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System Electronics

from Keio's Faculty of
Science and Technology

A smart infrastructure system
fusing ICT and control

Ryogo Kubo

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Electrical Engineering



In order to create a network environment that is comfortable for all “things”

of “information and communication technologies (ICT)” for network-based exchange of information and “measurement technologies” to control pieces of information thus obtained.

Eliminating “delay” – a major problem standing in the way of IoT

What is known as “IoT” is recently coming to the fore as a development in which all things are connected to the Internet thereby making our daily lives convenient. But IoT is not so easy to realize as it appears because countless things connected to the Internet vie and interfere with each other for the limited network resources. As a solution to this problem, Dr. Kubo reasons that a “smart infrastructure system” must be developed – a system in which all things are allowed to work in harmony (Fig. 1). According to Dr. Kubo, the key to solution is fusion

In order for more than one robot to work together, the first robot is given an instruction by a computer via a network to do a certain job. In the next step, the computer confirms (measures) that the job has been performed as instructed and then gives an instruction to the second robot for the next job to be done. Measurement and control enable repetition of this sequence of steps to make assembly work progress. What will happen if a delay occurs

The diagram illustrates the concept of Smart City and Smart Home. A central 'Control center' cloud is connected via blue lines to two 'Micro-control center' buildings. One micro-control center is connected to a cityscape, and the other is connected to a house. The house is shown with a person sitting on a sofa, a potted plant, and a refrigerator. The cityscape includes various buildings, trees, and a person walking. The diagram shows how a central control system manages smart infrastructure and smart homes.

with confirmation of the signal that conveys the message that the job has been performed as instructed? Judging mistakenly that the required job has not been performed yet, the computer will issue the same instruction again. But the job has actually been done. This kind of error will bring the operation nowhere. Such a communication lag is referred to as “delay,” which is regarded one of the greatest problems the IoT era will face.

“As a matter of fact, researchers have discussed delay-associated problems over the years. In fact, some assumed a certain amount of delay beforehand and programed it in the computer to control the robot. However, this is far from a final solution to the problem,” maintains Dr. Kubo. Instead, he thinks that problems involved in the current mega-networks must be resolved from the bottom up.

One possible approach is to introduce local control as shown in Fig. 1. “For example, consider an intersection where collision accidents occur frequently, and vehicles passing there are to be brought under collision avoidance control via a network. Installing a small-capacity micro-control center near the intersection will suffice since this control is needed only within a very small area of the intersection.” Generally speaking, when transmitting a piece of information over the Internet, it once goes to the main control center in the network and then comes back. Naturally, the greater the distance the information travels for a round trip and the more devices it passes through, the greater a delay will become. In actuality, however, there are many pieces of information that need not go to the main control center. These pieces can be dealt with by setting up micro-control centers well short of the route. Controlling from nearby is sure to be the fundamental solution to delay in communications.

What is fusion of ICT and control?

However, you cannot say that this alone resolves all the network-associated problems of the IoT era. What is truly needed here is the fusion of ICT and control technologies as proposed by Dr. Kubo (Fig. 2). With the ability to

specifically control individual things, this technological fusion can bring to a close problems arising as a result of various things intertwined with each other.

Let’s explain it a little more in detail. To move a thing via a network, we need to control the target first and measure its result, then use it as feedback for the next control task (see blue arrows in Fig. 2 “Control over Networks”). Meanwhile, it is also important that the network itself, which moves that thing, is working in an optimal condition. To make it possible, loops for measurement and control are provided (see green arrows in Fig. 2 “Control of Networks”). ICT and control are already fused together in both the blue and the green. In addition, harmonious interaction between ICT and control further ensures that things can move in an optimal condition via the network.

As shown in Fig. 1, the control center and micro-control centers play these vital roles.

Arrival of a comfortable network society

What the fusion of ICT and control technologies can do is far-reaching.

Let’s look at an example here. Given the limitation to network resources, it is impossible to transmit all pieces of data fast at a time. We humans sense virtually no delay in transmission if it is a matter of less than one millisecond. Tasks that actually require such a minimal delay are very few – only the above-mentioned car collision avoidance control at an intersection, operation of sophisticated medical equipment, and some other cases do.

