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修　士　論　文

Interactive Planning for Personal Academic Research Roadmapping

北陸先端科学技術大学院大学
知識科学研究科知識システム基礎学専攻

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2004 年 3 月

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2004 年 2 月

インタラクティブプランニングを用いた
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キーワード：　知識マネジメント，　インタラクティブプランニング，
テクノロジマネジメント，テクノロジーロードマップ

近年、知識は経済成長のための資産や資源の一つの要素として社会的に認められている。社会に認められ、特に産業界において注目されている知識の一つとして、テクノロジマネジメントがある。テクノロジマネジメントは、知識科学と知識マネジメントの重要な分野となっている。テクノロジマネジメントは、技術の管理と理解される一方で、情報の管理や技術創造のためのプロセスの管理などの意味もある。

大学は技術革新に重要な役割を果たすが、テクノロジマネジメントに関する理論や解決策を提案するためには、産業との結びつきといった背景が必要である。しかし、産学の連携が不足であるため、テクノロジマネジメントの理論と解決策の研究は進んでいない。

産業界と大学の協力及び理解が増すに従って、多くの研究者及び科学者は、テクノロジマネジメントを大学に導入することが重要であると考えるようになった。

一方、テクノロジーロードマップは、政府、企業、産業界で広く使われるようになっている。テクノロジーロードマップは、テクノロジーの全体的な体系と将来を分析し、テクノロジー開発や利用に活用される。加えて、テクノロジーロードマップは、マネージャーがマーケットをよく理解のを助けることができるため、大変重要視されている。

以上のような背景のもと、本研究では、研究室に対応したテクノロジーマネジメントの条件を考慮にいれた上で、研究室における研究のガイドラインとなり、インタラクティブプランニングを用いた研究活動のロードマッピングを提

案した。アカデミックリサーチの特性を生かした研究活動をサポートすることを目的として、研究室のロードマッピングサポートシステムを開発した。

Interactive Planning for Personal Academic Research Roadmapping

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March 2004

Keywords: Knowledge management, Interactive planning, Technology roadmap

Now the knowledge is recognized as important as physical, financial capital and natural resources for the economic growth. With such a common social recognition of the importance knowledge, much attention has been paid to the management of technology (MOT) in business organizations, which is an important branch of knowledge science and knowledge management. To many, MOT means managing engineering. To others it means managing information, managing development, managing manufacturing operations, and so on.

Although academy plays an important role in technology innovation, little work has been done to deal with the MOT in academy, mainly because the ivory tower lacks some certain business or commercial background, on which most of current theories, solutions, methodologies about MOT are based. But things are changing. With the increasing cooperation and understanding between industry and academy, some researchers and scholars realized it is important to introduce MOT to academy.

Technology Roadmapping has been widely used as a tool to help firms better understand their markets and make informed technology investment decisions. It is a planning process - led by industry - which can assist firms to identify their future product, service and technology needs and to evaluate and select the technology alternatives to meet them.

In this thesis, I put forward a new methodology for the MOT in academy is integrating Interactive Planning (IP) and Technology Roadmapping, and then developed a prototype of the roadmapping support system, and it can be used smoothly. More function will be added into the system in our future work. And for being a good system, it need to be continuously improved.

Contents

Chapter 1

Introduction

1.1 Problem: MOT in Academy

With coming of the knowledge age, knowledge economy and knowledge management have caught increasing interests in both academia and business. Now the knowledge is recognized at least as important as physical, financial capital and natural resources for the economic growth. With such a common social recognition of the importance knowledge, much attention has been paid to the management of technology (MOT) in business organizations, which is an important branch of knowledge science and knowledge management.

To many, MOT means managing engineering. To others it means managing information, managing research, managing development, managing manufacturing operations, managing the activity of engineers and scientists, or managing functional activities without concern for the total spectrum of activities that encompass the business concept to commercialization process [9].

Although academy plays an important role in technology innovation, little work has been done to deal with the MOT in academy, mainly because the ivory tower lacks some certain business or commercial background, on which most of current theories, solutions, methodologies about MOT are based. But things are changing. With the increasing cooperation and understanding between industry and academy, some researchers and scholars realized it is important to introduce MOT to academy. As mentioned by Prof. Nakamori in his introduction to the COE (Center of Excellence) project of JAIST (Japan Advanced Institute of Science and Technology), "it is vital to begin to continuously and systematically develop the theory of technology creation, verifying the theory in scientific laboratories, and improving the theory by feedback from practice"[11].

1.2 Objective: A New Methodology for MOT in Academy

Technology Roadmapping has been widely used as a tool to help firms better understand their markets and make informed technology investment decisions. It is a planning process - led by industry - which can assist firms to identify their future product, service and technology needs and to evaluate and select the technology alternatives to meet them [5]. Okutsu introduced technology roadmapping for the MOT in universities of science and technology. By integrating the Soft System Approach and technology roadmapping, she put forward a methodology for supporting academic researchers to generate emerging technology as core of technology innovation [12].

In this thesis, we will put forward a new methodology for the MOT in academy is integrating Interactive Planning (IP) and Technology Roadmapping. IP is regarded as a famous methodology for solving creative problems [8]. It was put forward by R.L. Ackoff [1, 2, 3, 4] whose work has had a major impact upon all of the various branches of the management sciences. IP is a methodology that effectively realizes the insight of "plan or to be planned for" by endorsing it in its philosophy and providing a set of practical procedures through which the philosophical message is empowered.

The methodology put forward in this thesis has the following advantages:

- The "idealized designs" in IP process can make researchers generate their maximum creativity.

- It can give a forward feed back before academic researchers begin their research activity. It is common that research work is carried out by a research group or research team, rather than an individual. By participating in the process of making technology roadmap, academic researchers can understand the role they can play in the research group and the research project. The three important principles of IP, namely participative, continuity and holistic will make a research project being operated smoothly.

- It can promote the knowledge sharing among researchers. In the process of making technology roadmap, all members of the research group will offer their ideals and suggestions, and when the real research work is carried out, those team members can continually give their suggestions.

  Based on the new methodology put forward, a prototype of a web-based system was developed by using JSP (Java Server Page) technology. This system aims to support the process of developing technology roadmap for academic researchers, so we will call it Academic Technology Roadmapping Support System.

1.3 Organization of the Thesis

This thesis is composed of 7 chapters. Chapter 2 briefly reviews the current status and problems of academic labs. Chapter 3 introduces the conceptions of MOT and Technology Roadmapping. Chapter 4 first introduces the IP approach, and then a new methodology for the MOT in academy is put forward by integrating IP and Technology Roadmapping. Chapter 5 gives the real application of the methodology. Chapter 6 introduces the prototype of the Academic Technology Roadmapping Support System. Chapter 7 is the conclusion of the thesis, which covers the advantages and disadvantages of the methodology and the future work. References are given after the Chapter 7.

Chapter 2

Current Status and Problems in Academic Laboratories

This chapter mainly introduces the current status and problems related to this research in academic laboratories. The first section of this chapter explains the issue about the cooperation among industry, academy and government, and the activity of technology licensing office. The second section describes the problems related to this research – communication during research, importance of making research plan, and features of academic research.

2.1 The social environment of academic laboratories

2.1.1 Cooperation among Industry, Academy and Government

It has been widely realized that it is very important to promote the cooperation among industry, academy and government. Tanaka summarized the sense of the promoting the cooperation as:

- For realizing the knowledge society, it is necessary to continuously create knowledge assets and make a good use of the knowledge assets.
- It is necessary for creating a society with both strong knowledge stock and strong knowledge flow.

2.1.2 Doing Right Things and Do Things Right

There is famous saying that doing right things is more important than doing things right. For carry out research, a researcher firstly need to decide what he/she wants to and should do, that is to say he must decide his research topic (the right things or where he/she want to go). And for deciding right things, he/she needs to identify what kind of ability or resource he/she has, in other words, he/she has to know clearly where he/she is. After he/she knows where he/she is and where he/she want to go, it's time for him/her to find some ways to do things right, i.e., he/she need to know how he/she can reach his/her goal.

We can often heard such voice from some researchers (especially refresh men in graduate schools) who are going to start a new project, "what can I do", "what should I do", and "how can I do". The purpose of this research is to find a new methodology to help academic researchers to solve those problems.

2.2 The Problems Related to This Research

2.2.1 Communication during research

The communication among researchers has very notable effect for the innovative research. That's the reason why there are so many academic conferences, symposia, workshops and seminars. The information about the newest innovation or discovery may be formed and distributed by researchers oral communication, rather than papers in various journals or other publications. Although the publications are better organized than oral communications, there is delay because it takes time to write, submit, evaluate, revise and publish papers. The communication among researchers from different field is especially valuable, and such communication is very important for promoting innovative research. It will result in different association of ideas, if we review recent big discoveries, we will find many of those discoveries were carried out by researchers from different field together. There are many cases that communication among researchers in different fields finally result in a new research field which is very important for the progress of the whole human society. For example, the "bioinformatics" is a hot research field in recent years; many researchers from both biotechnology field and information field are contributing to this new research topic. So a good methodology for the MOT in academy must have the ability to promote the communication among researchers from the same or different field.

2.2.2 Importance of Making Research Plan

Plan is important for all human activities, not only for research. A good plan can avoid the following unpleasant things:

- Activities make no sense, just waste of time.
- Principles and benchmark are lacked during activity.
- The purpose or the destination is unaware.
- The time of end the research is also unaware.

A good plan is very useful for controlling the progress of activities. It will help people to reach their destination by shortest distance. Without a plan, many time and resource will be used in waste activity. A plan is a good guidance for activities, it can enable that activities are carried out in the right direction. And it is also promise that the right thing will be done rightly by the right people at the right time. Of course, plans should be dynamic. It is difficult for people to consider all situations or emerging accidents when making a plan, so a plan should be continuously refined. For an individual researcher's plan, it should also consider the progress of the whole research project. This is very important when a research group or a research team is working on the same research project. The methodology for the MOT in academy must have the mechanism to support researchers to make their research plan.

2.2.3 Features of Academic Research

The R&D in industry can be divided into two types, market-driven R&D and technology-driven R&D. Corresponding to the two types of R&D; there are two types of organizational structures input-type and output-type. In the input-type organization, much attention is paid to technology, and R&D groups are mainly formed based on different technology field; in the output-type organization, much attention is paid to market, and R&D groups are formed based on different project [12].

The input-type structure has the following advantages:

- It is helpful for the accumulation and expansion of the information and knowledge about scientific technology.
- It can create an atmosphere in which researchers with special technol-

ogy inspire each other to do the best.

The disadvantages of this type are: the cost of adjustment of people will be bigger when carrying out the R&D for new products.

The output-type structure has the following advantages:

- The cost of people adjustment will be small for developing some special products or services.
- It is easy to adjust when facing competition from other companies' products, and the cost of products adjustment is small.

The disadvantages of this type are:

- It cannot accumulate and expand information and knowledge about scientific technology.
- It is difficult to educate and train members to be person with special ability.

Okutsu applied the above classification method to academic laboratories [12]. She mentioned that academic laboratories also could be divided into input-type and output-type. The feature of input-type labs is: the research is based on researchers' free imagination and spirit of exploration, and even there are connection between those labs and the industry, the target of the labs is to develop technology, rather than products; The feature of output-type labs is: those labs carry out research together with companies (or companies consign research task to the labs) for developing new products.

The main target of academic labs should be "budding technology" and "creative invention", and academic labs should also have the function for the accumulation and expansion of scientific knowledge and function for inspiring researchers. In this sense, academic labs belong to input-type which pay much attention to science and technology. When considering the communication between researchers from different field, the academic labs should be output-type since it can promote the communication among researchers from different field.

