TRON Forum

IEEE MILESTONE

The Pioneering TRON Intelligent House, 1989

November 2024

TRON Intelligent House Honored as IEEE Milestone

in 2024 following last year's TRON Real-time OS Family

TRON Forum

The "TRON Intelligent House," completed in 1989, has been recognized as an IEEE Milestone. This follows the recognition of the TRON real-time OS family in May 2023[note 1], marking a remarkable achievement for two consecutive years. The commemorative plaque presentation ceremony was held at the University of Tokyo on November 28, 2024.

Reasons for Recognition

To be recognized as a Milestone, an achievement must have been publicly available for at least 25 years and have made significant contributions to the development of society and industry. The TRON Intelligent House was completed in December 1989, nearly 35 years ago. Recognition also requires widespread public documentation of the achievement. This requirement was fully met through extensive coverage in both Japanese and international media, including magazines like *Popular Science*, academic journals such as *IEEE Micro*, and broadcasts by BBC and CNN. It was open to the public from April 1990, with about 10,000 people visiting over the course of about a year. The TRON Intelligent House is still frequently cited as the origin of smart houses.

The term "smart house" began to be used in the 1980s, and similar projects emerged in Europe and the United States. However, these seemed to remain as one-off research and development projects without progressing to full-scale commercialization. In contrast, the participating Japanese housing manufacturers for the TRON Intelligent House conducted research and development with clear paths to commercialization. They first implemented their technologies in the TRON Intelligent House and subsequently developed them into commercial products.

Figure 1: TRON Intelligent House

Technologies that were implemented and later became common include: washlet/healthcare monitors, healthcare data transmission, scene lighting, human-sensing floor lights, comprehensive alarm settings, DSP sound field emulation, automatic plant watering, liquid crystal glass windows with adjustable transparency, and indoor sensor networks (for environment and temperature), among others. This wide range of innovations greatly stimulated the architectural and home appliance industries.

While the original "TRON Intelligent House" was eventually demolished after fulfilling its research objectives, its innovative spirit lives on in subsequent projects such as "Toyota Dream House PAPI" (2004), "Taiwan u-home" (2010), "The University of Tokyo Daiwa Ubiquitous Academic Research Building" (2014), "Toyo University INIAD HUB-1" (2017), "Open Smart UR Startup Model Housing Unit" (2019), and "Open Smart UR Life Monitoring Housing Unit" (2022). The results have been used in many other buildings as well, contributing to the development of the construction industry.

The Advanced Nature of the TRON Intelligent House

The official name of the recognized achievement is "The Pioneering TRON Intelligent House, 1989." The reasons for recognition are outlined as follows:

> The first TRON Intelligent House was based on the concept of a Highly Functionally Distributed System (HFDS) as proposed in 1987. Built in Tokyo in 1989 using about 1,000 networked computers to implement the Internet of Things (IoT), its advanced human-machine interface (HMI) provided 'ubiquitous computing' before that term was coined in 1991. Feedback by TRON's residents helped mature the HFDS design, showing how to live in an IoT environment.

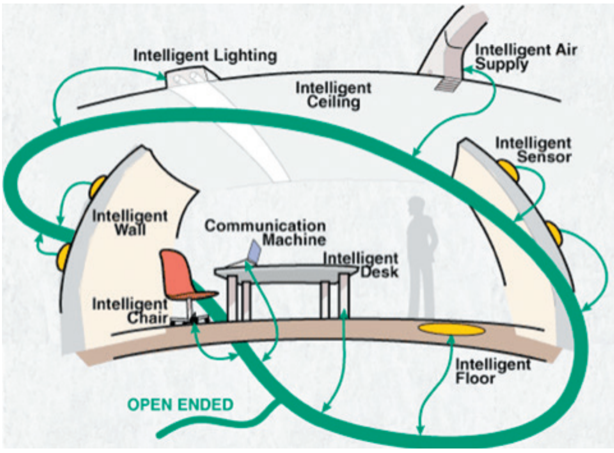


Figure 2: HFDS (Highly Functionally Distributed System)

TRON Project proposed the basic concept of a "Highly Functionally Distributed System" (HFDS) in 1987[note 2]. It proposed an environment that supports human activities from various aspects by placing numerous advanced components called intelligent objects - consisting of sensors, computers, and actuators - in our everyday surroundings, and having them communicate and cooperate with each other. The project then conducted research and development to implement this concept. Intelligent objects are what we now call IoT edge nodes. In the context of housing, not only home appliances and housing equipment but also furniture, walls, and ceilings were turned into intelligent objects.

HFDS is what came to be known as the "ubiquitous computing environment" in 1991[note 3], and is now known as the "IoT environment" - an architecture where numerous intelligent objects are connected by multiple networks and further linked to external computers for coordinated operation. Against the backdrop of the world's first commercial Internet service emerging in 1990 (1993 in Japan), the TRON Intelligent House anticipated the modern

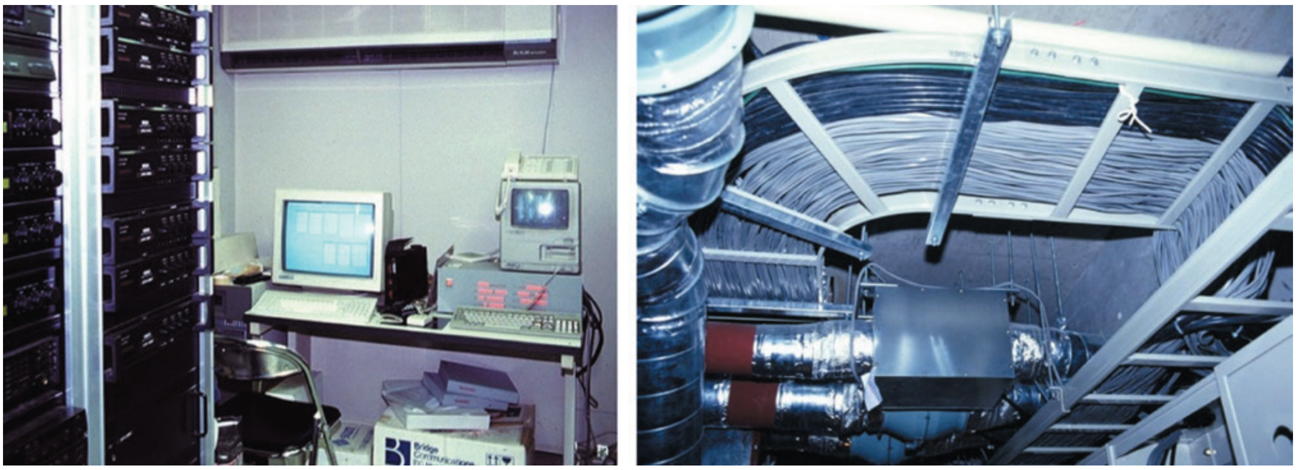


Figure 3: The basement computer room and extensive wiring

1) https://www.tron.org/ieee-milestone/
2) “Ken Sakamura: The Objectives of TRON Project: Open-Architecture Computer Systems”, Proceedings of the Third TRON Project Symposium, Springer Verlag, pp.3-16., 1987.
https://link.springer.com/chapter/10.1007/978-4-431-68069-7_1
3) Mark Weiser: The Computer for the 21st Century, Scientific American, September 1991, Vol 265, Issue 3.
https://dl.acm.org/doi/10.1145/329124.329126

IoT environment using 1989 technology. It emulated the IoT environment by smartening edge nodes with numerous embedded microcomputers and network connections, using several workstations installed in the basement computer room and connecting devices with a large amount of wiring. It also transmitted diagnostic data from home healthcare devices to hospital computers via ISDN connections.

Assuming the practical application of network environments, the project advanced research and development of essential technologies needed to realize a ubiquitous computing environment (=HFDS). The TRON Intelligent House served as a living laboratory, where actual residents provided ongoing feedback that informed iterative experimental improvements. These efforts established it as a pioneering "smart home." Its substantial influence on the industry further contributed to its recognition as an IEEE Milestone.

