An application of a foresight-based new product planning model

A case study of a large household appliance manufacturer in China

Benjamin J.C. Yuan
Institute of Management of Technology, National Chiao Tung University, Hsinchu, Taiwan, Republic of China

Chun Yi Liu and Shun Chuan Ho
Department of Information Management, Yuanpei University, Hsinchu, Taiwan, Republic of China

Hector K.M. Kao
Institute of Management of Technology, National Chiao Tung University, Hsinchu, Taiwan, Republic of China, and

Po Chang Shen
Advantech Co., Ltd, Hsinchu, Taiwan, Republic of China

Abstract

Purpose – Under such circumstances, how to assign the highest priority for future products which will create the greatest value will be the key success factor for a product planning model. The purpose of this study is to construct an improved planning model for new products based on the theoretical structures of technology roadmaps and patent analysis.

Design/methodology/approach – This study takes the perspective of a product planning strategy, using technology roadmap developed by Institute of Manufacturing Technology of the University of Cambridge, combining with scenario planning and patent analysis. The main body of the proposed model is the technology roadmap of the product. Through patent analysis, the technology roadmap was integrated into the hierarchical execution of product planning to improve the disadvantages of the original technology roadmap and thereby clarify the content of the implemented procedure. With the planning of digital home products in a large household appliance manufacturer in China as a case study, the feasibility of the proposed model was verified.

Findings – The improved planning model for new products comprised five planning phases: market scenario planning, product feature analysis, technological development analysis, patent combination analysis, and resource allocation. A matrix corresponding to product planning was established. The case study is to find out the developing trends in next-generation product features in six different scenarios of digital home for M, a home appliance manufacturer. There are five steps of the product planning model. The product planning model provides enterprises with integrated information from market demand, technology as well as patents. At the same time, it is easy to maintain and reproduce. The authors expect the model to make a contribution to practical product planning.

Originality/value – This model should become an essential prediction tool for enterprises developing new products and can assist in decision-making and strategic implementation.

Keywords Digital home, Patent analysis, Scenario analysis, Technology roadmap, Household appliance manufacturer, New product development, New product planning, China, Product development, Product planning

Paper type Research paper

Chinese Management Studies
Vol. 6 No. 3, 2012
pp. 444-461

1750-614X
DOI 10.1108/17506141211259131

Introduction

Cooper and Kleinschmidt (1998) conducted an attrition rate survey for the development of new products, and found that four out of seven new products reached the development stage, and 1.5 products are eventually mass produced; but only one new product eventually succeeded. Hollins and Stuart (1990) indicated that the proportion of products that successfully survive the entire process from creation to successful production is only 4.75 per cent. In other words, more than 95 per cent of the money invested in the development, design, and marketing of new products does not produce actual returns. Therefore, it is crucial for businesses to conduct comprehensive planning and management of new products to boost their competitiveness.

Current methods used in developing and planning new products include the workflow method, technology road mapping, and patent analysis; each of these methods has its pros and cons. Technology road mapping and patent analysis, in particular, are gradually becoming more important, due to their suitability for long-term product development. Furthermore, the development of new products is intricately related to the protection of intellectual property, and businesses invest large amounts of resources to boost the protection and competitiveness of their intellectual property rights. For example, businesses in Taiwan invested 207.2 billion TWD on research and development in 2006 alone. The maintenance of intellectual property, on the other hand, cost 200 billion TWD, thus making it crucial for business to effectively integrate the planning of new products and the management of intellectual property in order to optimize synergy.

Past studies on the planning of new products did not involve a product planning model that integrates the workflow method, technology roadmaps, patent analysis, and the scenario method. The purpose of this study, therefore, is to construct a model for the planning of new products, and to incorporate technological and corporate strategies to assist businesses in identifying new product development opportunities, and managing patents in existing business environments and product lines to ensure the maintenance of their long-term competitiveness.

This study proposed a model for the planning of new products based on product planning strategies, and with reference to the technology roadmap developed by the University of Cambridge Institute for Manufacturing, incorporating scenario analyses and patent analysis and the five stages of market scenario analyses, product feature analyses, technological development analyses, patent combination analyses, and resource allocation. The proposed model can be used as a reference for business decisions and implementation. This study also proposes strengthening the correlation between levels and uses of homography matrices to conduct conversions to transform the product development map into a version that is easier to manage and reproduce. This study also investigates the digital home product planning process implemented in a home appliance company in China (hereafter referred to as M) to verify the feasibility of this model.

Literature review

New product development

In the current global climate where technological advances are rapid and products change constantly, it is necessary to conduct product innovation continually as well as reducing cost, product differentiation, and centralization. Song *et al.* (1998) classified products into real products and progressive products. Real new products refer to an

innovative product, production type, or delivery system; progressive products, on the other hand, refer to modified and enhanced products, production types, or delivery systems. This study proposes that consumers consider products to be superior when they are more efficient or satisfy a currently unfilled need.

New product development process

Past studies have proposed various product development processes. Booz, Allen and Hamilton (1982) classified the product development process into three different levels based on the perspectives of three driving forces: consumers, competitors, and technologies. Balachandra and Friar (1997) investigated more than 60 studies on the development of new products, and proposed an R&D planning contingency model based on three dimensions, namely, innovation, market, and technology.

Cooper (2000) classified the product development process into seven stages. Cooper *et al.* (2002) also found that 70 per cent of the companies they investigated used the traditional stage-gate process to conduct product research and development.

Patent analysis

Tens of thousands of new products are patented each year, so merely viewing the original patent documents is completely useless in the planning of new products. Patent analysis is thus used to transform patent data into patent intelligence to derive value for the development of products. Patent maps are a common form of patent analysis, and systemizes the organization of patent information. Patent maps can transform complex patent information in two-dimensional form to facilitate interpretation.

