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Developing Strategic Decision Making Process for Product and Service Planning

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***Abstract*--It is imperative to forecast advanced or emerging technologies to aid in decision making on firm's R&D investments and business plan for commercialization efforts. Even though a company must align R&D planning with overall business planning such as manufacturing, sales and marketing, personnel, and finance, systematic management approaches are limited in it based upon the prediction of technological change and speed. This paper aims to provide a decision support tool to aid in strategic service planning and technology development in a firm. The study is to enhance strategic development of service and product with the consideration of emerging technologies. This model helps decision makers to easily identify emerging technologies and new research fields with systematic decision making process.**

I. INTRODUCTION

Technological change is associated with a high degree of uncertainty. Technology forecasting (TF) is continuously recognized as influences in the transformation of individual behavior, organization, economy, society and culture in such a turbulent world. The endeavor to grasp the performance potential of current and emerging technologies has brought attention to the significance of technology forecasting (TF) in strategic planning. Therefore, govermnent and companies have continuously strived to predict the impacts which technology developments are likely to have on future society as well as business environment.

Since 1960's, long range planning has been increasingly used by corporate management [1]. Long range planning is a formalized activities involved in setting a long-term goals for business and define specific plans to achieve these goals [2]. In the mean time, the primary needs of TF shifted from govermnent to private companies. Around late 1960s, Erich Jantsch and Robert Ayres described that the company started to focus on the integration of technological forecasting with long-range planning, and the implications for organization structure and operations [3][4]. Most firms have some framework of formalized planning. Forecasting is one of the essential inputs to planning [1]. Furthermore, with the rapid change of technology platform, while many companies are integrated with other functions and govermnent policies, TF activities such as the technology roadmap, business/technology strategy, and information technology (IT) has gained more significance than the accuracy of prediction. In practice, TF is inevitably needed to help decision makers to identify and assess opportunities and threats in firms' competitive business environment, allocate resources in R&D portfolio and new product development, and develop strategies in creating strategic alliances such as licensing in/out and joint ventures. TF is imperative to corporate planning group and R&D laboratories not only to formulate business and technology strategy but to review R&D program.

II. RESEARCH BACKGROUND

Strategy is mostly concerned with the long term. It is significant to identify the need for change. In this regard, a variety of technology forecasting methods have been developed and applied to various industries, organization for the benefit of different purposes. Due to business uncertainty growing in its complexity, the firm has made its efforts on environmental scanning such as bibliometric/patent trend analysis and market analysis to indentify increasingly diversified needs of customers, in order to establish a steady grasp of technology initiatives as well as to improve its future position. In the last four decades, especially after the widespread availability of Information Technology (IT), some of the different approaches using much information like patents, journals, and research awards, have been continuously developed by different researchers combing with many other tools. Cho and Daim chronologically discuss the characteristics, origin, and advantages/disadvantages of each TF method in detail [5].

Many studies point out that a combination of different approaches and methods are required to improve the accuracy of forecasting, since a combination of multiple techniques enables forecasters to analyze various perspectives (organizational, technological, economic, political, personal, social, and environmental) [6]. Furthermore, it is of significance that the interaction of exploratory, or opportunity-oriented, and normative, or mission-oriented, forecasting be stated correctly [7][8]. There are a number of papers to combine with other TF tools in order to offset weaknesses of one forecasting technique such as technology roadmapping with scenario technique [9], Delphi with cross impact analysis [10], Bibliometric with growth curves and system dynamics [6], and technology roadmapping with morphological analysis and text mining [11], etc.

The selection of appropriate technology forecasting methods depends on the nature of the technologies (e.g. disruptive vs incremental technology) and assumptions inherent in them [12]. It would also depend on uncertainty surrounding technology development, data availability, technology difficulties, funding for R&D. Previous study briefly identifies the applicability of technology characteristics such as disruptive/discontinuous and continuous technology in different methods for the benefit of TF by thorough literatures review [5]. In this regard, this method also has some limitation in diverse applications. This study more focus on enhancing strategic planning of service

and product with the consideration of emerging technologies using roadmapping process with FGI, Delphi, and Data Mining tools.

III. RESEARCH OBJECTIVES

Along with the increase of service sector which account for about 79.6% of the U.S. economy in 2011, not much attention has been paid to the integration of product-service in technology developing process. Consequently, the strategic technology development planning and systematic integration process has become a significant issue. The main objective of this study is to fulfill the needs for developing a new strategic decision process that integrates quantitative data from patents and literatures based on exploratory approach and expert analysis to develop a technology product-service roadmapping process for emerging technologies with consideration of services. This study attempts to develop a generic product-service roadmap framework for smooth and efficient roadmapping in practice. To demonstrate the methodology, the research is applied to smart grid technologies in electricity industry.

The goals of the proposed research are:

- Extend existing Technology Roadmap (TRM) models to include a layer for service generation.
- Develop a strategic decision method to capture emerging technologies in the application area integrating the use of research award/publication/patent data in the existing TRM methodologies.
- Develop an emerging TRM in the application area of smart grid technologies and services in current electric power delivery system.
- Propose strategic decisions to meet future needs and give recommendations to the policymakers, researchers and other stakeholders to better develop and implement R&D projects in the country.

Three major research objectives have been defined to address the research gaps identified. Ultimately, this study attempts to fill research GAPs and provide a practical approach on how to integrate two or more techniques into strategic decision making process.

Research Gap 1: New technology roadmapping frameworks are needed to define the relationship and differentiate among services, products and technologies.

- The technology roadmap providing "service layer" has been introduced but there is no existing model that focuses on understanding how this new layer can be incorporated effectively in technology roadmapping (TRM) process for strategic development planning.
- There is little literature that describes how product service integration should be carried out and helps developing service offerings for product developments.
- Inter-operable standardization effort is a critical prerequisite in smart grid system, but not much research has been done in existing technology roadmap with consideration of standardization.

Research Gap 2: There is a lack of useful, user-friendly techniques that incorporate quantitative data and expert analysis simultaneously in technology forecasting in order to capture emerging technologies and future service needs.

- Most literature describes the high-level framework steps recommended to complete a roadmap, not providing much practical knowledge of detail process.
- Very few techniques on emerging technology roadmaps.
- Most models rely solely on expert decision and do not incorporate quantitative data effectively.

Research Gap 3: Most electricity organizations offer sub-optimal services where gaps can be filled with better management of technology.

- There are few methods to developing a TRM with product-service integration for a smart grid service organization (Smart Grid Service Provider).
- There are a couple of smart grids roadmaps initiated by IEA (International Energy Agency). But there is no known technology roadmap to integrate emerging technologies and services to be identified in order to meet the customer needs.
- With the recent emergence of smart grid technology, the management of smart grid services and emerging technology in the electric power industry is fragmented and has not well organized or integrated with respect to the strategic planning of integrated offering.

