Application of Catalytic Effect to Create Innovation

Mariko Shiromura, Hiroshi Suzuki
Japan University of Economics, Tokyo - JAPAN

***Abstract*--There exist a lot of incremental innovations to solve superficial problems. Breakthrough type innovation, however, is expected to solve latent problems. Consequently it realizes safe and wealthy society and competitive economy. Incremental innovation is realized by summation of several solutions in a conventional fixed dimension. The authors think that breakthrough type innovation is realized by expanding this dimension to missing dimension.**

A bladeless electric fan, a smart-phone, the cloud computing are the examples that new business model was born in a different dimension from conventional one. The authors propose a method to create this new dimension by the chemical model of catalytic effect.

As an example; the innovation caused by smart meter is described. It is simply replacement by of an analog meter to digital within telecommunication in a fixed dimension to realized AMR (Automated Meter Reading). However, smart grid is applied as catalyst, smart meter get the opportunity of AMI. This creates breakthrough type innovation in electric power industry.

The authors give some examples of catalytic effect producing new dimension such as smart phone, smart grid, etc.

I. INTRODUCTION

Many incremental innovations are used to resolve superficial problems. Breakthrough innovation, however, is expected to solve latent problems. Consequently, it realizes a safe and wealthy society and maintains a competitive economy.

Incremental innovation is realized as a summation of several solutions in conventional fixed dimensions. The authors describe breakthrough innovation as achieved by expanding these dimensions to a missing dimension. This process is realized by a catalyst.

Several examples, such as the internet, smart-phones, and cloud computing, which were breakthrough innovations, arose in a different dimensions from conventional ones. The authors propose a method to conceptualize this new dimension as analogous to a chemical model of catalytic effects.

As a concrete and detail example, innovation deriving from smart meters for watt-hour measurements might be described. Smart meters work in a fixed dimension to realize automated meter reading (AMR) if they simply replace an analog watt-hour meter with a digital meter having telecommunication capabilities. However, if the smart grid is applied as a catalyst, then the smart meter might create several new capabilities such as an advanced metering infrastructure (AMI). This creates breakthrough innovation in the electric power industry.

The authors first explain the concept of Meta-Engineering to create innovation in order to explain the importance of catalyst in Chapter II. They re-define catalysis as providing a missing dimension from conventional ones in Chapter III. This model is applied to the creation of breakthrough innovation in Chapter IV. Several examples are introduced to support this modeling in Chapter V: smart meters, smart phones, bladeless electric fans, fish finders, and others. Finally, the authors discuss what catalysts are necessary to promote breakthrough innovation.

II. CONCEPT OF META-ENGINEERING

The limitation of conventional engineering [1] for innovation creation is that the issues are readily apparent. Many existing conditions must be considered. Only technologies are applied to solve the issues. Little additional societal value is provided by resolving the issues. This chapter proposes the concept of Meta-Engineering.

The authors designated the effort of mining potential issues and resolving them by removing their limitations as "Meta-Engineering" (Fig. 1). The definition of Meta-Engineering is the following [2] [3] [4]:

First, one finds the hidden and not readily apparent issues in society. Then the appropriate sciences, technologies, and arts are sought to resolve the issue by neglecting existing constraints. In many cases, it is difficult to resolve the issue merely by releasing a single one. It is often necessary to converge several sciences, technologies, and artistic creations. Finally, we implement this solution in the real world and obtain new additional value for society.

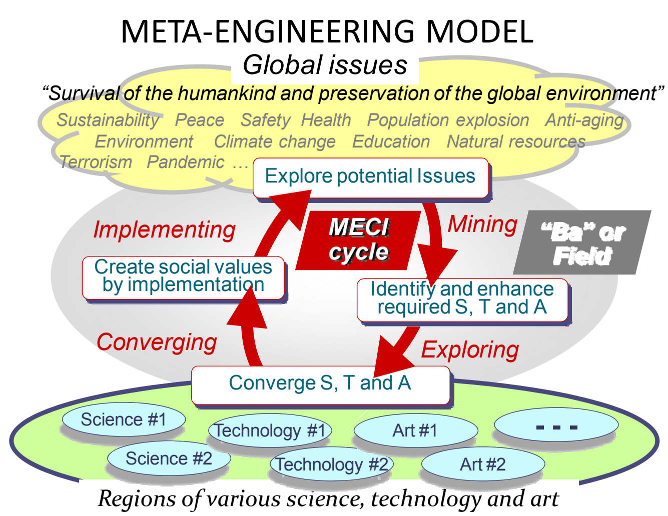

Fig. 1 Meta-Engineering Model.[4]

