Study on Roadmapping Process with Integration Methods for Supporting Scientific Research

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ABSTRACT

With the development of Management of Technology (MOT) in industry, the study of Technology Roadmapping methods have become a hot topic for researchers in this area, and many technology roadmapping methods have been proposed. Unfortunately, the most widely used technology roadmapping methods only deal with forecasting and planning in industry. This paper considers to deal with some problems of the Scientific Research (SR) in a university setting and proposes a roadmapping system with integration methods suitable for use in universities. First, the paper introduces differences between MOT in industry and SR in university, along with a detailed framework for supping SR in university. Then, integration methods are explained and a roadmapping system is proposed, based on a case study concerning integrated forecasting for a transportation fuel cell roadmap. We hope that this system will become a powerful tool for knowledge management and knowledge creation for SR.

Keywords: Roadmapping Process, Integration methods, Transportation fuel cell forecast, Systems thinking

1. INTRODUCTION

How researchers can utilize the vast amount of available information and knowledge to make decisions regarding their future research is an extremely important research field. As Fig.1 shows, MOT involves only knowledge management, while SR embodies both knowledge management (KM) and knowledge creation (KC). How to support scientific research in a university setting, especially when researchers are making decisions about their future research is the problem addressed in this study. With the development of MOT in industry, the study of technology

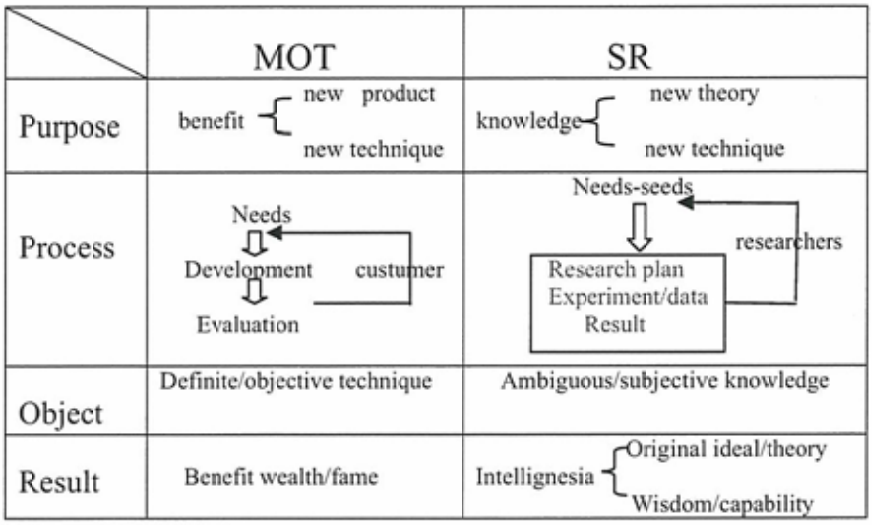

Fig.1 Comparison between MOT and SR

roadmapping methods became one of the hot topics in this area. Many technology roadmapping methods have been proposed. Unfortunately, the most widely used technology roadmapping methods only deal with problems in industry as a way to do forecasting and planning. In this paper, we introduce a roadmapping system to deal with the problem of SR in a university setting after a case study on making a integrated transportation fuel cell roadmap.

2. FRAMEWORK AND INTEGRATION METHODS

Researchers can easily obtain a great quantity of information and data from the Internet, but sorting through that information and data to find new research topics, to support knowledge management and knowledge creation, is not a trivial problem.This is one of purposes of SR in a university setting. In this paper , we propose the system outlined in Fig.2. In this framework, tow kinds of