TABLE 1. RESEARCH GOALS AND QUESTIONS

Research Goals	Research Questions
Extend existing TRM models to include layers for product-service integration and standardization	RQ1: How can features of emerging technologies be assessed with respect to services? RQ2: How can we make a strategic plan with the integration of products and services effectively?
Develop strategic decision making process for an emerging technology in the application area of smart meter for smart grid service organizations.	RQ3: What are the possible paths of technology development in this area? RQ4: What technologies are related to the services identified in the organization? RQ5: What are the gaps between service requirements and expected technology development paths?
Improve the accuracy of technology forecasting through integrating data mining method and the TRM technique	RQ6: Can we get a better forecast through use of award, publication and patent data than we would get through experts and other traditional methods? RQ7: How can features of emerging technologies, products and services be assessed with respect to future drivers?

IV. RESEARCH APPLICATION

With the soaring oil price, energy efficiency and management is a key element required for sustainable economic development. For this research, smart grid services and technologies are selected for the application area.

Smart Grid Applications for Industry and Infrastructure:

1) Problem in electric power industry
- Aging infrastructure
- Continued growth in demand
- The integration of increasing numbers of variable renewable energy sources and electric vehicles
- The need to improve the security of supply
- The need to lower carbon emissions

2) Smart grid services
- High increase service for demand response and energy efficiency
  - It requires a cost-effective way and relatively short implementation times
- Efficient integration of variable renewable energy resources
- Efficient management of electric vehicle recharging services

3) Service Gaps
- Compliant with industry standards for interoperability and security
- Real time demand response
- Integrating renewable energies and new service associated with them like power resale of electric or hybrid vehicle

4) Standardization Issue
- Standardization is one of the key elements to promote smart grid services with a framework for interoperability.
- Early and active participation in standardization process will minimize the potential cost impacts on customers that might arise if utilities adopt technologies that later become obsolete
- Smart grid standards have the potential to radically transform utility business models
- Not many studies have been done using comprehensive approach with integrating new products, emerging technologies and services as an enabler.

The electric grid is transforming from a static arrangement of mechanical devices to a dynamic array of highly intelligent and extremely capable networked devices. The electric grid more easily connects with renewable energy sources, such as wind and solar, and is designed to charge electric vehicles and control home appliances via a so-called "smart" devices. Along with these recent trends, the smart grid technology has been highlighted as the information technology backbone that enables widespread penetration of new technologies that today's electrical grid cannot provide. This study will present the emerging areas of smart grid technologies, services and applications in electricity industries. The research will describe the characteristics of smart grid service management and the strategic areas of focus such as AMI (Advanced Metering Infrastructure) which includes smart meter.

V. RESEARCH METHODOLOGY

The service sector has been becoming increasingly significant in that customer value is defined by some combination of product value and service value. At first, IBM calls out that the economies of the world are becoming more and more service drive [13]. Since the concept of service science was first introduced by IBM's Almaden Research Center in 2002 when it acquired PriceWaterhouseCoopers Consulting [14], it has begun to draw attention in academic as well [15] [16][17]. The objective of service science is "to increase the productivity of the service industry, promote innovation, and create greater validity and transparency when assessing the value of investments in services" [14]. The development of "service sciences" has introduced new challenges in managing and forecasting technology.

Product-service system (PSS) has been popularized in practice and literature since late 1990s [18]. Its definition varies, however, PSS is typically defined "a marketable set of products and services capable of jointly fulfilling a user's need, the product/service ratio in this set can vary, either in terms of function fulfillment or economic value" [18]. PSS represents the transition that product is not simply seen as a competitive advantage asset any more. Service with product plays a more significant role in customer satisfaction and market success. Therefore, one of the significantly required studies is to provide the strategic decision-making process that allows companies to adapt themselves to the specific conditions of their marketplace [19]. The roadmap associated with services can be classified into two categories. The first is service roadmap which focuses on developing roadmap of service elements delivering major service with accompanying minor goods and services such as food and logistic services or pure service, where hybrid is the offering type in which goods and services are equal in balance like IT services [20]. The second is to include service layer independently with generic technology roadmap format. Kameoka et al introduce a Service Integrated Technology Roadmap that adds the "service layer" to the traditional roadmap structure [21][22]. This is recognized as an independent layer that is important in a strategic roadmapping process. However, it is a product roadmap with a simply added service layer and consequently not the integrated roadmap, not providing much description in terms of roadmapping process.

Hence, there is still research gap in the literature with respect to how to develop an integrated roadmap incorporating service in technological development planning. It is recognized that the next generation of technology roadmapping incorporates the service sciences in the roadmapping process yet the concept has been introduced with no known methodologies published to date to develop

