deployment ratio for storage batteries (including V-to-H) from April 2021 to March 2022, and the cumulative number is the total number of houses sold, including new and renovated units, as of the end of March 2022 (based on our research).

3. Project with the Ministry of the Environment

The Ministry of the Environment implemented a project on "Development and Demonstration of Technologies Promoting CO_2 Emission Control Measures" in FY2021 (name changed to "Development and Demonstration of Carbon Neutral Technologies through Regional Co-Creation and Cross-Sectoral Collaboration" in FY2022), with priority theme (1) "Development, demonstration, and cost reduction of energy self-sufficient decarbonized housing modules for dealing with worsening disasters and infectious diseases." Under this project, the "Development and Demonstration of Energy Self-Sufficient Housing Units" Technology Development and Demonstration Theme presented by Sekisui Chemical Housing Company in collaboration with Nichicon Corporation, the Central Research Institute of Electric Power Industry (CRIEPI), and the University of Tokyo Institute of Industrial Science (IIS) was adopted by the Ministry of the Environment in April 2021 (Figure 7). As the representative business operator of this project, we started technological development together with the three collaborators in June 2021. With the "New Smart Power Station FR GREENMODEL" (hereinafter, "New Green Model") launched in October, we conducted evaluation and verification through test house users to further enhance and spread this technology for promoting energy self-sufficiency. Test houses based on the "New Green Model" released in October 2021 were also equipped with high-capacity PV, e-PocketGREEN (Tribrid Energy Storage System), HEMS, and ventilation and air conditioning systems for all rooms. Test house users have started to move in to the "New Green Model" houses from around April 2022. We have collected electricity data via HEMS starting with users that have already moved in and will interview and survey them after they have actually lived in the houses.

Achieving a decarbonized society by 2050 entails the active utilization of clean PV power and the promotion of an energy self-sufficient*10 lifestyle that avoids the purchase of electricity as much as possible. In this project, we will acquire and analyze data on the amount of electricity used in real life and determine how much reduction in CO_2 emissions can be achieved using houses equipped with high-capacity PV and with the high-capacity storage battery "e-PocketGREEN," which were developed to achieve this lifestyle. e-PocketGREEN has a storage capacity of 12 kWh, which is about twice the capacity of conventional storage batteries*12. It also enables high output (4 kVA) even in the event of a power outage. It uses a power conditioner with a Tribrid specification that enables linkage with the V-to-H system so that the combined use of EV further increases the power storage capacity. In both normal times and during power outages, power generated by the high-capacity PV can be stored and consumed independently (Figure 8). In addition, both the storage battery

Figure 8: Menu of systems installed at test houses and items for evaluation and demonstration

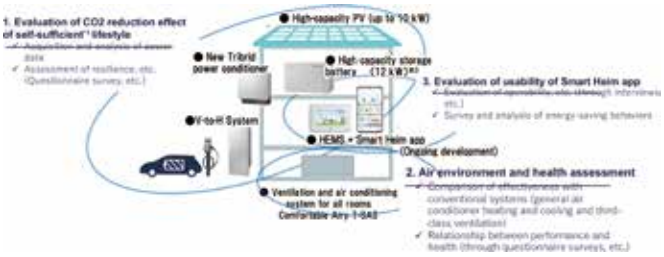
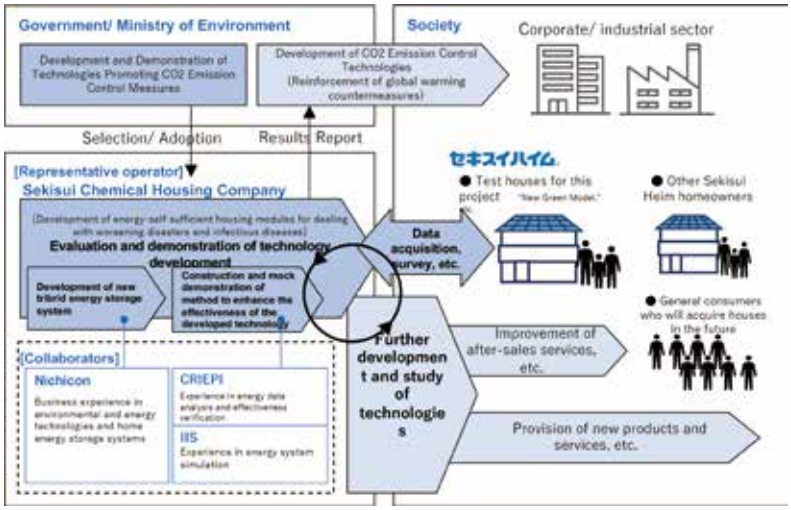


Figure 7: Evaluation and demonstration flow in the project and vision for future deployment



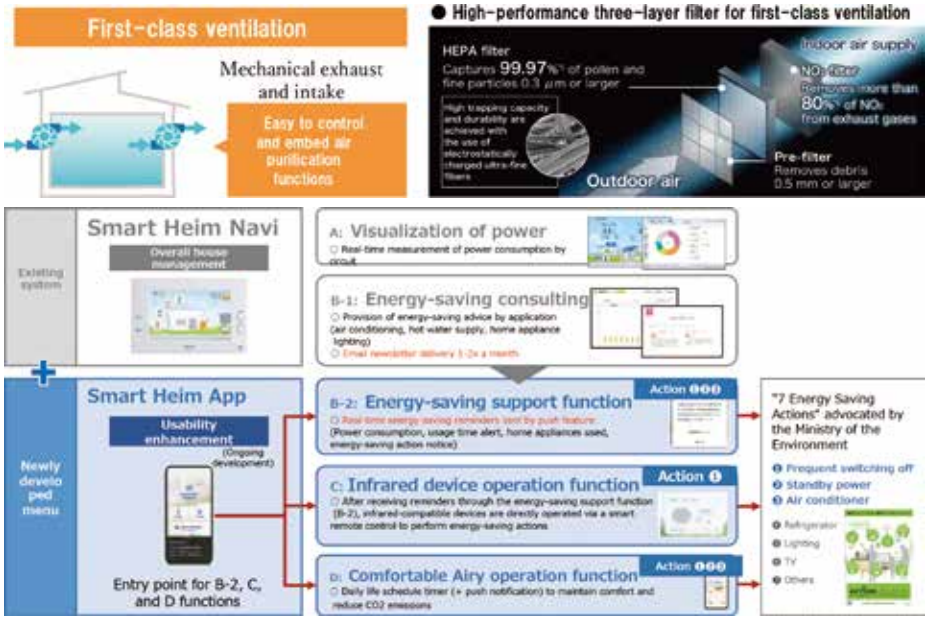
*12 Calculated from the storage capacity of the battery with the highest shipment volume, based on the "Net Zero Energy House Support Project Research Conference 2020" conducted by the Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI). Storage battery capacity of 12 kWh is the catalog value and is different from the actual usable capacity.

and power conditioner can be installed at high places to prevent damage from flooding. The V-to-H system enables saving space by separating the V-to-H stand and the V-to-H pod that connects to the EV, making it easy to install the equipment in parking spaces. We will also collect feedback from the test house users and evaluate the resilience and convenience of installing these systems.