Meta-Engineering places the "why" question at the beginning of every process. Always keeping the "why" in mind, Meta-Engineering circulates the four processes into a spiral. The spiral process includes "mining potential/latent issues from a bird's eye view (M)," "exploring and strengthening necessary sciences, technologies and arts by thinking outside the box (E)," "converging these sciences, technologies and arts to generate solutions (C)," and "implementing the solutions into challenges creating social added value (I)." This process is represented as MECI or an MECI cycle [3]. Another new issue emerges in this cycle. The image of the four revolving processes is important. One reason for returning to the process of mining a new issue is that innovation is meaningless unless it continues. Furthermore, the four processes repeat cyclically.

In that sense, it is a spiral rather than a cyclical feedback. It means that the world might change by introducing new things, but some other potential issues arise because of that new introduction.

This MECI process is cultivated in Meta-Engineering field or "Ba" in Japanese. "Ba" is a necessary condition for innovation creation[4]. The authors devote particular attention to the catalysis effect of this "Ba."

III. REDEFINITION OF CATALYSIS

Catalysis is the increase in the rate of a chemical reaction attributable to the participation of an additional substance called a catalyst. With a catalyst, reactions occur faster and with less energy. Because catalysts are not consumed, they are recycled. Often only tiny amounts are necessary. In the presence of a catalyst, less free energy is required to reach the transition state, but the total free energy from reactants to products does not change. A catalyst might participate in multiple chemical transformations. The effect of a catalyst might vary because of the presence of other substances known as inhibitors or poisons (which reduce the catalytic activity) or promoters (which increase the activity). The opposite of a catalyst, a substance that reduces the rate of a reaction, is an inhibitor. [5]

For example no reaction occurs even if hydrogen and oxygen are combined. However, water is generated when copper (Cu) is added to this combined gas. Copper (Cu) is used in response to oxygen, and the formed CuO is produced. CuO reacts with hydrogen and produces water and copper (Cu). Then copper worked as catalyst. As another example, an excitation electron and a positive hole in the photo-catalyst produce energy from the light in the solid material that absorbs light, and causes a chemical reaction to function as an activity class and wake up an oxidation–reduction reaction for various chemical substances on the photo-catalyst surface (Catalysis Society of Japan).

As mentioned above nothing happens merely by mixing hydrogen with oxygen, but a numerator called water is generated with copper catalytically. The action to convert it into the new dimension is defined as the catalytic action. This phenomenon can be portrayed as the diagram shown in Fig. 2. It is a simple mixed gas on the plane that oxygen coexists with hydrogen, but the water, as the third dimension, is produced by adding copper as a catalyst. In this way, the authors understood that a missing dimension was created by a catalyst.

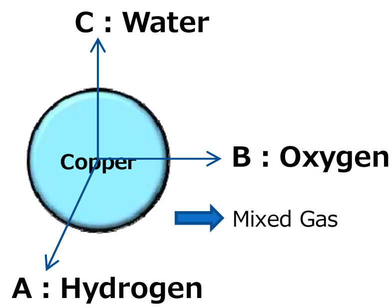

Fig. 2 Redefinition of Catalysis.

IV. APPLICATION OF CATALYSIS MODEL TO INNOVATION

Innovation is defined by Joseph Schumpeter as a new combination of several factors [6]. The authors apply the concept of catalysis to this new combination, producing a new dimension. Conventional combinations can produce incremental innovation without catalysis. Breakthrough innovation, however, requires a new combination provided by catalysis. Regarding Management of Technology (MOT), conventional combinations of management and technology have produced many of the incremental innovations depicted in Fig. 3. In this figure, management is presented as one dimension and technology as another. These dimensions provide a plain on which many incremental innovation occurs.

If catalysis is adapted to these management and technology, it can produce breakthrough innovation in a missing dimension. This model suggests that catalysis has an important role in creating breakthrough innovation. The authors do not define what the catalyst in this MOT case is: it is expressed as X.