The interior of the TRON Intelligent House was committed to a well-designed approach that didn't overtly display computers. Special attention was paid to ensuring that all housing equipment could be easily operated by residents regardless of their technical expertise. This commitment to accessibility drove the development of sophisticated Human-Machine Interface (HMI) design guidelines[note 4]. These standards were later published in an IEC (International Electrotechnical Commission) technical report[note 5].

Conclusion

TRON Project, from its start in 1984, has proceeded by defining requirements top-down with future applications in mind, and then researching and developing the fundamental technologies, operating systems, and microchip architectures needed to realize these requirements. The TRON Intelligent House was one of the important future application research initiatives that followed this process.

The relatively smooth and quick recognition this time[note 6] was due to the foresight of the HFDS vision that formed the backbone of the TRON Intelligent House, and the existence of numerous documents demonstrating its influence. It is a great joy to receive this honorable Milestone recognition in the year marking the 40th anniversary of TRON Project.

For this recognition, we would like to take this opportunity to express our gratitude to the IEEE Tokyo Chapter members, Professor Emeritus Tomohiro Hase of Ryukoku University who served as an advocate for the IEEE History Committee, and many others who provided reviews.

4) “TRON Intelligent Living Human Interface Standard Handbook” (Japanese), Personal Media Corporation, 1993
5) “Guidelines for the user interface in multimedia equipment for general purpose use”, Technical Report IEC TR 61997, 2001. https://webstore.iec.ch/en/publication/6269
6) March 29, 2024: Submission of Milestone recognition application documents. May 1: At the History Committee managing IEEE Milestones, a vote passed to recommend the application to the IEEE Board of Directors (BoD). June 24: Final recognition at the BoD meeting, and receipt of official notification.

Column IEEE Milestone

IEEE (Institute of Electrical and Electronics Engineers)[note 7] is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. IEEE and its members frequently cited publications, international conferences, technology standards, and professional and educational activities, inspire a global community through IEEE's highly cited publications, conferences, technology standards, and professional and educational activities. IEEE is trusted in a wide range of areas from aerospace systems, computers, and telecommunications to biomedical engineering, electric power, and consumer electronics.

The IEEE Milestone program recognizes outstanding technical achievements in IEEE's areas of interest, namely electrical and electronic engineering, which have been in existence for at least 25 years and have made significant contributions to the development of society and industry[note 8]. It evaluates technological innovations and excellence that benefit humanity as seen in unique products, services, seminal papers and patents.

To date, over 260 Milestones have been approved worldwide. Among the older ones, even Benjamin Franklin's letter to the Royal Society in England describing his kite experiments to investigate lightning in the 1700s has been recognized as a Milestone. Post-World War II recognitions include the invention and mass production of the transistor and the invention of radar. In the IT field, Intel 4004, Ethernet, Xerox Alto, Apple I/II, and Macintosh are among those recognized. There are also many Milestones related to power generation and satellite communications, reflecting the breadth of fields covered by IEEE[note 9].

In Japan, more than 40 achievements have been recognized, including QR Code, Mount Fuji Radar, and the Shinkansen (Bullet Train). These achievements stand as a testament to Japan's century-long excellence in electrical and electronic engineering, particularly highlighting the remarkable growth and innovation of these industries in the post-war era[note 10].

No.	Name	Dedication ceremony
1	The Pioneering TRON Intelligent House, 1989	November 28, 2024
2	Laser Ionization Mass Spectrometer, 1988	November 15, 2024
3	Toyota Prius, the World's First Mass-Produced Hybrid Vehicle, 1997	October 30, 2024
4	Commercialization of Multilayer Ceramic Capacitors with Nickel Electrodes, 1982	March 8, 2024
5	TRON Real-time Operating System Family, 1984	October 14, 2023
6	Perpendicular Magnetic Recording, 1977	October 9, 2023
7	QR (Quick Response) Code, 1994	September 26, 2022
8	Inverter Air Conditioners, 1980-1981	March 16, 2021
9	Physical Contact Push-Pull Technology For Fiber Optic Connectors, 1986	March 5, 2021
10	First Commercial Digital Signal Processor Chip, 1980	December 15, 2020
11	First Operational Large-Scale Latent Fingerprint Identification System, 1982	December 15, 2020
12	High Electron Mobility Transistor, HEMT, 1979	December 18, 2019
13	Outdoor Large-Scale Color Display System, 1980	March 8, 2018
14	Discovery of the Principle of Self-Complementarity in Antennas and the Mushiake Relationship, 1948	July 27, 2017
15	Nobeyama 45-m Telescope, 1982	June 14, 2017
16	Invention of a Temperature-Insensitive Quartz Oscillation Plate, 1933	March 6, 2017
17	Map-Based Automotive Navigation System, 1981	March 2, 2017
18	Keage Power Station: Japan's First Commercial Hydroelectric Plant, 1890-1897	September 12, 2016
19	High Definition Television System, 1964-1989	May 11, 2016
20	Emergency Warning Code Signal Broadcasting System, 1985	May 11, 2016
21	Vapor-phase Axial Deposition Method for Mass Production of High-quality Optical Fiber, 1977-1983	May 21, 2015
22	The MU (Middle and Upper atmosphere) radar, 1984	May 13, 2015
23	TPC-1 Transpacific Cable System, 1964	November 12, 2014
24	20-inch Diameter Photomultiplier Tubes, 1979 - 1987	November 5, 2014
25	Gapless Metal Oxide Surge Arrester (MOSA) for electric power systems,1975	August 18, 2014
26	Sharp 14-inch Thin-Film-Transistor Liquid-Crystal Display (TFT-LCD) for TV, 1988	June 10, 2014
27	Line Spectrum Pair (LSP) for high-compression speech coding, 1975	May 22, 2014
28	Birth and Growth of Primary and Secondary Battery Industries in Japan, 1893	April 12, 2014
29	Toshiba T1100, a pioneering contribution to the development of laptop PC,1985	October 29, 2013
30	International Standardization of G3 Facsimile, 1980	April 5, 2012
31	First Practical Field Emission Electron Microscope, 1972	January 31, 2012
32	First Direct Broadcast Satellite Service, 1984	November 18, 2011
33	Commercialization and Industrialization of Photovoltaic Cells, 1959-83	April 9, 2010
34	Kurobe River No. 4 Hydropower Plant, 1956-63	April 9, 2010
35	First Transpacific Reception of a Television (TV) Signal via Satellite, 1963	November 23, 2009
36	Development of Electronic Television, 1924 - 1941	November 12, 2009
37	Development of Ferrite Materials and Their Applications, 1930-1945	October 13, 2009
38	Yosami Radio Transmitting Station 1929	May 19, 2009
39	The First Word Processor for Japanese Language, 1971 - 1978	November 4, 2008
40	Railroad Ticket Examining System	November 27, 2007
41	Development of VHS, a World Standard for Home Video Recording, 1976	October 11, 2006
42	Pioneering Work on Electronic Calculators, 1964-1973	December 1, 2005
43	Electronic Quartz Wristwatch, 1969	November 25, 2004
44	Tokaido Shinkansen (Bullet Train),1964	July 13, 2000
45	Mount Fuji Radar System, 1964	March 6, 2000
46	Directive Short Wave Antenna, 1924	June 17, 1995

7) https://jp.ieee.org/, https://www.ieee.org/
8) https://ieeemilestones.ethw.org/
9) https://ethw.org/Milestones:List_of_IEEE_Milestones, https://ethw.org/Milestones:List_of_Milestones
10) https://ieee-jp.org/activity/jchc/milestone_jusho.html

The Evolution of TRON Intelligent House

Ken Sakamura

Since its inception in 1984, TRON Project has aimed for a future where computers are embedded in everything, making objects intelligent, and these objects are interconnected via networks to work cooperatively towards a single goal. We have been advancing research on this concept, which we named Highly Functionally Distributed System (HFDS). This concept would later evolve into what we now know as ubiquitous computing and the Internet of Things (IoT).

The 2024 IEEE Milestone recognition evaluated the TRON Intelligent House's initiative and subsequent buildings constructed based on its concepts as having made significant contributions to the industry. This article looks back on the original TRON Intelligent House and its subsequent developments.

