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A Suggestion on the Roadmapping Process to Make an Integration Roadmap between Service-Device-Technology–With a Focus on the Case of U-City

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A SUGGESTION ON THE ROADMAPPING PROCESS TO MAKE AN INTEGRATION ROADMAP BETWEEN SERVICE-DEVICE-TECHNOLOGY – WITH A FOCUS ON THE CASE OF U-CITY

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Abstract

The Technology Roadmap(TRM) is a technical strategic decision support framework in order for the anticipation and projection of the changes of technologies in the future, which has higher uncertainty in general. While the importance of technology management is receiving more attention these days, the research works on the TRMs have been limited to project future technology trends yet diversely studied in different sector such as the service industry The aim of research is therefore to explored and proposed a integrated roadmapping process based on the service oriented business model which based on technology. Proposed methodology has been applied into smart city development project to validate its usefulness and benefits

Keywords: TRM, u-City, Service, Device, Technology

1. Introduction

In the current circumstances where the technical changes are dynamically evolving, the decisions on the choice of technology are a critical for many companies to sustain their competitive advantages. As the future technology lies obscure and uncertain, it becomes more critical to make a proper strategy in response and prepare to advance as far as possible to whatever strategic goals we have. In this case, if it is possible to make an accurate anticipation on the future technology agreed upon by a reliable number of experts, a very important value in strategic planning of technology can be provided[7] [61]. As a decision support tool for the technology strategy support for the anticipation and proper response for future technical development [32] [50], which throws at us a very high amount of uncertainty, a TRM is receiving more and more attention lately. But, even though the weight the service industry carries in terms of the economic structure is even heavier[43], previous literatures so far have been studied with focuses on specific industrial technologies and product development, while the researches of the TRM reflecting the views from the service area have not been relatively explored [65]. In an industrial structure weighing over the service department, the role of technology is as a vehicle to deliver the invaluable service to the customers, and the value creation occurs not by the products themselves but by the uses the customers make [68].

Therefore, in this research, our aim is to make a projection on the development of ubiquitous devices and technologies in the future in respect of the services and propose an integrated ubiquitous city (u-City) technology roadmapping process that is systematic, standardized, and capable of supporting the making of development strategy.

2. Literature Review

2.1. TRM

2.1.1. TRM Definitions

Galvin, who was a former CEO of Motorola and came up with the concept of TRM earlier, defined as follows. His definition has been cited by many scientists since then [5] [10] [32] [56]: *'An extended view of the future in a field created by the accumulated knowledge and imagination of experts in that field.'* In addition, in another research with Motorola as the research subject, he defined it as *'determining the necessary actions to be taken by an enterprise in order to secure the experience, components and processes for the demands in products and services in the future.'* [55] Since then TRM definitions have proposed by many scholars with different perspectives as shown Table 2-1.

Table 2-1 TRM Definitions

Sources	Definitions
Garcia & Bray (1997)	A document created as a result of technology roadmapping process
Kostoff & Shcaller(2001)	An auxiliary tool to concrete the links between the research program, development program, objective capacity and requirements thereof
Kappel(2001)	A document that helps the viewer recognize the critical definitive factors in the market, product, and technology, which form a part of the business
Probert &	Participants' views to envision the

Radnor(2003)	ways to fulfill their goals
Rinne(2004)	A map that shows the direction of technology and development of products using it
Uhm(2004)	A documentized outcome out of a type of technical planning process based on the market needs
Phaal(2004)	A flexible method widely applicable in industry to help establishment of plans that are strategic and of wide scope

2.1.2. TRM Types

Phaal(2001) broadly divided the types of TRM in two ways, by their objectives and forms [52]. He studied 40 TRMs and categorized them in 8 forms according to their objectives. They illustrated different types of TRM including product planning, service/capability planning, strategic planning, long-range planning, knowledge asset planning, program planning, process planning and integration planning [32]. Among these, Service/Capability Planning is used in making expectations on the impacts of the technical development on services, and Long-range Planning is for making expectations of technology on a national scale by expanding the planning time horizontally [52].

Phaal also have categorized different formats of a TRM which including: multiple layers, bars, graphs, tables, pictorial representation, flow charts [52]. Among these, the Multiple Layer type of roadmap is the most generic format to use when TRM is developing. A multiple number of layers (technology, products, market, etc.) components this type of TRM and what it does is that it connects the technology with the products, services, and business system while manifesting the hierarchies between the layers and showing the evolutions/improvement that happens within each layer. The Bar-shaped roadmap is a simplified version, which has its own merits when one tries to understand the TRM the easy way [52]. Currently all national-level TRMs concerning the ICT technologies use the Multiple Layers type or Bar type[45] [46].

2.1.3. A Research Study on The Technology roadmapping Process

A roadmapping defines as an activity to create a roadmap and communicate for it [21]. Groenveld (1997) defined roadmapping as *'a process that contributes to the integration between business and technology, as well as to the definition of technical strategies by illustrating the interactions between the technology and products over time in consideration of long term and short term view from the product and technology.'*[17] Meanwhile, Garcia and Bray (1997) also defined as *'a technical process based on the necessity to help the process of identifying, choosing, and developing technologies to satisfy the needs over the products.'* [15]

Of all different studies on technology roadmapping, researches on the national level the processes have been proposed respectively by Industry Canada, U.S. DOE, and Lee et al.(2007) [37]. Firstly, Industry Canada has been so far drafting the TRMs for respective industries – all 8 of them, including aviation, electricity, and medical- , and in this process has been actively engaged in the research of technology roadmapping. In the preliminary activity stage of this research, it emphasized the importance of the establishment of Steering Committee for the development of the TRMs in order to clarify the roles and responsibilities of the organizations involved in the roadmapping process, with a comment that, for the head of this committee, an expert on the process itself rather than an expert on the technology would be more suitable[20]. The processes of US Department of Energy generally resemble those of Industry Canada. However, it differs from them in a sense that it induced the technical issues by the assessments of technical needs and developed the TRM based upon the priority order between these [66]. Lastly, Lee et al. (2007) proposed a six stage roadmapping process for the national level R&D roadmap development and applied the demand analysis, environment analysis, technical assessment, portfolio and priority analysis to develop a more detailed and systematic TRM [37]

2.2. u-City Development

2.2.1. Definitions of u-City

There are various definitions of u-City in previous studies as shown in Table 2-2. Reviewing different definitions proposed by different government agency, u-City provides its citizens with services via its infrastructure based on ICT infra technologies. That is, as the u-City industry grows, the identification and projection of the ICT technology that can meet the future demands of the city is critical, since the ICT technology is the very fundamental infrastructure of u-City's services in recent years.

