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Transdisciplinary Approach for Industrial Innovation Management

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Abstract: After the invention era of 20th century for computer and communication technology, information and communication technology (ICT) industry calls for innovation which transforms inventions in 20th century to societal values. The present paper examines current industrial efforts for the innovation and explores possible approaches to the innovation. Transdisciplinary approaches which has been stemming from traditional systems engineering are identified the most promising to the goal. Among transdisciplinarity, importance of computational management science is emphasized and, in order to realize this idea, current researches on systems dynamics and multi-agent simulation are examined from the view of systematic innovation support.

Keywords: ICT industry innovation, transdisciplinarity, system engineering methodologies, systems dynamics, multi-agent simulation.

1. INTRODUCTION

It is general understanding that information and communication technology (ICT) industry calls for innovation which transforms the technological inventions developed in 20th century to societal values. The ICT industry is exploring clues of the innovation as well as methodology managing the innovation. The fact that innovation management methodology should stand on thorough understanding of interplays among society and technology definitely implies necessity of transdisciplinary approaches.

Systems engineering has been providing methodologies for integrating engineering and sociological knowledge, which is regarded as an entry discipline for transdisciplinarity. Among systems engineering methodologies, control engineering and operations research have significantly contributed to improving performance of enterprise operations in these decades. Service engineering, which is presently attracting interests from industry, is expected to contribute to enterprise value creation and governance with new technology such as risk management as well as ubiquitous electronic devices. For the next step, industrial innovation shall be managed and supported by extension of systems engineering which provides deep understanding of industrial ecology and invention of desirable institutional structures. Remarkable computational power, we have got nowadays, looks providing opportunity and reality for this attempt.

In order to manage and support industrial innovation, the methodology should have capability of integrating multidisciplinary knowledge, simulating the knowledge for better understanding the domain, and seeking the best structure based on the knowledge. We have two candidates as the methodology bases which satisfy the requirements for understanding; multi-agent simulation and systems dynamics.

This paper presents the following topics in respective sections;

(1) Background and typical examples of innovation needs in the ICT industry with requisites for innovation management and support methodology,

(2) Historical review of systems engineering contributing to integrating diversified knowledge in terms of innovation management and support for industry,

(3) Review and critics of present candidates, multi-agent simulation and systems dynamics, as the methodological bases for innovation management and support.

2. CURRENT PRACTICES PREPARING FOR BUSINESS INNOVATION

2.1 Background for the ICT industry innovation

Perez [1] analyzed innovation processes for modern industrial societies including steam engines, railways, electricity, and automobiles and claimed that five consecutive steps, irruption, frenzy, crash, synergy, and maturity, necessarily appeared in the innovations.

The ICT industry met crash in 2000 as dot com collapse and is now going to enter the synergy step. According to Perez, the synergy step implies the original invention penetrates into and transforms the society. In this step, it is not possible to win in the market by technological competence. Only the innovator who provides the business model of ICT accepted by society in advance would be the winner. The ICT industry is very eager to develop their business models. The followings show some examples of our preliminary development studies.

2.2 Current practices supporting business decision making

(1) Business opportunity assessment for convergence of telecommunication and broadcasting

In order to improve use of terrestrial bandwidth, many countries are going to switch from analog to digital television broadcasting services. The switching brings big business opportunities where consumers can access contents through terrestrial television networks as well as fiber to the home networks. This duplication

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of access by consumers will trigger the change of money flow among the stakeholders such as broadcasting service providers, advertisers, advertisement agencies, content holders, video on demand (VOD) service providers, internet service providers, access service providers, and so on.

What industry will emerge by the convergence? To what degree is the capacity required for the new information flow? What terminal will consumers want to use? These are typical questions by the ICT industry. In order to respond to these questions, choice theory [2] is applied to estimation of growth of VOD service market as shown in Fig.1 for preliminary study.

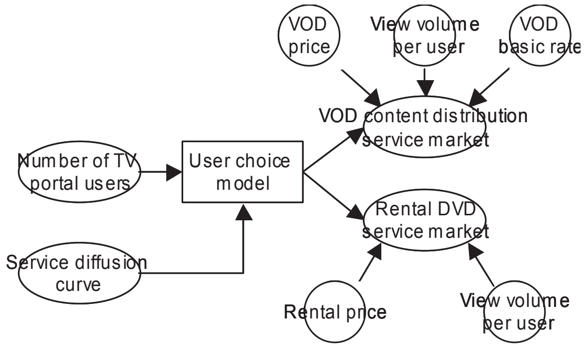

Fig.1 VOD service prediction by choice theory

(2) Business development of privatization of public services

It is generally understood that privatization of public services brings good economic efficiency. Water treatment and supply is one of the most expected privatization services. The ICT industry is interested in the privatization with its remote operation capability. However private company should find out economically acceptable business domains satisfying evaluation framework for public services. Fig. 2 shows possible business expansion steps for the privatization. It is often questioned what course of business expansion would be the most appropriate for privatization of water supply services.