1989 TRON Intelligent House

The TRON Intelligent House, completed in December 1989 in Roppongi, Tokyo (opened to the public in April 1990), was the first building to implement the HFDS concept.

In the TRON Intelligent House, computers, sensors, and actuators were embedded in many components that made up the house, making them intelligent, and these were interconnected through networks. As objects become "intelligent" by having embedded computers that can respond intelligently to external conditions, TRON Project calls such components "intelligent objects."

When intelligent objects are networked, various coordinated operations become possible. For example, the weather sensors installed on the roof can detect temperature, humidity, and airflow outside the house. This information is communicated to the window system, allowing the windows to open automatically to create a comfortable environment for the residents. If it starts raining, the windows automatically close, and the air conditioning system is notified to take over indoor environmental control.

If two TRON Intelligent Houses are adjacent, for instance, when someone tries to play the piano in a room with an open window, that piano sends information "piano is about to be played" to the neighboring house. The neighboring house then checks if anyone is sleeping. If someone is sleeping, this information is communicated to the window in the room with the piano, informing it that the window there needs to be closed. The air conditioning system is further notified that "the window will be closed, so room temperature adjustment is necessary." Once these actions are completed, the piano receives a notification that "it's okay to produce sound." The usage scenario of HFDS is to realize this series of actions in real-time within just a few seconds.

In the TRON Intelligent House, computers were embedded in all systems that made up the house—kitchen, toilet, bath, etc.—making them intelligent, and these were connected by networks to work together to provide convenience to the residents.

From the beginning, TRON Project aimed to create the infrastructure (social foundation) for the intelligent city of the 21st century. Therefore, we also considered standardizing the rules for human interaction with infrastructure, for example, making all the switches in this house operable uniformly according to the TRON guideline.

Let's look at the intelligent kitchen developed in cooperation with Sunwave. Cooking recipes are recorded on laser discs, and seasonings are dispensed in milligram units according to the recipe, and the oven switch is turned on and temperature and time are adjusted according to the recipe. The smart kitchen system operated in two modes: one for recording cooking recipe and another for automated recipe playback. In the recording mode, when you cook, everything is measured and recorded - how long the oven was used, how much seasoning was added. In the playback mode, the reverse happened - you could reproduce the

Figure 1: Full view of the south side of the TRON Intelligent House. The indoor and outdoor environmental/weather sensors constantly measure temperature, humidity, air pressure, wind speed, wind direction, rain fall, illuminance, etc. All the windows, including those in semi-outdoor space, are automatically opened and closed by computer control based on these measurements.

Figure 2: Outdoor weather sensors and indoor ceiling thermal sensor.

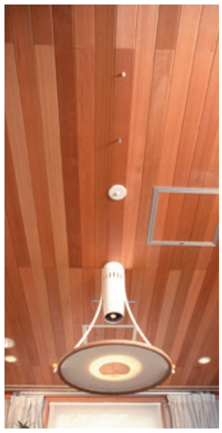


Figure 3: Sensors on the dining room ceiling. From the top: temperature and humidity sensor, airflow sensor, human motion detection sensor, and originally created lamp inspired by the TRON logo.

Figure 4: The semi-outdoor space is a garden with flowers, trees, and foliage plants planted in artificial soil, managed by a computer-controlled hydroponic system. In the foreground is a garden kitchen unit.

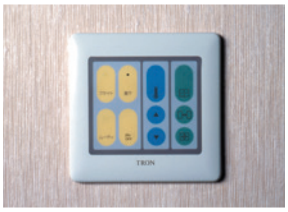


Figure 5: Switches follow the TRON guideline and can be operated uniformly.

Figure 6: Intelligent kitchen. The screen above the cooking counter is the display used by the computer-controlled cooking support system. It shows cooking instructions and serves as a touch screen. There is a similar display in the foreground.

Figure 7: Toilet system capable of health management.

cooking recipe, amount of seasonings, timing of heating, etc. that were recorded.

Additionally, we developed a computerized toilet system in cooperation with TOTO, who was developing the Washlet at the time. It had automatic urine analysis and measured blood pressure, and we prepared a system to send healthcare monitor data to hospitals using NTT's ISDN communication line for health management and other advanced experiments.

The construction of the TRON Intelligent House was done by Japan Homes, a subsidiary of Takenaka Corporation, but all other development was achieved through the joint research with private companies or donations.

The TRON Intelligent House was featured on the cover of *Popular Science* magazine, broadcast on BBC, and covered by many foreign media, attracting worldwide attention.

Figure 8: The cover and article of *Popular Science* September 1990 issue featuring the TRON Intelligent House.

Table 1: TRON Intelligent House Research Group Member Companies and Their Roles (in no particular order, company names and titles are as of that time)

Total Design & Intelligent Function Design	Ken Sakamura, Associate Professor, Faculty of Science, the University of Tokyo / Sakamura Laboratory
Main structure design and construction	Japan Homes Corporation
General equipment control & Information equipment	TAKENAKA CORPORATION / Eiraku Electric Co., Ltd.
Kitchen equipment	Sunwave Industry Co., Ltd. / Tokyo Electric Power Company
Water-related equipment	TOTO LTD.
Air conditioning equipment	Taikisha Ltd. / Mitsubishi Electric Corporation
Lighting equipment	Yamagiwa Corporation
Storage equipment	Motoda Electronics Industry Co., Ltd.
Audio equipment	Yamaha Corporation
Communication and information equipment	Japan Airlines Co., Ltd. / NIPPON TELEGRAPH AND TELEPHONE CORPORATION (NTT)
Planting management equipment	Daiichi Engei Co., Ltd.
Motorized opening/closing windows & Top lights	Sankyo Aluminum Industry Co., Ltd.
Various types of glass	Nippon Sheet Glass Co., Ltd.
Roofing material & Roofing work	Nisshin Steel Co., Ltd.
Furniture & Daily necessities	The Seibu Department Stores, Ltd.

Figure 9: Exterior view of PAPI

2004 Toyota Dream House PAPI

Toyota approached us with the desire to apply their advanced technologies developed in car manufacturing to the housing field. In preparation for the 2005 World Expo "Expo 2005 Aichi" (in Nagakute City, Aichi Prefecture), joint research between the University of Tokyo's Sakamura Laboratory and Toyota began. The result was the future house "Toyota Dream House PAPI," completed in 2004.

The building area is 408 square meters (approximately 4,390 square feet). It is a simple two-story box-type building that straightforwardly utilizes the rigid frame structure units. The entire surface is coated with photocatalyst, making it maintenance-free. While the original TRON Intelligent House had some challenges in addressing environmental issues, PAPI was easy to deconstruct, and the aluminum and glass exterior walls were all recyclable, incorporating various ideas for recycling and reuse on a unit-by-unit basis.

Internet and other ICT technologies were abundantly used. Although smartphones did not exist at the time, we developed a precursor device—Ubiquitous Communicator (UC)—at the Sakamura Laboratory and YRP Ubiquitous Networking Laboratory. We also prepared a network terminal that allowed users to know and control the house's status anytime, anywhere through a touch screen. In the original TRON Intelligent House in 1989, a computer room with over a dozen Sun Microsystems workstations was hidden in the basement, but in 2004, the same functionality was possible with lunchbox-sized units distributed behind the walls. Regarding wiring, in 1989, star-connected wiring connecting the sensors and actuators throughout the house filled the entire ceiling of the computer room, but in 2004, it was reduced to just a group of daisy-chain connected Ethernet cables with additional power cables. It can be said that what was not achievable in 1989 as a concept had become sufficiently practical and usable by 2004.

The idea of supplying power from a hybrid car to the house—the concept of using the car as a generator to supply power to the house in emergencies—was first tested here. This has now been put into practical use. Many other technologies used in the TRON Intelligent House and PAPI have gradually been put into practical use and have permeated our daily lives today, such as controlling home equipment through smartphones or voice recognition, health management using wireless wristband sensors, Home Energy Management System (HEMS), home fuel cells, dye-sensitized solar cells, photocatalytic self-cleaning exterior walls for houses, LED lighting for homes, BGM that follows residents' movements, and the use of wireless markers for indoor positioning.