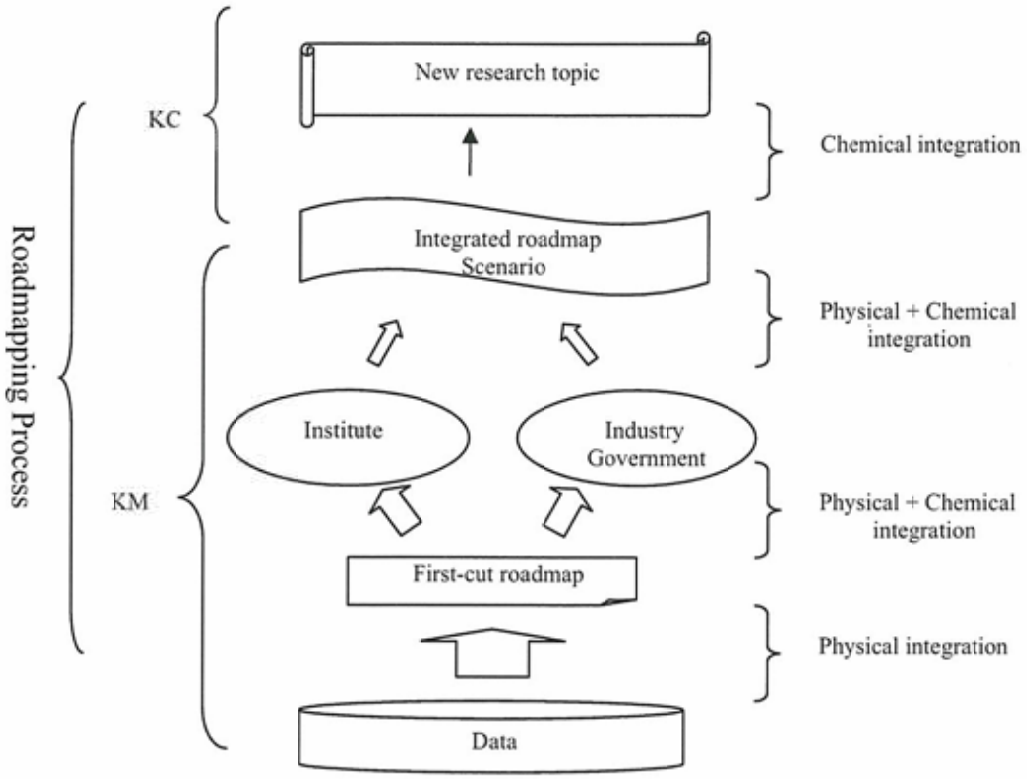

Fig2. Roadmapping system framework

integration methods are proposed, physical integration and chemical integration. Physical integration means 'architectural integration', which links things together while leaving the core design concepts (and thus the basic knowledge underling the components) untouched [1]. Chemical integration means 'meta-integration', which has a wider meaning, may touch the core concept, and change the overall characteristics [2]. For example, for enterprise integration, the architecture consists of [3]:

- Technical integration architecture
- Information integration architecture
- Business integration architecture
- Service integration architecture

The dimensions of meta-integration of enterprise are [4]:

- Goal and criteria
- Business process
- Application
- Information
- Hardware and software
- Network and communication
- Management

In this paper, we look at physical and chemical integration in terms of surporting SR in a university setting:

Physical integration: no new ideas, no new knowledge created

- Technology : Classsify the technology in a specific research field
- Marketing : Put the marketing information together to find the marketing requirement
- Societal influences: Collect the societal influences of every kind of technology

The pupose of physical integration is to collect and analyse the data and show the trend of the research topic to researchers. The methods of physical integration include summing up, concluding,and classifyin

Chemical integration: new idear, new research topic, new knowledgy created

- Information
- Application
- Communication
- Cooperation

The pupose of chemical integration is to do find the new research topic, to create knowledge by integrating information, application, communication, and cooperation. The methods of chemical integration include inference, abstraction, and creation.In this framework, we propose a roadmapping process with integration methods to support scientific research, especially to help reseachers make decisions about future research topics.

3. TECHNOLOGY ROADMAPPING

3.1 What is technology roadmapping?

Technology roadmapping is a disciplined process for identifying the activities and schedules necessary to manage technical (and other) risks and uncertainties associated with solving complex problems.

Robert Galvin, CEO of Motorola, 1998

Technology roadmapping is used as a planning process that gives decision-makers a means to identify, evaluate and select among strategic alternatives for achieving technological objectives in industry[5]. In this case, technology roadmapping is a technology developing process for supporting researchers doing scientific research in a university setting. A roadmap is an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of change in that field .

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The roadmap document resulting from the technology roadmapping process is the first step toward technological innovation [5]. In this case, the transportation fuel cell roadmap provides fuel cell information such as technology, marketing, and society influences to researchers, to support their decisions about future research or evaluate their current research.

3.2 What does a technology roadmap cover?

In industry, a technology roadmap document presents consensus on a number of topics: a vision of the industry at a set time in the future; what new types of products (or services) markets will be required; the enabling technologies to create those products; the feasibility of creating the needed technologies; the technological alternatives for achieving the needed technologies; and how to address these technology needs through R&D [6]. The roadmap document addresses the role of an industry's suppliers in creating the desired future, human resources needs, governmental and non-governmental barriers, and other topics [5]. In this case, transportation fuel cell roadmap presents such topics: the forecast of transportation fuel cell technology and market; the influence of the economy and environment.

