What is Systems Innovation? : Part II

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3. Disruptive innovation and system innovation

3.1 The system was outside the scope of the innovation discussions

The theme of the previous article was to show examples of system innovation around the world. The results of GAFA's core business had come from the construction, operation, and evolution of excellent systems, which have had a major impact on our lives. That is exactly what is called “system innovation”.The following points were explained: The origin of system innovation goes back to the power network initiated by Edison; the history of technology, such as the Ford conveyor production line and the British radar air defense network, has created many system innovations; the world's top-level system innovation was achieved during the high growth period.

In this second part of the paper, I would like to discuss system innovation in relation to the current discussions in innovation and discuss the relationship between system innovation and society/academy.

The discussions on innovation so far have been almost limited to the technological innovation of elemental technology or industrial products, so that the innovation of the system itself has not been highlighted. For example, 23 cases mentioned in “Reasons for Innovation” by Takeishi et al. (Yuhikaku, 2012), which is well-known as a case study of innovation in Japan, are all about elemental technology and industrial product innovation.

Clayton Christensen's “Innovator's Dilemma” (translated by Izuhara, Shoeisha 2001), which presented d“disruptive innovation” as a new form of innovation, received great attention. However, the book is mainly targeted at industrial products such as hard desks, excavators and electric furnaces. Other examples are CPUs, 50cc motorcycles, and flash memories. Fujimoto's “Destructive Innovation” (Chuo Keizai, 2013), which applies Christensen's discussion to the situation in Japan, is mainly concerned with only three industrial products: car navigation, netbooks, and solar cells.

However, if we focus our innovation on industrial products and elemental technologies, we cannot capture the intrinsic nature of technological progress. Technological achievements related to infrastructure that supports industries such as energy supply, logistics, production methods, management support, transportation communications, software, medical care, and so on, are undoubtedly innovations. Needless to say, it is necessary to take all of them into consideration, and naturally, the system will emerge as the engine that drives technological progress.

There are two reasons why the perspective of innovation has been limited. First of all, it is probably because most of the innovation discussers are from management areas, and their main concern was in the dynamics of corporate activities caused by innovation, rather than technological innovation itself. The other is that the innovation are related deeply to the level of maturity of modern technology as we see now. This is an important issue and will be discussed below.

3.2 The system appears as technology matures

The term “system” has come to be used in each field of science and technology with the centripetal force after each field has matured to some extent and has become more relevant to other fields. The positioning of each field needs to be clarified.

A few years ago, a “system nanotechnology study group” was born in the Institute of Electronics, Information and Communication Engineers, Japan, and many studies have been conducted. Also several years before this, American nanotech researchers proposed and promoted a new concept called “NBIC”: N for nano, B bio, I information, C cognition. There are times when many research organizations and projects named NBIC were launched in various countries. It shows the maturity of nanotechnology and has well matured and its influence spreads to other fields. “System Nano” was born from this context.

Biology has been ahead of this trend. About 30 years ago, “Systems Biology” was born as a new field of biology and is now growing into a major field of biological science. It is a field that attempts to approach the essence of life by incorporating mathematics, physics, and engineering through a system perspective. Since the 1970s, universities have been adding “systems” to the names of departments and majors. For example, “mechanical engineering” is named “mechanical system engineering” and “chemical engineering” is named “chemical system engineering”.

3.3 Destructive innovation and "oversupply of performance"

Christensen gave the answer as to what level of maturity is necessary for the system to appear on the stage in discussions about innovation. Christensen analyzed in detail that “oversupply of performance” occurred throughout the manufacturing industry, resulting in a chain of “disruptive innovation”.

“Over-supply of performance” means that the performance of the product exceeds the level required by the market; that is, “over-spec”. This means that modern technology has reached a high level of maturity. Originally, the role of technology was to respond to people's higher expectations, and achieving that aims was innovation. He called it “sustainable innovation”. And he pointed out that another more shocking “destructive innovation” has occurred, causing crustal contimuing in the industry. Thus he saw the essence of modern innovation there.

Christensen found the level of maturity of modern technology not only in high-end innovation but also in the transformation of the value network towards the low end; a new type of innovation with price disruption and new market formation. His analysis is full of insights.

But we see a completely different possibility of innovation there. That is s*ystem innovation*s. Just as the maturity of nanotechnology has created the concept of system nanotechnology, system innovation as a new form of innovation develops into a major one through the comprehensive maturity of modern technology.

<System innovation in medical engineering cooperation>
In addition to the construction, operation, and evolution of a huge state-of-the-art system such as GAFA, system innovation is currently aiming for new integration across fields and specialties based on knowledge integration and field collaborative creation. It leads to the system innovation. The performance of every single unit has become sufficiently satisfactory, so from now on, let’s try to compete with a “combination” of technologies.

The most successful systems innovation in recent years came from collaboration between “medicine” and “engineer”. A typical example is a surgery support robot whose representative is “da Vinci”. In the treatment of cancer, the operation using Vinci has achieved results that greatly exceed the surgeon's single operation in many respects, such as the operation time, degree of invasion, bleeding amount, risk of complications, and operator fatigue. The state-of-the-art medical equipment mounted on this robot: a high-vision three-dimensional endoscope, articulated arms and forceps, a multi-channel console, and a monitor with a touch screen function are well integrated as a system.

When da Vinci is considered as a system, a doctor's educational program and multi-console technology are also indispensable. The former created the beginning of a medical paradigm shift, in which the most advanced and dangerous procedure of surgery and the choice of surgery were learned from machines. With multi-console technology, people other than the surgeon, such as medical students, can now experience the progress of the actual surgery from the same viewpoint as the surgeon. This brought a breakthrough in medical education. It can be said that the excellent configuration as a total system including these peripheral devices and operation and maintenance technology brought about the success of da Vinci.