Table 2-2 Definitions of u-City

Sources	Definitions
Korea Land Corporation (2005)	A city that provides combined services via the integration of domestic IT industry and construction industry
Ministry of Information & Communication (2006)	A highly advanced future city that applies IT infrastructure, its technologies and services to multiple components of itself

Ministry of Construction & Transportation (2007)	A city that provides its citizens with U-services regardless of time and location by realizing the u-technology in the urban space for the enhancement of the city competitiveness and quality of lives for its citizens
Ministry of Land Transportation & Maritime Affair(2008)	A city that is managed by the network and provides the citizens with services and contents via the network for the human beings with the BUCI (fixed u-City infrastructure) and MUCI (mobile u-City infrastructure), build upon high-end technologies in information and communication

3. Proposing The Integrated Technology Roadmapping Processes & Case Studies

3.1. Integrated Technology Roadmapping Process

In this case, three major directions of strategies have been proposed for the development of TRM driven by the government that can be implemented in the u-City project.

- The establishment of a systematic classification of service-device-technology applied in u-City
- Development of proper TRM formats
- Accumulating a database of u-City service / device / technology

The deduction of the classification system of the subjects in drafting a roadmap is referred to as a critical step in creating a roadmap document in many studies [10] [37] [40] [58]. A government driven TRM tends to need a systematic policy in planning of the technical assignment and development [23]. Therefore, an identification process of the various services generally applicable of the entire scope of u-City development

3.2. A blueprint of Technology Roadmapping

In this research paper, an integrated technology roadmapping process is consists of 8 different processes including: “planning”, “demand identification”, “service identification”, “device identification”, “technology identification”, “roadmap drafting”, “roadmap adjustment”, and “follow-up stage.” (Table 3-1)

3.2.1. Planning phase

In the planning phase the vision and objectives about mid-long term strategy are to be set and the characteristics need to support this are identified. Also, the CSF(Critical Success Factors), which should be considered in the process of roadmapping and the ultimate outcome thereof, should be drawn up. And the task force that is ultimately responsible for the creation of the roadmap and the work group that provide help in the drafting stage are organized [71].

Table 3-1 A Technology Roadmapping Process For u-City Development

Phase1. Planning
Step1. u-City Mid-long term vision and goals identified Step2. Definition of Roadmap Activity1. Individual objectives of the roadmap Activity2. Setting boundaries and limits Activity3. Defining individual time table Step3. Critical Requirements for the Roadmap to be considered Step4. Organization of the Project Team Activity1. Identify the responsible party for the development of the roadmap Activity2. Working Group formed
Phase2. Demand Identification
Step 1. Identify urban problems Step 2. Infer the solutions and demands
Phase3. Service Identification
Step1. U-City Services classification Activity1. Classification Standard to be set Activity2. Service List-up Activity3. Making the service classification system and verifying it Step2. Service tendencies analyzed (Delphi)
Phase4. Device Identification
Step1. U-City Device classification Activity1. Classification standard to be set Activity2. Device List-up Activity3. Making the device classification system and verifying it Step2. Device tendencies analyzed (Delphi)
Phase5. Technology Identification
Step1. U-City technologies identified Activity1. Classification standard to be set Activity2. Technology List-up Activity3. Classification system established and verified Step2. Technical tendencies analyzed (Delphi)
Phase6. Roadmap Drafting
Step1. Roadmap formats developed Step2. The analysis of the interdependencies between service/device/technology Step3. Integrated Roadmap developed
Phase7. Roadmap Adjustment
Step1. Roadmap adjustment Step2. Roadmap verification
Phase8. Follow-up Stage
Step1. Execution Plan developed Step2. Execution of plan

Step1: Setting the Vision and Goals for the

development of min-long term strategies

In order to draw the mid-long term strategies for u-City, the future shapes of the city need to be anticipated with the philosophical discussion of the city also in consideration, and the principal direction and goals of developing the u-City have to be set. For this purpose, we conducted literature review studies on exiting city – relevant literatures and interviews with experts in the related fields. As a result, we identified six different visions of u-City, which are respectively 'a convenient city', 'a safe city', 'a comfortable city', 'a cultural city', 'a productive city', and 'a city open for participation.' In addition, since these visions can be accomplished by the improvement of the efficiency and effectiveness of the existing services and by providing and developing new services that the citizens require [42], we decided to establish a mid-long term strategy based not on Technology Push initiated by the production side but Market Demand driven by the requirements of the consumers[35].

Step2: Defining Roadmap

In this step, the objectives of developing the roadmap are clarified and the limits and scopes of the roadmap are determined. And theses should lead to the setting of the development time table for all aspects and preparation of a systematic preliminary processing. In this case study, we have defined three objectives of developing the roadmap. The first objective is to identify and verify the R&D subjects that can to presented to the 'national level of u-City development strategy' which is in turn to realize a high-end city in response to the ever-changing technical and service environment. The second one is provide a strategic direction for carrying out the program in considerations of the redundancy of tasks in the u-City development program driven by the government. Last objective is to play a role as the Project Management Office that controls and manages the program in consideration of the current status of service/device/technology and their future potential.

Step3. Identifying CSFs for the roadmap development

In this stage, we derived the CSFs as shown in Table 3-2 after doing interviews with experts who have experiences in the development of roadmaps and senior researchers who participated in u-City project team and its tasks. Particularly, connectivity with the objectives of the research, continued improvements and adjustments have already been verified as important factors in the existing empirical researches [28].

Table 3-2 The vision, objective, and CSFs in u-City roadmap

Vision	To exhibit the direction of the service in due to the technical development with a purpose to establish mid-long term strategies of the future vision of u-City
Objectives	- u-City Characterization - Enhanced Research - Competitiveness - Enhanced Research Efficiency - Exhibition of Technical Feasibility - Presentation of Technical Direction -Suggestion of Optimal Combination of the Services - Strategic Instructions for Service development
CSFs	- Organization Level Support - Effective Roadmapping Process - Link with proper roadmap objective - Reflection of the demands from the customers - Utilization of Specialized Research resources - Recognition of the Need of Utilization - Continued Improvement and adjustment

Step 4: Organizing of the Project Team

In this stage, the TRM team for the roadmap development is identified and the preliminary works before the Working Group is formed will be established. As for the forming of the project team, with the characteristics of u-City which has a very strong tendency toward combination and integration, we decided that it has the most importance to build a cooperating body between the project team members who participate in u-City R&D projects. Therefore, the necessary project group was formed out of the forming a project team and its cooperating entities, as well as experts of academic, industrial and government agencies. The fixed expert group included urban experts such as those from the main task research planning organization or other participating bodies for u-Eco City project, public officers from the related local governments, university professors, engineers, GIS experts, and also ICT technical experts, experts from IT service providers and communication service companies were involved as well.

3.2.2. Demand Identification

The wide variety of demands from urban citizens came from the problems of modern cities. In this phase, therefore, the problems that are given by the modern cities will be identified and solutions for them will be proposed by establishing u-City to discover the demands from the citizens. This will in turn serve as the basis for the ordering the services, devices, and technology in u-City in the future.