Figure 10: A visitor reception terminal that used T-Engine was installed at the entrance

Figure 11: Indoor facilities can be controlled in an integrated manner from the Ubiquitous Communicator (UC)

Figure 12: Sensors, ucode markers for recognizing the room in which a resident resides, air conditioning outlets, and spotlights are concentrated in slits along the ceiling perimeter

Figure 13: The information display in the kitchen cum dining room shows the house's status and news at a glance

Figure 14: Items in the refrigerator are managed with RFID tags. It is also possible to search for recipes that matches leftovers and display them on the information display.

Figure 15: Hybrid car and electric vehicle in the garage. Using the charging station for electric vehicles, electricity generated by the hybrid car can be supplied to the house in case of emergency

2010 Taiwan u-home

The "u-home," a joint project between the University of Tokyo's Sakamura Laboratory and Taiwan Land Development, was built in Taiwan in 2010 as a showroom for future housing. It focused on providing the ideas practiced in the two previous intelligent houses at a practical cost. The u-home served as a model room for Taiwan Land Development, with the aim of applying this concept design and technology to large apartment complexes in the future. While smart houses, starting with the TRON Intelligent House, had been built with futuristic concepts, the era of ubiquitous computing had arrived, making it an attainable future.

The showroom area is about 200 square meters (approximately 2,150 square feet), and the u-home is about 350 square meters (approximately 3,770 square feet) (excluding corridors, offices, and presentation rooms). Although smaller in total floor area than PAPI, which had a parking lot and swimming pool, it is quite spacious as a residence. It consists of a living room, dining room, master bedroom, guest room, bar & AV room, kitchen, pantry, laundry, and two bathrooms. This size in Taiwan would be considered an expensive mansion in the city, equivalent to what is called a "billion-yen condo" in Japan.

The design tone follows the Japanese modern style of natural material, simplicity, and symmetry carried over from the previous TRON Intelligent Houses, but uses deep red for curtains in consideration of the Taiwanese locale. Most of the furniture was newly designed and made in Taiwanese workshops, resulting in pieces that fit well in each room and are comfortable to use. The furniture placed in the entrance hall, living room, and dining room are antiques from China and Tibet.

The aim of u-home is to be an IoT house that pursues comfort and ecology by utilizing the latest ubiquitous computing technology. In other words, it is a home in which u-home senses the situation of the house and the people in it, and automatically controls the home to maximize comfort and ecology. Ecology includes energy conservation, and in some situations comfort and ecology may be in conflict, but the home is equipped with a mechanism that can resolve this well.

As you walk through the entrance, which is surrounded on both sides by greenery, the automatic door opens to reveal a wall of greenery. This is Suntory's Midorie wall greening system. Plants are planted in pods the size of small flowerpots, which are fitted into the wall in a mesh pattern, and are automatically fed nutrients and water by computer control. In addition to the entrance hall, Midorie is also

Figure 16: Indoor space utilizing automated watering green walls

Figure 17: Controlling the room with Ubiquitous Communicator (UC)

Figure 18: Wall-mounted touch screen

installed on the walls of the master bedroom and guest room.

The u-home is equipped with markers that emit ucodes to indicate locations and sensors that detect people, which are placed in various locations throughout the house. When the sensor detects a person, the illumination turns on automatically, and when there is no one, u-home actively turns off unnecessary illumination. The brightness of the illumination and the curtains are linked according to the time and the brightness of the outdoors (in the model room, this is virtual because it is in the basement). If background music or background video is set, these are also linked. If you want to control things yourself, you can use the Ubiquitous Communicator (UC). The UC recognizes the location ucode and becomes a remote control for the room you are in. There are also touch screen switches on the walls, which can be used to control the room in the same way as the UC. The touch screens have built-in temperature and light sensors, which monitor the environment. Using the information sensed, the system carries out the most appropriate control for the current situation or context.

Information from the human sensor, as well as control of illumination, electric curtains, electric locks on the front door, background music, AV equipment, etc., is carried out by the local controller using the μT-Engine appliance. In addition, information on visitors, energy, and the entire house is collected in the house server, and is used as a status display on the house monitor and as a parameter for overall control.

As a u-home gadget, when you stand in front of the large mirror in the main bedroom, information appears on the mirror like an electronic bulletin board. This includes weather forecasts for various locations, real-time news, family messages, and today's schedule. The weather forecasts and news are real-time information automatically extracted from Internet sites. Family messages and schedules are synchronized with the user's smartphone, tablet, PC, etc.

Home Delivery Box is installed at the back door of the u-home. By contracting with reliable home delivery and dry cleaning services, and managing the delivery staff with eTRON cards containing security chips, it is possible to safely receive and deliver packages. Security cameras are installed both inside and outside the house, so you can check the images from outside even when you are not at home. In addition, the sensing function automatically records suspicious movements, which can be used for crime prevention. The intercom also works in the same way, automatically recording visitors when you are not at home, so you can check them when you get home.

In order to ensure a safe and comfortable living environment, the exterior walls are made of Panasonic photocatalytic exterior wall material. This is a maintenance-free exterior wall that breaks down dirt using sunlight and easily washes away free-floating dirt with rainwater. The interior paint is a urushi lacquered bamboo charcoal paint that contains bamboo charcoal, and it has the effect of absorbing harmful substances and regulating humidity.

The bathroom in the master bedroom is fully equipped with a large bath, multi-function shower, sauna and cold bath, and background music is also played. The design emphasizes the importance of relieving fatigue and refreshing the body. There is an AV room with a large screen and a bar. If you place UC on the counter, it will show you cocktail recipes.

Figure 19: Delivery box

Figure 20: Master bedroom

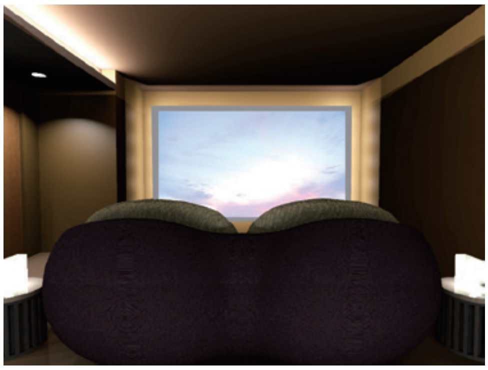


Figure 21: AV room

2014 The University of Tokyo Daiwa Ubiquitous Computing Research Building

By 2014, the information and communication environment surrounding us had changed dramatically. The iPhone was introduced in 2007, after which smartphones became explosively popular. In 2009, cloud big data platform services were launched, making big data processing easily accessible. Furthermore, in 2011, 6LoWPAN, a low-power wireless IPv6 network standard for home equipment, became practical as RFC6282. In TRON Project, T-Kernel 2.0 (T2) was released in 2011 as a network-compatible embedded system, and in 2013, μT2, suitable for smaller sensor nodes, was released, making it easier to develop embedded systems with high network affinity. With advanced big data processing technology and easily available cloud computing infrastructure, it can be said that the base technologies for realizing a ubiquitous environment were in place.

In May 2014, the Daiwa Ubiquitous Computing Research Building was constructed at the University of Tokyo as a platform for research on the concept of opening up embedded systems. It was built with a donation from Daiwa House Industry Co., Ltd. as a research building for the Ubiquitous Information Society Research Platform Center, where Sakamura served as the director. The exterior architectural design was handled by architect Kengo Kuma.

The building serves as a showcase of TRON technologies, implementing state-of-the-art intelligent building features, with major equipment and environmental control devices connected to the network, allowing information retrieval and control instructions through open APIs, making it a "programmable architecture." It enables immediate testing of various technologies in actual living environments, such as controlling equipment through voice recognition or controlling through gesture recognition from indoor camera images, and is becoming a significant push for ubiquitous research.