Network measurement information feedback in “Control of Networks”

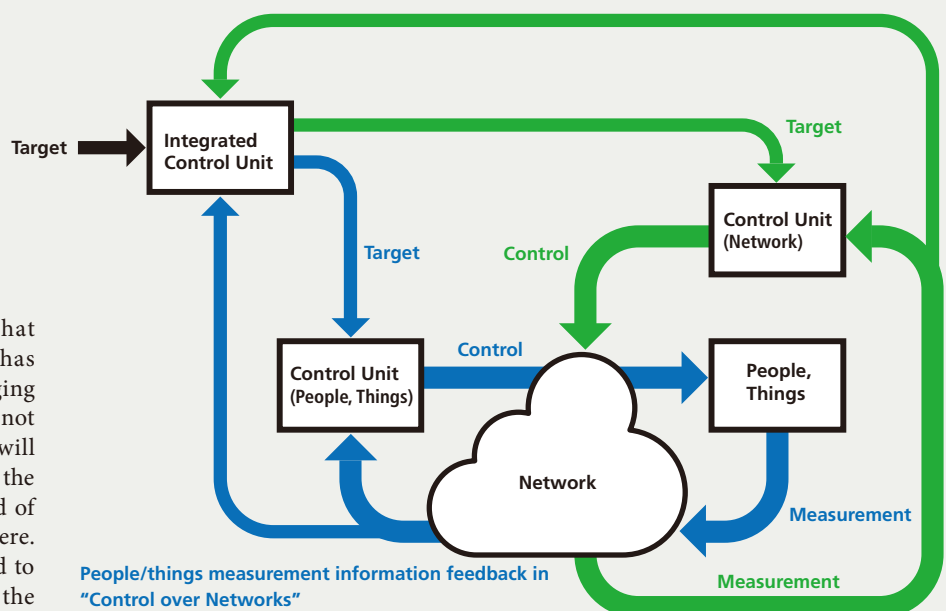


Fig.2 Fusion of ICT and control as envisaged by Dr. Kubo

In other words, when all things are connected to the Internet and need to work in harmony, we must sort out those requiring sophisticated control from others. This is necessary because it will enable the limited network resources to be reasonably distributed to suit individual things.

Dr. Kubo thinks that “things” connected to the Internet via IoT also include people. He continues, “When using a smartphone to download a piece of information, there always is a person at this end of the smartphone. As a service provider, it’s only natural for it to please customers.” But what annoys it is individual differences in customers’ likes and dislikes. Even though a piece of information has been downloaded at the same speed, some are happy with it and others not. If we can allot network bandwidths to individual smartphones flexibly after accurately determining such differences, we will be able to maximize satisfaction of smartphone users.

There are also other benefits. If we apply that technological fusion to a power network, energy-saving and efficient control of electric power will be possible while maintaining comfortability at the same time. In the event of network trouble including those caused by cyber attacks, we will also be able to make the right decision where to disconnect the network, thereby to minimize the damage.

When time comes for all things to work in harmony on the Internet, you may find the network control technology envisaged by Dr. Kubo playing major roles there.

(Reporter & text writer : Akiko Ikeda)



“Let’s take a ride” is my usual response when invited into something positive. This forward-looking attitude has helped me expand my horizons.

Dr. Kubo, who used to be a music-loving boy, is now strongly emerging in his career as a researcher in the field of electronics. Although themes of his study changed from college days and the years with NTT, his style of research based on fusion of diverse fields, just like various instruments striking a melodious harmony in an orchestra, seems to remain unchanged. Behind his choice of research themes, there has always been an aspiration to connect himself to as many people and things as possible.

What was your childhood like?

I was born in a family of five – father, mother, grandfather, aunt and myself. As a child I learned the piano under the strong influence of my mother who was a piano instructor. Also due to her influence, I loved classical music, of which the symphony “From the New World” was my favorite. As an elementary school boy, I belonged to the school’s chorus club and had the valuable experience of participating in the preliminary music contest sponsored by NHK (Japan Broadcasting Corporation).

When it came to classroom subjects, I was fond of science and social studies. I also liked to enjoy time with friends just like an ordinary schoolboy, playing TV games, outdoor sports and the like.

You say a home stay overseas in your high school days was an unforgettable memory, is that right?