Step 1: Identification of urban problems

Urban Problems means the social obstacles and nuisances caused by the structural imbalances that the city has. Gwon (2007) classified the urban problems into housing / land, transportation, environment/ sanitary, parks and greens, social development/ pathology, disaster control, leisure / tourism development / rehabilitation, government / taxation, rural outskirt development, metropolitan area / population intensity, local development / mercantile location, new town development and measured the intensity of each class[42]. In addition, Choi (2005) attributed the urban problems to reasons such as the shortage of public services, heavy traffics, inequality, over-developing, land shortage, and crimes. In Step 1, we identified 7 urban problems such as housing/land, transportation, disaster control / safety, environment/energy, parks and greens, landscapes of the city area, and civil participation[42].

Step 2: Solutions for Urban Problems and Deducement of The Demand for u-City

The urban problems introduced above can mostly be solved by developing u-City, and the solutions here are connected to the demand for u-City by the citizens [42]. Therefore, we conducted interviews with 15 experts from the fields such as the city, service, and technologies[42]. As a result, it was concluded that out of 17 urban problems 14 can be resolved. This demand is then again further narrowed down to 8 urban demands. (Table 3-3)

Table 3-3 Solutions for Urban Problems and Demands

Urban Problem		Solution	u-City Demands
Housing/Land	Inefficient use of Land	-	-
	Over Developing	-	-
	Housing Price Rise	-	-
	Low Quality Housing	Enhancement of the quality inside the housing by adopting ubiquitous services and technology	Automated Residential environment
Transportation	Clogging & Heavy Traffics	Promotion of public transportations and restraints on private vehicles	Efficient Management of public transportation
	Pollution	Regulating cargo vehicles and disel vehicles for minimize pollution	Systematic management of environment pollution
	Traffic Accidents	Providing real-time information on the accidents' occurences and establishing a systematic response system	Swift and accurate management of disasters
Disaster control/ safety	Natural Disasters	Providing accurate information on the weather and related facilities	Swift and accurate management of disasters
	Man-made hazards	Detection of the incidents and establishment of response systems	Swift and accurate management of disasters
Environment/ Energy	Air/Water/Soil pollution	Real-time detection of the contaminating source and establishment of response systems	Systematic management of environment pollution
	Installation, perating & Managing Environmentally Hazardous Facilities	Computerized Information Systems of Environmentally Hazardous Facilities	Systematic Control of Environmental Pollution
	Deflection of Fossil Energy	Monitoring energy consumption and building facilities that are environment friendly s	Efficient management of energy
	Insufficient user information	Enhanced accessibility toward information on parks' location, status, and facilities thereof	Convenient park facilities
	Lack of Convenience & Comfort	User-oriented facilities and providing such information to users	Convenient park facilities
Urban Landscapes	Bad Pedestrian Environment	Provide information on pedestrian walks	Comfortable urban environment
	Insufficient support facilities for minorities	Establishment of minority-oriented facilities and provision of information thereof	Comfortable urban environment
Civil Participation	Conflicts among individuals, areas, classes	Securing a participation route for the citizens in the urban planning process and interactive accessibility for the information	Open environment for participations by the citizens

3.2.3. Service Identification

In Service identification stage, the services of u-City get identified and the information is collected in a more systematic manner by establishing a service classification system. In addition, by monitoring the tendencies in these, a preliminary work before making the service layers of the roadmap for later stages is done.

Step1: U-City Service Classification

The services herein need to be classified properly, in order to promote a shared understating on u-City services, efficiencies in the project's execution, and help the local governments develop services that fit into their own unique requirements. For a u-City developer, this classification can be used and an indicator that helps him/her to check the current status of u-City services and to anticipate potential services which could be adopted later on. Also, a new unit of service can be developed by identifying the connections between the pre-developed services. In this regard, our intention is to establish a classification system in order to minimize the differences in understandings on the development of service models among the developers and allow systematic R&D projects.

Details of such activities include making the standards for the service classification, listing the services up, developing the service classification system and verification thereof. With a strategic goal to develop the classification standard, we performed nine multi-dimensional analyses on 228 detail units of services [42]. That is, Legal/Regulatory View, Space Factors, Human, and Functional Factors (Table 3-4). With the classification standard created as above, we made the service lists and had an expert group (of ten experts) verify them.

Step2. Service Trend Analysis

To identify the current and future trends of the u-City services we identified above, we conducted a two-stage Delphi survey (from Nov. 2008 to Feb. 2009) [42]. The reason why this kind of survey was necessary came from the very characteristics of u-City services. Since u-City services are very futuristic and cover a very wide scope, there is only limited effectiveness in gathering information from the ordinary citizens who never came across such things or from the scarce experts who are also limited to very narrow fields in their knowledge. That is where the Delphi survey method has selected, which is capable of gathering information from a relatively larger number of subjects, accumulating it, and finally allowing to make a decision with objectivity[36](Table 3-5).

Table 3-4 u-City Service Classification Standard

Standard		Classification	Reference
Legal	Laws	Administration, Transportation, Sanitary/Medicine/Welfare, Environment, Crime/Disaster Control, Facility Management, Logistics, Labor / Employment, Education, Misc.	[41]
Space Factor	Space unit	Buildings, Sidewalks, Districts, Facilities, City, Metropolitan	[42]
	Space Facility	Information Media Facility, Unit Space Control Facility, Combined Community Facility, Integrated Control Facility	[22]
Human	Provider	Public Services, Private Services, Joint Services	[29]
	Beneficiary	Public Sector, Citizens, Enterprises	[29]
Functional Factors	Purpose of Development	Resident Support, Commercial Support, Industrial Support	[42]
	Urban Activities	Health, Security/Safety, Community, Education, Economy, Leisure/Culture	[42]
	Human Behavior	Living, Working, Moving, Playing, Cybering	[1], [63]
	Methods	General Service, Specialized Service, Potential Service	[42]

Table 3-5 u-City Service Assessment Indexes and Definitions

Category	Sub Category	Operational Definition	Evaluation Scales
Development Adequency	Feasibility	The market volume and expected profit of the service	5 level scale
	Demand	Forecast on the service demand	
	Importance	The existence of benefits to be enjoyed by the public as a result of the service, regardless of the feasibility or demand	
	Influence	Consequential influence of the service over the related industries	
	Urgency	How urgent the service is needed	
Implicational Capacity	Time of Availability	The possible timeline when the service becomes available in consideration of technical development and regulatory modifications	Year
	Time of Application	Actual time when the service actually gets applied to the city	

For device and technology as well, we conducted similar Delphi surveys for the same reason. The subjects of the surveys consisted of 140 service experts from u-City related private corporations, 110 civil servants from the local government picked up according to 11 laws and regulations, and 70 urban service experts from the academic sector. In total, we have collected 147 survey answer sheets from them.

From the collected answer sheet, a database on the future prediction and current status of the u-City services has been built. This would be of an asset when updating the u-City roadmap once it is developed or drafting a new roadmap for some other city[42].