The Daiwa Ubiquitous Computing Research Building features an integrated API system encompassing eight key functions: alarms, outdoor and indoor sensing, lighting control, indoor air conditioning, elevator operations, power monitoring, and position tracking. The intelligent kitchen has a recording mode and a playback mode. Position recognition is an API that can determine the receiver's position by receiving ucode from BLE markers (transmitting ucode three times per second using radio waves according to Bluetooth Low Energy specifications that smartphones can read) installed at the building entrance, doors of each room, and elevator halls. Also, Wi-Fi access points are installed in locations suitable for Wi-Fi positioning, allowing position recognition using their signatures. Furthermore, the design of API allows for the continuous addition of APIs themselves according to research and development, such as APIs to access individual power management at the circuit/outlet level, electric locks,

Figure 22: Exterior view of the Daiwa Ubiquitous Computing Research Building

Figure 23: Ceiling with exposed piping

Figure 24: Tablet operation allows setting of context-based access control

Figure 25: Facility control app with attention to graphic design

surveillance camera images, and presentation equipment in the hall. To enable easy introduction of such diverse technologies, the building features an open ceiling design with accessible wiring ducts, allowing for seamless integration and future expansion of sensors, markers, cameras, and other IoT devices.

Environmental control is done from individual tablets or smartphones, so there are no switches on the walls. The lighting and air conditioning automatically activate just by someone’s entering the room, and adjustments are made from the apps. In conjunction with human motion detection sensors, if a smartphone's exit is detected and no one remains in the room, the lighting and air conditioning are turned off.

While the Daiwa Ubiquitous Computing Research Building is an experimental environment, to release such a programmable building environment to the world, it is necessary to eliminate security concerns when APIs are made open and published. Therefore, the Daiwa Ubiquitous Computing Research Building aimed to research and establish a context-based access control infrastructure. The "time, place, person" context can be read from APIs through the position recognition platform and various sensors. The context is combined with the app ID of the user's smartphone. A framework consisting of a description language and database was prepared to allow easy description of conditions such as "no entry except for staff on holidays" or "allow access to APIs by guest users during lectures." Using the uID architecture based on ucode, we focused on developing an open infrastructure for governance for programmable architecture that can flexibly perform access control of data and control in a ubiquitous environment according to the context.

2017 INIAD HUB-1

The campus of the Faculty of Information Networking for Innovation and Design (INIAD), Toyo University "INIAD HUB-1," established in 2017, represents a cutting-edge smart building infrastructure, incorporating a network of approximately 5,000 interconnected IoT devices in a building with a total floor area of 19,000 square meters (approximately 4.7 acres). The exterior design was handled by Kengo Kuma, the same architect who designed the Daiwa Ubiquitous Computing Research Building. The interior design, including building facilities, was done by Sakamura, incorporating various innovations. Teaching materials are projected onto screens, so classrooms have no blackboards or whiteboards, and chairs designed based on ergonomics were created to prevent fatigue even when sitting for long periods. The library has no paper books, and information is displayed through digital signage, thoroughly eliminating the use of paper.

INIAD HUB-1 itself serves entirely as an IoT teaching material. The sensors, lighting, air conditioning, lockers, elevators, and various other facilities and equipment are connected to the network and can be operated through APIs. These work in coordination according to the campus context or situation, providing people with the optimal environment and realizing a future campus that optimizes energy use. Here too, ceiling boards are not installed, allowing for future development in wiring and equipment additions. The environment is automatically recognized and controlled using the sensors on campus, and users can give instructions through their smartphones or PCs via the network.

INIAD takes advantage of its small-class system and

Figure 26: Exterior view of INIAD

Figure 27: Small classroom without a blackboard

Figure 28: Chair based on ergonomics

Figure 29: Media Center (library without paper books)

Figure 30: Digital signage

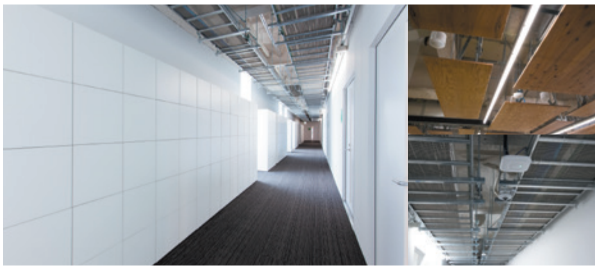


Figure 31: The ceiling is "exposed" to make it easy to install, replace, and wire research IoT devices such as sensors

Figure 32: With access rights, it is possible to control indoor facilities and even elevators through programming

Figure 33: Student lockers are all API-controlled with no handles, keyholes, or numbers, and students cannot use them unless they program them

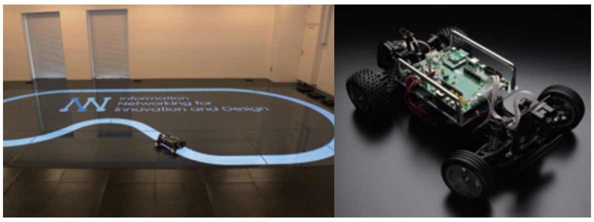


Figure 34: IoT Test Hub and T-Car

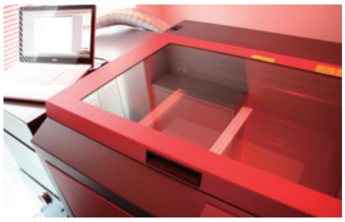


Figure 35: Makers' Hub

actively develops classes using APIs. For example, in programming exercises using IoT devices to control the classroom lighting, students can actually turn on and off the lights in the classroom they are in by calling the lighting control API in their program. Furthermore, by combining the lighting control API with the voice recognition API, it is possible to control the lighting by voice. Each student is assigned an intelligent locker as an IoT teaching material, but the door can only be opened by IoT control. Students are not given a UI, only provided with an API and access token, so they can only use their lockers after programming to link their smartphones or IC cards to the door.

In the IoT Test Hub experimental facility, model cars called "T-Cars" run, which have been modified to be controllable with network-connected IoT-Engines. Students create automatic driving programs that control T-Cars based on data from various sensors and network communication instructions, and drive them on test courses displayed on the floor display.

The Makers' Hub is a space for computer-aided manufacturing, providing an environment for students and faculty to quickly materialize their ideas. It is equipped with digital fabrication equipment such as 3D printers, laser processing machines, and 3D scanners, as well as measurement equipment for electronic work such as logic analyzers and oscilloscopes.

2019 Open Smart UR Startup Model Housing Unit

collaboration Hub for University and Business (cHUB), INIAD, Toyo University and the Urban Renaissance Agency (UR Urban Agency) signed a memorandum of understanding on January 30, 2018, for INIAD to provide technical cooperation using IoT and AI technologies to improve the living environment of UR rental housing. Under the new concept of "Housing as a Service (HaaS)," they have been considering the realization of "Open Smart UR," an attractive and safe living environment utilizing information technologies such as the IoT and AI.

In June 2019, they unveiled the "Open Smart UR Startup Model Housing Unit" in the Akabane-dai (Kita City, Tokyo, Japan) housing complex to present future living and verify its concept. The concept room, created inside the Star House preserved as a historical building, was designed as a living space that can measure various environmental changes, converting a 44 square meter (approximately 475 square feet) Japanese-style room into a one-room apartment and installing 44 sensors and computers.

It is an IoT house where various housing facilities cooperate to optimize the living environment. Furniture, home appliances, and various objects within the premises become "sensors" connected to the network, enabling a three-dimensional understanding of the context. For example, AI can detect abnormal states such as "a person has fallen" based on the data from the monitoring cameras and various image sensors, enabling early problem detection, suspicious person reporting, and crime prevention. Also, by having various devices cooperate across manufacturers through APIs, it can provide a safe living space, such as preventing heat shock by linking air conditioning and circulators, or provide a comfortable living environment by optimally controlling heating and cooling equipment such as floor heating and radiant cooling/heating based on various sensors installed in different locations.

As a programmable house that can flexibly respond to the lifestyles of diverse residents such as the elderly and disabled, it can be freely customized to turn on lights or TV just by voice commands or hand gestures, or automatically turn on lights and open/close blinds, in flexible cooperation with smart speakers and various sensor groups. Also, a large display on the wall shows the Open Smart UR service menu, allowing access to useful information for daily life and various service applications. It also presented various possibilities such as automatically ordering missing items from the refrigerator at an appropriate delivery time when deciding on a menu based on health management advice, through the cooperation of food delivery services with home appliances such as refrigerators and cooking equipment.