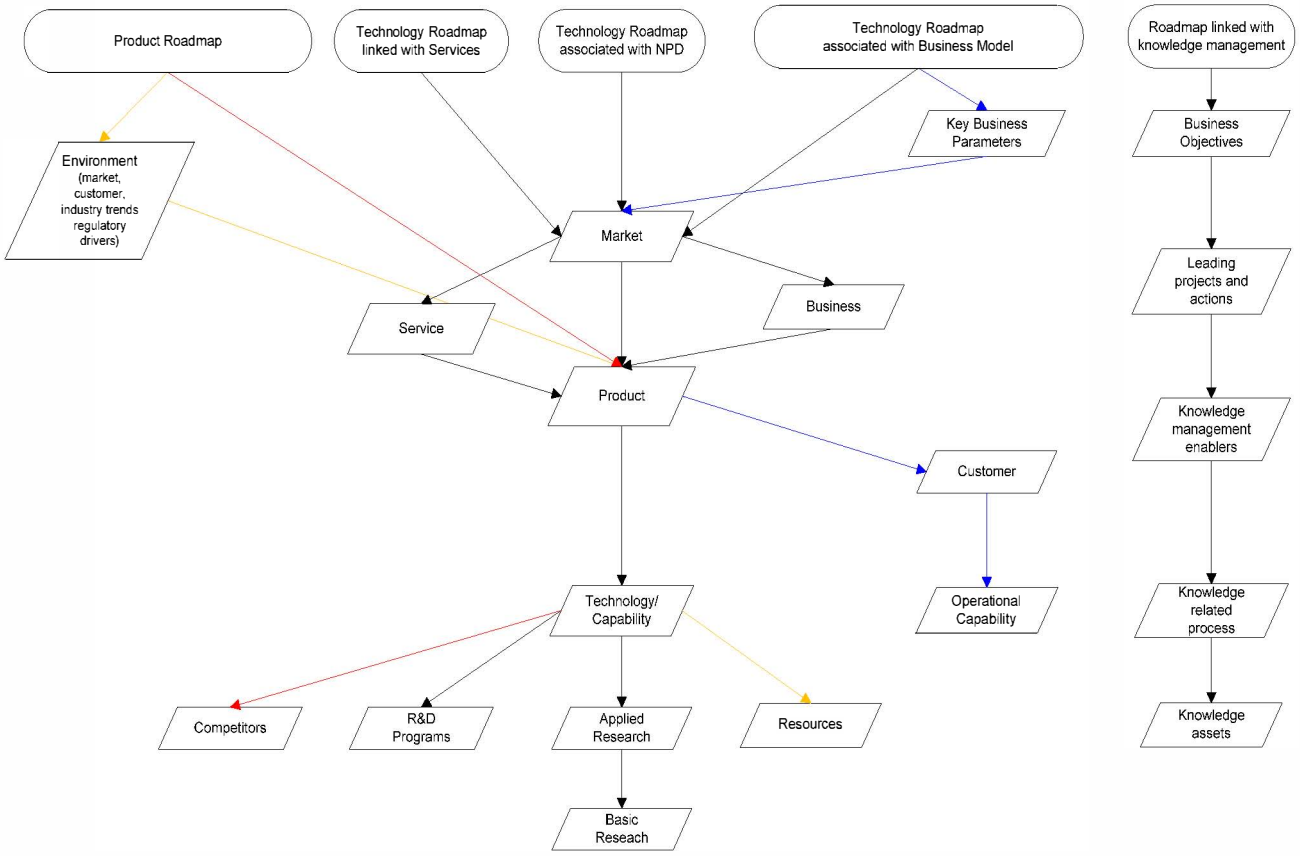


Fig. 1. The technology roadmaps associated with various elements

and construct the integrated product-service roadmap. This study also aims to represent how the product and service are jointly developed during the design phase to achieve the common goal in satisfying customer needs.

Technology roadmapping framework has evolved into different format through integrating the different elements such as new product development, services, business model, and knowledge management [22][23][24][25][26], as illustrated in Figure 1.

Emerging technologies deliver products or services that are cheaper, better or more convenient by invigorating growth within an industry or creating a brand new industry. Information technology makes it possible to offer a number of services in diverse industries including smart grid service in power industry.

Emerging technologies also require the need for forecasting methods that incorporate multiple techniques and combined forecasts. This research aims to combine explorative TF techniques (patent analysis, bibliometrics) and technology roadmapping with normative TF methods (Delphi, FGI) for the strategic selection of emerging technology in power industry, based on opportunities of future service needs.

Initially, the study identifies six conceptual roadmap types such as Emerging Technology-driven roadmap, Emerging Technology Service Initiative roadmap, Service Initiative roadmap, Product-driven roadmap, Service-driven roadmap, and Technology Policy-driven roadmap from cases.

First, emerging technology can drive service initiative and product development as well at the conceptual level. Emerging technologies deliver products or services that are cheaper, better or more convenient by invigorating growth within an industry or creating a brand new industry. This can be classified into two sub groups. One is emerging technology drive service initiatives to create a new product or meet the customer's needs, which is defined Emerging Technology Service Initiative roadmap.

Second is that emerging technology drive product development first and then adds new service to meet the customer's needs, which is called Emerging Technology-driven roadmap. In both cases, new services and products can be delivered as markets have yet undefined. For example, with the emergence of sales of electric vehicles, recent studies have considered "vehicle-to-grid" concept which could not only help cut electricity demand during peak periods, but also provide storage for renewable energy generation [27][28][29][30][31]. These ancillary services are imperative to the smooth and efficient operation of the power grid. Information technology mainly makes it possible to offer a number of services in diverse industries including smart grid service in electricity industry.

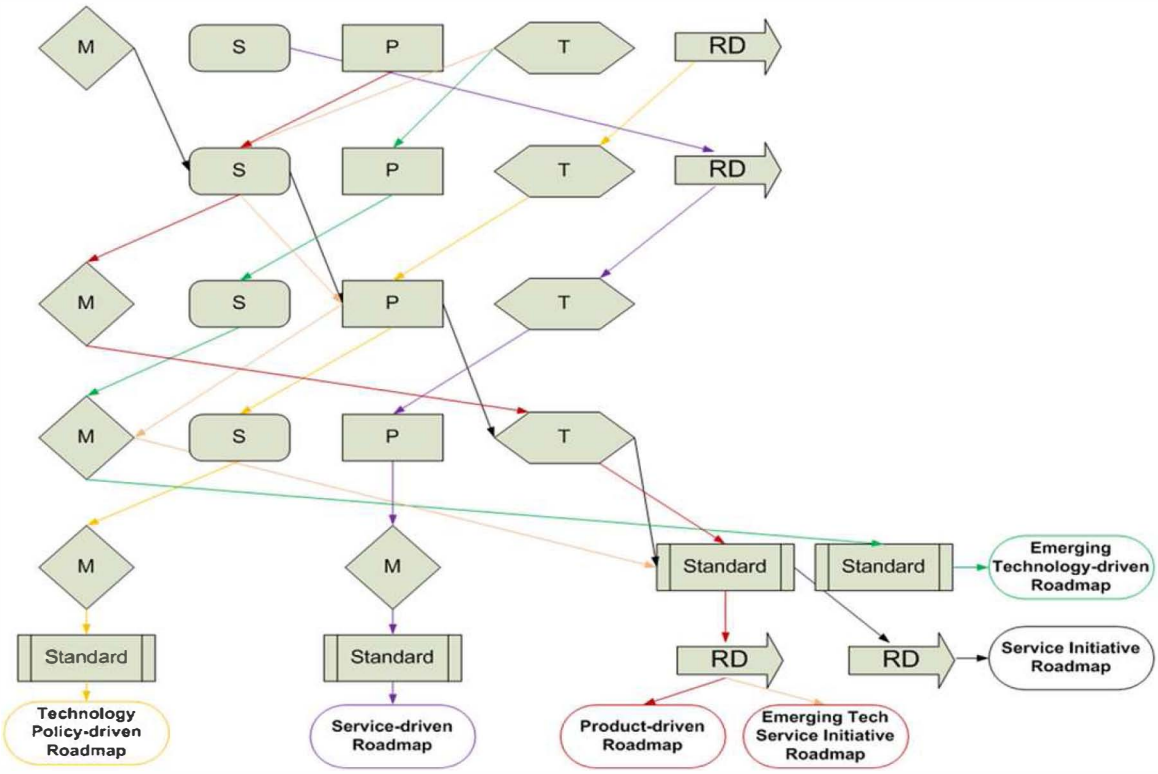


Fig. 2. Six Conceptual Types of TRM

Third, American Moon mission originally initiated by President Kennedy administration is one of the best examples to present Teclmology Policy-driven innovation. It was mainly driven by military competition with the Soviet Union, specifically following the "Sputnik Crisis" in 1957. It improved science and teclmology capabilities of USA which resulted in strong industrial performance afterwards. In the decade of the sixties, President Kennedy's dramatic decision to fund major teclmological initiatives and R&D program in order to land a moon is likely to be very vital for realization of teclmology and products, since some major agency such as NSF, NASA had ground out for development.