3.3 Why is technology roadmapping important?

In this context, companies must use effective tools to plan their future. Technology roadmapping is a way to identify future product or service needs, map them onto technology alternatives, and develop plans to ensure the required technologies will be available when needed [5]. In this case researchers will get the information that they want, find the society influence of the research which they want to do or they are doing, and do the development or evaluation of research topic by a roadmapping system.

3.4 How does technology roadmapping support researchers in doing scientific research?

The principal functions of technology roadmaps have been for representation, communication, planning, coordination, and technology forecasting and selection [7]. In this case, there are four approaches:

- Present a concept of the needs of transportation fuel cell technology and market.
- Forecast the trend of transportation fuel cell technology
- Provide the data not only for technology, but also include the society influences.
- Support researchers to do research plans (NC) or research evaluations (NM)

3.5 How do the integration methods work in roadmapping process?

In this paper, we will develop a roadmapping process with integration methods that will support researchers in doing knowledge creation. How the integration methods work in roadmapping process is shown in Figure.3.

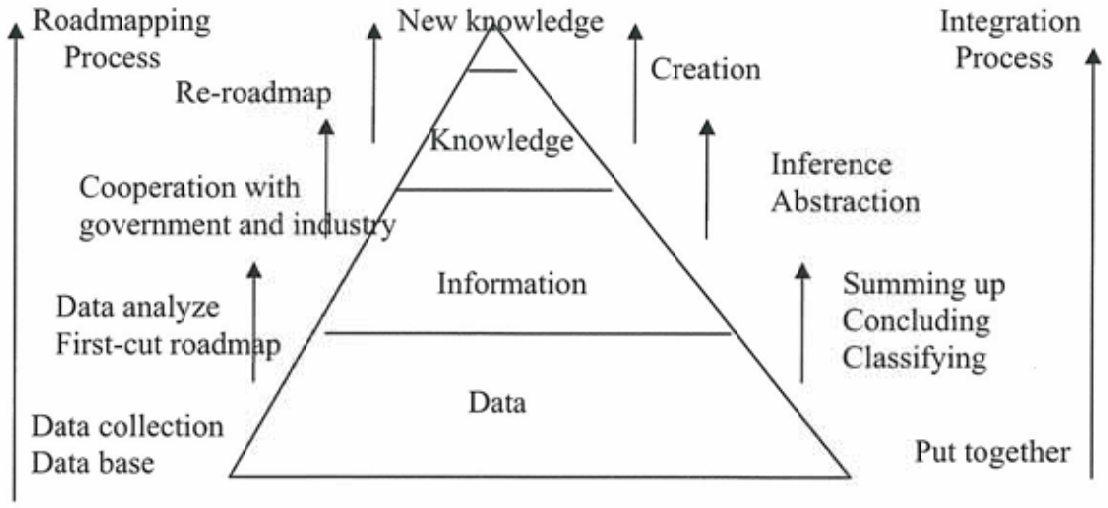

Fig3.Integration methods in the roadmapping process

4 CASE STUDY

In this paper, we examine forecasting for transportation fuel cells by roadmapping process with integration methods. The fuel cell can trace its roots back to the 1800s. A Welsh born, Oxford educated barrister named Sir William Robert Grove, who practiced patent law and also studied chemistry or "natural science" as it was then known, realized that if electrolysis, using electricity, could split water into hydrogen and oxygen then the opposite would also be true. Combining hydrogen and oxygen, with the correct method, would produce electricity. To test his reasoning, Grove built a device that would combine hydrogen and oxygen to produce electricity, the world's first gas battery, later renamed the fuel cell [8]. Because of its characteristics such as long durability, high efficiency and no pollution, the fuel cell has been used in several fields (this paper deals only with the transportation fuel cell). How do fuel cell researchers make their decisions about future research? How do they evaluate their current research topic? What kinds of information do they need and what information do they want? In order to address such problems, we carried out a case study on the forecast for a transportation fuel cell, using a roadmapping process with integration methods.

4.1 Why support for researchers?

Fuel cell researchers proposed a cooperative effort with industry, research insititutes and government for fuel cell technology development. In this cooperation, the most important part is between industry and research institutes [9]. In this paper, we present a concept for cooperative research for fuel cell technology development among industry, insititutes and government [10]:

- Industry: industries that introduce fuel cell products
- Institutes: universities that do fuel cell technology development research.
- Government: government organizations that make the policy for fuel cell technology and marketing development .