Figure 36: Exterior view of Star House

Furthermore, network environments such as IPv6, high-speed network lines, and 5G were also developed, enhancing the facilities as a smart house where one can work from home. The kitchen-cum-dining room, which consolidates various work functions, is equipped with a multifunctional dining table that transforms into a business desk, seamlessly switching to an office space.

The smart delivery box is connected to the network and controlled by a program. It is designed to facilitate smoother exchange of goods using individual recognition with 2D codes and webcams inside the box.

Thus, they established the "Open Smart UR Research Group" with companies that agreed with the concept and proceeded with the construction of more advanced experimental housing. In 2021, they set up the "INIAD cHUB Smart House Test Room" within INIAD as a facility for research group members to conduct various connection tests and service cooperation research. Here, each company brings in their own devices and services, connects them to the platform, and experiments and verifies cooperation with other companies' products.

Figure 37: Dining area and bedroom

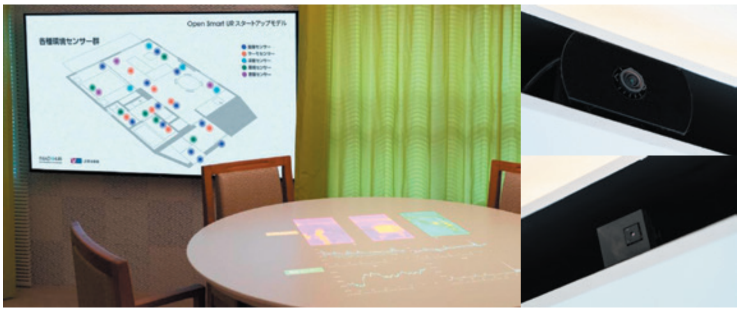


Figure 38: Cameras and sensor groups

Figure 39: Warning display for heat shock in the bathroom

Figure 40: Adjusting temperature unevenness with a circulator

Figure 41: Radiant cooling and heating in the bedroom

Figure 42: Open Smart UR service menu displayed on a large screen

Figure 43: Notification of food status inside the refrigerator

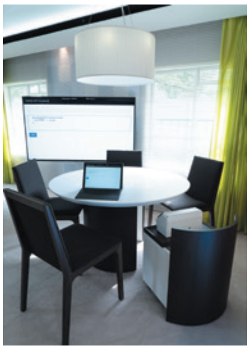


Figure 44: Concept furniture for teleworking. Room APIs can be controlled through programming.

Figure 45: Smart delivery box can be opened and closed using a smartphone

2022 Open Smart UR Life Monitoring Housing Unit

In October 2022, the "Life Monitoring Housing Unit" was completed, renovated from the former Akabane-dai apartment complex's plate-shaped housing, which was preserved as a registered tangible cultural property.

The customized model designed by Sakamura (Rooms 101 and 102) assumes elderly couples and young families as residents. With the concept of "housing to live in for a long time" and "housing that can change," it implements smart placement delivery spaces and movable robot furniture to effectively use the small 39 square meter (approximately 420 square feet) interior.

To collect various big data coming from the housing unit and obtain data for optimal housing design, more than 100 sensor groups were installed. Monitoring cameras, thermal image sensors, millimeter-wave radars, environmental sensors, water flow meters, gas meters, electricity meters, door opening/closing sensors, etc., were inconspicuously installed on the edges of the folded ceilings to monitor the movements of the residents and conduct life monitoring in the living environment. At the same time, function verification of various sensors through correlation of measurement data, and consideration of appropriate minimum sensor sets, and optimal placement are being conducted.

During the COVID-19 pandemic, attention was drawn to spaces for remote work and delivery spaces made of robot furniture that can receive packages without contact. The robot furniture can be used as a bed or sofa by moving storage furniture, allowing the living space to transform by switching between living mode, work mode, and sleep mode. The smart delivery box at the entrance has an automatic opening and closing door, can accommodate large items, and has refrigeration functionality, making it multi-functional.

Various facilities such as lighting, air conditioning, and smart locks can be controlled through API cooperation, allowing computer control of various home appliances and furniture. For example, saying "OK Google, good night"

Figure 46: Cameras and sensors installed on the ceiling

Figure 47: Sensor information displayed on the home monitor

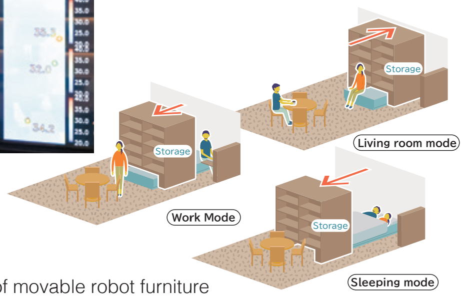


Figure 48: Mechanism of movable robot furniture

Figure 49: Robot furniture that serves as a sofa set during the day and a bed at night

Figure 50: Robot furniture with storage function that separates the tatami-floored bedroom and the slightly raised telework space

Figure 51: Robot furniture at the entrance with smart locker function

makes the tatami bed slide out to the living room side, and saying "Alexa, good morning" stows away the bed and opens the curtains. It connects not only to Google but also to Amazon Alexa and other open architecture-based systems. Also, displays in the living room and washroom show train and bus operation information and notices within the apartment complex.

In the model housing unit, actual living experiences are being conducted, and demonstration experiments are progressing through data acquisition and analysis (life monitoring). It will be used as a demonstration experiment site to realize rich apartment complex living by utilizing smart technologies such as IoT and AI.

2023 IoT+AI Smart Housing

"Sustaina Branche Hongyotoku" is located a 6-minute walk from "Myoden Station" (Ichikawa City, Chiba Prefecture, Japan) on the Tokyo Metro Tozai Line. It was originally built as a corporate dormitory, which HASEKO Corporation acquired and renovated. Of the 36 units total, 13 are designated as experimental housing units. Promoting "GREEN RENOVATION," it has introduced cutting-edge AI and IoT devices, acquiring data from the sensors to contribute to technological research and development.

One of these experimental units is the "IoT+AI Smart Housing," a joint project between INIAD cHUB and Haseko, designed by Sakamura. By IoT-izing the equipment within the housing unit, it has created an environment where everything can be controlled by API, and data is acquired from various sensors. The model housing unit was constructed under the concept of "AI assisting daily life."

Facilities include an entrance that can also serve as a delivery space by managing inner and outer doors with electric locks, a folding staircase that opens and closes when ascending to the loft, and robot furniture that autonomously changes shape to realize space efficiency and optimization through AI. The sensors installed in the house for state recognition are diverse. For example, by utilizing a refrigerator content sensor that automatically records the insertion and removal of items from the refrigerator, AI can combine ingredients and suggest cooking and shopping based on this history. It is a future image where residents can freely program and customize their living environment with AI assistance, utilizing various data collected from sensors. While smart houses have many sensors and

Figure 52: IoT+AI Smart Housing is designed as a residential experimental housing unit within Haseko's "Sustaina Branche Hongyotoku"

Figure 53: (Top) Automatic control robot stairs that serve dual purpose as a passageway and stairs to the loft
(Bottom) Numerous sensors installed in the room, including the refrigerator content sensor

Figure 54: Automatically controlled movable TV stand that allows a single large TV to be used for various areas

Figure 55: To install 150 sensors without performance degradation and without presence, black slits were created around the folded ceiling for installation

cameras installed to grasp the environment, this represents the culmination of expertise cultivated through the intelligent house series to cleanly hide and install various electronic devices without a sense of incongruity, realizing a highly designed interior.

* * *

When we look at the progress from the original TRON Intelligent House to subsequent houses and buildings, we can see the process of realizing the vision that TRON Project has been advocating from the beginning. It is a trajectory where concepts such as ubiquitous computing and IoT environments have become reality, step by step, by integrating cutting-edge technologies of each era. The intelligent house initiatives that began in the 1980s have evolved with the times. Over about 30 years, the fruits of numerous R&D efforts have been integrated into our daily lives. Looking at today's living environment, it's clear that past concepts have steadily come to fruition. These houses and buildings serve as important indicators of technological innovation and its penetration into society. They are truly "milestones" embodying a history of years of effort and innovation.