To realize a high-quality indoor environment, which is indispensable for living in the new normal, in June 2021, we developed the "Comfortable Airy T-SAS" ventilation and air conditioning system that provides the three functions of ventilation, air conditioning, and dust purification for all rooms. For the second layer of the high-performance three-layer filter, we used a HEPA filter that can capture 99.97% of pollen and fine particles 0.3 μm or larger*13 on a first-class ventilation system for stably performing both exhaust and intake mechanically. For the air-conditioning filter installed in the indoor air intake vent, we used an antiviral filter*14 that uses the antivirus processing agent Viru-taker™. In this project, with the technical cooperation of the National Institute of Advanced Industrial Science and Technology (AIST), we will verify the effectiveness of indoor air purification and thermal performance using these advanced technologies in comparison with generic systems (air conditioner heating and cooling and third-class ventilation) through actual measurements (Figure 9). We will also evaluate and verify the relationship between health and performance through user surveys and interviews.

To encourage energy-saving actions and reduce CO_2 emissions in daily life, we have standard-installed HEMS (Smart Heim Navi) to approximately 66,000 houses to date. In addition to analyzing the electricity usage data of these HEMS-equipped houses and providing energy-saving consulting services tailored to each house, we also included remote control and voice control functions for household equipment (lighting, EcoCute system, air conditioning, etc.), further enhancing daily life convenience and reinforcing awareness on energy-saving behaviors. To reduce CO_2 emissions by further improving the convenience of HEMS, we will develop a new application for smartphones. We will create an "integrated user interface" to control home equipment and appliances and verify its usability. Initially, we will pre-release the application to owners of Sekisui Heim houses already equipped with HEMS to investigate and analyze energy-saving behavior during the winter (heating period). We will then improve the application from the results of the analysis. Next, we will also verify the operation of the system during the summer (cooling period) through questionnaires and interviews, including test house users. Further, we will improve and re-evaluate the application to enhance the integrated user interface.

Figure 9: High-performance ventilation system and integrated user interface configuration diagram



*13 Pollen particle size was assumed to be 10 μm or larger, based on collection rate measurement results for atmospheric dust between 0.3 and 0.5 μm (based on research by Toray Industries, Ltd.). The value shows the initial performance of the filter at the time of delivery. It may be lower depending on the customer's environment and other usage conditions. The filter needs to be replaced (for a fee) once every five years (guide) to ensure performance. The value may be lower depending on the customer's environment and other usage conditions. It is not intended to treat or improve hay fever or respiratory diseases.

*14 Tested on the basis of JIS standards (JIS L 1922:2016 (ISO 1818184) for suppression of viruses attached to the filter. The filter is not effective against all viruses. It is not intended to cure, improve, or prevent disease. Also, the antiviral function for air passing through the filter has not been tested.

4. Latest Sekisui Heim Smart House

In anticipation of the risk of power outages due to frequent natural disasters, since 2012, Sekisui Chemical has been proactively proposing energy-self-sufficient houses*10, which are equipped with storage batteries and are aimed at enabling a lifestyle that avoids the purchase of electricity as much as possible. In 2021, we launched the New Green Model, the latest smart power station house model equipped with the newly developed high-capacity storage battery e-PocketGREEN*15 and can supply approximately 73% of annual electricity consumption (equivalent to 260 days)*16 with clean PV that does not emit CO_2 during power generation. In addition, we opened GREENMODEL Park showrooms in 20 locations nationwide where customers can have a hands-on experience of eco-friendly living in full-size homes, strengthening our proposal capability for energy-self-sufficient homes (equipped with storage batteries). We recently made proposals in anticipation of the risk of rising energy prices due to geopolitical factors. As a result, we were able to convince many customers of the importance of balancing environmental contribution and economic efficiency and having a reliable energy supply in times of disaster*17. This led to a significant increase in the number of GREENMODEL houses ordered in the second half of fiscal 2021 to 280%*18 compared to the previous year. Consequently, the storage battery deployment ratio in sales of newly built detached houses increased for the fourth consecutive year to a record high of 72%. We have installed storage batteries to a total of more than 47,000 houses since 2012.

5. Conclusion

As a leading sustainable housing company, we are committed to contributing to the reduction of environmental impact through the further promotion of 『ZEH』 and energy self-sufficient houses*2 (equipped with storage batteries). The smart house market, however, is still at an early stage of development and penetration. The nationwide penetration rate of ZEH in Japan is only 20% in 2020, both for custom-built and built-for-sale houses (calculated from the Sustainable open Innovation Initiative (SII) "Net Zero Energy House Demonstration Project Research Conference 2021" presentation material), pointing to an urgent need to increase penetration. Further, since this is only for the new detached house market, there is a need to also promote the penetration of ZEH in the new housing complex and housing stock markets. Also, collaboration and advancement of IoT devices centered on HEMS will also be crucial in the evolution of environment-friendly housing. This includes the automation of energy control, UI-based operation of home appliances and equipment, advancement of display systems, and the provision of data utilization businesses and services. Industry-wide co-creation to drive this evolution and penetration is needed to maximize the advantages for homeowners early on and accelerate the speed of penetration, both for new and existing houses.

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*15 e-PocketGREEN was jointly developed with Nichicon Corporation.

*16 [Calculation conditions] Building site: Nagoya; Power contract: Chubu Electric Power Co., Inc.; fully electrified; PV capacity, 9.72 kW; storage battery capacity, 12 kWh (green mode), air conditioning system in all rooms (Comfortable Airy (1st floor); EcoCute system; total floor area: 121 m2, UA value: 0.54; electricity usage: calculated based on HEMS data in an actual house. This value may not be reached depending on the environment and other usage conditions.

*17 Electricity can be used even in the event of a power outage only if the amount of PV power generated or the remaining charge of the storage battery exceeds the usage or output volume. Some equipment may not be available depending on the weather, season, usage volume, and simultaneous usage (output) volume. Electricity cannot be used if the storage battery is empty.

*18 Ratio of the number of GREENMODEL house contracts in 2H FY2020 and 2H FY2021 (based on our research).