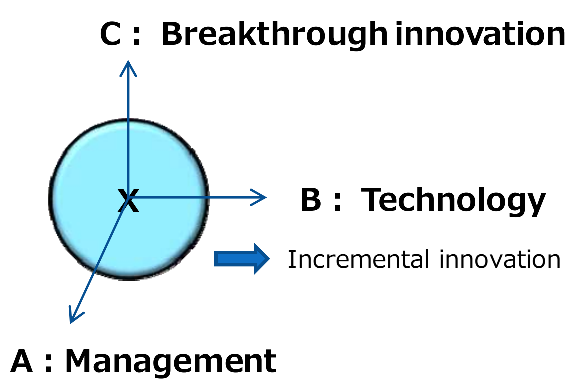

Fig. 3 Applied Model of Catalysis to Innovation.

This innovation process is depicted in Fig. 4. Incremental innovation is realized without a catalyst, but breakthrough innovation results from catalysis.

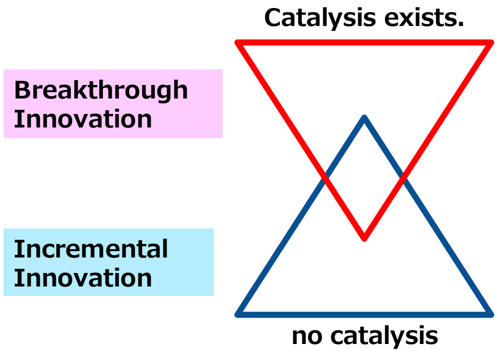

Fig. 4 Relation between Innovation and Catalysis.

In the paper of C. Christensen et al [7] innovation is classified in sustainable and disruptive. They define catalytic innovation as a part of disruptive innovation. And it primary intends social charge as objective. The approach proposed in our paper deepened the catalysis concept into the three dimension model.

V. EXAMPLES

A. Smart Meters

A smart meter is a type of watt-hour meter used for electric energy measurement. Its measurement is digitalized from a conventional analog method. It has a communication function between the meter, a data center of the power utility, and perhaps even home appliances. Usually, a remote control switch is included (Fig. 5).

If the smart meters are merely a combination of digital measurement and telecommunication, then they are merely tools for automated meter reading (AMR). However, smart meters can be used in a smart grid infrastructural arrangement.

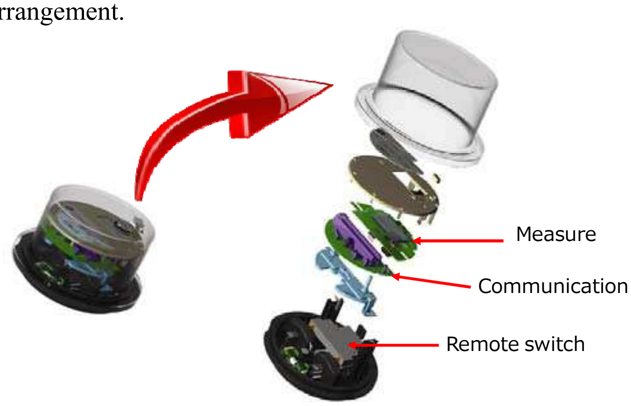

Fig. 5 Smart Meter Configuration.

Functions of the smart meters in a smart grid environment can be summarized as presented in Table 1.

TABLE 1 FUNCTIONS OF SMART METERS

- Data Acquisition (Periodically, On Demand, etc.)
- Billing
- Dynamic Pricing
- Alarms
- Remote service Breaking
- Load Control
- Software Program Modification by remote
- Automatic Reading with Gas and Water

Presumably, an advanced metering infrastructure (AMI) function can be realized as depicted in Fig. 6 by combining a back office functions of the power company, such as OMS, DMS, GIS, etc.