The methodology put forward in this thesis aim to enable the MOT in academic labs has the merits of both the input-type and output-type, avoiding the disadvantages of both types. By applying IP to develop research roadmap, not only can it create an atmosphere in which research on "budding technology" and "creative invention" is encouraged by "idealized design", but also it can promote the communication among researchers from different field since IP pays much attention to participation of stakeholders which is one of IP's three principles.

Chapter 3

Technology Roadmapping and Its Use in Academy

3.1 Technology Roadmapping

The fundamental purpose of the Technology Reviews and the Technology Roadmaps is to assure that we put in motion today what is necessary in order to have the right technology, processes, components, and experience in place to meet the future needs for products and services.

Bob Galvin
Motorola

3.1.1 Definition of Roadmaps

It was Motorola Inc. that firstly introduced the conception "roadmap" as a kind of strategic plan in 1970s. Now the term "roadmap" is used liberally by planners in many types of communities, and appears throughout the published literature. It appears to have a multiplicity of meanings, and is used in many different contexts [10]. Maybe the most widely accepted definition of roadmap was given by Bob Galvin, CEO of Motorola:

“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”. Bob Schaller’s definition of a roadmap is [16]:

“A science and technology roadmap provides a consensus view or vision of the future science and technology landscape available to decision maker. The roadmapping process provides a way to identify, evaluate, and select strategic alternatives that can be used to achieve a desired science and technology objective.”

And R.N. Kostoff define a roadmap as [10]:

“The representation of the structural and temporal relations among science and technology elements as they evolve toward products.”

3.1.2 Why Roadmapping

By now, more and more enterprises realize the importance of applying roadmap for their strategic planning. The key challenge for firms is to develop and sustain competitive advantage in a complex business environment. Markets and technologies are changing rapidly, cost pressures are increasing, customers are more demanding, and product life cycles and time-to-market are shrinking. In this environment, firms need to focus on their future markets and use strategic technology planning to stay ahead of the game.

Technology roadmapping is a comprehensive tool to help firms better understand their markets and make informed technology investment decisions. It is a planning process -led by industry - which can assist firms to identify their future product, service and technology needs and to evaluate and select the technology alternatives to meet them.

Technology Roadmapping can ensure that industry has access to the critical technologies needed to seize opportunities from the major market developments projected to occur over a 10 to 20 year timeframe. By providing strategies to access those technologies and by when, a technology roadmap can help firms and industries to position themselves better for the future [5].

According to Edward J. Coyle [7], roadmaps are also communication tools, not just planning tools. They enable owners to:

- Visualize the hierarchy of scenarios;
- See time relationship and dependencies in simple fashion;
- Legends provide an additional dimension for visualization.

Roadmaps can also condense a large amount of information into an intuitive format.

3.1.3 Different Roadmaps

Roadmap can be different things to different people. The common point of those different roadmaps is it can help its owners to make clear the following three problems:

1. Where are we now?
2. Where do we want to go?
3. How can we get there?

Private Roadmaps

For most of the enterprises, because roadmaps are in fact their strategic plan, so they don't want to share their roadmaps with others, otherwise they will lose their competitive advantages. Like Motorola Inc., it didn't want to show other people its roadmaps, but it would like to discuss the conception of roadmaps and share its process of making roadmaps with others. But things are changing, some companies, including Motorola, now believe that even their roadmaps are open, they can still have competitive advantages by reach their goal faster than their competitors.

In a same company, there may be many different roadmaps owned by different departments, different groups and different people.

Public Roadmaps

In recent years, many industry associations, government and not-for-profits organizations begin to regularly making and publishing roadmaps. And those roadmaps are commonly available to everyone, for example the International Technology Roadmap for Semiconductors (http://www.sematech.org).

A New Development: Roadmap Archives

[1] As Edward J. Coyle pointed out [7]: a new development now is that some companies and organizations start to build roadmap archives by using roadmap software tools. A roadmap archive means a large collection of software-based roadmaps in a common format. Corresponding to private and public roadmaps, there are two kinds of roadmap archives, namely private archives and public archives. The examples of private archives include:

- Motorola: Motorola Lans and PCS;
- Honeywell, Xerox, Edwards AFB;

[1] This subsection is mainly based on Edward J. Coyle's presentation in Strategic Roadmapping Workshop [7]

- Navy: The Navy Smartship Program.

The examples of public archives include:

- Purdue University, USA;
- Tsinghua University, USA;
- ITRS and IPS Web Sites (searchable pdf).

Software roadmaps archives, especially public archives, can provide the following usage:

- Searching
  - For duplicated efforts
  - For gaps and opportunities
  - To see what is happening
  - Educational
- Data Mining
  - Identifying Trends
  - Scanning an economy
  - Integrating in new ways
  - Need a roadmap ontology.

3.1.4 Three Broad Levels

[2] Roadmaps can be developed at three broad levels of resolution: industry, technology and product. Industry roadmaps define broader market goals that are applicable across an entire sector and provide focus for industry to identify and address market, regulatory and other barriers to growth and define a clear set of industry actions. Technology roadmaps identify, evaluate and promote the development of collaborative projects within and between industries to fill technology gaps and/or capture technology related opportunities. This guide focuses on this type of roadmapping. Product level roadmaps provide business managers with a comprehensive, long-range technology assessment of their future product needs. This type of roadmap provides a complete description of the product line, division or operating group of an organization. Industry Technology Roadmaps can be either is forward or backward looking. Backward roadmapping, or "customer needs'; approach, is preferred by firms and industries that are market-driven and interact closely with customers. Industries that are largely technology-driven are more likely to use forward roadmapping, or a "technology push" approach, and often set their own targets based on scientific knowledge.

Backward Roadmapping involves finding out how to reach a given target set by the marketplace. This could be a business goal, product, process and fulfillment of a legislative requirement or a technology. Forward Roadmapping is the process of building upon existing technologies until new targets appear. It aims to evaluate the potential of a given technology by considering the possibilities for the satisfaction of future needs.

[2] This and next subsection are mainly based on [5].

3.1.5 Roadmapping Techniques

Participants can also employ different techniques to develop a roadmap. Roadmaps can be constructed by:

- Expert based Approach: A team of experts comes together to identify the structural relationships within the industry and specify the quantitative and qualitative attributes of the roadmap.

- Workshop based Approach: This technique is used to engage a wider group of industry, research, academic, government and other stakeholders to draw on their knowledge and experiences.

- Computer Based Approach: Large databases are scanned to identify research, technology, engineering and product areas of relevance. High-speed computers, intelligent algorithms and other modeling tools can assist to estimate and quantify the relative importance of these areas and to explore their relationships to other fields. This approach is in its infancy, as large textural databases and efficient information-extracting computational approaches have only begun to emerge.

3.1.6 Process for Roadmapping

The process of roadmapping should be customized according to different objectives, different organizational culture, and so on.

Fig. 3.1 gives the key steps or decision points in producing a technology roadmap.

Dr. Rob Phaal, a professor in University of Cambridge, put forward a very practicable process for roadmapping which is called T-Plan[14, 15]. The standard process of T-Plan includes the following four workshops.

Figure 3.1: Producing a Technology Roadmap [5].

1. **Workshop 1: Market.** In this workshop, the following items or issues will be identified:

   - Performance dimensions
   - Market/business drivers
   - Prioritization
   - SWOT
   - Gaps

2. **Workshop 2: Product.** In this work shop, the following items or issues will be identified:

   - Product feature concepts
   - Grouping
   - Impact ranking
   - Product strategy
   - Gaps

3. **Workshop 3: Technology.** In this work shop, the following items or issues will be identified:

   - Technology solutions
   - Grouping
   - Impact ranking
   - Gaps

4. **Workshop 4: Roadmapping.** In this work shop, the following items or issues will be identified:

- Linking
- Gaps

Fig. 3.2 gives a typical roadmap produced by T-Plan.

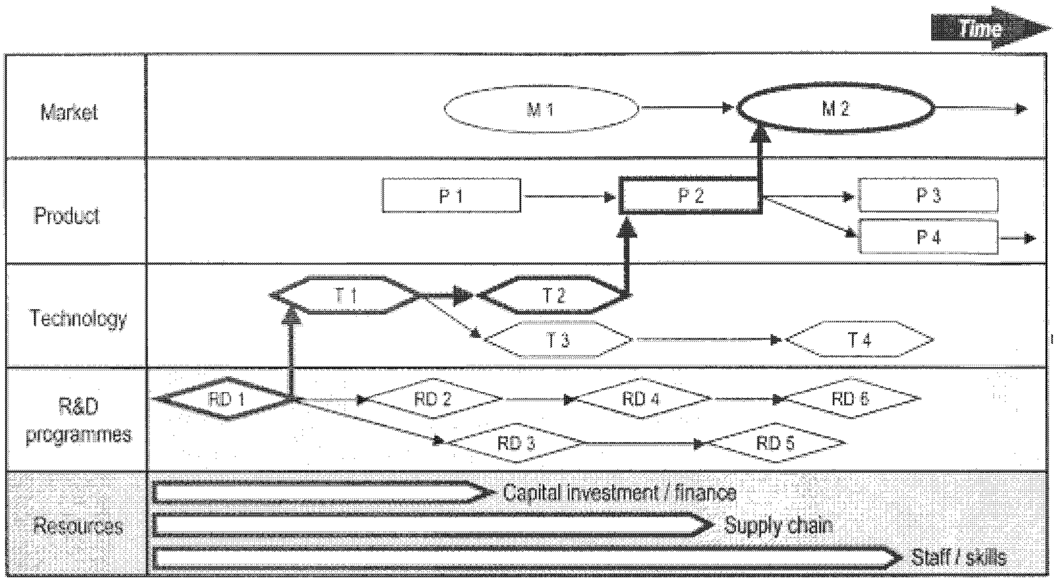

Figure 3.2: A typical roadmap produced by T-Plan [5].

3.1.7 The Difference between Technology Roadmapping and other Technology Planning

Technology roadmapping promotes enhanced collaboration, sharing of knowledge and reduces the risks of investing in technology.

Technology roadmapping differs from other technology planning - it is led by industry and driven by market needs. Technology roadmapping can be confused with methods of technological forecasting, such as scenario planning, trend extrapolation and historical analogy. These approaches aim to make projections of technological capabilities and predict the invention and diffusion of technological innovations into the future [17]. Similarly, Technology Foresight aims to identify new areas of science and technology research over an extended period of time. Roadmaps differ from these methods in one important respect. Unlike some methods where the end-point is forecast, the roadmap process starts with the end-point or vision clearly in mind and then traces the alternative technology paths to achieve it [18]. Roadmapping is a tool for companies to predict future market demands and to determine the technological processes and products required to satisfy them. This process is unique in that it encourages firms, R&D organizations, governments and industries to develop a shared vision of the future and explore the opportunities and pathways to achieve it [5].

3.2 Personal Academic Research Roadmaps

3.2.1 Application of Roadmapping in Academic Institutions

As a strategic planning tool, roadmapping techniques have been used in academic institutions. Many academic institutions publish their research roadmaps, for example, the Berkerley Lab in University of California make and publish a research roadmap for High-performance data centers [19]. As organizations, academic institutions also face the same problems as enterprises face: Where are we now? Where do we want to go? And how can we get there? In this sense, the application of roadmap in academic institutions is very naturally, and the roadmap techniques developed for industry can easily be adapted for academic purpose.

3.2.2 Individual Researcher's Roadmap

Roadmapping is also very helpful for any individual researcher. For a refresh man in a graduate school or any other researcher who want to start a new research project, he/she has to identify the answers to the three questions: Where am I now? What do I want to go? And how can we get there? Without a good plan, individual researchers may waste a lot of time and resource doing useless things. Individual researchers need a strategic plan for his/her research activity. A personal research roadmap will be very helpful in the following aspects.