HOMETACT: The Cutting Edge Smart-home Platform in Japan

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1. Introduction —What is HOMETACT? —

The HOMETACT integrated smart-home service was announced in November, 2021, consisting of a system side that includes TACTCORE, an IoT platform for real estate management business, a HOMETACT application and TACTBASE, a management portal function. It also has integrated smart-home user support, which includes equipment and configuration services and a call center (Figure 1). System development and platform operation is handled by Mitsubishi Estate. It is built to be reliable, with integrated service support through collaboration with enterprises such as the Bic Camera Group, it integrates smart-home related services that were previously fragmented by device or solution, and is provided as a single package (Figure 2). As of November, 2021, many manufacturers were participating, including home equipment manufacturers such as Rinnai and IoT device manufactures in Japan and overseas. The HOMETACT ecosystem is expanding rapidly, with further collaborations to be announced in the future.

Figure 1: HOMETACT platform overview

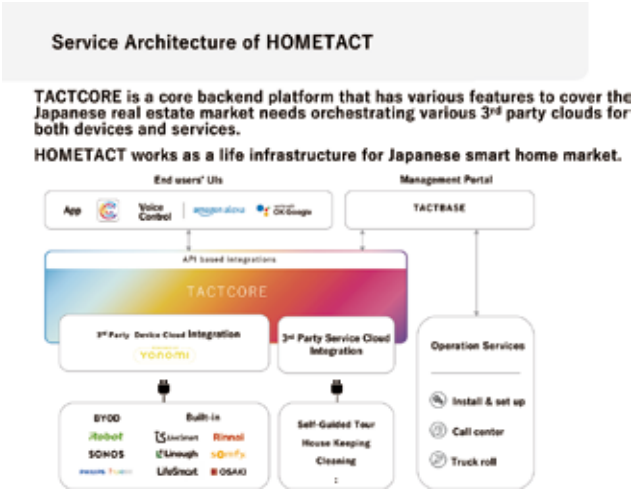

Figure 2: HOMETACT service provision organization

2. Why smart-home technology is not penetrating the residential space in Japan

Currently, HOMETACT is gradually being introduced into Mitsubishi Estate's "The Parkhabio" series of leasehold condominiums. Since the press release, there has been a strong reaction, including discussion initiated with many manufacturers of residential equipment and IoT devices and inquiries from many other developer companies in our own industry who are considering adopting the system. As background to this response, there are several obstacles to introducing smart-home technologies in the residential space in Japan.

HOMETACT aims to eliminate the following obstacles to introduction of smart- home technologies: (1) Applications for using it are fragmented and they cannot be operated together (multiple applications assumed), (2) It is difficult for users to install and configure themselves (installation hurdles are high), and (3) User services such as call centers and emergency support are not well developed. HOMETACT truly removes these barriers, and aims to spread smart-home technology broadly in Japan. Being an integrated developer and having a strong sense of these difficulties are important factors that have enabled us to develop HOMETACT. The fact that we have received inquiries from other companies in this industry also suggests that this service addresses some of the pain points felt in the real-estate industry. To encourage penetration of smart-home technology in the Japanese market, it is extremely important that services are easy for developers to adopt. A new approach that meets new customer needs and is different than existing Home Energy Management Systems (HEMS) is critical.

This article describes the strengths and extensibility of this service as an IoT platform and its user-interface and user-experience (UI/UX) design, starting with how HOMETACT came to be developed, and then touches on HOMETACT's goal of becoming the "new residential-space infrastructure."

3. History of HOMETACT development

As background to Mitsubishi Estate starting to develop an IoT platform as an integrated developer, we go back to June, 2018, when the "Mitsubishi Estate Residence Club" membership organization was launched. Initially, as the person in charge of promoting the project, I was working on the large project of integrating Customer Relationship Management (CRM) for each of the companies in our Residential Business Group with the existing member organizations, which were separate. After the launch, however, developers felt that the system's content capabilities were limited in terms of "building a digital customer contact point." Developers had initiatives to expand opportunities for providing real-estate services such as renovations and agency for buying and selling, to advance marketing with various sales promotions, and to build customer loyalty (i.e. holding events, presentations, etc.). To build a stronger customer contact point, they felt a need for a digital system able to connect with customers at a more basic, lifestyle level. Around 2017, we began seriously considering introducing smart-home technology universally, prompted by our interest in using smart locks as a customer contact-point, but this beginning encountered many issues. At the time, recognition of smart locks was very low compared to now, and there were concerns that we no longer face (although some hold deep-seated biases), such as "it seems dangerous," "a real key would be safer," and "what if it got hacked." As such the hopes of the aforementioned Mitsubishi Estate Residence Club and Mitsubishi Estate properties, to introduce and collaborate on smart-home functions in our properties, did not come true.

4. Collaboration with YONOMI, Inc., including American market survey

However, it became clear that the image of using smart locks and smart-home systems as a digital customer contact point was increasing day-by-day, and market studies continued after the Mitsubishi Estate Residence Club was established. In 2019, smart-home market surveys in the USA had become established. It was there that we encountered YONOMI, Inc., which was providing a cloud-based IoT platform specializing in smart-home technology.

There are many smart-home platform developers in the USA, but the particularly unique point with YONOMI, Inc. is that, rather than developing their own applications, they provided developers with know-how and an environment (service) able to connect with a wide range of devices, like the YONOMI ONE IoT collaboration platform. It provides IoT device API control for implementing automation that others do not allow easily. The shock when I first saw multiple manufacturers' IoT devices operating together in their offices is unforgettable. It convinced them that "this is essential technology for implementing UX not seen before in Japan," and triggered the start of more collaboration.

In that moment, the established notion of smart-home technology in Japan, which did not go beyond simple operations through an infrared remote control and could only achieve space productions such as lighting using high-end, wired devices, was smashed resoundingly. Thus, the HOMETACT project came to life based on the theme of "Producing new smart-home experiences in Japan through API collaboration."

5. Start of negotiation toward API collaboration with manufacturers in Japan

YONOMI, Inc. is expanding collaboration with many major international manufacturers of IoT appliances and devices that already announced collaborations with HOMETACT, including Philips Hue, SONOS, and Roomba, the robot vacuum cleaners from iRobot Inc., and we expect such collaborations to continue to expand in the future. This is an extremely important aspect for HOMETACT extensibility in the future. It will be important for the company to build a network for API collaboration with major Japanese device manufacturers, to utilize this strength in the future.

As you know, there are still few examples of platform or device API collaboration among domestic manufacturers in Japan, and when we actually began negotiations, several major manufacturers refused for various reasons such as, "we cannot move forward on providing an API," or "we have not adequately organized our API." In spite of this, HOMETACT has currently announced collaboration with several manufacturers, who sympathize with the HOMETACT vision of "creating new smart-home experiences in Japan through API collaboration," and we have a history of promoting joint development through steady collaborative effort (Figure 3).