IEEE Milestone Commemoration Ceremony

Date: November 28, 2024
Venue: Daiwa Ubiquitous Computing Research Building, The University of Tokyo

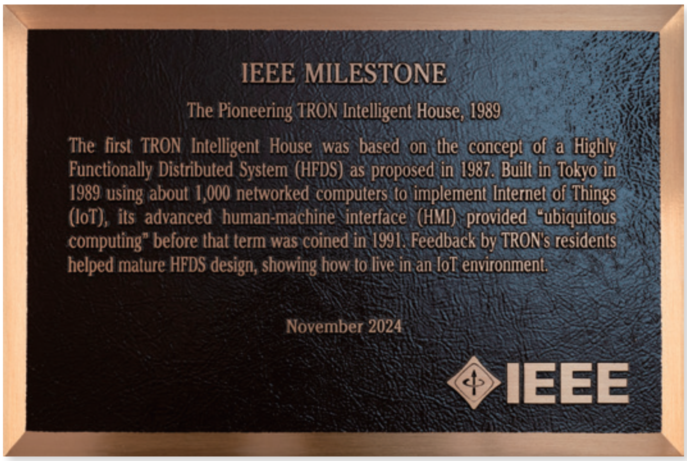
In June 2024, the "TRON Intelligent House" was recognized as an IEEE Milestone under the title "The Pioneering TRON Intelligent House, 1989." To commemorate this recognition, a presentation ceremony, unveiling ceremony, and commemorative lecture were held on November 28.

The venue was the Ishibashi Nobuo Memorial Hall in the Daiwa Ubiquitous Computing Research Building at the University of Tokyo's Hongo Campus. This building was designed and constructed under the supervision of Professor Emeritus Ken Sakamura of the University of Tokyo, who led the TRON Intelligent House project, making it a fitting location as it represents part of the legacy of the TRON Intelligent House being recognized today.

Attendees included Professor Emeritus Ken Sakamura; Dr. Kiyoharu Aizawa, the IEEE Tokyo Section Chair; Dr. Toshio Fukuda, 2020 IEEE President; Dr. Isao Shirakawa, Chair of the IEEE Japan Council History Committee; Professor Noboru Koshizuka from the Graduate School of Interfaculty Initiative in Information Studies, the University of Tokyo; Dr. Yosuke Aragane of Nippon Telegraph and Telephone Corporation (NTT), and other representatives from TRON Forum and related organizations.

During the event, Dr. Fukuda presented the commemorative plaque to Professor Emeritus Sakamura, followed by a commemorative photograph session and a memorial lecture by Professor Emeritus Sakamura. Afterward, the attendees moved to the entrance hall on the first floor, where Professor Emeritus Sakamura, Dr. Fukuda, Dr. Aizawa, and Dr. Shirakawa unveiled the plaque. The plaque was installed next to the IEEE Milestone plaque for the TRON Real-time Operating System Family from 2023, resulting in two prestigious plaques being displayed side by side.

In the following sections, we report on the day's proceedings, including a video message from Dr. Thomas Coughlin, the 2024 IEEE President, who was unfortunately unable to attend the ceremony in person.



IEEE Milestone Commemorative Plaque

IEEE MILESTONE

The Pioneering TRON Intelligent House, 1989

The first TRON Intelligent House was based on the concept of a Highly Functionally Distributed System (HFDS) as proposed in 1987. Built in Tokyo in 1989 using about 1,000 networked computers to implement the Internet of Things (IoT), its advanced human-machine interface (HMI) provided 'ubiquitous computing' before that term was coined in 1991. Feedback by TRON's residents helped mature the HFDS design, showing how to live in an IoT environment.

November 2024

Organizer's Speech

○ **Kiyoharu Aizawa (IEEE Tokyo Section Chair**)

I am delighted to welcome so many of you to today's IEEE Milestone award ceremony. Last year, we held a similar ceremony in this venue for the TRON Real-time Operating System Milestone award. It is truly remarkable to have awards presented in two consecutive years, and I am deeply honored to participate in this ceremony again as Section Chair.

The IEEE Milestone program recognizes groundbreaking innovations in electrical and electronic fields that have made significant contributions to society and industry's development, with the requirement that at least 25 years must have passed since their development. When an achievement is recognized as an IEEE Milestone, a commemorative plaque is presented and displayed at a relevant location. Since its establishment in 1983, there have been 263 IEEE Milestones worldwide as of 2024. These include achievements ranging from Benjamin Franklin's work in the 18th century and the invention of the Volta battery, to numerous computer-related technological innovations in semiconductors and information communications from the 20th century onward.

Looking at the number of Milestone recognitions by country, Japan has an exceptionally high number, second only to the United States, with 46 recognitions as of 2024. The first Japanese achievement to be recognized was Directive Short Wave Antenna (Yagi Antenna), with its plaque displayed at Tohoku University. This latest recognition, "The Pioneering TRON Intelligent House, 1989," becomes Japan's 46th Milestone and the Tokyo Section's 23rd. Other achievements recognized this year include Toyota's Prius and Shimadzu Corporation's mass spectrometer, placing this achievement alongside such distinguished Milestones.

This recognition focuses on the housing application and its underlying Highly Functionally Distributed System (HFDS) at the upper end of the TRON architecture. In contrast, last year's recognition of the TRON Real-time Operating System represented the foundation level at the lower end, resulting in consecutive recognitions of both the upper and lower ends of the architecture. These achievements have contributed to the advancement of today's Internet of Things (IoT), making them truly worthy of IEEE Milestone recognition.

Greetings by Guests of Honor

○Toshio Fukuda (IEEE President 2020)

IEEE is an organization with 470,000 members across 160 countries, managing 200 academic journals and nearly 2,000 international conferences annually. We also handle high-quality publications and standardization efforts. IEEE was founded in 1883, and the Milestone recognition program was initiated in 1983 to commemorate IEEE's 100th anniversary.

The TRON Intelligent House, completed in 1989, was realized through the interconnection of 1,000 computers. This system was truly a groundbreaking achievement that pioneered the way globally, and can be considered the origin of today's IoT technology. This recognition was achieved in a remarkably short period of approximately one year from application to approval, which demonstrates the outstanding merit of TRON Project.

Currently, TRON technology is being utilized in various aspects of society, and this recognition has brought renewed awareness to this fact. I believe this will further promote innovation in these scientific and technological fields.

○Isao Shirakawa

(Chair, IEEE Japan Council History Committee)

TRON Project has long been a highly renowned research initiative, and I believe this recognition is, if anything, overdue. As chair of the History Committee in Japan, I have been looking forward for many years to seeing significant achievements like TRON being recognized as Milestones. I hope this will lead to even greater success in the future.

○Noboru Koshizuka

(Professor, Graduate School of Interfaculty Initiative in Information Studies, the University of Tokyo)

The TRON Intelligent House, completed in 1989, attracted considerable attention when I was a graduate student. I remember watching Professor Sakamura taking the lead and my seniors working enthusiastically on the project. In my recent research, I found that just one newspaper company had published over 40 reports about TRON Project, with more than 2,000 reports covering the entire TRON Project, which made me realize the tremendous impact it had on society. As a member of the Interfaculty Initiative in Information Studies, which now houses two IEEE Milestone plaques following last year's recognition in 2023, we will continue to strive to produce world-class achievements worthy of this legacy.

○Video Message from Thomas Coughlin

(IEEE President)

I am Thomas Coughlin and I am the 2024 president of the IEEE. I am glad to be able to talk to you today. First of all, I would like to congratulate on the IEEE milestone dedication to the pioneering TRON, Intelligent House, 1989.

IEEE milestones recognize the achievements of distinguished men and women on whose shoulders we now observe the creation of new technologies. I am quite sure that the parties involved in creating the Smart House 35 years ago are very happy on this occasion. I will save the explanation of the Pioneering TRON Intelligent House 1989 because I am sure the experts will be talking about this.

But I would like to mention one thing. The Smart House was built in an era when the term ubiquitous computing was not yet coined, and the concept of the Internet of Things had to wait more than a dozen years before it became popular. It was controlled using a holistic view of the house called HFDS, or Highly Functionally Distributed System. That is an impressive achievement.