Fourth, product cannot simply drive value creation opportunities but also change the market structure, so called game changer, through integrating with service to meet customer's latent needs which is defined as product-driven roadmap in this research. One of the best examples is Apple's iPhone in the cellular phone market. Apple's innovative new handset device creates and intrigues strong market growth of smartphone with touch-screen displays as well as i-Tune and Appstore services which popularize and make it easier for customers to use voice, text, entertainment, email, and internet, providing computing functions by hundreds thousands of software to support it. Despite of a lack of telecommunication experiences, the well-aligned product and service of Apple transform an existing market rule of game as taking dominant design in well-established mobile phone market. It successfully satisfies a customer's latent need and demand for mobile internet services. The market has been driven by rapid adoption of smartphone by users. The services provided by Apple have been established as *de facto* standards and have driven competitor's teclmology development as well. Apple leads the market and takes the market share of RIM's BlackBerry devices, which has security line of wireless e-mail solutions as its competitive advantage. Finally, RIM released Z10 which has smartphone features without thumbs-friendly physical keyboard like iPhone to catch up the market.

Fifth, service can drive a new way to develop new product and lead a market. New service with no precedent product or existing teclmology or innovative service offerings are typically required to specify strategic plan to create an entirely new market or unprecedented value propositions. Creative service system design initiates teclmology application and product development to use services more conveniently. For this case, service driven teclmology roadmap can be used to develop strategic plan for the development of new innovative services. For instance, Amazon offers e-commerce of a variety of goods, ranging from book selling to E-book, clouding service, and instant content streaming service with Kindle products by ten thousands of software to support it. Amazon proposes its new service, linking product like Kindle series to exclusive content. In this case, one of the keys to successful teclmology development is to ensure that products are offered with services in tune with the marketplace. Teclmology is just prerequisites of service offerings. Amazon does not have much knowledge to develop and design new product. The

manufacturing and most of components are outsourced to the Chinese companies. Now, Kindle is established as its technical product to provide best its services to satisfy customer's needs. As Jeff Bezos mentions its strategy, Amazon aims to make revenue not by selling its product but by providing its unique services.

Sixth, it is recognized that the next generation of technology roadmapping incorporates the service sciences in the roadmapping process yet the concept has been introduced with no known methodologies published to date to develop and construct the integrated product-service roadmap [18][19]. Kameoka et al introduce a Service Integrated Technology Roadmap that adds the "service layer" to the traditional roadmap structure. This is recognized as an independent layer that is important in a strategic roadmapping process. This format can be defined service initiative technology roadmap which focuses on identifying a specific aspect of service initiative with respect to each market driver. Organizations that provide services need to understand and strategically plan to this product/service integration based on technology. It can be used in product and service development planning.

Therefore, the proposed framework of this paper to integrate product, service and standardization is to begin with identification of technology roadmap format. Presented in Figure 2 is the overall process of this research.

A. Stage 1: Identify the structure of technology roadmap

First, the relations among technology, product and service should be identified. This study employs Hierarchical Decision Model (HDM) to determine the structure of technology roadmap with respect to service, product and technology relationship. This phase aims to help with the selection of best-fit framework for organization's planning efforts.

For the pair-wise comparison, I created initial form to determine the relative importance of six elements in technology roadmap in order to develop the appropriate format. Allocate a total of 100 points to reflect how much possibility a perspective drives significantly in comparison to the other element.

B. Stage 2: Identification of Key and Emerging Technologies using Data Mining

Exploratory technological forecasting is the attempts to predict the technological state-of-art that will or might be in the future [32]. It starts from today's assured knowledge of what has happened in the past up to the present day and is predicting towards the future events. After the emergence of Information and Communication Technology (ICT), some of the different approaches using much information like patents, journals, and research awards, have been continuously developed by different researchers combing with many other tools. The purpose of this phase is to identify the technologies that will be available. In this phase, a pre-defined list of key technologies and keywords is utilized to gather basic frequency, growth rate of each technology and co-citation statistics over time for presentation in the next phase. The method of data mining needs the effort of the experts not only by providing appropriate keywords and phrases but also by identifying newly available products and integrating those to the organization rather than eliminate the need for expert analysis. Therefore, this phase is also reviewed by the researchers who have expertise in each domain.

Figure 4 illustrates that we can see there are obvious relationship and time lags between the layers in technology roadmap for any technology area. The earliest is the currently announced research projects that have been funded, all the way to the currently available patents and commercial products.

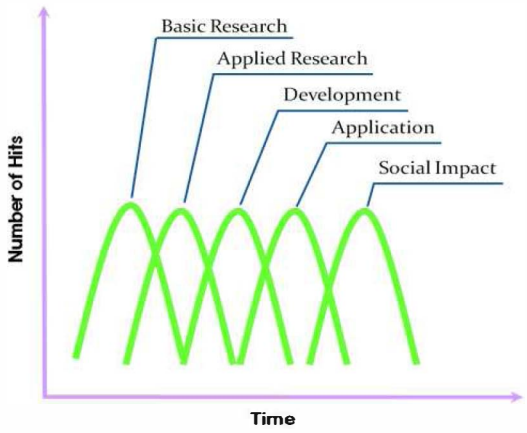


Fig. 4. Bibliometric estimate of stage of innovation and time lag [33].

Market		vs		Service
Service		vs		Product
Product		vs		Technology
Technology		vs		R&D Program
R&D Program		vs		Standardization

Fig. 3. The form of pair-wise comparison

At any given point in time, we have access to a variety of data sources that support the various layers of the roadmap. This model proposes that the prospective roadmap can be created by mapping different data sources to expert creation of the various roadmap layers and identifying the time lags that will be likely to occur between each element.

TABLE 2. SOURCES FOR DATA MINING TO TECHNOLOGY ROADMAP LAYERS

Roadmap layers	Data sources
R&D Program	COS funding, NTIS, NSF DB, SCI,
Technology	Compendex
Product	SCI, Compendex
	US patents, WIPO

The study uses five data sources such as Community of Science (COS) funding opportunities, NSF funding DB and NTIS (National Technical Information Service) which contains summaries of scientific, technical, engineering, and business information products since 1964, Web of Science as a Science Citation Index and Compendex as an Engineering Index which provide a comprehensive science and engineering bibliographic database, to support the R&D program and technology layers. Furthermore, this research employs US patent data, the largest patent system in the world, has been fully computerized since 1975 [34] as well as World Intellectual Property Organization (WIPO) database which United Nations founded in 1970, in order to deploy the product layer of the roadmap.