- It can make researchers to clearly understand what are the bases of his/her research (where he/she is now), what kind of results his/her research aims to get (where he/she wants to go), and what activity he/she should do (how he/she can get there).

- It can promote the communication among researchers, especially in a research group or in a same lab. As Edward mentioned[7], roadmaps are also communication tools, not just planning tools. Sometimes academic researchers need to work on a same big project, roadmaps can make clear every researcher's role in the project.

- It is helpful for supervisors to understand each researcher's progress. In a personal roadmap, there are milestones of the researcher's research activity, thus it is easy for supervisors to know what the researcher has done, what he/she is doing, what he/she will do, and when and how.

Little work has been done considering every individual researcher's roadmap. This thesis will put forward a process of making personal research roadmaps by applying interactive planning method that will be introduced in the next section.

3.2.3 The Contents and Format of Personal Academic Research Roadmaps

The contents and format of personal academic research roadmaps in this thesis follows the ATRM (academic technology roadmap) model put forward by Okutsu [12]

There are five blocks in the ATRM model, as shown in Fig. 3.3.

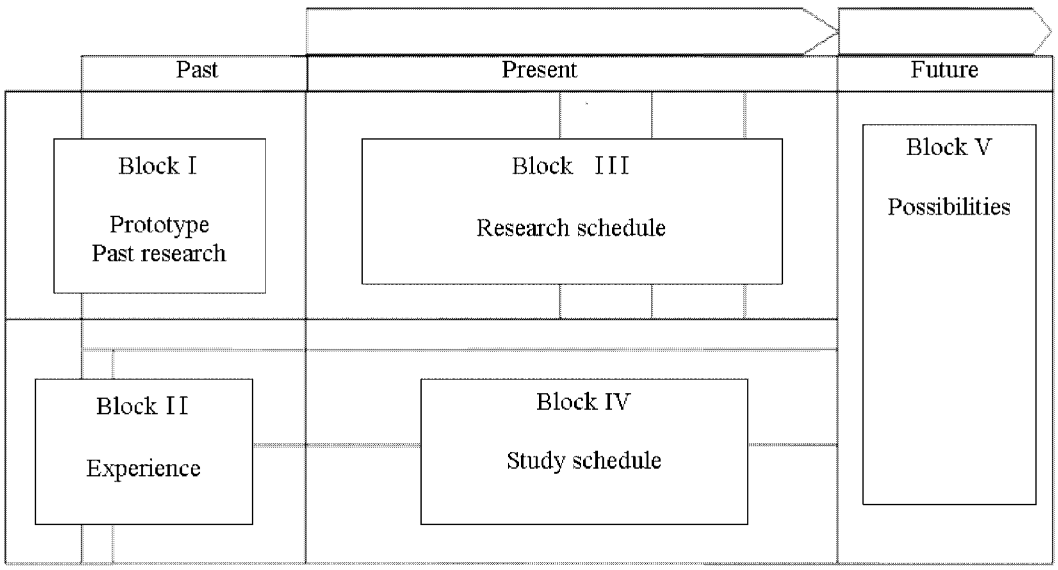

Figure 3.3: A personal research roadmap's format and contents.

- **Block I: Prototype or past research** –This describes what the researcher want to focus on and what is the current status about the research object.

- **Block II: Experience** – This describes what kind of skill/knowledge the researcher already have.
- **Block III: Research schedule** –This describes what research projects will the researcher do and the schedule and milestones of doing those projects.
- **Block IV: Study schedule** –This describes what kind of skills and knowledge will the research study for fulfilling its research plan.
- **Block V: Future possibilities** – This describes what kind of future work can be done after finishing the research schedule in block III, and what kind of future achievements can be obtained.

Chapter 4

Interactive Planning (IP) and Its Use in Personal Academic Research Roadmapping

4.1 Interactive Planning (IP)

[1]

4.1.1 Introduction

Interactive planning differs significantly from two more commonly used types of planning: reactive and proactive.

Reactive planning is tactically oriented; bottom-up planning that consists of identifying deficiencies in an organization's performance and devising projects to remove or reduce them one by one. It is deficient in two ways. First, it is dedicated to removing deficiencies. Unfortunately, when one gets rid of what one does not want, one does not necessarily get what one does want, and may get something much worse. Second, it deals with the parts of the organization separately despite the fact that the performance of the

[1] This section is mainly based on Ackoff's Brief Guide to Interactive Planning and Idealized Design[4] and Robert's book named Creative Problem Solving[8].

organization and its parts depend more on how the parts interact than on how they act independently of each other.

Proactive planning is strategically oriented; top-down planning that consists of two major activities: prediction and preparation. It is based on the assumption that although the future is essentially uncontrollable, with good forecasting an organization can control, at least in part, the effects of that future on the organization. Therefore, proactive planning is concerned with planning for the future, not planning the future itself. And the future(s) it plans for are bound to be different than anticipated in significant ways. For this reason very few proactive plans are carried out to completion.

Interactive planning is directed at creating the future. It is based on the belief that an organization's future depends at least as much on what it does between now and then, as on what is done to it. Therefore, this type of planning consists of the design of a desirable present and the selection or invention of ways of approximating it as closely as possible. It creates its future by continuously closing the gap between where it is at any moment of time and where it would most like to be.

4.1.2 Principles of IP

IP has three important principles, participative, continuity and holistic.

The participative principle rests upon two connected ideas in Ackoff's thought. The first is that the process of planning is more important than the actual plan produced. It is by being involved in the planning process that members of the organization come to understand the organization and the role they can play in it. It follows, of course, that no one can plan for anyone else-because this would take away the main benefit of planning. The second idea is that all those who are affected by planning should be involved in it. This is a moral necessity for Ackoff, but it also stems directly from the philosophical argument that objectivity in social systems is “value full”. The participative principle states, therefore, that all stakeholders should ideally participate in the carious stages of the planning process.

The second principle is that of continuity. The values of the organization’s stakeholders will change over time and this will necessitate corresponding changes in plans. Also, unexpected events will occur. The plan may not work as expected, or changes in the organization’s environment may change the situation in which it finds itself. No plan can predict everything in advance, so plans, under the principle of continuity, should be constantly revised.

The final principle is the holistic principle. We should plan simultaneously and interdependently for as many parts and levels of the “system” as is possible. This can be split into: (a) a “principle of coordination”, which states that units at the same level should plan together and at the same time-because it is the interactions between units rather than their independent actions which give rise to most difficulties; and (b) a “principle of integration”, which insists that units at different levels plan simultaneously and together, because decisions taken at one level will usually have effects at other level as well.

4.1.3 Five Phases of IP

There are five phases of interactive planning. These, however, must be regarded as constituting a systemic process, so the phases may be started in any order and none of the phases, let alone the whole process, should ever be regarded as completed. The five phases are:

1. Formulating the mess
2. Ends planning
3. Means planning
4. Resource planning
5. Design of implementation and control.

Formulating the Mess

During this stage problems, prospects, threats and opportunities facing the organization are high lightened. A recommended way of doing this is to work out the future the system is currently in. This is a projection of the future that the organization would be faced with if it did nothing about things, and if developments in its environment continued in an entirely predictable way. Such a projection requires, according to Ackoff, three types of study:

- Systems analysis-giving a detailed picture of the organization and how it works, who it affects and how, and its relationship with its environment;
- An obstruction analysis-setting out any obstacles to corporate development;
- Preparation of reference projections-which extrapolate on the organization's present performance in order to predict future performance if nothing is done and trends in the environment continue as now.

Synthesizing the results of these three types of study yields a reference scenario, which is a formulation of the mess the organization is currently in.

Ends Planning

Ends planning concerns specifying the ends to be pursued in terms of ideals, objectives and goals. The process begins with "idealized design", which is both the most unique and most essential feature of Ackoff's approach. An idealized design is design for the organization that the relevant stakeholders would replace the existing system with today if they were free to do so. An idealized design is prepared by going through three steps:

- Selecting mission-which is a general-purpose statement incorporating the organization's responsibilities to its environment and stakeholders, and propounding a vision of what the organization could be like which generates commitment;

- Specifying desired properties of the design-a comprehensive list of the desired properties stakeholders agree should be built into the system;

- Designing the system-setting out how all the specified properties of the idealized design can be obtained.

It is desirable to go through these steps twice to prepare two idealized designs-one constrained assuming no changes in the wider containing "system", the other unconstrained (i.e. with changes in the containing system allowed). If the differences between the two versions are great, then the organization will clearly have to concentrate much effort in bringing about changes in the so-called "wider system" during the rest of the planning process.

Idealized design is meant to generate maximum creativity among all the stakeholders involved. To ensure this, only two types of constraint upon the design are admissible. First, it must be technologically feasible, not a work of science fiction. It must be possible with known technology or likely technological developments; but it should not for example, assume telepathy. Second, it must be operationally viable. It should be capable of working and surviving if it were implemented. Constraints of a financial, political or similar kind are not allowed to restrict the creativity of the design.

Ackoff is equally clear that the aim of idealized design is not to produce a Utopia that specifies what the "system" should be like for all time. This would not be sensible since the values of stakeholders, and what they hold to be ideal, are bound to change. Hence they should be able constantly to modify the "system". Nor would utopia be possible, because the designers will not have at their disposal all the information and knowledge necessary to resolve some important design issues or to predict the state of the organization's environment far into the future. For all these reasons, it is essential that the designed system be capable of rapid learning and adaptation. It must be highly flexible and be constantly seeking to improve its own performance. In short, what is intended is the design of the best "ideal-seeking system" that the stakeholders can imagine. This will certainly not be static, like a utopia, but will be in constant flux as it responds to changing values, new knowledge and information, and buffeting from external forces.

An "ideal-seeking system" obviously requires a very particular kind of organizational design, capable of rapid and effective learning and adaptation. Ackoff, in fact, supplies an outline for such a "responsive, decision system". This contains five essential functions:

- Identification and formulation of problems (threats and opportunities);
- Decision making-determining what to do about the threats and oppor-

tunities;

- Implementation-doing it;
- Control-monitoring performance and modifying actions to prevent repetition of any mistakes;
- Acquisition or generation, and distribution of the information necessary to carry out the other functions.

There are further recommendations in Ackoff's work about the design of appropriate management information systems about issues of organizational structure (e.g. centralization versus decentralization) and, as we have seen, on how to achieve a participative organization.

Those organizations willing to undertake idealized design should, according to Ackoff, reap considerable benefits. In particular, the process is said to:

- Facilitate the participation of all stakeholders in the planning process;
- Allow incorporation of the aesthetic values of the stakeholders into planning;
- Generate a consensus among those who participate;
- Release large amounts of suppressed creativity and harness it to individual and organizational development;
- Expand participants' concept of feasibility, revealing that the biggest obstruction to the future we most desire is ourselves;
- Ease implementation, since people are more inclined to implement plans in which they have a say.

Means Planning

The output of Stage 1 of interactive planning was a reference scenario; setting out the future the organization is currently locked into if it does nothing and if the environment does not change its behavior drastically. The output from Stage 2 was an "idealized design" setting out in detail the future the organization would like to have. During Stage 3, means planning, policies and proposals are generated and examined with a view to deciding whether they are capable of helping to fill the gap between the desired future and the way the future looks like being at the moment. Creativity is needed to discover ways of bringing the organization towards the desirable future invented by its stakeholders. Alternative means to reach the specified ends must be carefully evaluated and a selection made.