Incidentally, I attended the milestone dedication of the TRON Realtime Operating System Family 1984 in October of 2023 in Tokyo, and I met Dr. Ken Sakamura on the campus of the University of Tokyo, who would be the recipient of the milestone of the Pioneering TRON Intelligent House 1989 today. Congratulations, Ken.

Now as president of the IEEE, I would like to remind you about what the IEEE is and what it can do for you. On this occasion, an IEEE milestone is just a tiny bit of what the IEEE is all about. IEEE, for instance, can help you with your careers. It's the largest technical professional organization in the world.

An example of how this could help you is it can help you develop communication and networking skills that can help you in your careers. Even in Japan, I understand that moving from one job to another is gaining momentum among the younger generation, and it is quite common elsewhere. In order to thrive in such an environment, you need to be able to have lifelong learning and to develop the skills that could keep you up to date and help you to be competitive.

I believe IEEE representatives at this dedication ceremony can assist you in helping you achieve your goals. And I wish you, the audience, have great success in what you do and that you make a difference, and I hope you do great things to make the world a better place, because the motto of the IEEE is advancing technology for the benefit of humanity.

Thank you for the opportunity to talk to you today.

Congratulatory message from the industry

○ **Katsuhiko Kawazoe**
(Representative Member of the Board and Senior Executive Vice President, Nippon Telegraph and Telephone Corporation)

In 1989, our company NTT cooperated with the TRON Intelligent House project primarily through our research laboratories. The concept of nodes with various functions in a house being connected via networks and working together to provide optimized services became a pioneer of today's IoT. In this project, we also conducted experiments involving automated urine analysis equipment and blood pressure monitors in toilets, transmitting data to hospitals through our ISDN lines. The concept of remote medical care, which was extremely advanced for its time, has now become commonplace.

Currently, NTT is advancing research and development of IOWN (Innovative Optical and Wireless Network), working on projects including remote medical care and robot-assisted remote surgery. We take pride in the fact that the roots of these technologies can be traced back to the TRON Intelligent House.

*Read by Dr. Yosuke Aragane
(Vice President, Head of IOWN Development Office, R&D Planning Department, NTT Corporation)

Acceptance Speech

○ **Ken Sakamura**
(Professor Emeritus, The University of Tokyo)

I have been fortunate to have opportunities to be involved in IEEE activities for many years, serving as the editor-in-chief of IEEE Micro and participating in various international conferences. Through these experiences, I have felt the need for Japan to commnicate more actively it is excellent technologies and initiatives to the world. I will continue to work, albeit in my modest capacity, to demonstrate the historical value of Japan's technological innovations to the global community.

Regarding this recognition, I would like to express my deepest gratitude to everyone at the IEEE Tokyo Section for their tremendous support and cooperation.

About IEEE

Institute of Electrical and Electronics Engineers (IEEE) is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. IEEE and its members are renowned through frequently cited publications, international conferences, standards, and professional and educational activities. They are trusted in a wide range of fields, from aerospace systems, computers, and telecommunications to biomedical engineering, electric power, and consumer electronics.

About IEEE Milestones

In electrical and electronic engineering as well as computing programs, the IEEE Milestones celebrate significant technical achievements in all fields related to IEEE. They are part of the IEEE History Committee program and are operated through the IEEE History Center.

IEEE Milestones recognize and evaluate technological innovations and excellence that contribute to human benefits, as seen in unique products, services, significant papers, and patents.

IEEE established the Milestones Program in 1983 in conjunction with the 1984 Centennial Celebration to recognize the achievements of the Century of Giants who formed the profession and technologies represented by IEEE.

Each milestone recognizes a significant technical achievement that occurred at least twenty-five years ago in an area of technology represented in IEEE and having at least regional impact. As of November 2024, more than 260 Milestones have been approved and dedicated around the world.

About TRON Project

TRON Project, launched in 1984, is an industry-academia collaborative project for the development of computer architecture. Led by Ken Sakamura, IEEE Life Fellow/IEEE Computer Society Golden Core Member and Professor Emeritus of the University of Tokyo, also serving as the Director-General of Collaboration Hub for University and Business (cHUB), Faculty of Information Networking for Innovation and Design (INIAD), Toyo University and Director of YRP Ubiquitous Networking Laboratory, the project advances development in various computer fields, ranging from RTOSs and development environments for embedded systems to IoT networks.

The results of TRON Project are widely used in embedded systems around the world, from consumer products such as automotive engine controls, digital cameras, and mobile phones to industrial applications such as factory machinery control and spacecraft control, and further to architectural applications such as furniture, houses, and buildings.

TRON Project promotes open architecture and has conducted its activities under this principle. Furthermore, it has contributed to the international standardization of infrastructure technologies by actively proposing technical specifications as standard proposals to international standardization bodies.

About TRON Forum

TRON Forum was established in 2002 to promote TRON Project. It has actively engaged in initiatives centered around T-Engine Project, which establishes development environments for embedded systems, and the operation of Ubiquitous ID Center, including ucode.

In May 2015, Chair Ken Sakamura was awarded the ITU's 150th Anniversary Award, as the sole recipient from Asia alongside figures such as Bill Gates, for advocating the open architecture TRON, which became the origin of ubiquitous networking and the IoT. In addition, in January 2023, Chair Sakamura received the IEEE Masaru Ibuka Consumer Technology Award from IEEE for his leadership in developing an open and free OS for embedded computers used in consumer electronic products. These activities have garnered international acclaim.

Ken Sakamura Profile

Born in Tokyo in 1951.
Professor Emeritus of the University of Tokyo, Director-General of INIAD cHUB, Doctor of Engineering.

Since 1984, he has been developing the open computer architecture TRON. TRON RTOS is now widely used around the world in mobile devices, home appliances, automotive engine controls, and spacecraft controls, and in 2018, it was adopted as the embedded OS IEEE 2050-2018 for the IoT by the IEEE. In 2023, the "TRON Real-Time OS Family" was recognized as an IEEE Milestone.

He is also extensively engaged in the broad-range design and development for furniture, housing, museums, buildings, and cities.

IEEE Life Fellow, IEEE Computer Society Golden Core Member. Editor-in-Chief of *IEEE Micro* magazine (1998-2002).

In 2015, he was one of the six individuals globally chosen for the International Telecommunication Union (ITU) 150th Anniversary Awards (ITU150 Awards) for his significant contributions to the improvement of people's lives worldwide through innovation, promotion, and development in information and communication technology. In 2023, he received the IEEE Masaru Ibuka Consumer Technology Award.

2001 Ichimura Academic Award, Special Prize

2001 Information Processing Society of Japan, 40th Anniversary Best Paper of '90s Award

2001 Minister of Economy, Trade and Industry Award

2001 The Takeda Award

2002 Director of YRP Ubiquitous Networking Laboratory

2002 Chair of T-Engine Forum (now TRON Forum)

2002 Minister for Internal Affairs and Communications Award

2003 Medal with Purple Ribbon

2004 The Okawa Prize

2005 Prime Minister Award of the Industry, Academia and Government Cooperation Contribution

2006 Japan Academy Prize

2006 C&C Prize

2015 ITU150 Award

2017 Professor Emeritus, the University of Tokyo

2018 TRON-based Embedded OS IEEE 2050-2018 established as IEEE standard

2023 IEEE Masaru Ibuka Consumer Technology Award

2023 TRON Real-Time OS Family recognized as an IEEE Milestone

2023 The Institute of Environmental Art and Design, Grand Prize

2024 The Order of the Sacred Treasure, Gold Rays with Neck Ribbon

2024 TRON Intelligent House recognized as an IEEE Milestone


IEEE MILESTONE
The Pioneering TRON Intelligent House, 1989
The first TRON Intelligent House was based on the concept of a Highly Functionally Distributed System (HFDS) as proposed in 1987. Built in Tokyo in 1989 using about 1,000 networked computers to implement Internet of Things (IoT), its advanced human-machine interface (HMI) provided "ubiquitous computing" before that term was coined in 1991. Feedback by TRON's residents helped mature HFDS design, showing how to live in an IoT environment.
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