When I was an elementary school fifth grader, I began to attend a cram school four to five days a week. Thanks to the cram school, I was able to pass the entrance examination for the Shiba integrated junior and senior high school. One of the most impressive memories of those days is a two-week visit to New Zealand that I had as a senior high school first grader on a short-term student exchange program. As my first ever visit overseas, basic English was all I could speak. But I could somehow communicate with local people, which was an exciting experience for me. I also remember enjoying a traditional dance performance by Maori and a typical New Zealand dish of green peas and ram. It was around this time that I became interested in

foreign languages and cultures.

Why did you choose science and technology instead of music or foreign language?

Perhaps, it was mainly because of my father’s influence, who was an employee of a manufacturing company. At the Shiba High School that I attended, many of my classmates chose that course, so I didn’t hesitate to go that way. I was admitted to Keio University Faculty of Science and Technology.

Yet, it didn’t mean I had lost my interest in music and foreign languages. Even after joining Keio, I continued to pursue music-related activities energetically, such as by belonging to the Keio Mandolin Orchestra (as a percussionist) and setting up a new orchestra together with my friends from in and outside of Keio. As this new orchestra had many horizontal connections, many joined it from other universities to eventually become a 50-member orchestra. In addition to holding our own regular concerts, we also took part in other university’s campus festival by joining in orchestral accompaniment for an opera, which was truly enjoyable.

As for foreign languages, I chose German as my second foreign language and even took Russian and Italian language classes under general curriculum.

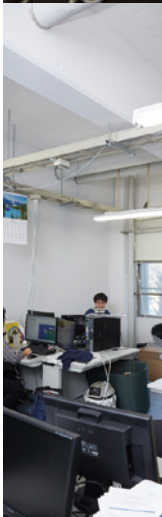
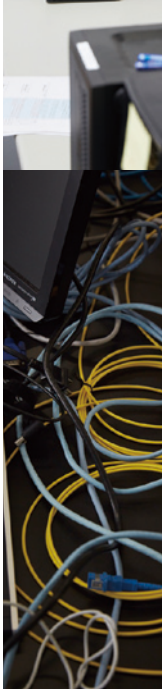
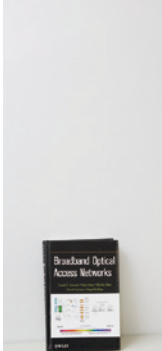
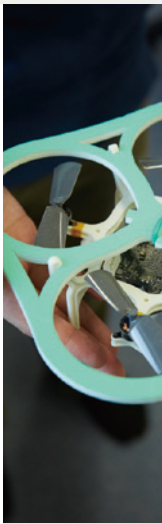
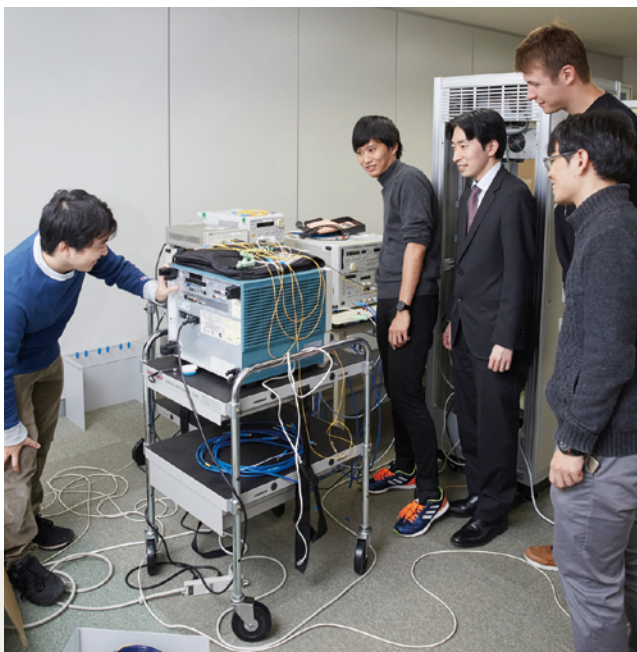
In retrospect, while enjoying music and foreign languages for pure enjoyment, I may have felt something of scientific fun in musical chords and grammatical laws of languages.

What did you learn at Keio Faculty of Science and Technology?