Resource Planning

During this stage of planning, Ackoff recommends that four types of resource should be taken into account:

- Inputs-materials, supplies, energy and services;
- Facilities and equipment-capital investments;
- Personnel;
- Money.

For each type of resource, questions have to be asked in relation to the chosen means. For example, it must be determined how much of each resource is required, when it will be required, and how it can be obtained if it is not already held.

Design of Implementation and Control

This "final" phase of interactive planning concerns itself with seeing that all the decisions made hitherto are carried out. "Who is to do what, when, where and how?" is decided. Implementation is achieved and continually monitored to ensure that plans are being realized and that desired results are being achieved. The outcome is feedback into the planning process so that learning is possible and improvements can be devised.

4.2 IP and Roadmapping

The five phases of IP can be clearly mapped to the three important problems that roadmapping aims to answer. The first phase of IP, namely "formulating the mess", in fact tries to solve the problem "where are we now"; the second phase of IP, namely "ends planning", corresponds to the problem "where do we want to go"; and the rest three phases of IP - "means planning", "Resource Planning" and "Design of Implementation and Control" – are for solving the problem "how can we get there". Fig. 4.1 shows the relationship between IP and the three important problems which roadmapping aims to solve.

The new methodology for MOT in academy presented in this thesis is an integration of IP and roadmapping. In the following section, a detail description of process of the new methodology will be given.

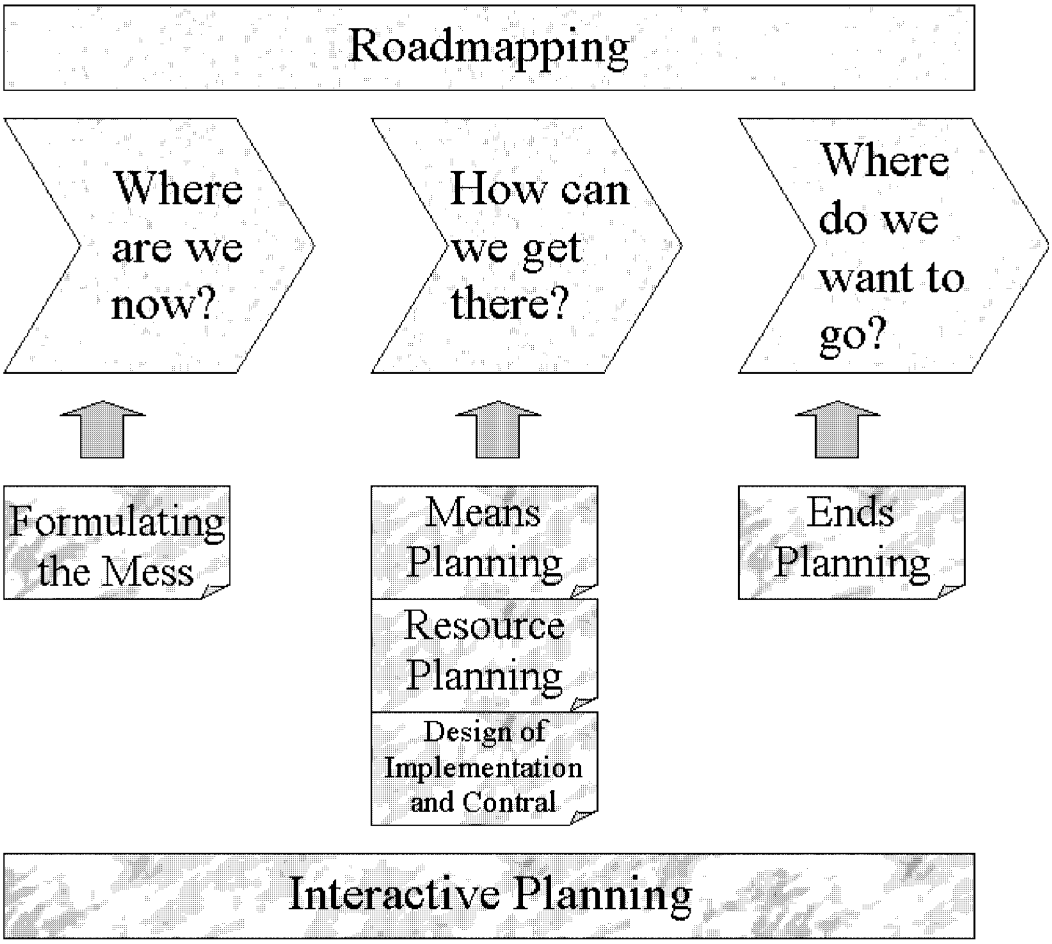

Figure 4.1: IP and Roadmapping.

4.3 A New Methodology for MOT in Academy by Integrating IP and Roadmapping

This new methodology has six phases with some cycles among those phases. The following is the description of those phases.

- **Phase 1: Forming groups**

  The new methodology suggests that the roadmapping be a team work. This accords with the "participative" principle of IP. Groups can be formed inside single labs, and it is also suggested that a group be composed of different researchers from different labs, even different field. Two kinds of members must be included in a group. The first is experienced researchers, for example, professors, associate professors and so on. It is not necessary to have too many experienced researchers, but at least one. The second is knowledge coordinators. Knowledge coordinators mean those people who can manage creative research activities based on the theory of knowledge creation [11, 13]. Knowledge coordinators can be master students, doctor students or any other people who have the ability to be knowledge coordinators. Commonly one group needs one or two knowledge coordinators. For the effective communication among every group members, the number of members in a group should not be too large. Also if the number of members is too small, it will be not good for knowledge sharing and knowledge acquisition. The author suggests a group with number range from 6 to 12.

- **Phase 2: Explanation form Knowledge Coordinators**

For applying the methodology smoothly, at first, the knowledge coordinator needs to explain the following things to all group members.

- The role of every member;
- The conception, purpose and importance of MOT in academy;
- The usage of personal research roadmap;
- The contents and format of a personal research roadmap;
- the process of making personal research roadmap;
- The schedule of the group's roadmapping activity.

Totally the explanation should make every member know what's the aim of the group, what should he/she do, and when, where and how. During the explanation, any member is encouraged to ask questions that he/she is not clear.

- **Phase 3: Description of present situation**

In this phase, the experienced researchers give a description of present situations that include:

- Basic knowledge in this research field;
- The leading groups/labs over the world in the research field;
- List of journals related to this field;
- The common equipments needed in this field;
- Any other information and knowledge which is helpful for members making their research roadmap.

In fact, it is very difficult to explain all those information in one time. So this phase commonly includes several workshops.

- **Phase 4: Every member's current status and idealized design**

  In this phase, firstly, every member need to list his experience, this means what kind of skill/knowledge he/she already have. The list should be open to every group member, so that they can give their good opinions and ideas in the later discussion. Every member's list of skill/knowledge should be documented as in Block II in the formatted roadmaps (Fig. 3.3) introduced in Chapter 3. For this part, commonly a researcher or student can do it by himself/herself. Then each member identifies his/her prototype of his/her research issue and summarizes the current research on the issue. This part should be documented in the Block I in Fig. 3.3. From the viewpoint of IP this and the Phase 3 are "Formulating the Mess". In this process, member can share their knowledge and experience by discussing with each other.

  By using IP's idealized design, every member describes his/her research goals. Each member is encouraged to generate maximum creativity. Each member's idealized design will be discussed by the whole group, and each member the can refine, modify his/her idealized design according to whole group's knowledge.

  The future possibility (Block V in Fig.3.3) can also be identified in this phase by discussion.

  In this phase, the knowledge coordinator(s) of the group need to arrange several workshops until each member's idealized design is passed by all (or most of) the members.

- **Phase 5: Research schedule and study schedule**

  By Phase 4, two problems of roadmapping have been solved, which means each member now know where he/she is and where he/she wants to go. Now it's time to solve the problem how to get there.

  In this phase each member put forward his/her research schedule (Block III in Fig.3.3) and study schedule (Block IV in Fig.3.3) which can fulfill his/her research goal and present it to all group members. It is also that a member can present more than one options. After getting opinions and ideas from group members, each member can refine and modify his/her research schedule and study schedule.

  The same as in the Phase 4, the knowledge coordinator(s) of the group need to arrange several workshops until each member's research schedule and study schedule are passed by all (or most of) the members.

  This phase is corresponding to "Means Planning" (research schedule) and "Resource Planning" (study schedule) of IP.

- **Phase 6: Implementation and Control** By Phase 5, each researcher's personal research roadmap is ready. Although many efforts have been paid for making a reasonable research roadmap, it is still a first-cut roadmap. It means the roadmap should be continuously refined in practice, which accords with the continuity principle of IP. And the knowledge coordinator(s) should arrange regular seminars, workshops to monitor and control the implementation of personal research roadmaps.

Fig. 4.2 shows the process of making roadmaps by using IP.

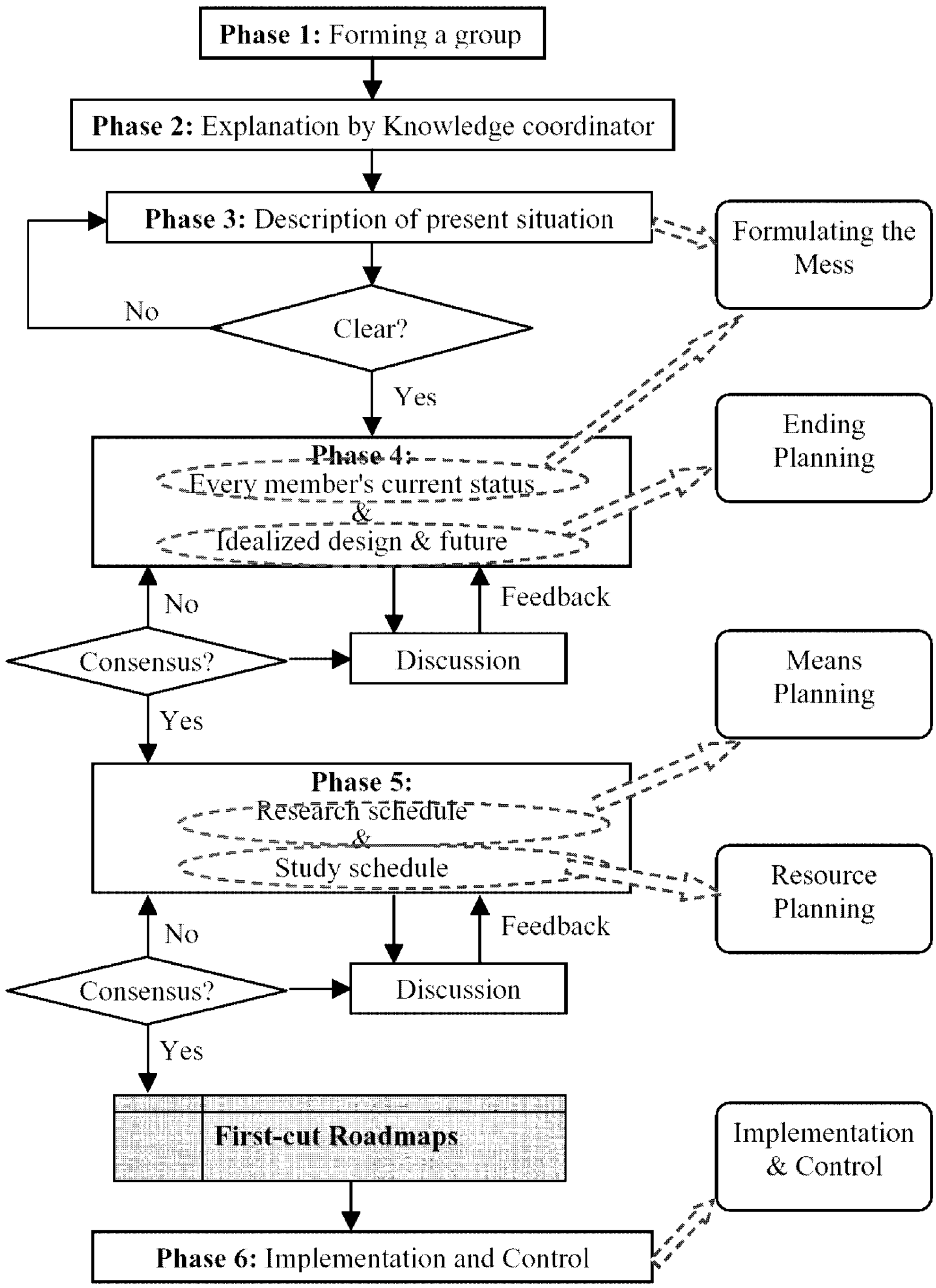

Figure 4.2: Process of Making Roadmaps by IP.