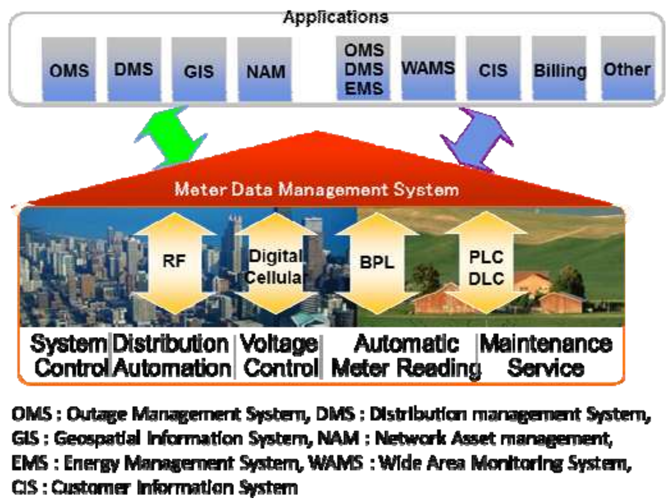

Fig. 6 Smart Meter Functions with Advanced Meter Infrastructure.

This explanation is depicted in Fig. 7, which posits the effect of a smart grid as a catalyst.

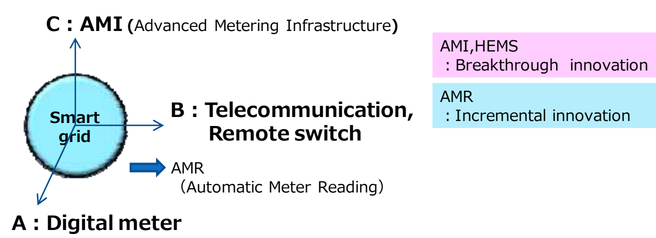

Fig. 7 Model of Smart Meters.

B. Bladeless Electric Fan

For needs calling for uniform wind motion and pressure, electric fans of two kinds can be used. The first uses blades but with an internal and an external one for a normal electric fan (Fig. 8). The wind created by the fan is linear. It resembles a natural breeze from an artificial source. In contrast, a non-conventional electric fan has no blades in its structure, but sends air at 10 several times the rate of the air which is input through the outer slit (Fig. 9).

Fig. 8 Electric Fan with Traditional Method for Natural Wind.

Fig. 9 Bladeless Electric Fan.

This second method creates the new dimension for electric fans without blades from the technique of the conventional one (Fig. 10). The catalysis arose from an innovative company that moved beyond the traditional definition by which an electric fan needs blades.

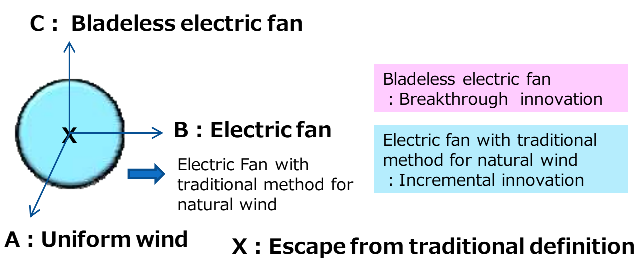

Fig. 10 Model of Bladeless Electric Fan.

C. Smart Phone

For cellular telephones, a feature phone with many functions was produced using conventional cell-phone techniques in Japan, Europe and others. This incremental innovation was realized on the plane of the combination of conventional telephone techniques and usability. In contrast, a smart-phone has special emphasis assigned to its usability. Design intentions are to apply a new interface, creating a new dimension that corresponds to the new traits of the user interface and visual characteristic. Smart-phones were created as a breakthrough innovation (Fig. 11). In this case, the catalyst was the thinker who conceived a new idea out of the box, who abandoned conventional cellular phone features.

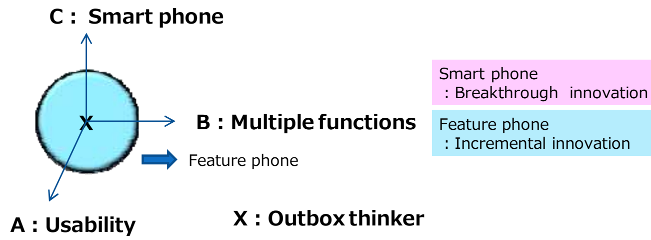

Fig. 11 Model of Smart Phone.