The other is the Human Genome Project; automation of DNA sequencing. The genetics research style of the 1970s was to read genes in the laboratory in detail using laboratory equipment. However, due to the huge amount of genetic information, it was necessary to perform decoding as a factory “operation” by large-scale automation. Achieving this required a major shift in thinking for biologists who were proficient in various techniques and procedures for handling living creatures. Japanese researchers were the first to propose automation in the world, but they could not be realized in Japan. It was the United States that took the lead as a grand business of reading human genes.

Regarding collaboration in specialized fields, in addition to “medical engineering” collaboration, sociology, cognitive science, agriculture, etc. are rapidly progressing. Past cases show that “system” is inevitably manifested when fields collaborate.

4. What is system innovation?

4.1 The system is changing

To define system innovation, you must first answer the question of what a system is. However, it is difficult to answer this question at this stage. It has become difficult to capture the real image of modern systems with the definition used so far: the integration of functional elements to achieve their objectives. The scale and complexity of the system are growing tremendously.

The Internet search engine mentioned in the previous part of the article circulates the Internet hypertext, which is said to be already in the hundreds of millions of people around the world, on average 30 times a day, and answers tens of millions of questions every day. It is difficult to grasp such a system with human senses. The breakthroughs in computer science, communications, software engineering, sensing technology, etc. have made it possible to make significant breakthroughs in systems. These systems not only respond to changes in a rapidly changing world but continue to evolve while incorporating changes. In front of us, there is a system that has greatly changed in many ways, and it is difficult to define it properly.

4.2 Structure of System Innovation

The new definition of the system is left for future work. Let's think about its role here. We are unable to understand detailed mechanism of a huge and complex system. They are almost completely black-box. On the other hand, we can no longer do anything without using systems. Our lives are sustained by systems in terms of energy, food, traffic communications, finance, medical care, disaster prevention, and so on. We live by what the system brings and services. And science and technology provide it. In other words, the system is the contact point that connects science and technology with society. A system is absolutely necessary to bring the achievements of science and technology to society.

If we represent the era of systems based on the premise that science and technology have spread all over our lives, it will look like the Figure 1. The world has a three-layer structure: a science and technology layer (knowledge layer), a social layer where people find meaning and live in reality (value layer), and a system layer that mediates both.

(figure)

Figure.1 illustrates the importance of the system in the modern world. The arrows numbered from ① to ④ in the figure represent what is passed from layer to layer. The explanation is as follows.
① "From the science and technology layer to the system layer": Advanced technologies, methods, and theories used in system construction. Mainly used to improve the technical performance of the system.
(2) From the system layer to the value layer: Improve the quality of life created by the system, improve new value, corporate profits and productivity.
③ "From the value layer to the system layer": Establishment of an environment that accepts system construction. For example, elimination of vertically divided organizations, relaxation of regulations, and development of platforms.
④ "From the system layer to the science and technology layer": Discovery and submission of new research topics including missing links. The need for a seamless combination of technologies.

This part needs to be described in more detail, but here we will not go any further due to space constraints. I would like to leave a detailed examination for another opportunity.

<System innovation connecting three layers>
System innovation is the act of creating new value by building, operating, and evolving systems. I stressed that the system is an interface that connects science and technology with society. The specific structure is shown in FIG. System innovation can be achieved by turning the loop of FIG. The starting point of the loop can be anywhere in the three layers. It is also necessary to partially turn the loop between the two layers. The goal of turning the loop (①-④-①) between the system layer and the science and technology layer is “society can enjoy the maximum results of science and technology”. The goal of the loop between the value layer and the system layer (③-②-③) is to “enrich people's lives through systemization and increase the profits of companies and related organizations”.

In practice, several loops occur simultaneously, and system construction is performed while being related to each other, and innovation progresses. It is the same as other innovations that system innovation has both an interface with science and technology and an interface with social value. However, since system innovation is closely linked to the “business model”, the connection with the value group tends to be emphasized. The connection with academics must be more emphasized.

Although not represented in FIG. 1, meta-level activities have begun to integrate individual system domains contained in the system layer; the system of systems, reference architecture, data standardization. These are activities within the system layer that accelerate system innovation. I would like to discuss this in the future.

5. Summary

Advances in science and technology are accelerating in all fields. In order to distribute the results to society reasonably and smoothly, it is necessary to construct an excellent system. The reason why our center has established an “Academic Council” and seeks the cooperation of academic teachers is to promote the close connection between the system layer and the science and technology layer.

On the other hand, society becomes more and more complex and interests change in a complex manner. The obstacles that prevent the construction of a rational system are unfortunately increasing. Especially in Japan, where the negative effects of vertically divided society are strong, system construction itself can be a powerful reasoning and driving force to overcome obstacles. The most important mission of the center is to fill the gap between the system layer and the value layer.

What has been described in this paper is only a conceptual explanation of system innovation. To further enrich the concept of system innovation, various ongoing technical, academic, social and political activities such as “Fourth Industrial Revolution” and “Connected Industry”, need to be comprehensively viewed from the viewpoint of system innovation. Through that, we would like to present the way Japan should go. This issue will be actively discussed in the center.

The word "system innovation" does not appear to be a technical term in Europe and America. The word "system" is so common that it may have been overlooked. Although buzzwords such as IoT, big data, digital twin, and CPS are flooding, we want to establish system innovation as a concept originated in Japan, and at the same time, it hopefully leads to the future success of the center.

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