In the above narration, little attention has been paid to the holistic principle of IP. This principle is very important in case all the group members are working on a same project. In this case, it is necessary to make different roadmaps with hierarchy. That is to say, the group needs to make different level roadmaps as shown in Fig. 4.3. The lower level roadmaps should obey its up-level roadmap.

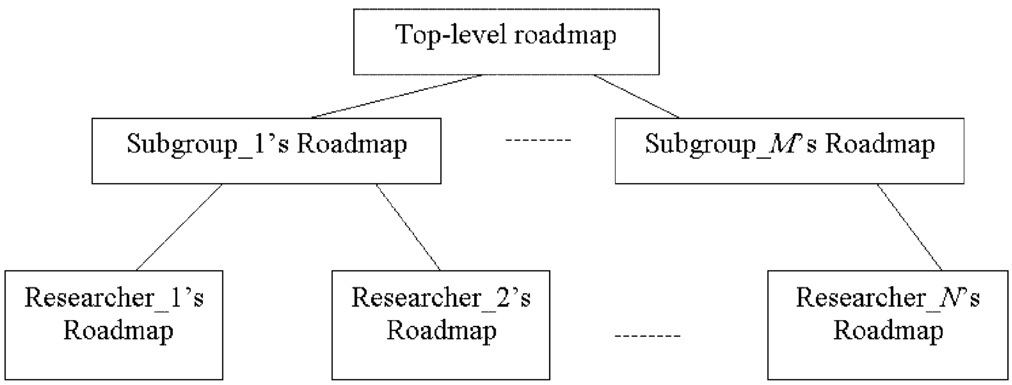

Figure 4.3: Interface for selecting language.

Chapter 5

Application of the Methodology

In this chapter, the application of the methodology in Nakamori Lab (School of Knowledge Science, Japan Advanced Institute of Science and Technology) will be introduced. In the following, the application will be introduced according to the six phases put forward in Section 2 of Chapter 4.

5.1 Phase 1: Forming a group

JAIST (Japan Advanced Institute of Science and Technology) started a 21st century COE program from October 2003, led by Prof. Nakamori. This program will establish an interdisciplinary research field called the **Study of Scientific Knowledge Creation**. The new research field of Knowledge Science is the basis of this program, which models the process of knowledge creation and supports knowledge management [11, 13].

Several doctor students and researchers will do their research within the framework of the COE program. And the main purpose is to develop the lab knowledge management theory and system. But they have little ideas about where they should start, and where they aim to go and how they can reach their goals. Making their personal roadmaps is very important and very helpful for their research work.

One aim of this program is to provide support to those researchers in School of Material Science, JAIST. So when forming the group, several students and researchers from School of Material Science and School of Information Science was invited as consultants.

Table 5.1 shows the members of the group and their responsibilities in the group.

Table 5.1: Group Members and Their Reponsibility

Name	Responsibility	Title	School of
Y. Nakamori	General Leader	professor	Knowledge Science
T. Ma	Group Leader	postdoc	Knowledge Science
S. Liu (Author)	Knowledge coordinator	M2	Knowledge Science
W. Huang	member	D2	Knowledge Science
J. Yan	member	D1	Knowledge Science
J. Tian	member	D1	Knowledge Science
B. Liu	consultant	associate	Material Science
D. Zhou	consultant	D2	Material Science
M. He	consultant	D2	Material Science
Y. Fang	consultant	D1	Material Science
B. Lu	consultant	D1	Material Science
L. Xue	consultant	D0	Material Science
J. Xiang	consultant	D2	Information Science

In Table 5.1, M2 means a master student in second year; D1 (2) means a doctor student in first (second) year; and D0 means a research student who will enter doctor course. The aim of the group is to making personal research roadmap of Dr. Ma, Mr. Huang, Ms. Yan and Ms. Tian.

5.2 Phase 2: Explanation by Coordinators

A workshop was hold, and in this workshop, the author, who act as the knowledge coordinator, explained the following issues:

- what is MOT?
- Why MOT is important in academy?
- What is roadmapping?
- Why do we need roadmapping?
- What is a personal roadmap? (The Fig. 3.3 was shown to every member.)
- What is Interactive Planning?
- The process of making personal roadmaps.
- The action schedule of the group.

In this workshop, members asked questions where they didn't clear and shared opinions and ideas of roadmapping.

5.3 Phase 3: Description of Present Situations

Before the group was formed, several workshops about COE program had been held, and the COE leader Prof. Nakamori explained in detail about the COE program during those workshops. So in this phase, two workshops were held. In the first workshop, Dr. Ma, who serve as the group leader, gave a simple description of the COE program mainly for those members came from the School of Material Science and the School of Information. Then a brainstorming was carried out with the topic “what kind of support is needed for supporting scientific research”. Many ideas were got by brainstorming, all those ideas were classified into four groups, which are:

- Support for research planning;
- Support for doing experiments;
- Support for writing papers;
- Support for promoting communications.

After summarizing those ideas, another workshop was held to see what kind of work could be done according to those ideas.

The report of those two workshops, provided by Dr. Ma, can be seen in the Appendix A of this thesis.

5.4 Phase 4: Every member’s current status and idealized design

In this phase, firstly every member wrote out what kind of skill/knowledge he/she already held. It is not necessary to have much discussion on this because every member knew what he had learnt.

Then every member wrote out his/her research topic and what kind of models and work had been done related to this research topic. Other members gave suggestions, opinions and additional knowledge related to this research topic. For deciding every member’s research topic, two intensive seminars were hold, and finally every member’s research topic was passed by the group. For instance, Dr. Ma’s research roadmap by now is shown in Fig. 5.1

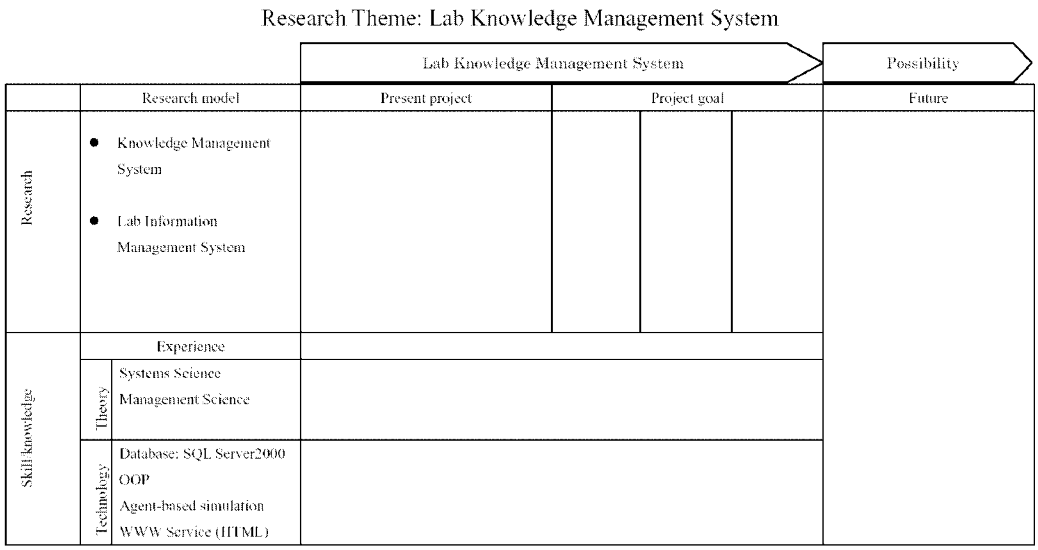

Figure 5.1: Dr. Ma’s research roadmap–with research topic, research models and experience.

After every member had their topics, research models and experience, they began to consider their goals by idealized design. And every idealized design was discussed in seminars (here another two seminars was held). And finally every member decides his or her goals. For instance, Dr. Ma’s roadmap now become that in Fig. 5.2.

5.5 Phase 5: Research Schedule and Study Schedule

By phase 4: those members who wanted to make their personal roadmaps had clearly where they were and where they wanted to go. In this phase, the problem “how can they get there” should be solved.

Research Theme: Lab Knowledge Management System

		Lab Knowledge Management System				Possibility
	Research model	Present project	Goal			Future
Research	● Knowledge Management System ● Lab Information Management System		Online Web-based Friendly interface Intelligence (searching., analysis & automatic report)	Easy sharing, acquisition of: Background Knowledge News Any useful information	Easy sharing, acquisition of literature within research group and comments.	Institution (University) Level Knowledge base (Data Warehouse) Web-based Mining Literature Mining
Skill/knowledge	Experience	Additional knowledge/skill				Theory of Knowledge Creation
	Theory: Systems Science Management Science					
	Technology: Database: SQL Server2000 OOP Agent-based simulation WWW Service (HTML)					

Figure 5.2: Dr. Ma's research roadmap–adding goals and future possibility.

Three seminars were hold in this phase. Every member was required to write out his/her research schedule and study schedule before the first seminar and presented in the first seminar. Other members gave their comments and ideas about the research schedule and study schedule, and then the owners of those schedules will modify their schedule according to those opinions. Such things repeated in the following two seminars. After the three seminars, we found consensus appeared about the seminar, so no additional seminars in this phase were carried out. Fig. 5.3 was a fulfilled roadmap of Dr. Ma. For showing it in a page, there is no detailed schedule in the roadmap, which should was documented in other files

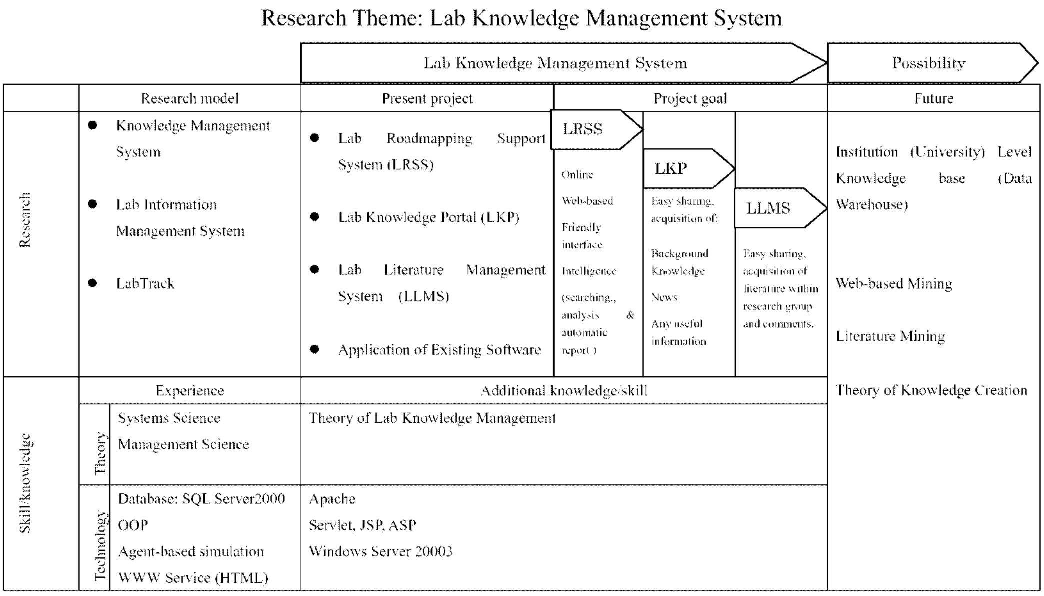

Figure 5.3: Dr. Ma's research roadmap–fulfilled.