3.2.3. Device Identification

In Device identification stage, a classification of device has been made to collect the related information and monitor the necessary progresses in a more systematic way which eventually stacks up as a preliminary work for the device layer within the roadmap.

Step1: u-City Device Classification

In the u-City environment, multiple devices perform various functions that can be recognized by the users in physical or virtual connections via the network. Therefore, in this study, if a function is performed by a multiple number of devices grouped together, they have been recognized as a single unit. In addition, when using the networks, it is possible that the newly recognized device (which is actually a group of devices connected together) spread over a wide range of physical locations, we have set up a space-oriented classification standard for a more clear identification of these. Such a classification system will serve as a preliminary work for the collection of device–related information and monitoring the current progress, which eventually support a better understanding on the various devices used in u-City and systematic acquisition of information.

The first step of the detailed activities is to set up the classification standard of the devices, which we did in space type, infrastructure components, and formal types. The definitions of these three standards are given in Table 3-6 below. The space type (node, landmark, path, edge, district, metropolitan) and infrastructure components (ceiling, walls, floors, combined, network) are, as mentioned above, space-oriented standards for the classification of the devices, while the formal type is separate independent, single devices (standalone) and grouped/combined devices that work as a group.After setting up the classification standards, we identified the devices that already exist in/out of the country or that are likely to be developed in the future to classify them in the classification standards we selected 10 experts from the related fields verified the completed device classification system.

Table 3-6 u-City Device Classification Standard

Standards	Definitions
Space Type	The location where the device lies, or the range in which the devices can communicate with each other
Infrastructure Components	The location where the devices are installed when the device is connected with the existing infrastructure
Formal Type	The number of the devices needed to perform their functions or whether the devices are connected with other devices.

Table 3-7. u-City Device Assessment Index and Definitions

Category	Sub Category	Operational Definition	Evaluation Scales
Device Importance	Marketability	Overall assessment of the current market competitiveness of the device, as well as the future growth potential thereof	5 level scale
	Consequential Influence	Overall assessment of the technical influence of the Device toward other devices and industry and economic consequences thereof	
	Feasibility	Expected economic profits there from	
	Economic Soundness	The soundness of the device application in the city in consideration of the economic costs is assessed.	
	Utilization	The extent of the utilization of the device	
Device Level	Device Maturity	Assess which stage of development the device is currently at	Introduction/Growth/ Maturity/ Fade out
	Device Productivity	The availability of existing production facilities for the device and likelihood of mass production	(0~100)%

Device Anticipation	Time of Availability	The expected time when the development of the device is completed and the device becomes available in the market	Year
	Time of Application	The likely time when the device becomes actually applicable to u-City in consideration of various circumstances, such as the laws, regulations	
	Intensity of Plausibility	Assess how sure the respondent feels about his/her answers on the Time of Application	5 level scale
	Obstacles for the introduction of the device	Name possible obstacles that might come up with trying to apply or actually apply the device to u-City	Lack of Core Technology/ Immaturity of the Industry/ High Required Investment Volume

Step2. Device Trend Analysis

Like the services, we conducted Delphi surveys (from Nov. 2008 to Feb 18, 2009) for the analysis of the progresses with the devices. 108 technical experts who worked in u-City related departments of private corporations, 30 experts from the academic sector who are specialized in the u-City field have been surveyed and we got 97 responses back from them in total.

In previous literatures, the marketability, feasibility, capability of development, and possibility were assess in order to find out the tendency with the devices. [27] [71] [62]

In this study, we reorganized the detailed they presented to suit the requirements of our tasks (Table 3-7), and added Time of Availability, Time of Application, and the intensity of plausibility of these items to anticipate the likely time of actual application of the device in u-City.

3.2.4. Technology Identification

In stage of technology identification, a classification system is made in order for a systematic acquisition of technology-related information and check out the connected progresses as a preliminary work before making technical layers of the roadmap later.

Step1: u-City Technology Classification

Due to the nature of the case we have at hand, we firstly had to make an overall classification system for the ICT technologies applicable to u-City and identify the technology in accordance with this classification. In addition, in this study, we assumed a daily life environment where the information flows into the user via ubiquitous infrastructure.

Baek(2004) divided the process where the service user gets the information and give the response thereof into three stages, Awareness, Decision, and Action.[4] Under this conceptual classification, five major categories, Sensing, Networks, Processing, Interface, and Security were again conceived in terms of the technical functions and roles, as shown in Table 3-8 [3] [11] [48] [59]. Also, we identified the individual technologies that belonged to each category from industrial data and existing literature.

The u-City related technologies collected were again divided into 12 sub categories and 27 detail categories, resulting in 114 technology factors. And we had an expert group that consisted of 10 experts interviewed for the validation of the adequacy of the technical classification, accuracy of the classification standard, technologies to be left out or to be considered as overwrapping.

Step2: Technology Trend Analysis

For the technical tendency analysis, we conducted a Delphi survey with ICT technical experts from industrial, academic, R&D background (from Nov. 2008 to Feb. 2009)

The targets of the survey consisted of 126 technical developers from private information or communication service providers, 100 experts from the academic sector, and 50 researchers from the technical research institutes run by the government, from whom we collected 226 answer sheets. In addition, the answers we had were heavily concentrated on the network and sensing part, which turned out to be 65% of the total answers.

In the anticipatory survey over the mid-long term development of technology, the subjects of the technical assessment were mainly focused on the importance, current technical level, and future anticipations on further development of such technology [49] [45] [12]. Therefore, we organized the technical assessment indexes in Importance, Current Level, and Future Expectations as shown in Table 3-9. In addition, similar to service and device tendency analysis, we separated the expected time of availability and application to the city so that the actual possibility of the technology's application to u-City could be figured out [8] [9] [45] [12].

Table 3-8 u-City Technology Classification Standard

Category	Definition
Sensing	Monitor any external changes of status and transmit the collected data to process and respond to the signals from the sensors
Processing	Process the data from the sensors with proper analysis and decisions
Network	Connecting each device and user for the support of efficient communication
Interface	Convert the information that flows between the devices or between the users and devices into a more intellectual form (Graphical, Textural)
Security	Control illegal accesses to the information from the users or facilities over the entire ubiquitous environment and protect personal privacies