D. Simulacre Software Architecture [8]

Components of conventional computing systems were divided individually, and were modularized with changes of the related computing systems. Modules were integrated to meet the needs of the user side. They became able to bring about a new combination. Completed by this new combination, they came to provide services that depend on the new sense of value of the user. The authors assumed this new combination simulacre and sought to produce a service-based model to a base in a model of the simulacre. The authors regard these in conjunction with a flow shifting to a service base from a product base. The concept of simulacre came from culture research [8]. Simulacre is French word and defined by Jean Baudrillard "Simulacre and Simulation" in 1981 as secondary creation.

Services demanded by users with a new sense of values were various. The new combination was never a single idea. It was therefore difficult to develop the combination to a service that a user demands even if the service offered to the user was considered from a product base. It becomes necessary to imagine the new service value of the user without being conscious of its past constitution. Therefore, the authors suggest a service business based on the model of the simulacre.

In this case, the catalyst is cultural research that changed the conventional computer architecture.

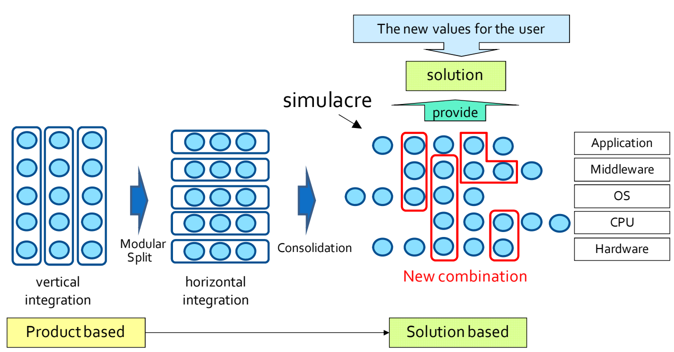

Fig. 12 Simulacre Software Architecture.

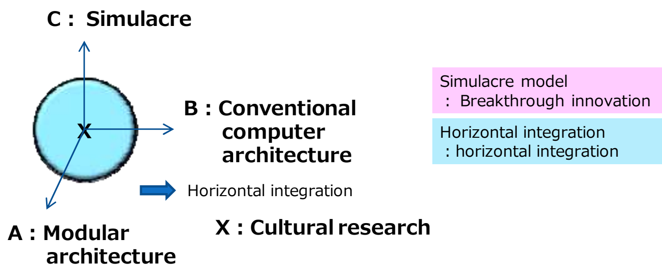

Fig. 13 Model of Simulacre.

E. Echo-Sounder for Use as a Fish Finder [9]

During World War II, the Japanese Navy developed and applied echo-sounders to detect submarines. After the war end in 1945, Japan was prohibited from conducting military research. It applied this technology for civil applications. One application was echo technology using ultrasonic sounding. Furuno Electric applied this technology to detect fish in 1948 (Fig. 14). Japanese people needed protein, but it had only a thin supply of beef, pork, and chicken in that era. Fish were therefore increasingly necessary to provide protein for Japan's increasing population. The company studied several technologies and ultimately succeeded in applying ultrasonic technology to this application.

As a conclusion, Japan had echo-sounder technology and applied it in private applications, not a military technology, through institutional changes made after the end of the war. This institutional change can be regarded as a catalyst for innovation (Fig. 15).

Fig. 14 Echo-Sounder Used as a Fish Finder.

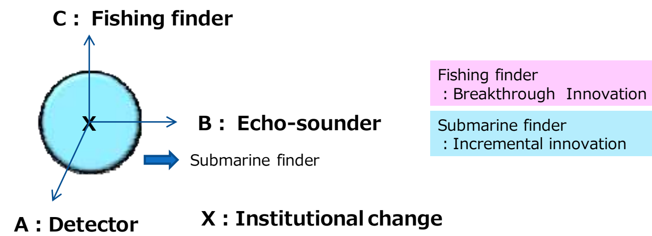

Fig. 15 Model of Echo-Sounder for Fish Finder.

VI. CONCLUSIONS

The authors applied a catalysis model to cases of breakthrough innovation. This model defines catalysis as creating a missing dimension that is not discussed in incremental innovation. Differences between incremental innovation and breakthrough innovation depend on the existence of a catalyst. Several innovation examples were selected and explained. In the study, numerous catalytic technologies were selected such as smart grids, out of the box thinking, escape from conventional discipline, cultural research and institutional change. For future breakthrough innovations, more catalyst candidates must be sought and assessed.

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