5.5.1 Phase 6: Implementation and Control

After finishing a personal roadmap, it is the researcher's responsibility to implementate it. During the process of implementation, the researcher may adapt his/her roadmap according to some special situations. As a strategic planning, roadmapping is a never end process.

For control, the author suggested regular seminars and report to monitor how things going on.

5.5.2 Evaluation of Roadmaps

By now, there are no special measures to evaluate what is a good roadmap and what is a bad roadmap. It is up to the owner of the roadmap to decide whether the roadmap is good or bad. Another way for evaluating roadmaps is to see what kind of achievements is obtained by following the roadmap.

Similar to Ackoff's idea that the process of planning is more important than the actual plan produced, here the author would like to say that the process of roadmapping is more important than the roadmaps produced.

Let's see some comments from those who making their personal roadmap by using the methodology introduced in this thesis.

"In the process of roadmapping, little by little, I become to know what direction should I go. It's really helpful for my research." (Ms. Tian, a first year doctor student).

"I have done my research for PH. D. for one year, it makes me clear what I have done and what I should study and research next step by roadmapping, and it also makes me to realize the sense and future of my research." (Mr. Huang, a second year doctor student).

"I will continously refine my personal roadmap, not only for getting a better roadmap, but the process of making roadmap enable me to improve my research activity and lookout the future of my research. " (Dr. Ma, a postdoctoral researcher).

In a word, those who making and improving their personal roadmap feel they are more clear about where they are, where they want to go, and how they can reach there.

Chapter 6

A Roadmapping Support System

Knowledge Management, as a strategy, is independent of information technology. However, the appropriate information technology, applied judiciously to the proper phase of the knowledge life cycle, can significantly improve the efficiency and effectiveness of the KM process [6].

The system introduced in this chapter is expected to have the ability to support the roadmapping process introduced in previous chapters. The users of this system are supposed to be in the same lab (virtual or real) or in the same research group.

By now, we only developed a prototype of the system, but it can be used smoothly. More function will be added into the system in our future work. And for being a good system, it need to be continuously improved.

6.1 Introduction to the Interface and Functions of the System

6.1.1 Log in the System

The System provides both English and Japanese version. Before logging in, users can select which language he/she'd like to use. As shown in Fig. 6.1.

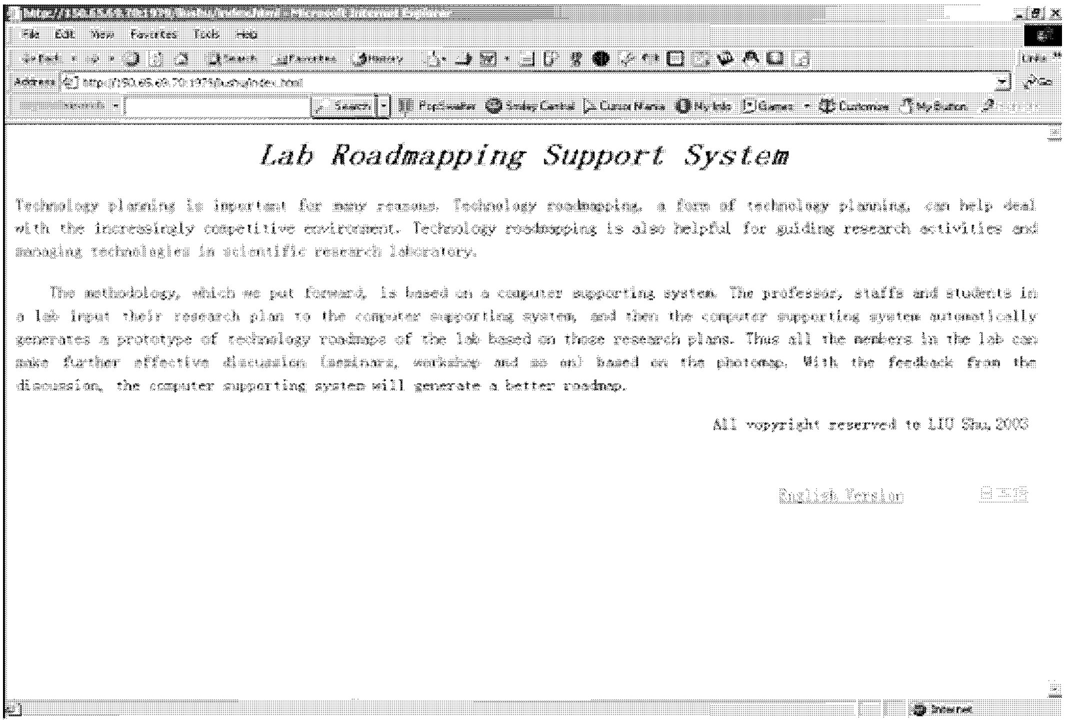

Figure 6.1: Interface for selecting language.

After selecting language, the system will ask users to input name and password (see in Fig. 6.2). The user name and password are administrated by an appointed person who is called the roadmapping system administrator of this lab. The administrator makes the list of names and password for each lab member and gives a user name the password to each user. As a prototype, the current system doesn't provide an interface for users to change their password; this function will be added in future work.

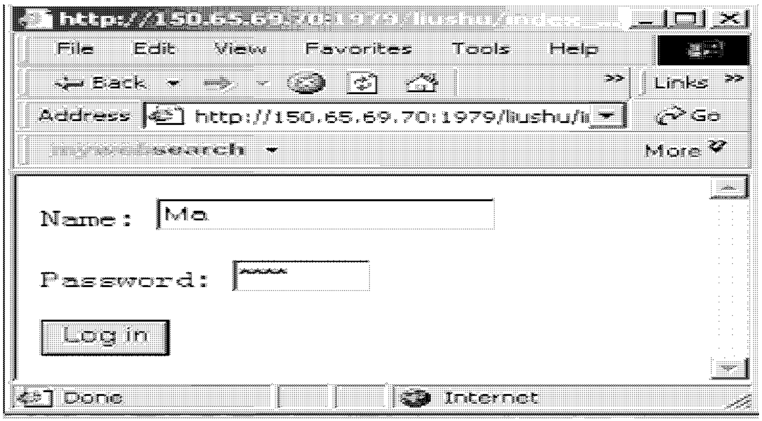

Figure 6.2: Interface for logging in.

After "login in", users can see what they have already input, as shown in Fig. 6.3. At the top of this interface, there are five hyperlinks, in the following; the functions linked to those hyper linkers will be introduced in detail.

6.1.2 Edit Research

The first hyperlink "Edit my research" provide the interface for users to input or edit the information needed for making their own research roadmap. That information includes:

- Experience (skill/knowledge) – list of the skill or knowledge the user have learnt or held.
- Research model – list of what the user's research will be focused on? And what is the current status in this research model?

- Present project – list of the projects the user is doing.
- Project goal – list of what the projects aims to. Here users need to input the schedule of their research plan:
  - Starting and ending time of each stage.
  - Each stage's aim.
  - Detailed description of each stage.
- Additional skill/knowledge – the skill/knowledge the user holds may be not enough for fulfilling the aim of the projects, so the user need to learn some additional skills and knowledge.
- Future possibilities – list of the future possibilities based on current project and research plan.
- Research topic – topic of the user's research.
- Abstract – if a user already have some ideas or already have some results of his/her research, he/she can input his/her research abstract here. Or as what is common doing in academy, the research plan can be write here as a short article.
- Keywords – list of keywords of the research.

Almost all the above items except "research topics" and "abstract" can include more than one records, for example, a user can input more than one experience. The system provides "add a new one" and "delete the last one" functions for users to increase or decrease the number of records for most of the items, as shown in Fig. 6.4 .

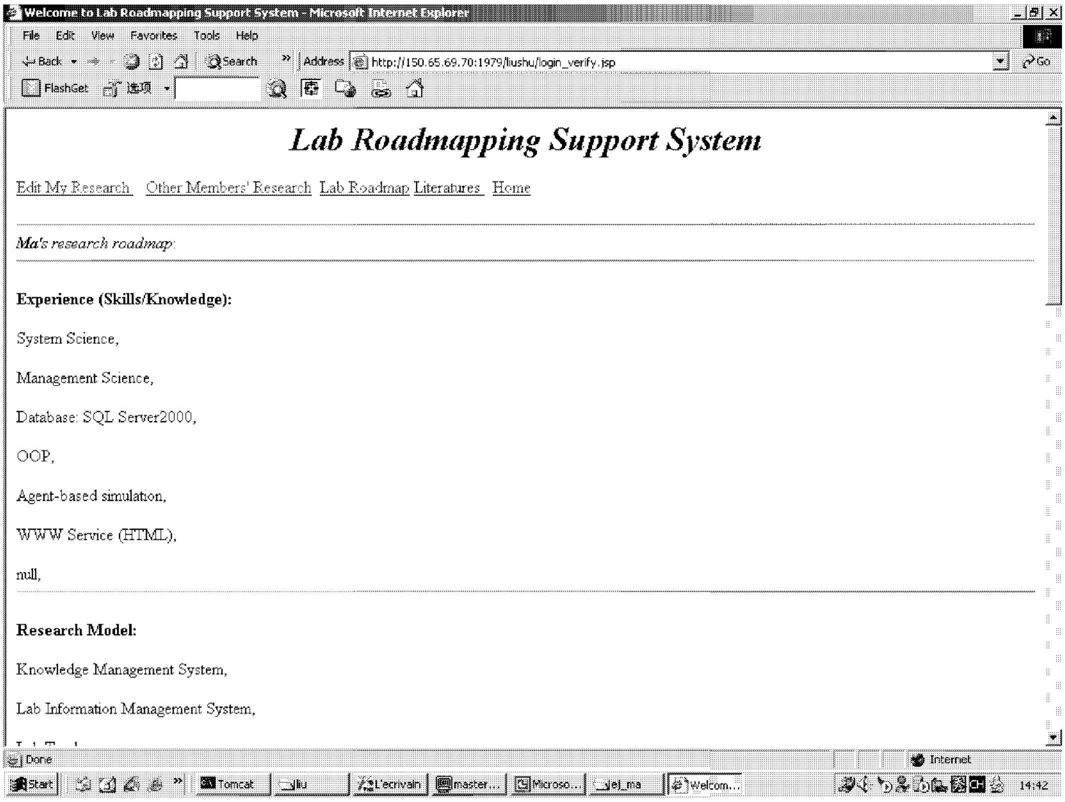

Figure 6.3: Interface for showing what the user have input.