As Figure 4 shows, there is an obstacle to realizing cooperation between industry and institutes. In industry, there is support from the technology development and marketing sections to obtain patents [11]. In universities there are no such organizations to support researchers in their scientific research. On the other hand, as shown in Figure 5, government uses reports from industry to get the data to make policies for fuel cell technology development, while industry gets the data from universities to create marketing strategies and develop fuel cell technology [12], but where will the researchers in university who want to do scientific research, get their data? So in this paper, the purpose of the case study is to do support for fuel cell researchers to do scientific research in university.

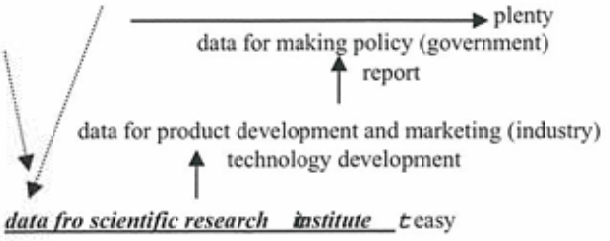

Fig.4 Cooperation between industry and academy

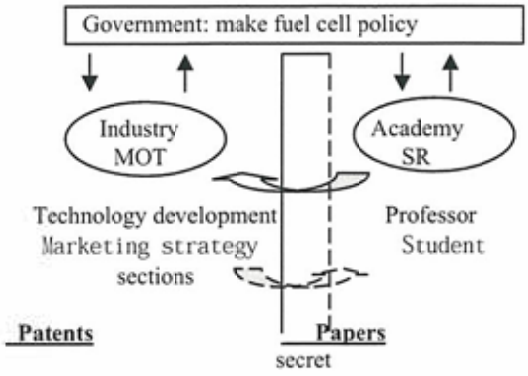

Fig.5Data resource of fuel cell

4.2 How to support fuel cell researchers?

Timely, advantageous, and original research is what researchers want to do. Fuel cell researchers what to know how fuel cell technology will be developed, what are the advantageous of fuel cells, what are the societal influences on fuel cell technology [13]. In this paper, as a case study, we will do a forecast (2000-2030) with fuel cels technology, market, and society influences (economic and environmental). Fuel cells are used in several fields but in this case we do the forecast only for transportation fuel cells:

- Data collection: Collect data of transportation fuel cell with four sides: fuel cells technology, marketing, economic influence such as costs and benefits, and fuel environmental influences such as how much CO2 will be decreased after fuel cells are in wide use, by using the internet and papers, and structure a transportation fuel cells database.
- First-cut Roadmap: Analyze the data collected and produce a roadmap of transportation fuel cell as shown in Figure 6.
- Idea exchange: Show the roadmap to fuel cell researchers; collect their opinions about the roadmap and ideas for forecast items, and find out what further information they need.
- Cooperation: Collect information in accordance with what researchers want to know from industry and government about the the technology, marketing and societal influences of fuel cells.
- Re-roadmap: Integrate the data and improve the transportation fuel cell roadmap.

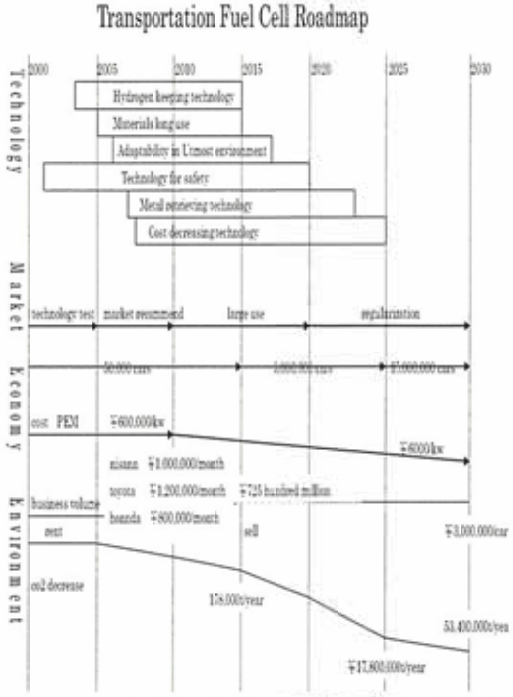

Fig.6 First-cut transportation fuel cell roadmap

5. ROADMAPPING SYSTEM

Figure 7 shows a roadmapping system based on the case study of the thetransportation fuel cell roadmapping process and i-system [14].