Figure 3: HOMETACT supported devices/participating company list

So why did domestic and international manufacturers approve API collaboration and decide to participate with HOMETACT? It became clear in discussion with each manufacturer that their real intention was to increase use of their IoT devices. Although each manufacturer was building cloud services and developing applications, provision of these products was scattered and ultimately, user registration rates were low and in many cases the functionality they had created was not being used.

Manufacturers were not able to obtain adequate usage data either, and they were not able to expand potential business models utilizing IoT. Of course, developers using the devices also could not get feedback on user satisfaction, so in many cases users did not continue using the IoT devices. In fact, the smart-home market in Japan was caught in a negative spiral.

With HOMETACT, users simply log in, and they can immediately start using the IoT devices already installed and configured in the residential space. By using "Scenes" and "MyRules" as described below, they can configure their smart home as they like within a matter of minutes. We do not think a better UX exists from a user perspective. It has been implemented at HOMETACT Lab Akasaka (a laboratory providing experience of HOMETACT device linking and space production—details below) and in our Group properties (The Parkhabio series of Mitsubishi Estate Residence leasehold apartments), and provides a smooth home-automation experience like never before. The following sections describe "Scenes" and "MyRules" supporting home automation, which are key features of HOMETACT.

6. Get familiar with home automation using "Scenes" and "MyRules"

HOMETACT has two functions: "Scenes" and "MyRules"; that form the core of home automation.

As its name implies, a "Scene" is a function that allows simple linked control of IoT devices for a scenario in everyday life, such as "Good morning," "I'm going out," "I'm home," or "Relax mode." With HOMETACT, residents can freely combine "installed devices" that were provided with their apartment with "bring-your-own devices" that they have purchased, such as SONOS Wi-Fi audio speakers, Philips Hue smart lighting, or a Roomba robotic vacuum cleaner, and configure linked operations easily. In addition to operation from the app, Scenes can also be initiated with a voice operation, by linking with Google Assistant or Alexa.

A "MyRule" adds a trigger (condition) to device operations without requiring an app or voice command, such as "When I arrive at the nearest train station in the evening, turn on the air conditioner cooling, start the bath, and turn on the lights and music," (using the smartphone location and time as the trigger) or "Open the curtains and start the air conditioner cooling at sunrise" (starting multiple devices triggered by sunrise). This function is what implements "real" home automation (automated control). Compared with "Scenes", which can control groups of IoT devices for a given scenario in daily life, "MyRules" are for somewhat more-advanced users, but they are very effective for blending the smart home into the user's own life.

During the service launch, we considered including preset Scenes and MyRules (for example, creating a typical "Good Morning" setting, etc.), but when we conducted user testing, younger participants in particular were able to create their own within one or two minutes, even without explanation, so we decided to provide the service without presets and assume users would create their own freely. For both Scenes and MyRules, users can select behaviors of the associated device intuitively (Figure 4), and there is no need to jump to the apps provided by each manufacturer. A major feature of HOMETACT is that all configuration can be completed within it.

Figure 4: Concept screen-shot of a "Scene" list

In considering the HOMETACT UI/UX, we also designed the operation buttons for each device to be simple and minimized the linked functions as much as possible. For example, a hot-water heater remote control has a simple one-button design with a bathtub icon beside it to fill the bath automatically, which is the button that we would push each day (Fig. 5). Each device operation button is separated into a title and detailed functions (two or three levels), but supporting every function provided by the manufacturer could be confusing for users, so we did not hesitate to pare down the linked functions to make function selection easier for users when creating Scenes and MyRules as described above. Although manufacturers put effort into creating their function set, they tend to include functions users will not use. To design the HOMETACT UI/UX from a user perspective, we also collaborated with a team from an overseas design firm, and we have had success with this type of implementation.

Of course, this UI/UX needs to be improved constantly. Often in Japan, application services are not updated after they have been launched, but users interact with their smart homes every day so there is much feedback that must be collected carefully, and an agile organization for improving functionality is essential. It is now almost one year since the service began and we have been issuing monthly updates of varying size to continuously improve the service.

Figure 5: Concept screen-shot of Rinnai "Bath remote control"

7. Next generation space infrastructure

HOMETACT is currently being provided as a smart-home service focused on home automation, but it can also provide solutions to various social issues in the smart-home domain.

One such area is extensibility in the field of real-estate tech. There is little need to explain linking with smart locks as digital transformation (DX) for real-estate management work. The inefficiency of managing physical keys is a heavy burden on management companies, so use of smart locks is spreading as companies work seriously on DX, and this is definitely a factor in the increasing popularity and use of smart locks. HOMETACT implements linking with smart locks, which enables developers and real-estate management companies to increase property value and customer satisfaction with smart-home technology, and it can also be used for DX of management work. The global trend toward smart locks is already irreversible, so we can expect it to continue to increase. Combining smart locks and smart-home technology is also already becoming main-stream as a new residential device in the USA. HOMETACT can also link with the Linough Inc. "Smart Preview" service, which supports un-staffed previewing of properties, so by using HOMETACT with that company's smart lock (Ninja Lock M), management companies can support keyless management and previews.

A second area is as an point of entry for lifestyle-related services. Smart-home technology can make life more convenient with home automation, but it can also have the role of connecting with lifestyle-related services within the home. For example, a smart lock could be used to allow lifestyle-related services to enter the home, such as for deliveries, for domestic help, or for nursing care visits, and could provide opportunities for services such as monitoring or health care for users (residents), based on data detected by sensors and other devices.

Lifestyle-related services using IoT, like those described above, will continue to spread, and considering that both hardware and software IoT support will be needed in the residential space in the future, developers providing residential spaces will not simply be required to install the latest devices and appliances, it will be important for them to introduce services that have ongoing expandability in software. As software in the residential space, HOMETACT is driving extensibility within the home by expanding API linking with lifestyle-related services.

A third area is linking with the energy-management domain. So far, HOMETACT has expanded its ecosystem with API linking, but we are also considering linking with ECHONET Lite, in anticipation of linking with Home Energy Management Systems (HEMS) in the future. The trend to reduce CO2 emissions is recently considered to be an urgent issue by developers, and user awareness of ecological issues has increased dramatically, so contributing to reducing CO2 is recognized as an extremely important theme in this domain. We have received a range of industrial and academic support in studying this theme, and as a company, we are working hard in this area to spread HOMETACT as lifestyle infrastructure in the residential space for the future.