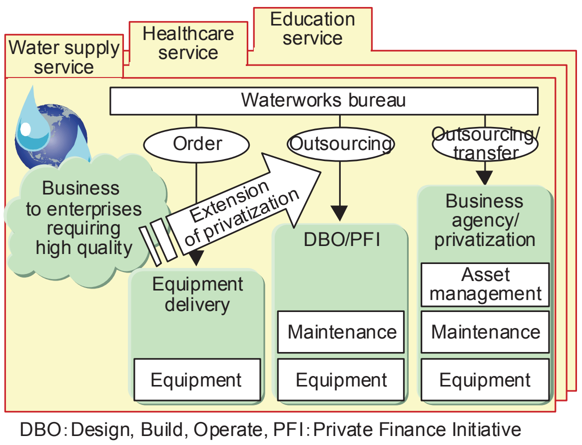

Fig. 2 Business development for privatization of public services

(3) Development of knowledge base for new business planning and launch

Big companies such as Hitachi launch a lot of new business in their diversified business divisions. It is quite important to share and use the experiences of new business planning and launches within the company for the better engagement. Figure 3 shows a system supporting planning and launching new business based on knowledge archives, which is starting to be applied to real business environment.

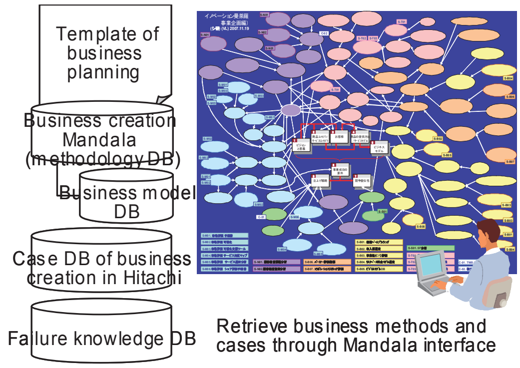

Fig. 3 New business planning and launching support system with Mandala interface

3. SYSTEMS ENGINERRING METHODOROGIES FOR BUSINESS INNOVATION

3.1 Requirements for industrial innovation

As stated in Section 2, the ICT industry faces decision making for quickly developing new profitable businesses, of which background include convergence of telecommunication and terrestrial broadcasting, sustainable low carbon society, aged society with efficient and qualified public services, and so on.

The decision making also requires to consider selection and concentration strategy of business areas as well as global resourcing strategy.

In order to make qualified decision making, the industry should have deep insight of possible future society where technology and people are interacting with each other in complex way.

3.2 Overview of systems engineering methodologies for socio-industrial problems

Figure 4 depicts systems engineering methodologies being currently applied to socio-industrial problems.

Operations research and control engineering have significantly contributed to core businesses such as supply chain management (SCM) and operation of large complex processes, which are essential parts of industrial activities. Further advancement of these technologies will be required by industry for resolving global environmental as well as world closer issues and opportunities.

However, expectations to systems engineering methodologies are not limited to these resolutions. Recently, service engineering is significantly received interests from industry. There are a variety of expectations for the service engineering ranging from product innovation in manufacturing industry to improvement of productivities in service industry.

If we restrict ourselves as ICT product suppliers, the products might serve customers' operations such as SCM and productions as well as governance and value creation of customers. For the better governance of enterprises, communication modeling and design methods within enterprise attract researchers' interests [3]. For better value creation, risk and uncertainty management methods for new business and new product development are also tackled by systems researchers [4]. These researches are regarded as service engineering in its narrow definition that is emerging recently.

Significant efforts have been devoted to the society problems shown at top of Fig. 4 such as global environmental issues, population issues with food concerns, and so on since 1970s. Work by Meadows on global environmental problems is one of the most representative efforts among them [5].