Consequently, we can identify the research gap and market opportunity for R&D planning using this portfolio matrix with the measurement of growth rate of patent, literatures and R&D funding and absolute size of them at each stage of innovation and time lag.

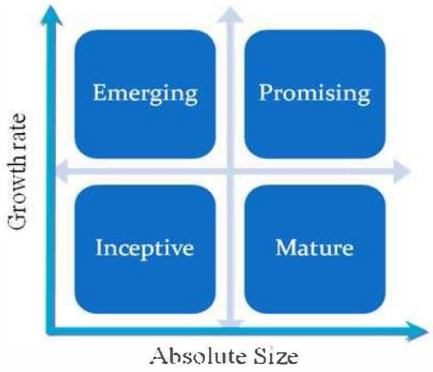


Fig. 5. Identification of Emerging Technologies

C. Stage 3: Identification of the Technologies, Availability and Standardization

The purpose of this step is to identify technologies that will be available and standards that would be in place during each phase of the roadmap. This stage uses a multi-round Delphi process to capture information from the technology experts. The panel consists of representatives from government-funded research institute or laboratories, corporate research center and universities. This panel will:

- Develop a list of emerging technologies that support smart grid (e.g. smart meter)
- Forecast emerging technologies, interdependencies and timing of availability
- Estimate the competitive technologies and current technology level
- Estimate the technology metrics values for each identified technology
- Review current technology standards and discuss potential standards and time in place

The experts will be presented with the data mining results from the previous step and using a web-based instrument the first round of the Delphi gives experts an opportunity to modify the pre-developed list of technologies and estimate the time of occurrence.

In addition, currently existing standards will be provided to the committee based on the literature review, mapped to the technological requirements. The experts will identify the key challenges with the standardization of situational awareness and deploy extensional mapping of potential standards relevant for the requirements of the future smart grid.

The time span will cover the next 10 years broken into 3 phases. Subsequent rounds of the Delphi will be conducted as needed to verify and modify the first round data.

D. Stage 4: Identify product and service elements

At this phase, it needs to develop blueprint for product and service elements, which allows a company to explore all the issues inherent in developing or managing product and service offerings. It can reduce the potential for failure and enhance management's ability to deal with issues effectively. Products are typically tangible objects which has time and space dimension, while services are comprised of activities or processes that solely exist in time. Recently products and services have been symbiotically linked together. In this step,

TABLE 3: THE OUTLINE OF DATA MINING

Process to this analysis	
Define the technology area	Selection of experts according to each technology domain
Establish the problem domain (year, year of publication)	
Patent/Literature database selection	Review of results of patent and literature data
Keyword selection	
Search all scientific and technical publications/patents for relevant technology	
Patent/Literature/R&D funding data analysis	
- # of patents/publications/R&D funding	
- Growth rate of n in patents, literatures and R&D funding	

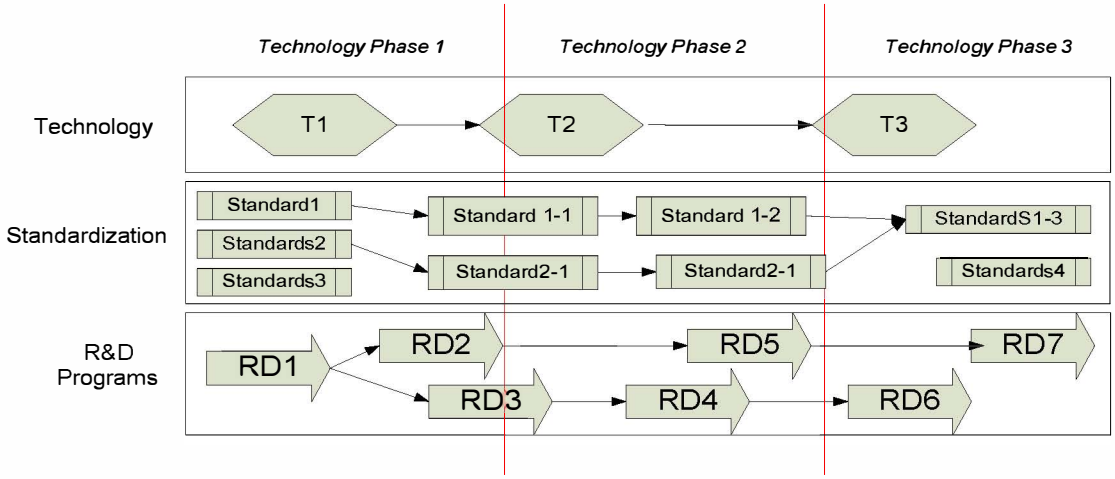


Fig. 6. Technology, Standards and R&D Programs Layer Creation

all product and service elements have to be identified. Some products and services may still need to identify themselves and others may be integral part in company's portfolio.

We can find the answers to critical questions:

- What product attributes do customers care about?
- What service attributes do customers concern?
- What are the most preferred features?
- What relationship do they have between products and services?

TABLE 4: IDENTIFICATION OF PRODUCT AND SERVICE ELEMENTS

	Product	Service	Integration
Element #1			
Element #2			
Element #3			
Element #4			
Element #5			
Element #6			
Element #7			
Element #8			

There are a variety of forms of product and service integration. Tukker proposes eight types of product and service system [35]. Figure 7 also illustrates a range of product-service offerings based on the analysis of the customer-supplier interface [36].

Total customer value is said to be comprised of the sum of the product and service value. For this study, servitization level should be identified to fulfill the demand of product and service more successfully in a way that measure the relative value of product and service features. It can be simply calculated by multiplication of relative value of products (RVP) and relative value of services (RVS). Demand fulfillment range from 0 to 1, based on value of the expert decision.