8. Conclusion — Building an ecosystem —

We have described HOMETACT from various perspectives, and we hope that if you are an organization or enterprise desiring to spread smart-home technology, you will make full use of HOMETACT. Even internationally, it is very rare to see developers starting smart-home platform services, and to the contrary, one could say that the Japanese market has been instrumental in establishing such services. To develop the smart-home market in Japan, we cannot depend on the conventional approach, in which developers combine and assemble functions that manufacturers develop in fierce competition. A new ecosystem must be built with collaboration among developers, manufacturers and lifestyle-related service providers, as has been put into practice with HOMETACT. To do so, collaboration among industry, government and academia will also be essential, and we plan to continue developing HOMETACT as next-generation lifestyle through many and various types of collaboration.

[Reference: HOMETACT installation example]

Installation is complete on three Parkhabio Series properties: The Parkhabio Yoyogi Hatsudai, The Parkhabio Azabu Juban, and The Parkhabio Koishikawa.

■ The Parkhabio Yoyogi Hatsudai

■ The Parkhabio Azabu Juban

■ The Parkhabio Koishikawa

[HOMETACT Tours]

Reservations are required for the "HOMETACT Lab Akasaka" showroom, where HOMETACT can be experienced (in the Mitsubishi Estate Home Akasaka Housing Gallery, Tokyo, Minato-ku, Akasaka 7-5-5). This is a laboratory where people can have a smart-home experience like never before, as described in this article. For a tour, please do not hesitate to inquire as indicated below.

■ HOMETACT Lab Akasaka

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DIY Smart Home for the Elderly:Implement wellness monitoring for parents living elsewhere using IoT

Akiko Wada
Wellness Monitoring Tech Coordinator

1. Smart home for the elderly

After my father passed away last year, I spent several months converting our family home, where my 79-year-old mother lived by herself, to a DIY smart home. My goal was to watch over my mother, who is at risk for stroke, and to prevent falls and hyperthermia remotely. With early dementia, difficulties due to mistaking the date or day of the week is common, so I also wanted to help her check the date and day of the week, and to check any upcoming plans.

The results were beyond my expectations. The time and psychological burden on family watching over her remotely was greatly reduced, and being able to see inside the home enables us to handle any trouble that occurs quickly. She also has difficulty walking, so adding voice commands to appliances and lighting also greatly reduced discomfort and inconvenience in daily life. I found her playing songs from her favorite singers on YouTube and enjoying it.

It also changed me. Sometimes I would lose my patience and speak harshly, "Mom! I'm always telling you, you have to check the date first!" and hate myself for it. But I am doing that less now, and when faced with a new difficulty, I now get excited thinking, "I'm sure I can solve this using IoT too!" I can handle visitors remotely with the smart door bell that I installed, and I can use it to connect with neighbors and my mother's friends too.

This article introduces my initiatives to convert a family home to a smart home to help and watch over an elderly person, some points of note from the installation, and some issues for the future.

2. First, a list of issues

The highest priority was to check wellness. Creating a system to notice if something goes wrong in the house as quickly as possible, helps reduce not only my concern, but also my mother's concerns. She has also suffered a mild stroke, and with vascular brain disease, starting treatment as soon as possible after onset can greatly affect the prognosis for life and recovery. There is also increased risk of broken bones from a fall, and of hyperthermia when remaining immobile for long periods of time during the summer.

Regarding fall prevention, hand rails were already installed and steps were eliminated, but falls could still happen easily if she gets up during the night and moves around in the dark, or in the early mornings when her body is stiff from the cold. She has difficulty walking, and just getting up is onerous, so she has sat for long periods after sunset without turning on the lights, and spent the whole day without opening the curtains. These conditions are not desirable for mental health.

She also has difficulty knowing the date and day-of-the week, due to disorientation that occurs in the early stages of dementia. As a result, she has called a taxi and travelled 30 km to the hospital on a day that she does not have an appointment, and often has waited in the entry-way to meet the home care service person for long periods on the wrong day. Hearing her grieve, "Is there something wrong with my head?" was heartbreaking!

3. Cameras and other sensors: The eyes for watching over

I first worked on network cameras. I installed two cameras in the living room and the bedroom, where my mother spends most of the day. These were from the American company, Arlo Technologies, and originally intended for crime prevention. They are connected to the network by Wi-Fi and automatically record video for about 10 seconds before and after they detect movement, which is stored in the cloud for a set period of time. This recorded video and the live video can be checked using a smartphone app, so by just looking at the list of recorded videos, I can check that the daily routine is going smoothly, meals are being eaten, interactions with home helpers are okay, and I get clues to any changes in her bodily condition by watching how she moves around the room. She has also fallen in front of the bathroom and

Figure 1: "Arlo Pro 2" 130 degree, wide field of view network camera

in the entryway, so I also installed a Xiaomi network camera with a lens that can rotate 360 degrees in the hallway.

To help with wellness monitoring using the cameras, I also installed three sensors from SwitchBot Inc. One was a person detector in the toilet. It is configured to notify my smartphone each time she uses the toilet, so I can check that everything is okay without having to check the camera app frequently throughout the day.

I attached an opened-closed sensor to the front door. It also has movement and light-level sensors, so I get notifications on my smartphone if my mother approaches the door. If she is at the entrance getting ready to go out when there is no scheduled home care or hospital appointment, I can talk to her through the speaker of the network camera in the hallway and let her know she is mistaken. I also get a notification when she returns home, so I can say "Welcome home!" through the same camera.

I installed a networked temperature and humidity sensor in the living room. This is configured to send a notification to my smartphone if the room temperature exceeds a set value during the summer, mainly to prevent hyperthermia. The price was moderate, just under 2,000 yen, so I plan to add one to the bedroom as well this year.

4. Smart remote controls for high cost-performance

What my mother was most happy about were the "Google Nest Hub" smart display and the "SwitchBot Hub Mini" smart remote control. By registering the infrared remote controls of existing home appliances, a smart remote can control all of the appliances at once from a smartphone. By also linking with a smart speaker or smart display with an AI assistant, such as Google Assistant or Alexa, household electronics can be controlled with voice commands such as, "OK Google, turn on the air conditioner," or "Alexa, turn off the television".

All of the electronics in our family home are ten years old or more, so they certainly do not support IoT. Nevertheless, by installing a smart remote control for only about 4,000 yen, the air conditioner and ceiling lights can be turned on and off with voice commands through a smart speaker, and I can also do it remotely. It is an all-powerful device for home monitoring. The house is 40 years old, so there is no remote control for the ceiling lights, but attaching a "finger robot" to the wall switch for about 2,000 yen, makes them smart. It is a marvelous device with a short arm that comes out and physically pushes the switch on the wall when it receives a Bluetooth signal. I also attached a special device to the curtain rods so I can say "OK Google, open the curtains half-way," to open the left and right curtains.

Doing complex actions, like opening the door to the living room and pushing the wall switch to turn on the light while holding a coffee cup in one hand, can lead to a fall, so just adding voice control for the lights can reduce this risk.