As sophomores, we students were asked what department to choose, and I chose the Department of System Design Engineering. There was a reason for it. Although I entered Keio initially opting for “Learning Gate 4” (Mechanics), later I became increasingly interested in electrical engineering and wanted to learn studies based on fusion of the two disciplines. So I joined Prof. Kouhei Ohnishi’s lab to pursue robot control. To be more specific, I studied how to remotely transmit the feel of a robot arm when it touches an object. It was an important study because this technology would be vitally needed to control fine movements of surgical robots. Not only did I learn from Prof. Ohnishi a lot about control and robotics, but I also learned the basic attitude researchers like us must acquire in approaching the essence of things.

After that, you joined NTT for a few years, right?

From around when I belonged to the lab as a senior, I began to feel a vague yearning for a researcher’s career burgeoning





in myself. This was also when I was engaging in research into a remote control robot. So, I began to find “network control” – the theme leading to my current research subject – interesting. I decided to find employment with a business upon completion of my master’s course. NTT was the company I chose because I thought it would allow me to pursue research into network technology. At the NTT lab, I did research on optical communication networks.

As part of the NTT lab first-year member training program, there was a system requesting, immediately after entering the company, newcomers like myself to set a theme and advance research on their own. After consulting an advisor, I came up with a number of themes, of which I finally chose the development of an energy-efficient optical communication network. It was because I felt energy problems becoming closer to me while I was engaging in the study of controlling motors and other electric appliances at Keio. At the beginning there was some criticism, saying that energy-saving wouldn’t be necessary given that the optical communication network was developed as an energy-efficient system by its nature. But my point was that if the optical network prevails among countless households and the number of devices skyrockets, energy-saving effects would be enormous. My idea was accepted and the research project started. I made my proposed prototype system, conducted experiments on it and then made a proposition for standardization. I found my research efforts rewarding as the project began to produce positive results.

It was just about that time that I, now with a doctor’s degree as a company employee, received an offer to return to Keio. Interested in a position in education as well as a researcher’s career not to mention, I took advantage of the offer to return to Keio. Coming to the Keio Department of Electronics and Electrical Engineering, I’m now making the most of my specialties – system control and communication network – as the basis to realize a smart infrastructure system enabled by integrated control of diverse systems including those of electric power, communications, mechanics and even human behavior.

To conclude this interview, please tell us how you find Keio University, your alma mater.

Looking back at my life up to now, I can say human

relationships that I enjoyed have been extremely valuable. For example, I joined the mandolin orchestra only because I happened to be hailed during a campaign for inviting newbies. There are also many research themes that I took up, inspired by participants whom I met in academic meetings. Of course there are many things I initiated on my own, but that alone couldn’t have expanded my horizons this much, I’m sure. This attitude of mine may sometimes appear passive, but inspirations coming from others often proved to be good as they motivated me to meet new challenges that I wouldn’t have taken up otherwise. I can make good use of such suggestions to create my own original ideas. Therefore, I’m trying to keep a forward-looking attitude, always open to any positive suggestions and offers.

In this sense, Keio University has many students with diverse backgrounds, making it an ideal place to learn. Some are so-called “inner students” who came from Keio Yochisha Elementary School and up while others joined Keio through the university entrance exam. Also, there are many students who have overseas experiences. This diversity of students makes Keio just like Keio. Speaking of labs, too, members with varied ways of thinking and personalities can make their labs much more resourceful. This holds good especially when it comes to the study of electronics that concerns the real world.

◎ Some words from students ... ◎

● I’m studying cyber security and flight control of unmanned aerial vehicles (UAVs). The study of UAVs inevitably involves mechanical aspects because we actually fly a drone. Although there have been few precedents of mechanics-related research at the Kubo lab, I asked Dr. Kubo to give priority to my challenge. When I was an undergraduate senior, I had the privilege of receiving Dr. Kubo’s attentive, detailed guidance for my research. Now in the second year of master’s course, I’m basically free to choose research themes, occasionally receiving his advice as needed.