Table 3-9 u-City Technology Assessment Indexes

Category	Sub Category	Operational Definition	Evaluation Scales
Technology Importance	Marketability	Overall assessment of the technology's current market competitiveness and the potential for future growth	5 level scale - Very high - High - Intermediate - Low - Very low
	Consequential Influence	Assessment of the technology's potential influence in other technologies and the industry, as well as the economic consequential influences	
	Feasibility	Expected economic profits	
	Economic Soundness	Financial cost of the actual application of the technology to u-City	
	Application	The extent of the utilization of the technology	
	Potential of future evolution	Whether a continued research and development of the technology has the potential of bring forth a next generation of the current one	
Technology Level	Technical Maturity	Evaluate at which point of the development stages the technology is	Introduction/Growth/Maturity/Fade out
	Domestic Level against the global status	Assume the technical proficiency of the country with the most advance technology in that field as 100, and evaluate the domestic technical proficiency against it	(0~100)%
	Most Advanced Nation	Pick the country which has the most advanced technology in that field	Choose from Korea /USA / Japan /EU/ETC
	Existence of a substitute or resembling technology	Existence of a substitute / resembling technology that could be used in similar purpose	YES / NO
Technology Anticipation	Time of Availability	The time when the technology is expected to become available or commercialized in the market for first-hand uses	Year
	Time of Application	The time when the technology can possibly be applied to u-City, in consideration of legal or regulatory adjustments as well	
	Positiveness of the Anticipation on the Times	Evaluate the positiveness of the surveyee's assumption on the time of application for the technology in u-City	5 level scale

	Obstacles of the technology	Name the possible obstacles for the technology to be applied in the related industry	- Lack of Core Technology - Immaturity of the Industry - High Required Investment Volume

3.2.5. Roadmap Development

In roadmap drafting stage, a format for the roadmap is developed and drafted by using the collected data from the definition steps of service, devices, and technology.

Step 1: Developing a Roadmap Format

In this step, a simple and easy-to-understand roadmap format is developed. The parallel axis of the u-City roadmap is divided into three terms, 'near future (up to 2013)', 'possible future (2014 to 2020)', and 'far future (2021 and beyond)'. 'Near future' means a relatively closer point of time in the future where it is possible to predict the changes with the infrastructures and related technologies. 'Possible future' means the kind of future that is close to the current time and it is still possible to make predictions without too much trouble. The end of the 'possible future', that is 2020, is also a time schedule most of the national development projects are pointing to, and it is necessary that our plan for the u-City development remains linked to this. 'Far future' is an assumed point of time where all of the services and values the u-City is meant for can be realized without any technical restraints.

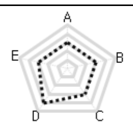
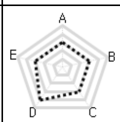
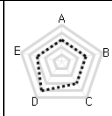
The vertical axis of the roadmap stands for, respectively, each individual service in case of a service roadmap, and individual technology in case of a TRM. As for the form of the roadmap, we have chosen the 'Bar' type from the list of the roadmap forms suggest by Phaal [52], as we thought this could best descript the direction of the development of each service and technology.

The meaning of the diagrams in the u-City roadmap format in Table 3-10 is as below. The beginning point on the Bar shaped arrows means the time when the development of the service, device, or technology starts. In addition to that, the time of availability and the time of application are respectively marked with a triangular icon. The time of availability means the time in which the subject becomes commercialized in the market. However, even after the commercialization, there still can remain the legal, regulatory issues as well as the matter of standardization, there might be a gap between the time of availability and the time of actual application to u-City. Hence they are marked separately with different markings. Other than these, the current maturity of the service, device, and technology is marked in five colours, and the production capability of the device and current domestic technical proficiency are marked with a shaped-diagram for better readability.

Step2: Interdependency Analysis

In the previous phases, the information from the service, device, and technology sectors has been gathered separately. However, with separated information, it is difficult to understand what kind of device u-City requires, or the service than can be provided via such a device. It is not easy to decide what kind of technology is necessary to make it come true, either.

Table 3-10 Service/Device/Technology Layer Formats

Service	Diagram	Device	Diagram	Technology	Diagram
Name	Unit Service Name	Name	Device Name	Name	Technology Name
Time of Availability	Availability	Time of Availability	Availability	Time of Availability	Availability
Time of Application	Application	Time of Application	Application	Time of Application	Application
Importance	 A: Feasibility B: Demand C: Importance D: Influence E: Urgency	Importance	 A: Marketability B: Consequential Influence C: Feasibility D: Economic Soundness E: Utilization	Importance	 A: Marketability B: Consequential Influence C: Feasibility D: Economic Soundness E: Application
Maturity	Introduction Growth Maturity Fade out	Maturity	Introduction Growth Maturity Fade out	Maturity	Introduction Growth Maturity Fade out

		Production Capability	● : 100% ◕ : 76% ~ 99% ◑ : 51% ~ 75% ◔ : 26% ~ 50% ○ : 0% ~ 25%	Domestic technical level against Global	● : 100% ◕ : 76% ~ 99% ◑ : 51% ~ 75% ◔ : 26% ~ 50% ○ : 0% ~ 25%

To solve this problem in the existing studies, QFD method has been incorporated in this research. The characteristics of this method are [51] [25] [2] [17] :

1. Market Oriented Approach
2.Convenient in figuring out the interdependencies between the layers in a Roadmap
3. Applied in the planning phase of the Roadmapping process

The above characteristics suited our purpose of this step, which is to systematically identify the service/device/technology that can satisfy the citizens' needs (1) and understand the interdependencies among these (2). However, unlike the existing studies which did a QFD analysis in the planning phase of the roadmap and conducted roadmapping with this on the bottom-line (3), we remembered that there are countless services/devices/technology in different time and location for the implication of u-City and the importance of these factors do change over time. Hence, we will first establish a database with collected data, and apply QFD in accordance with the situation we face to figure out the interdependencies.

Also, in the existing studies that applied QFD in roadmapping[51] [25] [17], the distinction between the product and service is rather vague. So, they could not present a methodology for QFD that is capable of analyzing the customer demands, products and services simultaneously. However, Lee et al. (2008) proposed that the product and services existed in the same level, and suggested a modified method of QFD that is capable of identifying the first-hand relationships between the customer demands, products, and services [2].

In this study, we adopted the QFD method proposed by Lee at al. (2008)[2] to clearly separate the services and products that could be realized in u-City and at the same time understand the customer demands and their relationships with theses.

To begin with, we performed a preliminary QFD analysis to figure out the interdependencies between the urban demands, services, and devices as shown in Figure 3-1. As a result, we could pick up the most importance services and devices to satisfy the urban needs and figure out how these are linked up with the technology.

Step 3: Integrated Development of the Roadmap

In this step, the roadmap format developed in Step 1 and the interdependencies between service/device/technology picked up from Step 2 are put together as a basis to visualize the collected data. Figure 3-2 shows an example roadmap for the integrated environmental pollution control service, universal resident card service and public transportation information service. The 3 services with the most weigh as the result of QFD analysis were identified along with the related devices and technology as well. Then the information on these items are conceptualized in the roadmap's format.