If she forgets to turn off the living room air conditioner, she can do it from the bedroom, and by starting it automatically, the room can be warmed up before she gets up.

Figure 2: Moving the curtains using the roller on the top

5. AI assistant complements an elderly person's cognitive function

Someone asked me, "Can a 79-year-old use an AI assistant?" Actually, I was also a bit skeptical, but advances in current speech-recognition technology have been great, and they can understand and answer questions even if they are a bit unclear. I also wrote some common phrases, such as "Okay Google, turn on the lights," and "What is the schedule for today?" on tape using a magic marker and attached them to the table and in the bedroom.

Figure 3: Voice commands needed to use the AI assistant

The AI assistant also actively manages her schedule and gives reminders to take her medicines in the morning and evening. My tasks were to create a Google account for her and enter plans such as her hospital and rehabilitation appointments into the online calendar. When she says "Okay Google, good morning," the assistant reads out here plans for the day, and she can say "What are this week's plans?" to check upcoming plans. After breakfast,

it asks, "Did you take your medicine this morning?" Just having this reminder greatly reduces the times she forgets to take the medicine. If a family member asks her each time, "Did you take your medicine?" she is likely to resist saying, "I know, I know! I was just taking it now!" but it does not seem to hurt her self esteem to be reminded by the AI assistant.

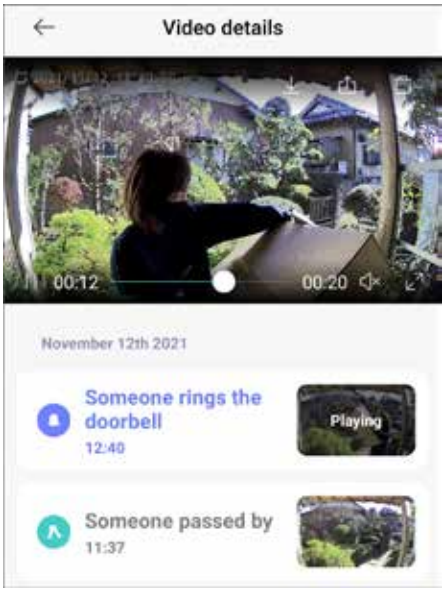
There is one more reason why voice commands are necessary. As my mother's cognitive and decision making functions have declined, she is having more difficulty with operations that require "pushing a lot of buttons," in other words, with remote controls and her smartphone. She has no trouble with voice commands.

Now, she can enjoy music on the smart display, just by specifying a singer's name, such as "Okay Google, play a song by Ichiro Toba." She is not aware that this is playback from YouTube Music, so when I checked the app history, I noticed that she tried to stop playback unsuccessfully several times with the command, "Okay Google, stop the CD." I added a setting so that playback would also stop with the command "Stop the CD."

6. Meet visitors remotely by making the entryway smart

The entryway is an important part of the house because it connects the inside with the outside, but problems can also occur there. My mother has difficulty getting to the door when visitors ring the doorbell so increasingly often, she just pretends not to be home. Thus, even people worried about her who come to visit can get turned away. For this, I installed a smart lock and a smart doorbell. Both connect to the internet by Wi-Fi, so I get notified on my smartphone when someone comes to the door. I can check using the camera and respond if she is having a nap or otherwise cannot. If it is a familiar delivery company or a neighbor, I can temporarily unlock the door remotely and have them leave the parcel or a note in the entryway. If she falls out of bed and cannot move, I can also unlock the door remotely and ask a neighbor to help her back into bed, or I could ask them to call an ambulance if that was necessary. Before now, I had no way to know what was happening in the house without going home, so I would not have been able to call an ambulance either. Actually, there was a time when I stopped work and travelled three and a half hours to the family home to find her fallen out of bed and had to call an ambulance. She had been there more than half the day and was dehydrated, so it was a dangerous situation.

Figure 4: Smart door bell screen in the smartphone app



7. Family home smart-home conversion exceeds expectations

I am still continuing by trial and error, but it has been very effective so far. Earlier, if the weather report said "Today will be a mid-summer day," I would worry all day long about whether my mother had turned on the air conditioner properly. If I called to ask her to turn it on, she might start an unpleasant argument saying, "Who do you think you're worried about?" Now, if the living room gets warmer than a set temperature, I get a notification, and if she has not turned on the air conditioner despite the higher risk of hyperthermia, I can do it remotely.

Increasingly, my mother cannot answer her mobile phone when I call, but this is not a problem because we can talk through one of the cameras or smart speakers. I also see her smiling more often in video calls.

It has improved my relationship with my mother. It takes time to accept that parents are aging, even though you understand it in your head. There can be even life-threatening risk so, while I might have spoken harshly earlier, saying, "Mom! How many times do I have to tell you!" I have changed my mind-set now, to saying, "It's no longer reasonable to depend on her judgment and cognitive ability, so maybe we can solve this with smart technology." Thinking about the best way to handle a situation also feels a bit like a game challenge, so I can react more positively to new difficulties than I did before.

Google Assistant has a bigger heart than her own daughter. It answers brightly, without a hint of irritation, even if she asks, "What day is it today?" over and over. Looking at the logs, I even saw interactions like "Okay Google, thanks a lot!" "You're welcome!" It acts like a personal valet for my mother, so I hope to expand what it can do for her in the future.

Providing care to a parent whose physical and mental abilities are weakening can be depressing because it can sow seeds of fear and uncertainty regarding one's own old age. Through these efforts, I can now envision a brighter future. I now think, "I can use IT to complement declining physical and mental abilities and to reduce inconvenience and disability somewhat," "Technology will continue to advance, so I should be able to have a comfortable life even when I'm old," and "Soon I'll even be able to climb Mount Everest in VR, even if I can't leave the house!" This is another result of converting our family home to a smart home.

8. Issues with smart homes for seniors

When I published stories of this experience on a web site and SNS, they attracted interest and concern from people of my generation, saying things like, "I want to do the same thing in my family home," and "One of my parents is also living alone, so I have the same worries and needs." Another person said, "I'll need this information in the near future too."

Even if both parents are still healthy, just a small event can change things quickly, so it may be good to start introducing these technologies early, so they can get used to them.

Another issue is that smart home devices are now available at volume appliance shops and net shops, so they are very easy to obtain and set up. However, for elderly people to install them themselves, the hurdles are high. Their children could also be in their 50s or older, so not everyone will be skilled at setting them up, which consists mainly of configuring a smartphone app.

Since the person configuring it is not the user, it can be difficult to know how to best link multiple user accounts, and it takes effort to restore everything if trouble occurs.