(Reporter & text writer : Akiko Ikedaa)

For the full text of this interview

<http://www.st.keio.ac.jp/kyurizukai>



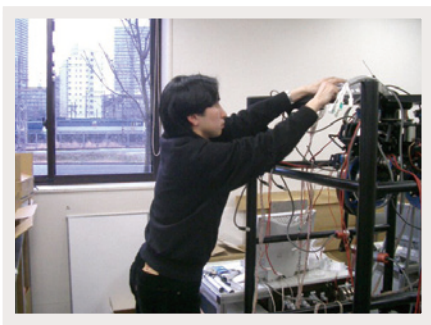
There are always some unrefined or rough aspects behind research works that aim for smartness.

I’d like you to enjoy such unrefined aspects.

Ryogo Kubo

Born in Tokyo, Dr. Kubo specializes in system electronics, especially focusing on fusion of communication network and system control technologies. He received his B.E. degree in system design engineering and his M.E. and Ph.D. degrees in integrated design engineering from Keio University, Japan, in 2005, 2007 and 2009, respectively. In 2007, he joined the NTT Access Network Service Systems Laboratories, NTT Corporation, Japan. Since 2010, he has been with Keio University, Japan, where he is currently an Associate Professor at the Department of Electronics and Electrical Engineering.





Parallel Link Manipulator

In my college days, I devoted myself to the study of robot control at the lab of Prof. Kouhei Ohnishi, Department of System Design Engineering. This photo shows me adjusting a parallel link manipulator in the lab in the Shin-Kawasaki Town Campus. From the window, you can see JR Freight Company's rail yard. The area surrounding the campus now looks much different from those days due to progress of urban development.

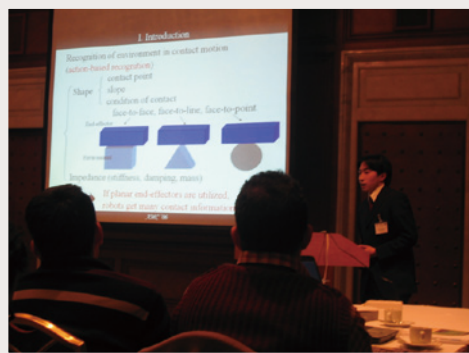


Mandolin Club

I belonged to the Keio University Mandolin Club throughout the undergraduate period, where I played my part as a percussionist. This photo shows the mandolin club performing "Dance of the Hours" from the opera "La Gioconda" (composer: A. Ponchielli). For this performance, I was in charge of timpani.

Ryogo Kubo's ON and OFF

Recently I'm trying to take as much time off as possible. As for music, I mostly enjoy listening these days rather than playing myself.



My International Conference Debut

This photo was taken when I made a presentation at an international conference for the first time. It was on the occasion of the 9th IEEE International Workshop on Advanced Motion Control (AMC 2006) held in Istanbul, Turkey. Two overseas students from Turkey were members of our lab in those days, who kindly showed me around the town of Istanbul.



Keio TECHNO-MALL

For the past several years, our lab has been participating with a booth in the Keio TECHNO-MALL (the annual exhibition organized by the Faculty of Science and Technology which takes place in December at the Tokyo International Forum). For our study of infrastructure systems, I think it's important for us to remain conscious of industries and users at all times. As such, all of our lab students work, in principle, as explanatory staff for our exhibit. Please come to the Keio TECHNO-MALL and visit our booth.