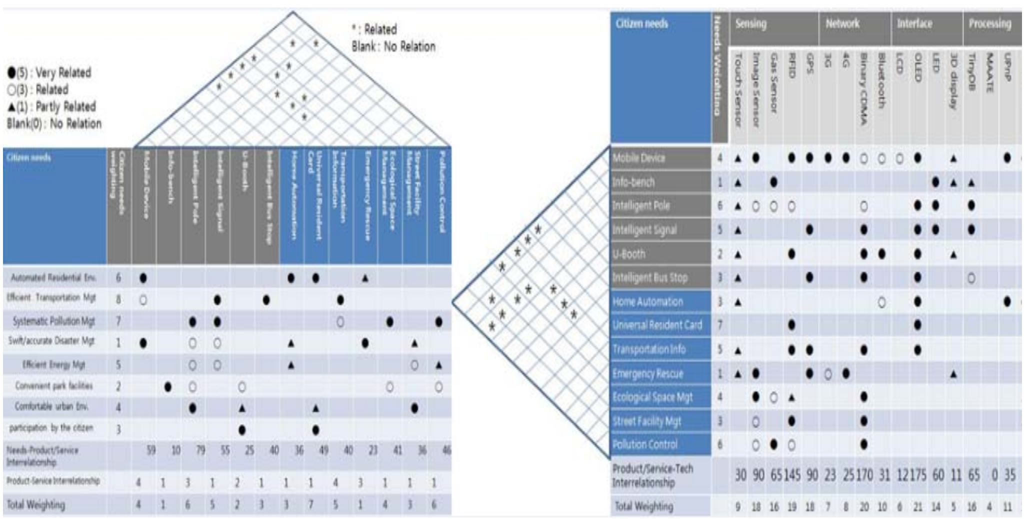


Figure 3-1. Analysis of the interdependencies between service/device/technology

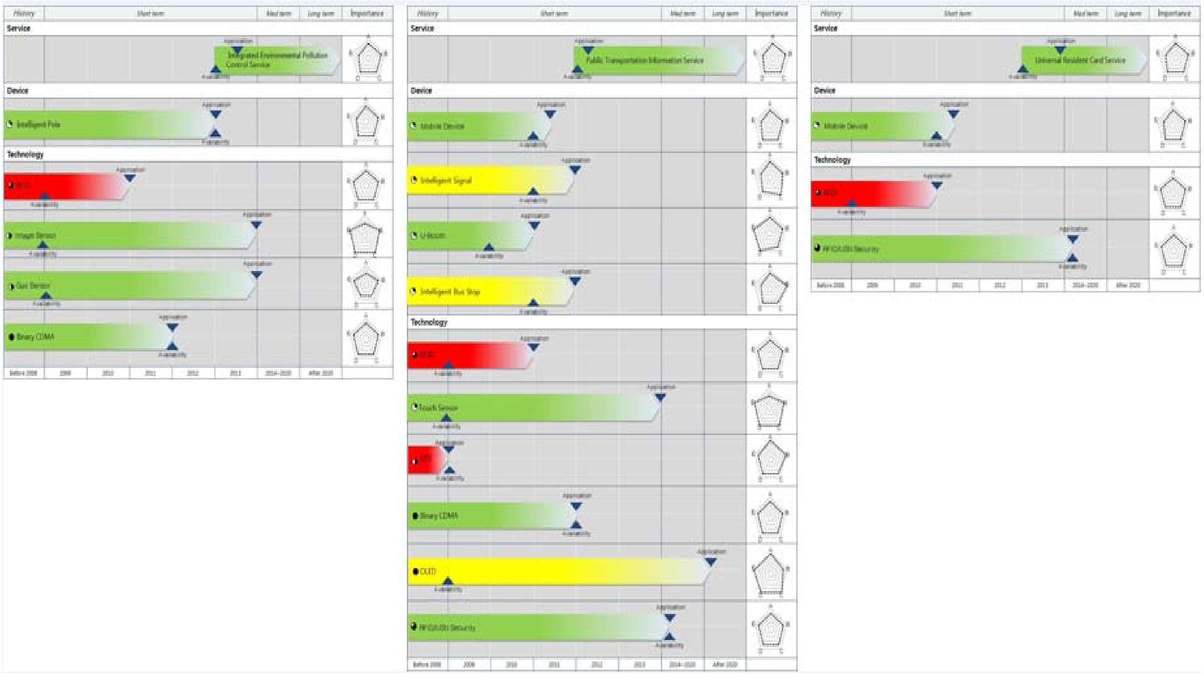


Figure 3-2 u-City TRM (before Adjustments)

3.2.6 Roadmap Adjustment

In this stage of 'roadmap adjustment', we will adjust and verify the projections in the previously made roadmap to make it better in terms of reliability and objectivity.

Step1: Roadmap Adjustment

Usually, since a roadmap contains information gathered from a number of different categories, the predictions from the expert in individual fields are not enough to make proper anticipations for the future. Therefore, a process of repeated adjustment of the roadmap once it is preliminarily completed is necessary[5] In particular, roadmapping process that resemble our own in this study, there can be errors amount the collected information when putting together the roadmap, since the surveys on the future prediction regarding service/device/technology are given by expert group from different fields. In this step, we will identify the troubles discovered on the roadmap and modify them though internal discussions and using secondary data in order to enhance the credibility and accuracy of the roadmap.

An example of such an adjustment process is shown in Figure 3-3. The time of application for the integrated pollution management service, intellectual traffic signals, and intellectual bus stops were found to be 2012, meanwhile the time of application for the OLED technology necessary for these services turned out to be after 2014. To solve this problem, experts from service, device, and technical fields have been interviewed and the existing data have been reviewed against the secondary data. As a result, it was concluded that OLED technology for the service will only be applicable to the city in 2014, and the roadmap was modified accordingly.

Step2: Verification of the Integrated Roadmap

According to Kostoff & Schaller(2001), it is not possible to completely figure out the roadmap before the completion of it, even for the experts who drafted it, and it is required to get help from other experts to secure the credibility of the roadmap[32]. Hence, in this study, we added the verification processes into the methodology to have the validity and credibility of the roadmap, and had internal researchers and external experts in the field of u-City services and technical backgrounds involved in it.

3.2.7. Follow-up Stage

In this stage, the roadmap from the roadmap – development stage will be evaluated and an execution plan will be set up. The feasibility study and establishment of a sustained updating system will happen, too. In our case, we will perform continued adjustments and enhancement for the TRM though surveys and interviews with the experts and using secondary data from the other research institutes and the media. This will serve our purpose in drawing a consensus on the completed roadmap as it contributes to the accuracy of the data. And, an integrated execution plan will be provided, which is based on the priority assessment via QFD analysis. This plan is to assist the decision making process for the selection of technology and development. Furthermore, the information gathers since the definition stage of each territory will be accumulated as a DB for a more systematic sharing and management within the project team. This can be translated in line with the study by Kim [28] which pointed out 'the establishment of adequate software system' as the key factor in the utilization of the roadmap.