Current apps for smart-home devices have not been created with "wellness monitoring" in mind either, so in some cases they do not fit with what is needed. For example, when I installed the person sensor in the toilet room, I needed an alert if a person was not detected for over three hours, but when setting an automatic notification for not detecting movement, the maximum time was 30 minutes. I suspect this was designed for applications such as automatically turning off lights or air conditioning when a room is empty. The need to respond as quickly as possible if a parent has a stroke and cannot move was not envisioned.

The preconception that the elderly cannot use the internet is also a barrier to using smart technology. In fact, if the initial setup can be done by someone who is comfortable with smartphone apps and IT devices and can anticipate elderly people's needs and risks, the elderly person can manage well using voice commands. Family can also use the devices for remote wellness monitoring. Many older people with early-stage dementia may also find using voice commands to be more fun than using a remote control covered with buttons.

Of course, as dementia progresses further, voice commands may also become difficult, but even in that case, devices can be configured to turn on the air conditioner and read out the day's schedule with a single command, such as "Okay Google, good morning." Various sensors can also be configured to trigger actions.

9. The need for a wellness-monitoring Tech Coordinator

I also received inquiries from people who wanted to set up smart-home technology for their aging parents, but did not have the time or know-how. There is a need for a so-called "Wellness monitoring Tech," a person who can provide advice on introducing IT technologies and products for wellness monitoring for the elderly, and sometimes installing and configuring it. I could use the experience and know-how I have gained converting my family home with smart-home technology to provide free consultation online or if necessary, to start acting as an agent or giving support for a fee. Just as it helped me, such an effort would reduce the burden on those worrying about monitoring wellness for parents who live apart from them using smart-home technology. It could also contribute to having fewer people left behind in the unfortunate situation of dying in isolation, which is a heavy burden to bear.

Many products such as network cameras, smart door bells and smart locks have been appearing on the market these past years. If care managers and others involved in care and welfare of the aged could get the necessary product information and knowledge to use them, they could reach more of the people that need them. Family homes without an internet connection are also an easy problem to solve, using a low-cost SIM + mobile router, among other options.

Figure 5: Configuring to give a periodic reminder to take medicine

10. Conclusion

How and where will we spend the final stages of life, perhaps reaching 100 years of age? At the moment, my mother can just manage life by herself in her home, and she earnestly desires to live there with her pet cat, as she has become accustomed. She could also move to an institution, but this is not what she wants and I do not want to insist, just because it is dangerous to be alone. At the same time, I do not want to quit work, return home, and devote myself to her care.

Wellness monitoring tech is a powerful tool to enable elderly people to live in their own homes safely and to reduce the burden on family members watching over them. I look forward to further advances in technology and seeing products and services on the market that are optimized for wellness monitoring of the elderly.

= A Serial Introduction Part 1 = Winners of ITU-AJ Encouragement Awards 2023

In May every year, The ITU Association of Japan (ITU-AJ) proudly presents ITU-AJ Encouragement Awards to people who have made outstanding contributions in the field of international standardization and have helped in the ongoing development of ICT.
These Awards are also an embodiment of our sincere desire to encourage further contributions from these individuals in the future.
If you happen to run into these winners at another meeting in the future, please say hello to them.
But first, as part of the introductory series of Award Winners, allow us to introduce some of those remarkable winners.

Kei Ando
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Fields of activity: 3GPP RAN, O-RAN

Contributions to 3GPP RAN and O-RAN Alliance standardization

I am very honored to have received this prestigious encouragement award from the ITU Association of Japan. I would like to express my sincere gratitude to all at ITU-AJ and everyone else involved.

After I joined NTT DOCOMO in 2011 I worked for about six and a half years on development of commercial mobile phone devices and 3GPP standardization. At 3GPP, I was involved from updating LTE-Advanced to introducing the first edition of 5G NR, standardizing frequency bands among other things. The intense technical discussions with various Japanese and international companies to achieve better communication quality and global harmonization of frequency bands left a strong impression on me.

Currently, I am working in the RAN Plenary to set NTT DOCOMO's standardization policy, mainly on frequency bands and RF topics. Since July 2022, I also participated in the O-RAN Alliance, in planning of use cases using Open RAN solutions and in administration activities for releases. In work with the O-RAN Alliance I am facing areas that are new to me, such as open interfaces, intelligent functions and virtualization technology, so I am working proactively and studying every day.

In the future at 3GPP, we expect to study the possibilities for 6G, with Release 20 in about 2025. As in the past with 3G, 4G and 5G, NTT DOCOMO will lead discussions on 6G standardization, creating value for customers in the 2030s and contributing to 6G implementation. As part of that effort, I will use the experience I have gained in standardization, from LTE-Advanced through to 5G NR, and work to contribute even a small amount to 6G standardization with 3GPP and the O-RAN Alliance.

Hidenori Iwashita
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Fields of activity: ITU-T SG5

Standardization of soft-error countermeasures in telecommunication equipment

I would like to offer sincere thanks for receiving this prestigious ITU Association of Japan Encouragement Award. I would also like to thank the members of the TTC Soft-error Ad-hoc Committee.

Telecommunication service interruptions thought to be caused by soft errors due to cosmic-ray-induced neutrons (over-writing memory bits) and countermeasures have long been a difficult issue to solve (particularly increasing recently) for development and maintenance of communications equipment. To elucidate this phenomenon, in 2012 I established testing technology that uses an accelerator to cause neutron emissions, which then can reproduce soft errors in communications devices. This enables the effects of soft errors to be understood before they occur, so that improvements can be made to equipment and introduced into operating networks to greatly improve communication quality. To standardize this technology internationally, I proposed new work items for recommendations regarding soft errors, and in 2015, established discussion toward creating a recommendation. In 2016, a new recommendation, K.124, was established describing this set of recommendations in outline, and starting in 2017, I acted as associate rapporteur for ITU-T SG5 WP1 Q5, to draft the set of recommendations and hold discussions with telecommunications carriers and vendors in Japan and internationally. In 2018, the new recommendations were created: K.130 (Testing), K.131 (Design), K.138 (Criteria) and K.139 (Evaluation). In 2020, I contributed to creating K.150, which summarizes device information required to apply soft error mitigation measures. Currently, communications equipment conforming to these standards, with measures to mitigate soft errors, is being installed in real, operating networks. I am extremely pleased to see technology that I worked on as an international standard. In the future, I hope to continue to contribute to improving the reliability of telecommunications networks.

Chihiro Kito

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Fields of activity: ITU-T SG15 WP2, SG15 Q7 Rapporteur

Standardization activities for maintaining stable, high-quality communications infrastructure

I would like to offer sincere thanks for this ITU Association of Japan Encouragement Award at this time. I am very grateful to all who provided their support for these standardization activities.