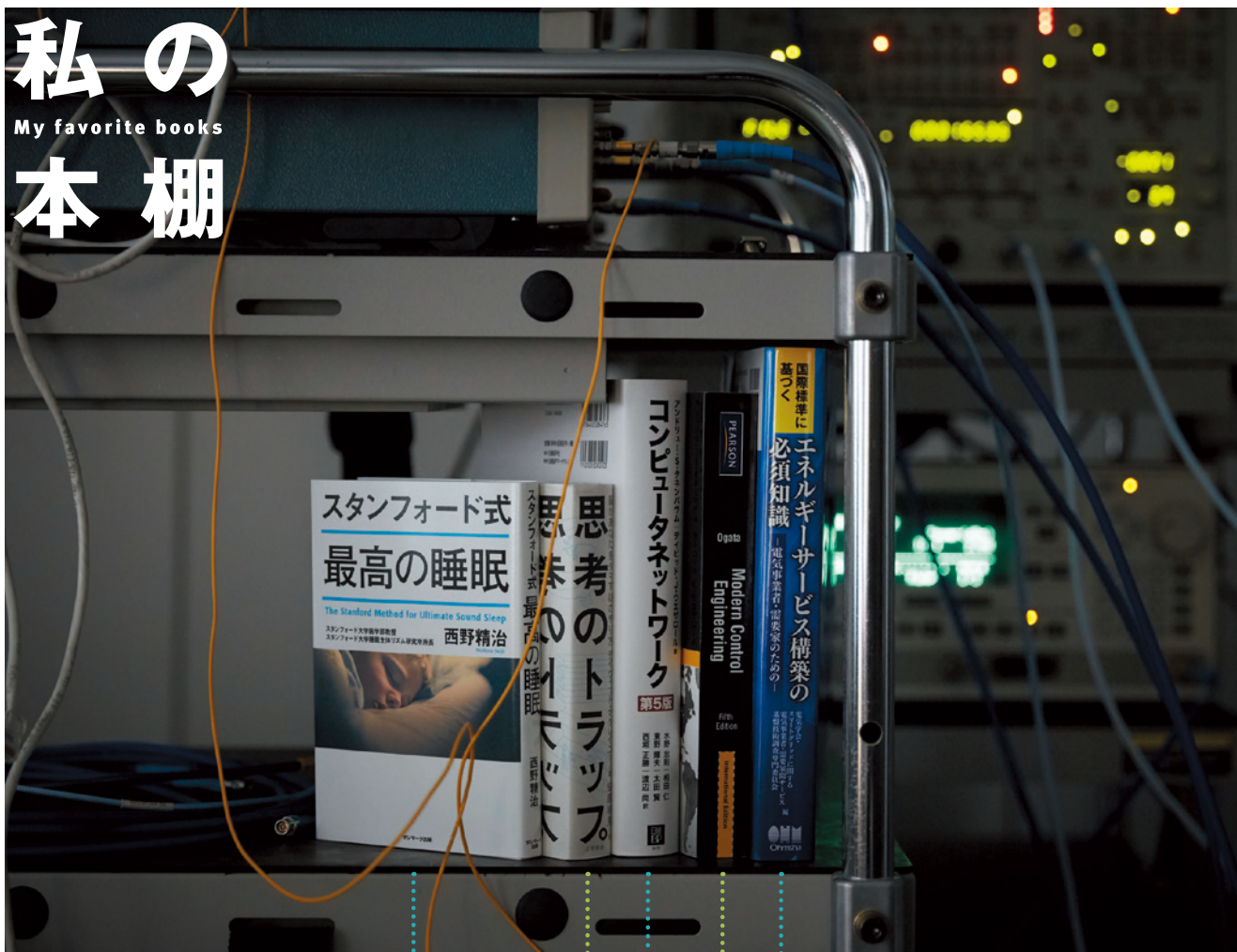
Family Trip

Our family recently visited southern islands of Ishigaki and Taketomi to enjoy holidays. All of us enjoyed the beautiful sea, unique flora and fauna, and delicious local dishes to our heart's content.



私の 本棚

My favorite books



What is good-quality sleep?

● The Stanford Method of Ultimate Sound Sleep

This book that I read recently may be a must-read book for students preparing for entrance exams as well as for researchers. In short, it says the quality of sleep is a vital key to maximizing the performance of your work or study while awake. In the field of communication networks, guarantee of "QoS" (abbreviation for the term "Quality of Service" regarding delay and other network qualities) comes up as a theme of discussion from time to time. We may also have to give some thought to another "QoS" (Quality of Sleep) to produce good research results.

Learning ICT networks

● Computer Networks Fifth Edition

This book gives beginners an easy-to-understand explanation as to how communication networks are structured, how computers are connected to each other, and how information is exchanged there. As such, the book is highly recommended to those who want to know an overall outline of network systems. This is the translated Japanese version of "Computer Networks Fifth Edition" co-authored by A. S. Tanenbaum and D. J. Wetherall.

Learning smart grids

● Conforming to International Standards: Basic Knowledge Necessary to Structure Energy Service Systems – for Utilities and Power Users –

This volume is a compilation of survey reports on smart grid by the Institute of Electrical Engineers of Japan (Investigating R&D Committee), for a part of which I was responsible as a writer. A smart grid is a next-generation power/energy infrastructure based on ICT. This book introduces smart grid standardization trends and use cases as viewed from user's perspective. What makes it unique are discussions about application of the latest network technologies and security.