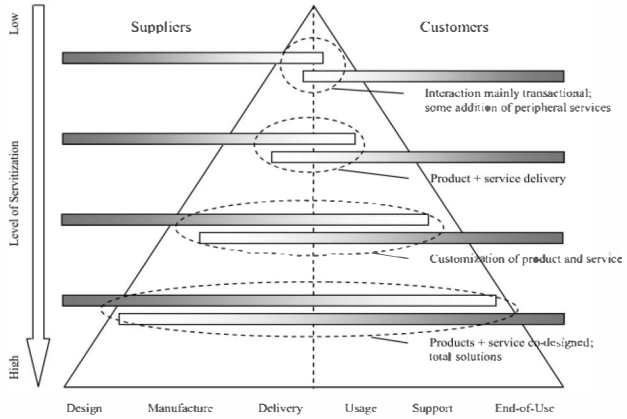
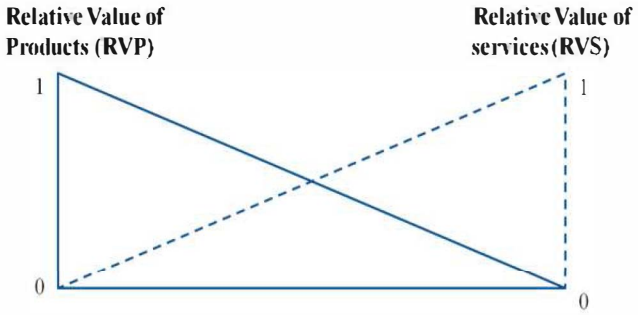


Fig. 7. Servitization Continuum: a view of the customer-supplier interface [36]



Demand fulfillment (D) = RVP * RVS
s.t. RVP+RVS = 1

E. Stage 5: New Service Specification

New service development based on anticipating latent customer needs is the complex task to specify. Many studies have highlighted customer involvement in the new product and service development process [37][38][39][40][41][42]. It is necessary to involve customers in the process of service development as a co-producer of services. The existing

models, however, do not effectively incorporate into the development of new product or emerging technology with services at the same time. There have been some of scholars who reviewed and developed new service development process describing the sequences of events. Largely due to the lack of an efficient development process, this research formalizes those steps to incorporate them in roadmapping process. At this stage, the study investigates new service design and development with the seamless integration of product and emerging technology. This research presents a conceptual framework for the integrated development of products and services with the focus of new service. The proposed model for new service specification in roadmapping process is comprised of 5 step sequence of activities, depicted in Figure 8. This service development framework focuses on how this process can be managed within roadmapping process.

1) Strategic planning

The new services should align with the overall objective of the organization. The general strategic direction must be set and policy guidelines for the new service development should be established at this stage. A new service strategy aims to search for new opportunities and identify appropriate new service ideas. With the product-service-technology relation strategy matrix, the company can identify new service and business opportunities.

A crucial part of strategic development is to determine the pre-defined business/market drivers that will be used in the research. This will be determined based on consultations with expert panels to identify strategic drives within the timeframe of the research.

In this step, as a means of tracking the performance of individual, including potentially disruptive technologies as well as exploring new opportunities, environmental scanning for forecasting is conducted to search through the technical, trade and business literature to identify events that may

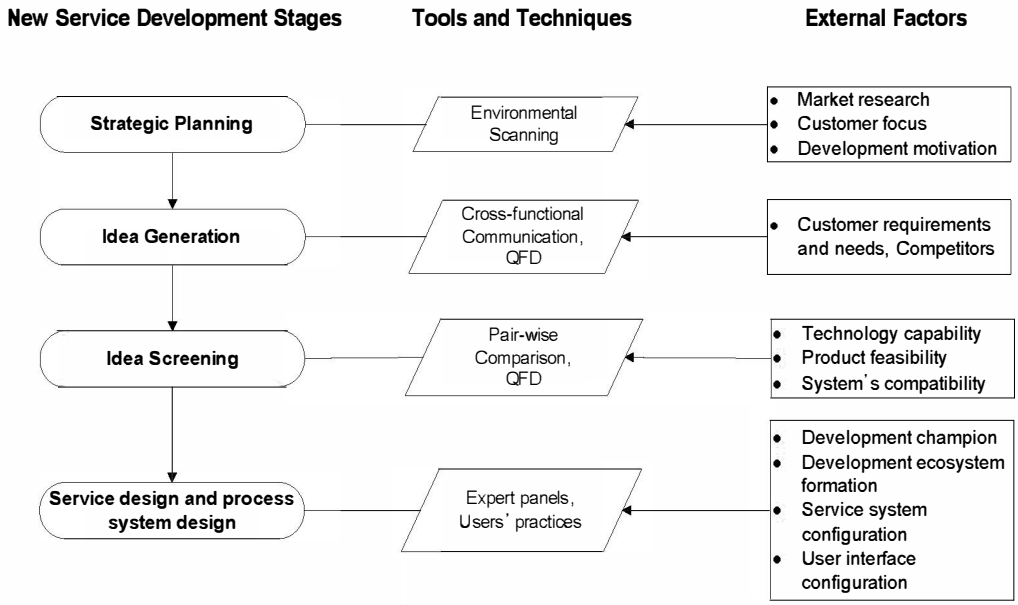


Fig. 8. New service specification in roadmapping process

Products / Offerings	Existing Products	New Products
Existing Services	Market sharing	Line extension
New Services	Market extension	New business

(a) Service-Product Strategy Matrix

Technologies / Offerings	Incremental Technologies	Discontinuous Technologies
Existing Services	Line extension	Reshape style
New Services	Service improvement	New business

(b) Service-Technology Strategy Matrix

Fig. 9. Product-Service-Technology relation

foretell significant later developments. Market demand, innovative products, govermnent regulations and teclmology policies could be major factors that have been influencing the target market. These drivers are unique to the geographical area (demographics define needs) and type of electricity organization.

For the application of the smart grid industry, strategic planning in growing electricity consumption and recent system failures have focused attention on the role that smart grids can play in improving electricity reliability, security and efficiency of electric power – especially by increasing system flexibility. For example, a number of people remember the historic Aug. 2003 blackout, when overgrown trees on power lines triggered an outage that cascaded across an overloaded regional grid. An estimated 50 million people lost power in eight northeastern states and Canada. According to a 2008 Lawrence Berkeley National Laboratory study, the power is out an average of 128 minutes per year[1] in pacific area including Washington, Oregon, California, and Alaska. Smart grid management transformed supply-focused forecasting into market-based demand forecasting, and other quantitative techniques to understand the rate of change and demand for specific smart grid services in the next 5-10 years.

2) Idea Generation

Ideas can arise inside the organization as well as outside of it. Idea generation can be easily implemented in roadmapping process to grasp the market opportunity of how to serve customers and provide time-to-market product features through improving the cross-functional cooperation required integrating teclmology, product, and market needs for the new product and service development with respect to customer requirements. Committee is organized not only to tap employee's knowledge and creativity but also to stimulate cross-functional communication among different divisions. Cross functional meeting established in a firm could help proactively to keep this process alive. It is supported with data mining in newspapers, business and popular press by facilitators. Idea generation should not be an isolated activity in this process. Competitors also can be a significant source of ideas for new services. Customer involvement in service development has been significant ingredient. Through customer's involvement, it typically achieves six major goals as follows [43]:

- Superior and differentiated service
- Reduced cycle time
- User education
- Rapid diffusion
- Improved public relations
- Long-term relationships

For the continuous and integrated feature of the development process, QFD (Quality Function Deployment) tool is employed to structure customer's requirements and needs into service development process.