In ITU-T SG15 WP2 Q7, which handles discussion related to maintenance and connectivity of outdoor optical physical infrastructure, I proposed a system for a set of maintenance and operation Recommendations for ITU-T, and contributed to organizing maintenance and operation Recommendations by creating new general provisions in L.330 and driving the work as editor for various Recommendations. Until recently operators in each country implemented their own schemes for maintenance and operations, and ITU-T Recommendations related to maintenance were meager. However, with the spread of optical communications, the number of outdoor facilities requiring maintenance by operators has increased dramatically. Thus, creating a standard scheme for managing the quality and reliability of large numbers of outdoor optical facilities above a certain standard and operating it continuously, in the form of an open ITU Recommendation, is essential to ensure the soundness of optical telecommunications networks globally. I recognize it as a duty of Japan, as a leading country in the spread of FTTH.

Optical communications has permeated life as important infrastructure, and social demand for maintaining high quality, stable communications infrastructure will increase greatly in the future. Japan has issues with maintenance of infrastructure, such as a shrinking workforce and degradation of buildings from the period of rapid economic growth, but there are also many maintenance and operation techniques being proposed using excellent new technologies such as image recognition, drones and optical fiber sensing technologies. I will continue working to promote standardization efforts in this area while following technology trends that can realize improved efficiency and labor saving in operations and maintenance, and to promote technical results from Japan.

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Fields of activity: Digital Terrestrial Television Broadcasting

Activities on International Standardization for New Digital Terrestrial Broadcasting Systems

Thank you so much for the honor of receiving this ITU Association of Japan Encouragement Award. I would like to take this opportunity to express my gratitude to ITU-AJ and the many other people involved, for their guidance and cooperation.

2nd-generation digital terrestrial television broadcasting (DTTB) systems, which utilize the latest video coding and transmission technologies and improve bandwidth efficiency, are being implemented globally, and R&D and trials on the next generation DTTB system is in progress in Japan.

When transitioning to new services using the 2nd-generation DTTB system, new and current systems had to be broadcast simultaneously until receivers supporting the 2nd-generation system had been widely adopted. When there are not enough vacant channels for new services, creating channels can be a major burden for broadcasters. In Japan, research with the goal of introducing new services in the same channel used for existing services began in 2019, and I also was involved in that research activity. When I started participating in ITU-R SG6 meetings, work on a new recommendation was also in progress, on guidance for introducing new services to help countries considering transition to the new system. I contributed to creating the new recommendation by adding concrete technical methods to introduce new services. Currently, I am contributing to ITU-R SG6 meetings by inputting results of research being done in Japan on the next-generation DTTB system to the meetings and reflecting them in reports and recommendations.

Demand for broadcasting continues to expand. Broadcasting is an efficient means for distribution of video content, and is important infrastructure supporting public safety. I will take this award as encouragement and continue my effort to contribute to international standardization activities and to the advancement and growth of broadcasting.

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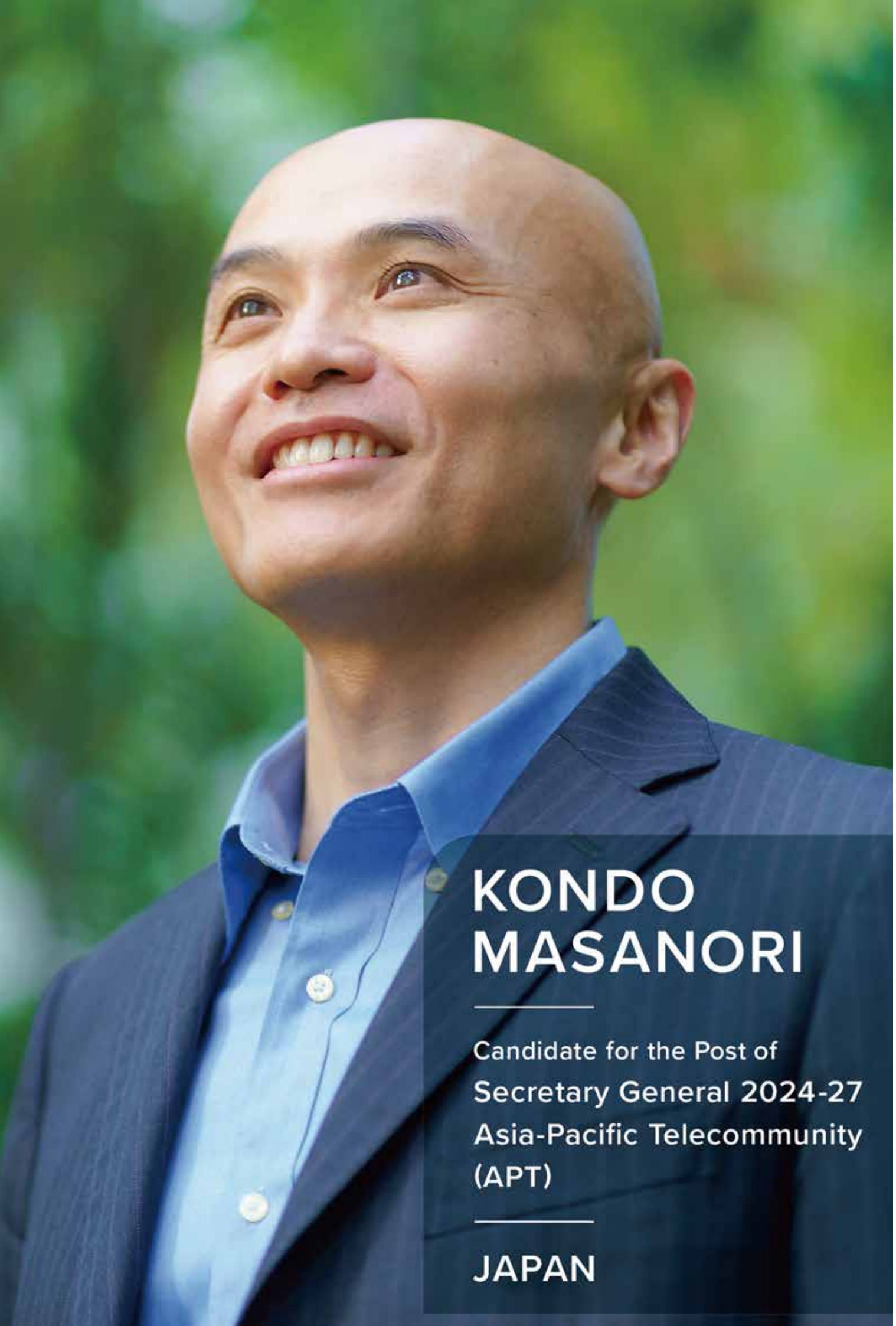

定価　一冊　一、六五〇円（本体価格　一、五〇〇円、消費税　一五〇円）　年間購読料　六、六〇〇円（本体価格　六、〇〇〇円、消費税　六〇〇円）