A book full of food for thought

● Traps in Thinking – 48 Ways the Brain Tricks You

Depending on cases, excessively subjective assumption can impede progress of your research. On the other hand, it's true that moderate assumption sometimes works as a positive driving force leading you to formerly unattainable success. This is not limited to research but can apply to various other situations as well. Someday, we'd like to become wise enough to make proper decisions after fully understanding the nature and limitations of human thinking.

Learning the basics of control

● Modern Control Engineering Fifth Edition

Soon after I became an undergraduate senior and was assigned to the Ohnishi lab, I read this book during a "Rinko" (a seminar, or journal club, where all of our lab members met to critically evaluate mutual presentations). It explains control engineering, in an easy-to-understand way, from the basics through to applications. Though written in English, I recommend it to students wishing to learn control engineering from now.

Internet in Its True Sense and Electronics

Ryogo Kubo

What does the term “Internet” mean? As “inter” stands for “between,” it naturally means a network that connects multiple networks. In this context, “networks” refer to information and communication networks. And what we call “IoT” (Internet of Things) is a world where all things are connected to each other via the Internet. Now some may say “It’s nothing new” and wonder why I talk about it anew. My point is that the currently

accepted idea of “Internet = information and communication network” is a false or misleading concept in the era of IoT.

Numerous “networks” can be found at work in this world – information and communication network, electric power network, city gas network, water and sewage network, transportation network, social network, and whatnot. In a smart infrastructure system of the future, all these networks of different kinds are expected to work together to create new forms of service formerly unavailable. In other words, networks of different kinds will collaborate with each other to form one huge network. This is the way the true Internet should be.

Should an existing power network fail due to a disaster, for example, it will be possible to charge electric vehicle (EV) batteries and

transmit the power using a transportation network. There may also be cases where it is faster to use a transportation network to deliver a hard disc of enormous data volume than forwarding the disc via an information and communication network.

Anyway, in order to realize a smart infrastructure system, we need to connect people and things to some kind of network and conduct cross-disciplinary information gathering and control. In this sense, electronics deserves to be called the fundamental discipline vitally needed to structure a smart infrastructure system as it deals with far-reaching areas of ICT and control. I sincerely hope an increasing number of students will learn electronics with an enthusiasm for supporting the coming IoT era.

Science and Technology Information

Keio Faculty of Science and Technology becomes the only “IBM Q Network Hub” in Japan

In March 2017, IBM Corporation initiated “IBM Q,” an initiative to create a general-purpose quantum computing system. Keio University Faculty of Science and Technology was chosen as the only IBM Q network hub in Japan in December 2017. Tasked with the promotion of research, education and industry-wide collaboration in quantum science and technology, it is one of the five regional hubs encompassing four continents of the world. In addition to Keio University, the IBM Q network hubs were established at IBM Research, Oak Ridge National Laboratory in the United States, University of Oxford in

the United Kingdom and the University of Melbourne in Australia.

The quantum computer has the potential to offer solutions to highly complex route search problems much more speedily and efficiently than conventional computers. Expectations are high that it will be applied to the financial industry intent on transaction strategies and portfolio optimization, as well as to automobile, chemistry and various other industries.

It has become possible for industries and research organizations from a wide range of fields to participate in this hub for joint



research into quantum computing, using the IBM Q system online. As a quantum computer boasting the world’s highest performance, IBM Q will enable researchers to pursue the most advanced quantum computing studies. Keio University Faculty of Science and Technology is currently preparing for establishing an environment for accessing the IBM Q.



Source: IBM

Editor’s postscript

The term “IoT” often reaches our ears recently. Using a smartphone for video recording and switching an air-conditioner ON from remote locations is now commonplace. Despite the many benefits of IoT we are receiving today, we actually know nothing about its structure and have taken such increasing conveniences for granted.

The example of the intersection cited in Dr. Kubo’s article must have given you a clear image of what’s going on in the world of IoT. His broad perspective, as represented by his statement “Things connected to the Internet via IoT also include people” overlaps his image as a percussionist playing timpani while overlooking the audience from the rear of the stage.

(Izumi Hagiwara)

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