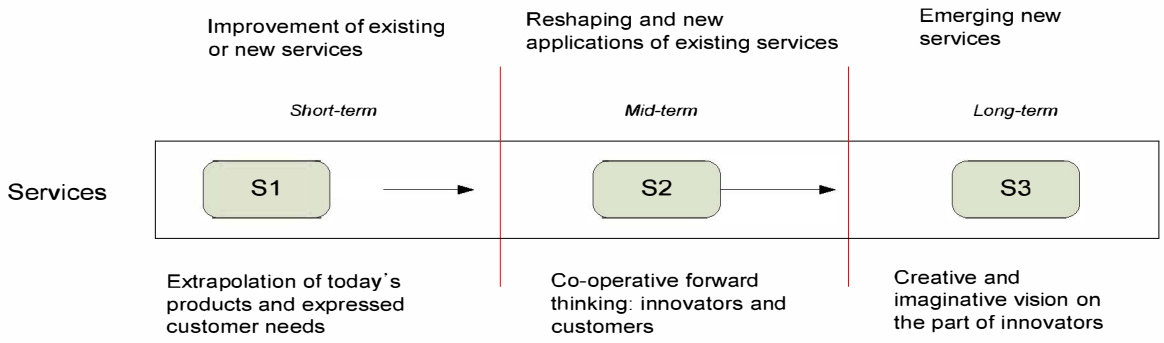
Shown in Figure 9 above, based on the strategic matrix of service and product as well as service and teclmology characteristics, service layer will be developed by expert panel, internal experts and external customers.

3) Idea Screening

Idea screening serves as a function for new service development and prioritization of them to capture the future market opportunity. It is to determine the quality of each idea generated from workshop so that the concept development could proceed. In this stage, expert panels are required to develop service delivery blueprints, review and finally evaluate them with pair-wise comparison technique. The cost and fees structure of a service concept should be articulated during roadmap workshop.

Prioritization of services based on following criteria with overall point of view:

- Market Opportunity (Market needs, growth, and size)
- Marketability (Service Superiority and Uniqueness)
- Service/Product/Teclmology/Company Fit



Source: adapted from [44].

Fig. 10. Service Layer Creation

[1] The data excludes interruptions blamed on extraordinary "major events" such as fires or extreme weather.

4) Service Design and Process System Design

Service design can be defined as "the work of specifying an idea about a new service in drawings and specifications" [45]. This stage provides a means of articulating the nature of new services selected from screening process. Multi-interface services are considered technology-driven service innovations that pose significant challenges to new or existing services with an more interactive and holistic view of designing service system in multichannel offerings [46].

Service design involves different components such as the service system and service process [47]. Service design and process system design can be achieved for the development of new services in roadmapping process as a final step of this stage. Activity design between services and products can support interface development to meet the customer's requirements. An activity diagram can be used to illustrate the flow of key activities taken by the different actors in delivering services over time in order to help design interactions, products and services. Multidisciplinary experts committee is asked to communicate and depict new service ideas in the roadmapping process.

Glusko introduces seven contexts for service design:

- Person-to-person service
- Technology enhanced person-to-person service
- Self-service
- Multichannel service
- Multiple device service
- Computational service
- Location-based and context aware service

At this step, activity diagrams using Unified Modeling Language (UML) can be structured to design service elements in a sequential manner. Interdisciplinary experts and various departments need to participate in this activity cooperatively. It is required to specify an idea about a new service in drawings and activity diagram.

On the other hand, Multi-level service design approach provides a means to integrate the different levels of service such as customer, service and product features. It aims to specify user, service, and product interface in interaction contexts of the multichannel service system. It provides overall view of the service system structure for the new product and service development.

F. Stage 6: Product and Service Integration with VOC

In this step, the product and service configuration will be identified by expert panel and Voice of Customers (VOCs). This step uses Quality Function Deployment (QFD) technique to identify the features that are required for products and services integration to meet the customer's desires. QFD is designed to support strategy planning activities by focusing on characteristics of a new or existing product or service from the viewpoints of market segments, company or technology-development needs. In this research, the house of quality incorporates customer requirements for the development of products and services, define quality requirements, and integrate product-service system. The output of QFD illustrates graphs and matrices that are translated into projects and development efforts that delivery enhanced customer value.

- Identify customer requirements and needs as voice of the customer (VOC)
- Identify the engineering characteristics of products and services that meets VOC
- Setting development targets and test methods for the products and services
- What are the elements of service quality that can be used as guidelines to identify customer needs and areas for improvement?

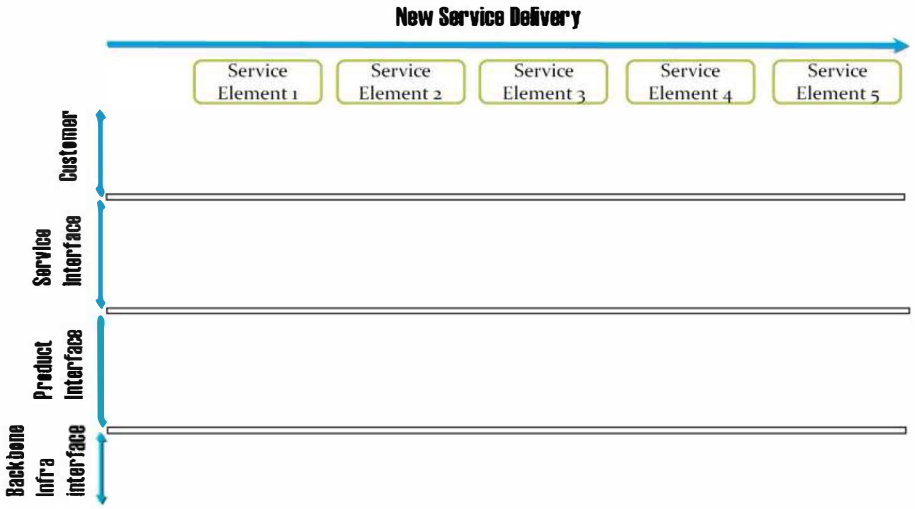
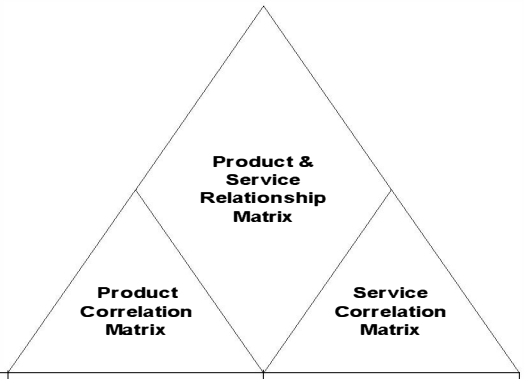


Fig. 11. New Service Process System Design.