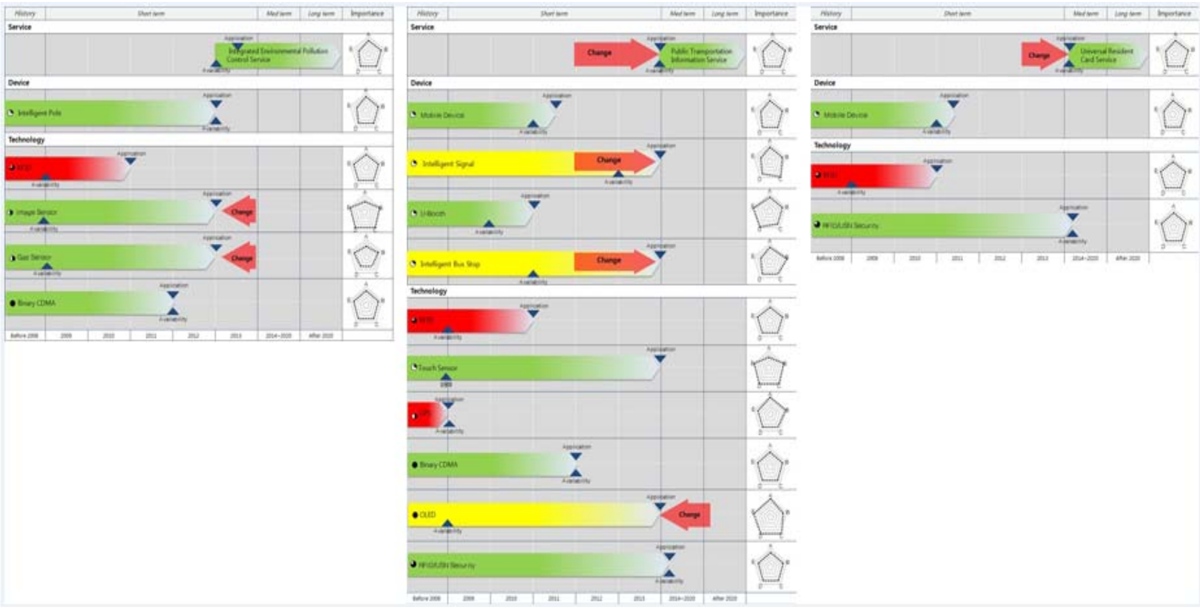


Figure 3-3 u-City TRM (after Adjustment)

4. Conclusion

4.1 Conclusion and Implication

In our study, we have carried out our research with emphasis on the classification system, development of roadmap formats, DB accumulation of the related information.

Firstly, a literary study on the characteristics of u-City and the TRMs thereof has been done, and with this on the foundation, a study on the u-City TRM was performed.

As a result, a formalized and systematic technology roadmapping process that supports the projection and strategy making on services / devices / technology needed in a development project of u-City has been proposed. In particular QFD methodology in roadmap's developing phase and the accumulated DB are unique characteristics in this technology roadmapping.

As using modified QFD, we could clearly distinguish the services and devices, as well as to identify the interdependencies between them. This is a step further from the existing studies that only suggested a modified QFD as it not only suggested but also applied in an actual case [2].

Also, Based on DB which is developed to collect and store various information, we will be able to support roadmap developments for other cities in the future or update the roadmap currently existing.

In this research, proposed roadmapping process is expected to be useful in TRM developments for not only u-City but also other technology based industries that involves a dramatic scale and continued needs for updating.

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References

[1] Alderfer, C., "Existence, relatedness, and growth: Human needs in organizational settings: Free press.", 1972

[2] An, Y.J., Lee, S.J., Park, Y.T., "Development of an integrated product-service roadmap with QFD", International Hournal of Service Industry Management, 2008

[3] Baek, D. H., Jin, H. C., "A Feasibility Study on the Location Based Services under Ubiquitous Environment ", Journal of the Society of Korea Industrial and Systems Engineering, 2007
[4] Baek, H.J., "Strategy for RTE implementation ", SDS Consulting Review, 2004
[5] Beeton, D. A., "Exploratory Roadmapping for Sector Foresight", University of Cambridge, 2007
[6] Chesbrough, H., J. Spohrer, "A research manifesto for services", Communications of the ACM, Vol.49, No.7, pp.35-40, 2006
[7] Choi, H. S., Eum, S. Y., Jeon, M. K., "Methodology study on Forecasting of Digital Society", KISDI, 2006
[8] Choi, M. H., Ahn, E. Y., " A study on the Evaluation Indicators of the Environmental Technology ", Korea Technology Innovation Society, 2003
[9] Choi, M. J., Jung, G. H., Lee, S. Y., Seo, H. W., ," The Evaluation of Technology Level on Korea's Mid & Long-term Strategic Technologies", Korea Technology Innovation Society, 2005
[10] Daim, T. U., T. Oliver, "Implementing technology roadmap process in the energy services sector : A case study of a government agency", Technological Forecasting & Social Change, Vol.75, No.5, pp.687-720., 2008
[11] Electronic Times, Ubiquitous White Book, 2005
[12] "Linking Between Needs of Future Life and IT-based Technology ", Electronics and Telecommunications Research Institute, 2006
[13] Ji, K.Y., Kim, M.G., Park, J.H., "Market Opportunity and Potential on u-City", Electronics and Telecommunications Research Institute , 2006
[14] Fitzsimmons, J. A., M. J. Fitzsimmons, Service Management: Operations, Strategy, Information Technology, McGraw-Hill, 6th ed., 2008.
[15] Garcia, M. L., O. H. Bray, "Fundamentals of Technology Roadmapping", Sandia National Laboratories, 1997
[16] Gerdsri, N., D. F. Kocaoglub, "Applying the Analytic Hierarchy Process (AHP) to build a strategic framework for technology roadmapping", Mathematical and Computer Modelling, Vol.46, No.7-8, pp.1071–1080., 2007
[17] Groenveld, P., "Roadmapping integrates business and technology, Research Technology Management, 1997
[18] Han, S. E., Kim, G., Jung, J. W., “Regulation on Diffusion of u-City Service Model”, The Korean Association For Public Administration, 2007
[19] Heijden, K.., Scenarios: The Art of Strategic Conversation, John Wiley, New York, 1996.
[20] Industry Canada, "Technology Roadmapping - A Strategy for Success " (http : / /www.ic.gc.ca/eic/site/trm-crt.nsf/eng/h_rm00049.html), 2000.
[21] Kappel, T. A., "Perspectives on roadmaps : how organizations talk about the future", The Journal of Product Management, Vol.18, No.1, pp.39-50., 2001
[22] Kim, B. H., “Contents of Law for u-City Construction”, Korea Research Institute for Human Settlements, 2008
[23] Kim, B. K., " Dynamic Technology Roadmap ", Korea Institute for Advancement of Technology, 2005
[24] Kim, C. Y., H. K. Kim, S. H. Han, C. W. Kim, M. K. Kim and S. H. Park, "Developing a technology roadmap for construction R&D through interdisciplinary research efforts", Automation in Construction, Vol.18, No.3, pp.330-337., 2009
[25] Kim, H.Y., Park, Y.T, "Development and Application of Web-Based Technology Roadmap : QFD and Scenario Panning Approach", Korean Institute of Industrial Engineers, 2004
[26] Kim, S. H., Joo, Y. J., Park, S. J., " Selection of the Promising IT Equipment", Technology Innovation Journal, 1998
[27] Kim, S.H., Ju, Y.J., Park, S.J., "A Method on the Selection of the Promising IT Equipment", Technology Innovation Journal, 1999
[28] Kim, S. S., " An Empirical study on practical use of TRM(technology roadmap) and R&D performance - focus on Korean enterprise", Yonsei University, 2008.
[29] Ko, S. H., “U-City and City Develop Business “, Korea Planners Association, 2007
[30] Korea Communications Commission, "Basic Plan for u-City Construction ", 2006
[31] Korea Land & Housing Corporation, ,"Plan for u-City development and Operation", 2005
[32] Kostoff, R.N., R. R. Shcaller, "Science and Technology Roadmaps", IEEE Transactions on engineering management, Vol.48, No.2, pp.132-143., 2001
[33] Kwon, J. C., Choi, J. W., Park, B. J., Hyun, J. S., Yoon, Y. J., Kim, J. B., “A Study on The Enactment of Regulations for Construction of u-City”, NIA, 2006
[34] Kwon, S. G., "u-City Concept and Trend", KETI, 2008
[35] Lee, C. Y., Lee, J.S., “Conjoint Analysis and QFD for a Reliable Starting Point of Technology Roadmap”, Korea Society for Innovation Management and Economics, 2007
[36] Lee, J. S., “Delphi Method”, Education and