- Intervention:
  The purpose of the research is to help researchers make decisions for future research under a cooperative effort of industry, institutes and government.
- Intelligence:
  Collect data in different fields such as technology, marketing, economic influence (costs and benefits), and environmental influences (air,water, noise pollutions), and structure a database. After data analysis, produce a roadmap.
- Imagination:
  Show the roadmap to researchers to collect their ideas and suggestions about the roadmap and identify their need for further information.
- Involvement:
  For industry and government, collect their relative product information, research topic and policy in accordance withresearchers want to know, and put all this information into the database.
- Integration:
  Integrate all the data collected from industry, institutes, and government, produce a new roadmap.

Then, move to a researchers idea exchange system, show the new roadmap to researchers and collect their new ideas. Move to a public hearing system, collect new product information, research topics and policies. Finally, move to an information integration system to integrate the data collected and obtain a new roadmap. Through this recurring cycle (Intelligence-Imagination-Involvement-Integration), researchers can comprehend recent and future forecasting information, not only in terms of technology, but also including the researcher's ideas along with policy and marketing information. Researchers can do their research planning and evaluation by the roadmap and integrated information. Therefore, we hope that this system will prove to be a dynamic and powerful tool for technology development at university research institutes and will be helpful in expediting cooperation among industry, institutes, and government.

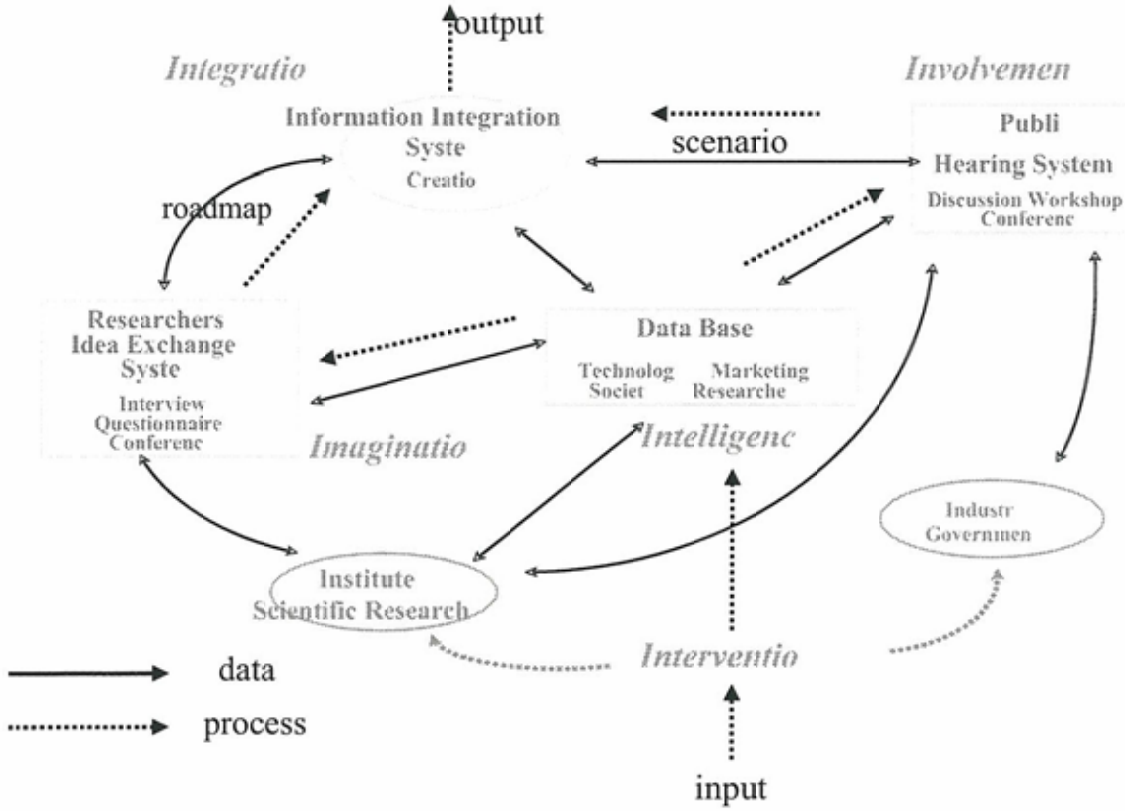

Fig.7 Roadmapping system for supportimg SR

6. CONCLUSION

Through a roadmapping system, researchers can do both knowledge management and knowledge creation, which are the two approaches of SR. Therefore, in this paper we have proposed a technology development roadmapping system for SR.

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