On the other hand, industrial innovation problem has been scarcely treated so far where industrial ecology calls for appropriate modeling driven by interactions among new technology and choice of people with economic background. It has been considered that competition between products and companies is hardly tackled even though the competition process is essential to systemize the innovation. However we are going to have new scientific bases for systemize the industrial innovation as mentioned in Section 4.

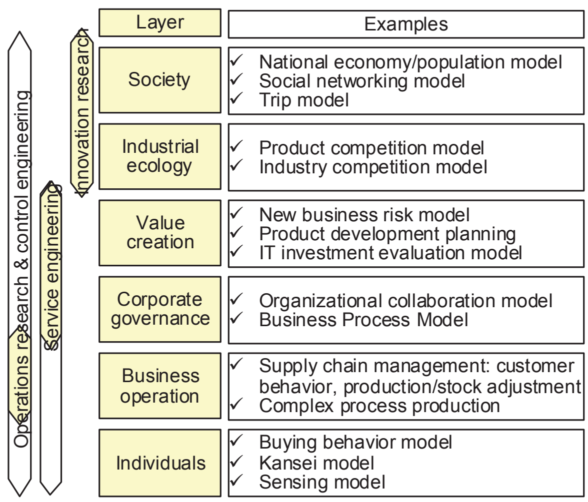

Fig.4 Systems engineering methodologies applied to industrial problems

4. APPROACH BASED ON COMPUTATIONAL MANAGEMENT SCIENCE

With expectation for emerging computational science [6], Harrison et al. [7] surveyed modeling and simulation technology for organization and management and reported that simulation technology worked in humanity and sociology appeared 8% in leading 10 research journals. They also introduced typology of simulation methods that classified into three categories; agent based models, systems dynamics models, and cellar automata models. Since idea of cellar automata is close to that of multi-agent, the present paper reviews multi-agent simulation and systems dynamics as bases for systemizing the innovation.

4.1 Multi-agent simulation

Agent is a computer program which is expected to behave as an entity of decision making in computer simulation. Since each agent can be equipped with its internal state, action rules based on its environment and internal state, rules for changing actions, and beliefs for the actions, it is expected that simulating multiple agents reproduces interesting phenomena such as market formation and crash as the result of interactions of decision makers.

So far many social phenomena have been modeled and simulated. Among them, multi-agent modeling for SCM might provide basis for describing innovation processes as industrial ecology.

Akkermans [8] modeled dynamics of business relationships among manufacturers consisting of multi-layered tiers for LSI production equipment industry, where his simulation has showed that difference of timeframe evaluating business performance affects the structure of trade relationship whether vertical or horizontal. This suggests that multi-agent models have desirable potentiality simulating industrial ecosystem.

However the study does not include behavioral change of participants which might cause some change in business relationship. Terano & Naitoh [9] showed that agents equipped with capability to revise their action rules were able to adjust to the structural market change. The modeled behavior is very important for simulating industrial ecosystem which has learning capability.

Modeling of industrial ecosystem for designing systematic innovation has not achieved so far, but these researches provide sufficient bases for the goal.

4.2 Systems dynamics

Systems dynamics proposed by Forrester [10] attracts researchers in humanity and sociology for intuitively simulating their mental models. Essence of systems dynamics is to model objective systems with positive and negative causal effects among component factors where effects possibly contain time lags.

Among the plenty works based on systems dynamics, consumer behavior models are relevant to simulating industrial ecosystem. Bass [11] proposed a diffusion model of new durable products paying attention on differences of consumer attitudes and showed the effectiveness validated by history of computer sales as well as history of memory chip sales.

Network effects, sometimes called as bandwagon effects, that utility of the product differs depending on its diffusion rate should be taken into account for simulating consumer behavior. Rohlfs [12] provided a theoretical framework for the network effects. Homma and Funabashi [13] are expanding the original idea to two-sided network effects where plural diffusion of products is a business determinant such as smart cards and shops accepting smart cards.

Models for consumer behavior might be derived through multi-agent form, however systems dynamic approach is suitable to get qualitative insight to the objective systems.

5. CONCLUDING REMATKS

Innovation that transforms inventions to social value is strongly expected by the ICT industry at the beginning of 21st century. In order to systemize innovation, the present paper has proposed that modeling of dynamics of industrial interactions featured by technology and social choice is essential and as the technological bases for the modeling current research on multi-agent simulation and systems dynamics are surveyed.

It is observed that these approaches for modeling are promising for our goal, but substantial efforts are definitely necessary to realize our expectation that includes way of systematic generation of institutional alternatives.

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