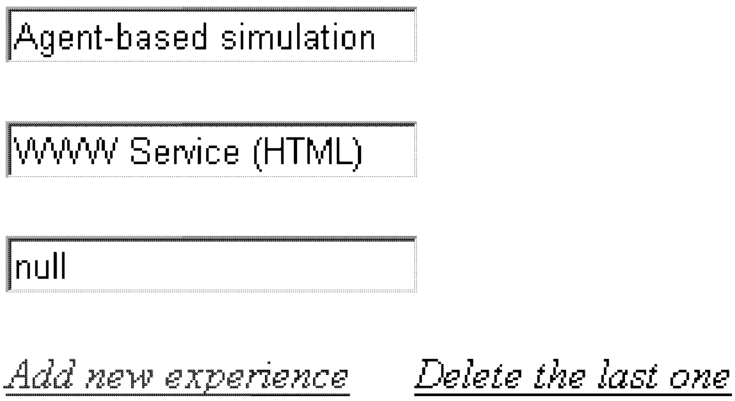

Figure 6.4: Interface for adding and deleting.

After finishing inputting and editing his/her information, the user needs to click the "submit" button for sending the information in a database.

6.1.3 View other members' research

We have argued the importance of the communication and cooperation among students/researchers in an academic lab or in a research group. So it make sense to let members know other members research plan. It will promote the understanding and cooperation among students/researchers. Viewing other members' research is especially for those who have just entered the lab or research group. It will make them to know what is the main topic in the lab, thus it can avoid them making a research plan unrelated to the alb. Viewing other members' research can also enable the director of the lab to control members' progress of research.

Clicking the "other members' research" at the top of Fig. 6.3, users can see a list of all other members in the lab, together with their research topics, as shown in Fig. 6.5. The detail of each member's research can be seen by clicking his/her name or topic.

6.1.4 RoadMaps

By clicking the "Lab Roadmap", users can see formatted roadmap of each member and the whole lab. The left part in Fig. 6.6 shows the name list of all the lab, while the right part shows the lab-level roadmap. In the lab-level roadmap, every member's research plan is denoted by a single line start from the center of the ellipse with his/her research goals at each stage being written on the line. The center of the ellipse denotes the current time while the outer of the ellipse means the future. The lab-level roadmap only

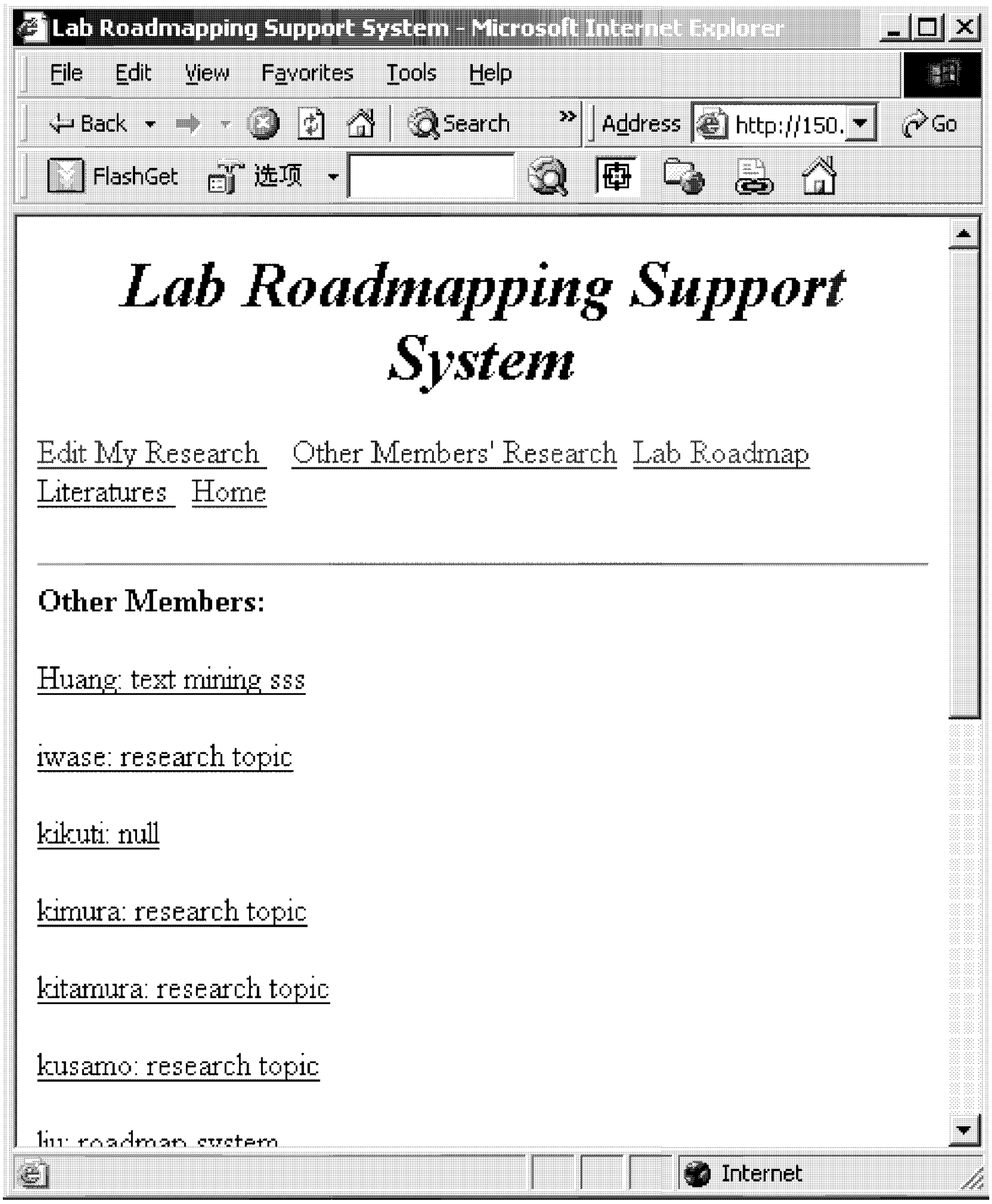

Figure 6.5: Links to other members' research.

provide a outline of each student's/researcher's research plan. By clicking the name in the list shown in the left part, users can see the detailed formatted roadmap, for example, by clicking name "Ma", the system will show Ma's formatted roadmap, as shown in Fig. 6.7.

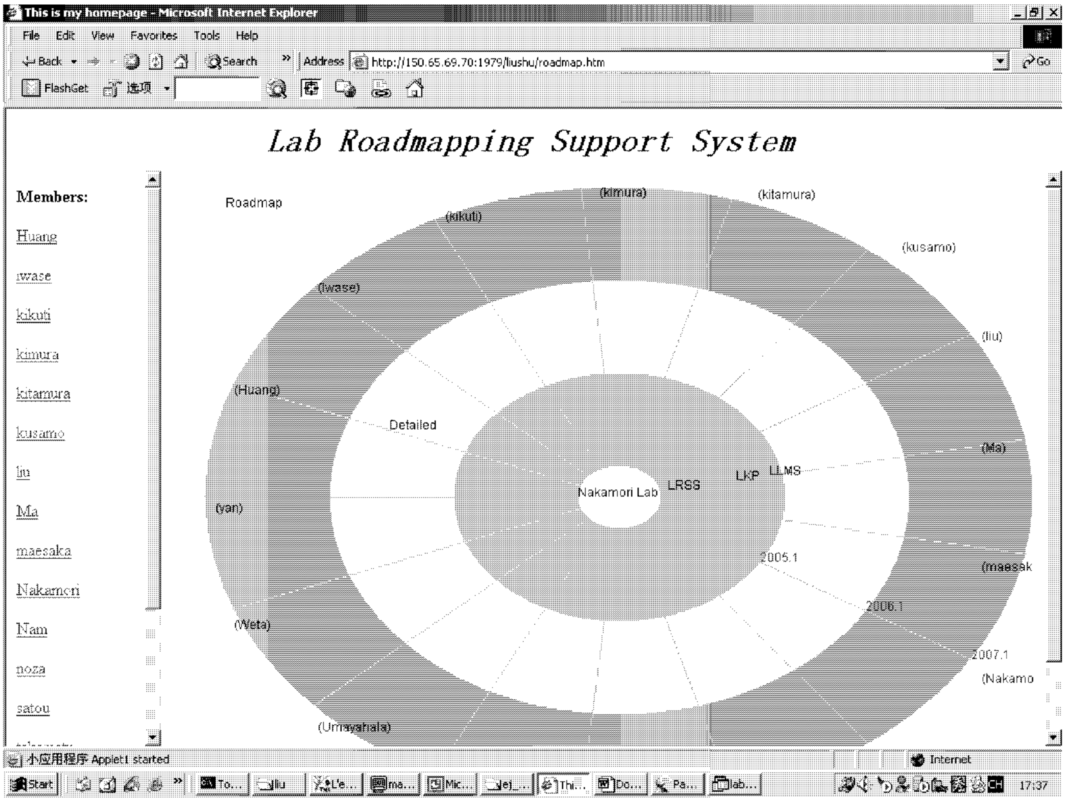

Figure 6.6: Lab Roadmap.

6.2 Techniques and Tools used for Developing the System

The system is a web-based system; users do not need to install special software in the client computer. They can use the system by browsers such as

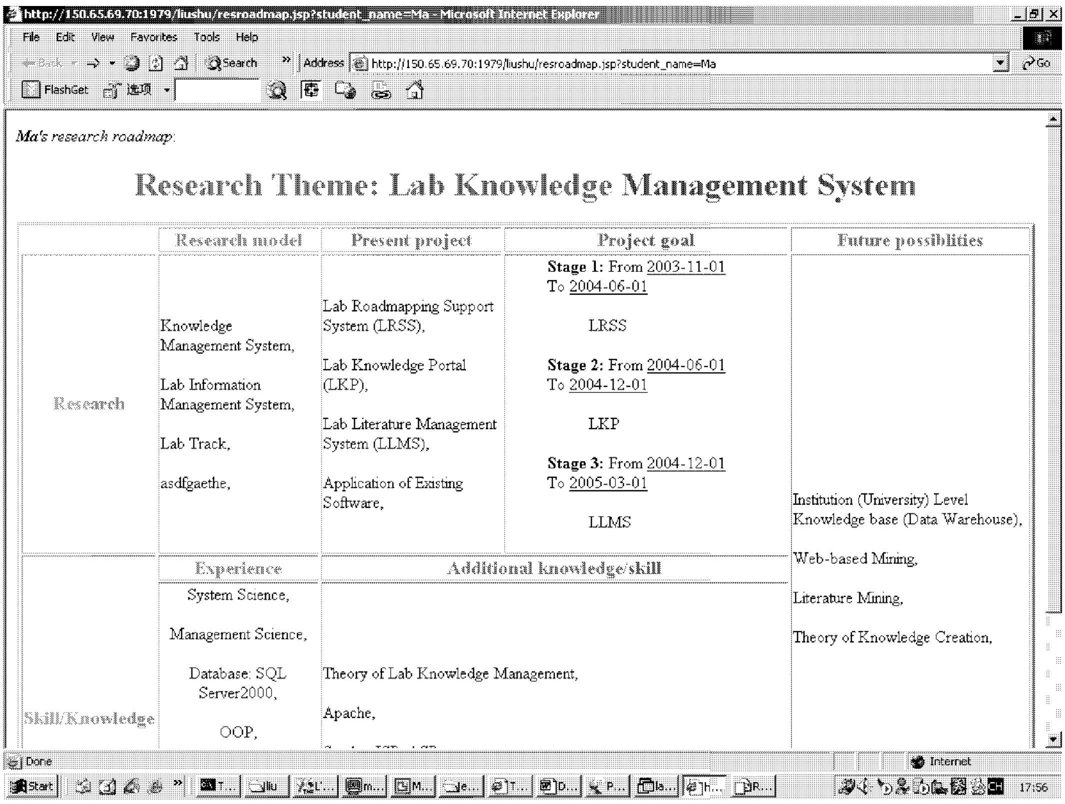

Figure 6.7: Formatted roadmap of Ma's research.