VOC	Product Features	Service Elements
Customer's Requirements and needs #1 #2 #3 #4 - - - - -	Customer-Product Relationship Matrix	Customer-Service Relationship Matrix
Technology Characteristics	Technology-Product Relationship Matrix	Customer-Product Relationship Matrix
Sum		

Fig. 12. The House of Quality with Products and Services

G. Stage 7: Strategic Decision Making

This stage identifies the prioritization sequence with respect to each layer such as market, technology, product, service, R&D program and standardization. HDM model is used to determine the priority for resource allocation. Different experts who take part in each workshop involve in strategic decision making process of each layer. The hierarchy of this model consists of 5 different layers such as Mission, Objectives, Goal, Strategy and Action Plan as presented in Figure 13. Each layer decided at stage 1 is assigned to the hierarchy of MOGSA. The final structure of hierarchical linkages among criteria is determined as shown in Figure 13 through the analysis of QFD in previous stage. Like roadmap layers developed in the previous steps, this hierarchical model has time dimension. So, it should be evaluated based on each time period (e.g. short term, mid-term, and long-term).

This stage provides the greatest benefit for a company's new product and service development. Expert panels will be asked to prioritize all criteria and determine the relative significance of each alternative in each layer. The judgmental quantification tool is used in this stage through the pair-wise comparison process. A series of judgment quantifications is obtained from expert panels of each layer who involved in deploying any technology, product and service and integrating them into business objectives.

There are several steps to this analysis.

1. Verify the Organization's Mission. Verify the drivers identified in previous steps.
2. Determine, verify and evaluate the Objectives of the organization with respect to the Mission.
3. Verify and evaluate the Goals with respect to each Objective.
4. Verify and evaluate the Strategies with respect to each Goal.
5. Verify and evaluate the Action Plans with respect to each Strategy.

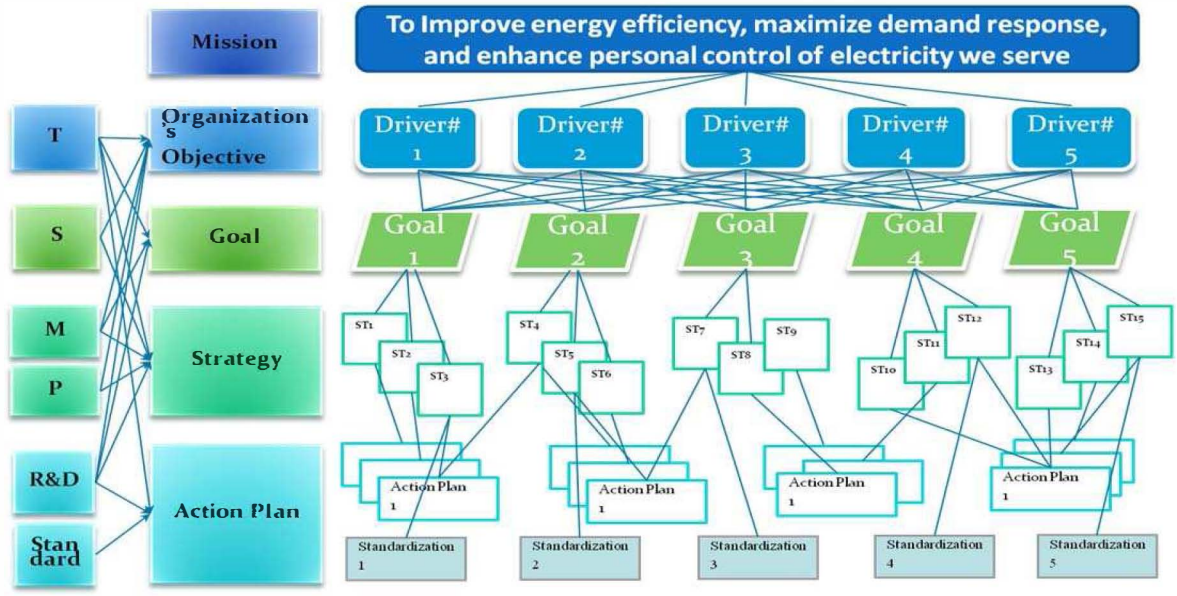


Fig. 13. Strategic Hierarchical Decision Model for prioritization

The result can provide the impact of each smart meter technology with respect to new services and products or market. Rather it is a way to quantify the weight of each layer over the span of the 10-year roadmap creation. Future phases of the model will identify the value of each technology with respect to each Product and Service and the overall Organizational Mission to aid in decision making for strategic planning. Since the technologies have been defined in distinct phases of the 10-year roadmap, recommendations can be made for the technologies with the highest value during in time phase.

VI. CONTRIBUTION OF THIS FRAMEWORK

The advantage of the proposed research is providing a decision support model to aid in strategic service planning and technology development. One of the contributions of this study is to enhance strategic development of service and product with the considerations of emerging technologies. This model enables a comprehensive forecasting considering normative and explorative approaches in order to assist policy maker, universities, research institutes/national labs and companies to make better decision on technology development and new research fields. The strategic decision support model developed in this study fills a challenging gap that a company is facing in turbulent environment in linking product and service development with a view of emerging technology fields. The calculation of relative importance at each level of roadmap can help organizations integrate emerging and incremental technologies and services into their strategic resource planning.

This model will provide various types of values as follows;

i. Policy makers can easily identify relative importance of national priorities in terms of the technologies, service and market perspectives.
ii. Universities, research institutes, and national labs can capture areas of research focus.
iii. Companies can identify the direction of customer needs and areas of commercialization endeavors.

This study is built upon the diverse theoretical groundwork in database, artificial intelligence, statistics, information retrieval, productivity analysis, and knowledge acquisition from experts. The fundamental model can be expanded to be applicable for a variety of industry fields. The application of power industry in this research will provide practical insights by indentifying and highlighting the R&D plan to be developed. Furthermore, the expected outcome of this research is to introduce a model that identifies the gaps between service drivers/needs and expected available technology products. Multiple sources of research data will be used to develop a roadmap that spans 3 different stages of time to evaluate and roadmap emerging technologies. The business and market drivers will be identified and mapped to service needs for the geographical area studied. Identification of these gaps can serve as a feedback loop to strategic smart grid technology management. It will also highlight where there are missing links in the technology roadmap that will prevent the company from filling the complete service needs. On the other hand identification of gaps in the technology realm will identify where not enough resources are being allocated to bring needed products to market.

This research not simply identify research gaps, but also select applicable and practical technology forecasting methods for future study in terms of smart grid technology. Use of multiple perspectives merging normative and exploratory approach can improve the accuracy of forecasting technological change. In summary, this study provides a new technology forecasting methods for the researchers and practitioners for their future work. New approaches with different combination of TF tools would be open to all forecasters.

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