Science press, 2001
[37] Lee, S.J., S.R. Kang, Y.S. Park and Y.T. Park, "Technology roadmapping for R&D planning: The case of the Korean parts and materials industry", Technovation, Vol.27, No.8, pp.433-445., 2007
[38] Lizaso, F., Guido Reger, "Linking roadmapping and scenarios as an approach for strategic technology planning", International Journal of Technology Intelligence and Planning, Vol.1, No.1, pp.68-86., 2004
[39] Lopez-Ortega, E., T. A. Concepcion and S. B. Viloria, "Strategic Planning, Technology Roadmaps and Technology Intelligence : An Integrated Approach", Proceedings of PICMET, , pp.27-33., 2006
[40] Martin, G., E. Eggink, "Creation of a Thermal Technology Roadmap in a Consumer Electronics Product Environment", Semiconductor Thermal Measurement and Management Symposium, 24th Annual IEEE. pp.106-111., 2008
[41] "Laws for supporting u-City plans and Construction", Ministry of Land, Transport and Maritime Affairs press, 2007
[42] “u-City future vision and mid-Long Term Strategy”, Ministry of Land, Transport and Maritime Affairs, 2008
[43] Nam, K. C., Kim, Y. J., "Challenges of IT Service Industry- perspective on Service Science ", National IT Industry Promotion Agency], 2008
[44] "ubiquitous and City”, National IT Industry Promotion Agency, 2008
[45] “Technology Foresight 2020”, National IT Industry Promotion Agency, 2006
[46] "National R&D Report", National Science & Technology Council, 2007
[47] Nishimura Michinari, “Future Design by Scenario Roadmap”, BADA press, 2005.
[48] Nomura Research Institute, “Ubiquitous Network and New Society System”, Electronic Times, 2003
[49] Park, J. S., "Forecast on S&T mid-long term Development”, NISTEP Report, 2004
[50] Petrick, I.J., A.E Echols, "Technology roadmapping in review: a tool for making sustainable new product decisions", Technological Forecasting and Social Change, Vol.71, No.1-2, pp.81-100., 2004
[51] Phaal, R., C. J. P. Farrukh and D. R. Probert, "Technology roadmapping - A planning framework for evolution and revolution", Technological Forecasting & Social Change, Vol.71, No.1-2, pp.5-26., 2004
[52] Phaal, R., C. J. P. Farrukh and D. R. Probert, "Technology Roadmapping: linking technology resources to business objectives", University of Cambridge, 2001
[53] Price S., R. Summers, "A Technology Roadmap for Rehabilitation Engineering", Proceedings of the 26th Annual International Conference of the IEEE EMBS, Vol.2, pp.3471-3473., 2004
[54] Probert, D., M. Radnor, "Frontier experiences from industry - academia consortia", Engineering Management Review, Vol.31, No.3, pp.27-30., 2003
[55] Richey, J.M., M. Grinnell, "Evolution of roadmapping at Motorola", Research Technology Management, Vol.47, No.2, pp.37-41., 2004
[56] Rinne, M., "Technology roadmaps : Infrastructure for innovation", Technological Forecasting & Social Change, Vol.71, No.1-2, pp.67–80., 2004
[57] Robert, A., Modesto, A., & Steven, C.. Strategic Management of Technology and Innovation. Research on Group Economy, 147-158., 1996
[58] Samsung Advanced Institute of Technolog, “TRM Manual”, 2000
[59] Samsung Economic Research Institute, "Ubquitous Computing: Business Model and Prospect", Issue Paper, 2003
[60] Schwartz, P., The Art of the Long View: Planning for the Future in an Uncertain World, Currency Doubleday, New York, 1996.
[61] Shengbin, H., Y. Bo, W. Weiwei, "Research on application of technology roadmap in technology selection decision", Proceedings of the Control and Decision Conference, pp.2271-2275., 2008
[62] Simon Coldricka,Philip Longhurstb, Paul Iveya, John Hannisc, "An R&D options selection model for investment decisions", technovation, 2005
[63] Statistics Korea, “2004 Lifetime Report”, 2005
[64] Strauss, J.D., M. Radnor, "Roadmapping for dynamic and uncertain environments", Research technology management, Vol.47, No.2, pp.51-57., 2004
[65] Suh, J.H., Park S.C., "Service-oriented Technology Roadmap (SoTRM) using patent map for R&D strategy of service industry", Expert Systems with Applications: An International Journal, Vol.36, No.3, pp.6754-6772., 2009
[66] U.S DOE(Department of Energy), "Applying Science and Technology Roadmapping in Environmental Management", 2000
[67] Um, K. Y., Choi, M. S., Eo, Y. B., Yoo, Y. S., Lee, B. N., "ICT Roadmap Case and Use", Korea Society for Innovation Management and Economics, 2003
[68] Vargo, S. L., R. F. Lusch, "Evolving to a new

dominant logic for marketing", Journal of Marketing, Vol.68, No. 1, pp.1-17., 2004
[69] Willyard, C. H., C. McClees, "Motorola’s Technology Roadmap Process", Research Management, Vol.30, No.5, pp.13-19., 1987
[70] Yang, D.W., "An Empirical Study on extracting significant technology valuation index of IT SMES", Technology Innovation Journal, 2005
[71] Yoon, M. S., “New Methodology for Strategy of national R&D: Integrating Technology Roadmap and Knowledge Map”, STEPI, 2004