Internet Explorer or Netscape. The following is the main techniques used for developing the system:

- Tomcat 4.1. Tomcat is the servlet container that is used in the official Reference Implementation for the Java Servlet and Java Server Pages technologies. The Java Servlet and JavaServer Pages specifications are developed by Sun under the Java Community Process. Tomcat is developed in an open and participatory environment and released under the Apache Software License. To learn more about getting involved, click here.

- SQL Server 2000. SQL Server 2000 is a popular DBMS (data base management system) developed by Microsoft. It was used as a back-end database in the lab roadmapping support system.

- JSP (Java Server Pages). JavaServer Pages (JSP) technology enables Web developers and designers to rapidly develop and easily maintain, information-rich, dynamic Web pages that leverage existing business systems. As part of the Java technology family, JSP technology enables rapid development of Web-based applications that are platform independent. JSP technology separates the user interface from content generation, enabling designers to change the overall page layout without altering the underlying dynamic content.

- Java and Java Applet. Java is a programming language developed at Sun Microsystems in 1990. It was known and became popular on the WWW because Netscape Navigator 2.0 Adopted and supported Java applets in 1996. Applets are little programs written in Java language. They are designed to run inside a web browser and to perform some tasks such as animated graphics and interactive tools. For running the system, client users need to download some Java plug-in. But users don not have to worry about this, the system will atomically check if there is the right plug-in in client computers, if there is no, then it will automatically download. What users need to so be to allow their computer to download and install the plug-in.

6.3 Further Development of the System

Although the system introduced above can be used smoothly, it is only a prototype by now. For being a good system, it need to be improved continuously.

We didn't introduce the hyperlink "Literatures". We believe that literatures are very important for research. But how to design and develop the subsystem for managing literatures remains as the future work.

More intelligence is needed in the future development of the system. For example, after a user inputting his/information in the system, the system can tell the user who are also doing the similar work, and who maybe have the skill/knowledge that the user need to learn.

Chapter 7

Conclusion and Future Work

The thesis first pointed out the important of applying MOT into academy, then argued that roadmapping could be a way of MOT in academy.

After introducing technology roadmapping and Interactive Planning, this thesis put forward a six-phase process for making academic personal research roadmap by applying Interactive Planning, and the application of the methodology in Nakamori lab was described. Finally the thesis introduced a roadmapping support system that was developed by the author, together with Dr. Ma.

Based on the research introduced in this thesis, the future work can include:

- Doing more case studies about the methodology (learning by doing) and refine the methodology;
- Doing further development of the roadmapping support system. Currently, the roadmapping support system is only a prototype. With the support from 21st JAIST COE program, a powerful and intelligent system with friendly-interface will be developed.

- Building roadmap archives which will provide the source for data mining on roadmaps which can identify future trend.

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Bibliography

[1] R.L. Ackoff, Redesigning the Future, Wiley, New York, (1974).

[2] R.L. Ackoff, The Art of Problem Solving, Wiley, New York, (1978).

[3] R.L. Ackoff, Creating the Corporate Future, Wiley, New York, (1981).

[4] R.L. Ackoff, A Brief Guide to Interactive Planning and Idealized Design, (2001), available at: http://www.sociate.com/texts/AckoffGuidetoIdealizedRedesign.pdf.

[5] Australian guide to developing technology roadmaps-Technology planning for Business Competitiveness: A Guide to Developing Technology Roadmaps, Emerging industries occasional paper, (2001), available at: http://roadmap.ecn.purdue.edu/CTR/documents/13_Technology_Road_Mapping.pdf

[6] Bryan Bergeron, Essentials of Knowledge Management, Wiley, 2003.

[7] Edward J. Coyle, Technology Roadmapping at Purdue University, A presentation in Strategic Roadmapping Workshop, Japan Advanced Institute of Science and Technology, January 22-23, 2004.

[8] R.L. Flood and M.C. Jackson, Interactive Planning, Creative Problem Solving: total systems intervention, Wiley, Chapter 7, pp. 143-165 (1991).

[9] G.H. Gaynor, Management of Technology: Description, Scope, and Implications, Handbook of Technology Management, McGRAW-HILL, pp. 1.3-1.29 (1996).

[10] R.N. Kostoff and R.R. Schaller, Science and technology roadmaps, IEEE Transactions of Engineering Management, 48 (2), 2001, pp. 132-143.

[11] Y. Nakamori, Towards Supporting Technology Creation Based on Knowledge Science, Systems Science and Systems Engineering, ICSSSE'03, Global-Link Publisher, pp. 33-38 (2003).

[12] S. Okutsu, A Technology Management Methodology for Academic Science Engineering Laboratories by fusion of Soft System Methodology and Technology Road Mapping, Master thesis, Tokyo Institute of Technology (2002).

[13] Outline of The 21st century COE program in JAIST, available at: http://www.jaist.ac.jp/ks/labs/nakamori/coe/index.html

[14] R. Phaal, C.J.P. Farrukh, and D.R. Probert, T-plan: Fast Start to Technology Roadmapping-Planning Your Route to Success, Institute for Manufacturing, University of Cambridge, 2001.

[15] R. Phaal, Overview of T-Plan: The Fast-Start to Technology Roadmapping–planning your route to success, A presentation in Strategic Roadmapping Workshop, Japan Advanced Institute of Science and Technology, January 22-23, 2004.

[16] Bob Schaller, TECHNOLOGY ROADMAPS: Implications for Innovation, Strategy, and Policy, doctor dissertation, George Mason University Fairfax, VA, 1999.

[17] R.R. Schaller, op.cit.., 1999, p.9.

[18] R. Scheer, Presentation to Renewable Energy Technology Roadmap Workshops, Australia, May 2001.

[19] William Tschudi, Tengfang Xu, Dale Sartor, and Jay Stein, Roadmap For Public Interest Research for High Performance Data Center Buildings, available at: http://datacenters.lbl.gov/docs/ RoadmapFinal.pdf, University of California.

Appendix A

Lab Knowledge Management System (LKMS)

A.1 What kind of support is needed for scientific research?

This report is based on several formal and informal discussions among researchers and students in three schools of JAIST. Considering the research behaviors in labs of natural science composed of three phases-phase of planning, phase of doing experiments and phase of writing papers, in the following, we identified what kind of supports is needed and how those supports can be provided.

A.1.1 Support in Phase of Planning (deciding research topic)

- **Basic knowledge in this field.** It means what kind of background knowledge and skills is needed for research in the research field of the lab. It is mainly introduced by professors and experienced researchers in the lab. Students can upload their questions, and most common questions should be included in the list of Q&A.

- **Leading groups/labs over the world in this field and their research topics.** Any member can provide the links or other information of groups or labs that he/she thinks is very famous in this field.
- **List of journals related to this field (level, difficulty, how long, etc).** Links, comments and news of those Journals.
- **Links to good websites related to this field**
- **The current status in this field** Mainly described by professors and experienced researchers in the lab, but any member can upload comments and news about the field.
- The common equipments needed in this field, and how to get those equipments. Mainly provided by the person (mainly the associate) who is in charge of the management of equipments. A Q&A is also needed here based on any member's question and answer.
- **Text mining tool for large amount of literatures.** The text mining methodologies are still in an infant stage. Maybe this part is the most difficult part in the system. It seems they are too difficult problem we must solve. The first one is how to get literatures. The second one is what kind of mining tool is needed. Here the mining tool can exist software tool or some new software that should be developed by us based on some new efficient literature mining methodologies.
- **Software system to support developing personal research roadmap.** Personal research roadmap can be developed by using some system approach, for example, SSM (soft systems methodology). The software

system should be helpful in the process of developing personal research roadmap as BPR (business process reengineering).

A.1.2 Support in the Phase of Doing Experiments

- **Knowledge base of how to use equipments.** This part includes manuals of experiment, standard operation by text and video demonstration, and some special skills. The lab should nominate a special person or a group to preparing the contents of this part. Any member should be allowed to upload their successful experience.

- **Knowledge about dealing with emergence: method, hospital, etc.** It is mainly provided by experience researchers. But any member should be allowed to upload their good experience.

- **Lab rules for experiment: how to get resource?** The rules should be open in the website.

- **Chemical medicine management systems: inventory management cost analysis tool.** Good management software is needed.

- **Information about agency for purchasing chemical medicine.** Links or other information about the agency. This part is only for those who are in charge of purchasing chemical medicine;

- **Waste liquid management.**Rules and good experience should be open in the website.

- **Knowledge about conserving chemical medicine.** This part is also provided by experienced researchers. Some rules about conserving chemical medicine should be open in the website.

- Tool for transferring experiment data. Different solutions for different labs and different experiments.

- Equipment registration system. Commonly each lab is in charge of some equipment that belongs to all the school or all the institute, not only to the lab. So people from outside the lab can also use those equipments. It is necessary to deal with equipment in the following three levels:

  – Lab-level: only the members of the lab can use it.

  – School-level: it is available for all the members in the school.

  – Institute-level: all members in the institute can use them.

A.1.3 Support in Phase of Writing Papers

- **List of journals related to this field, difficulty, level/importance, how long to be accepted.**

- **Required format for each above journal.**

- **Templates for writing papers.**

- **Templates for drawing graph.**

- **Information about special software tools for drawing graph.**

- **Standard token for experiments**– Provided by experienced researchers in the lab.

- **Useful phases in the field**– Provided by every member in the lab.

- **Software tool for auto checking and revising scientific papers.**

- **Academic moral education.** Rules for academic moral should be available in the website.

- **Software for retrieving references.**

Besides the above three phases, we also think the communication inside and outside labs are also very important for knowledge sharing, transformation and acquisition. So the LKMS should also provide functions that can promote communication.

A.1.4 Support for Promoting Communication

- **Information annual conferences related to the field.** Professors and experienced researchers know which conferences are suitable for the lab. And their links and other information should be available.

- **Lab BBS for exchanging ideas and promoting understanding each other.**

- **The list of labs which have cooperation relationship with this lab.** This information is provided by professors and experienced researchers in the lab.

- **Information about travel agency (for attending conferences)** Any member can provide this information.

How to continue research project since students will graduate sooner or later? This remains an open question. Maybe the above information and knowledge is helpful.

More modules and contents will be added into the system if researchers or students find that are useful for supporting their research. In recent years, it is widely believed that a research organization should promote the commercialization of its research achievements science that will benefit the whole society. So here we also propose that a LKMS should provide the function for promoting commercialization. The detail of this part will be discussed in our future work.

A.2 Development of LKMS for support scientific research

We can see an eligible LKMS is composed of many components with different functions. The process of developing the LKMS will involve very complex design and a large amount of engineering work. Those components of the proposed LKMS can be divided into the following four parts:

- **Knowledge Portal.** The technical solution behind a knowledge portal is a software package, which acts as background management tool and will enable researchers in scientific labs to arrange and publish useful information very smoothly. For example, experience researchers in a scientific lab can publish the basic knowledge in the field very easily.

- **Existing Software.** Many existing software can provide some functions that the LKMS need. For example, Cosmo GateEX (available at: http://www.kent-web.com), which is a very good tool for managing the schedule and memo of labs.

- **Inexistent Software.** Some of the function of the LKMS can't be fulfilled by existing tool. It is necessary to develop some Software that can provide those functions.

- **Special Solutions.** Some of the function of the LKMS is not common. For different lab, different solution should be provided. For example, about how to enabling the transferring of experiment data from equipments to computer, different lab use different equipment, so different solution is needed for enabling the transferring.

The above four parts should be integrated with a common interface. A web-based client/server structure will be a desirable solution.