The appropriate application of patent information analyses is necessary in the analyses of industrial technologies, investments, patents, research and development, and market monitoring. Furthermore, the integration of patent information and market share facilitates the planning and development of new products.

Technology roadmaps

Technology roadmaps create a product and technology development path that travels across time and through different fields to gain an overall understanding of the short, mid, and long-term development of market, products, and technologies, to ensure the effective allocation of resources. The creation of technology roadmaps facilitates the effective planning and development of new products and promotes communication between stakeholders to facilitate corporate development.

Willyard and McClees (1987) indicated that product technology roadmaps have eight main components. A report by the Australian Government of Department of Industry, Science and Resources Technology (2001), suggests that building technology roadmaps requires using the following steps:

- *Step 1.* Identify needs and profits.
- *Step 2.* Identify industry advocators and leaders.
- *Step 3.* Identify necessary resources and their sources.
- *Step 4.* Establish the technology roadmap development process.
- *Step 5.* Develop the roadmap.
- *Step 6.* Implement and verify the technology roadmap.

Most studies on technology roadmaps focus on theories and lack practical applications. Lee *et al.* (2009) thus recommended the combination of patent analysis with technology roadmaps to benefit from the complementary relationship. The expert opinions that come with the technology roadmap and the selection process inherent in patent analysis can ensure the comprehensiveness of the corporate strategies.

A compilation of the technology roadmap creation process shows that each process has the same four management cycles, namely: pre-planning, technology roadmap development, implementation, and modification. In the pre-planning stage, the objectives, range, and stakeholders are defined; in the technology roadmap development process, the technology roadmap is created; and in the implementation and modification stages, the created map is evaluated and the results are used as a reference for future planning and modification.

Technology roadmaps allow businesses to:

(1) understand consumer needs;

(2) connect existing business practices with long-term goals;

(3) provide an overview of business development at different stages to strike a balance between short-term and long-term development;

(4) boost product projection and key technologies to increase the efficiency of R&D investment;

(5) facilitate the management of technological development trends;

(6) establish a priority order to facilitate policy-making;

(7) centralize resources;

(8) promote communication between organizations and establish common vision and understanding; and

(9) shorten the time-to-market process to accelerate the profit creation process. While there are many advantages by using technology roadmaps, the real challenge lies in the incorporation of technology roadmaps.

Scenario planning

The word "scenario" was first used in the development of scripts for the theatre. The simulation of scenarios describes things that could happen in the future, as well as causal relationships. Studies have also disagreed on the definition of scenario planning and prediction. Scenario planning can include all future-oriented data that is used to plan and define future possibilities. The main difference between scenario planning and traditional prediction methods is that the latter focuses on the innovation or maturity of a time period, a type of technology, or a product; scenario planning, on the other hand, creates different scenarios based on the development of various optimistic and pessimistic possibilities.

In product development, scenarios are used to simulate what users need, do, or know in various situations in a systematic manner (Imaz and Benyon, 1999). Scenario analyses are conducted to simulate different scenarios to predict possible outcomes and to provide recommendations and possible directions for product development.

Digital homes

The main concept behind digital homes is the collaboration of broadband network connection and online content distributors to incorporate 3C terminal products and share digital content.

Most computer companies believe that digital homes have the personal computer at their core, and integrate the network connection at home to provide families with smart products that can transmit digital content or access external resources. Consumer electronics manufacturers, on the other hand, view digital homes as having the television at their core. Furthermore, mobile device manufacturers have also proposed the development of digital homes centered on the mobile phone. In broader terms, digital homes are not limited to multimedia applications. Other extensive concepts include most home functions such as control systems for home appliances, family websites, surveillance systems, telemedicine, and home care. However, the multimedia entertainment-centered digital home application is currently more advanced, and is thus the focus of development in many companies.

In terms of the actual application of products, the most common application is the use of digital home appliances to provide entertainment, followed by the use of personal computers to access information through an online platform, and automation and control applications such as sensors and security services. In terms of information application, on the other hand, the most common example is a family business in an effort to create an unobstructed family office environment. In terms of monitoring and security services, short-range wireless control technologies can be used to control home appliances and health care applications.

Foresight-based new product planning model

With the rapid growth of the global environment, the planning of technological resources has become a crucial factor in deciding corporate product development, and even the competitiveness of the company. It is thus necessary to continually develop new products to increase company value and maintain long-term competitiveness. The development of a comprehensive standardized product planning model is therefore at the core of the planning of management strategies.

The product planning model proposed by this study centers on the product technology roadmap, and incorporates patent analysis in the product planning process to improve upon the insufficiencies of the technology roadmap in clarifying the processed content. The product planning model is created through market scenario planning, product feature analyses, technological development analyses, patent combination analyses, and resource allocation. It is thus necessary to view the process holistically and to create a chart of the process (such as the homography matrix shown in Table I). The study also investigated the feasibility and efficiency of the model when applied in a home appliance manufacturer.

The five stages in the model are described as follows:

(1) *Market scenario planning*. When the degree of uncertainty is high and there are many unstable factors in an environment, the scenario planning method can be used to understand the current and future situations of the market. The method can be used to evaluate the current market situation through the assessment of consumer needs and the status quo of main competitors to both facilitate the

prediction of future products and market scenarios, and to adopt product development strategies for boosting competitiveness.

(2) *Product feature analyses*. After obtaining future product projections through the market scenario method, each scenario is processed through product feature analyses to predict the functions of future products. This can be achieved through secondary data collection, such as the evaluation of key product features in focus groups.

(3) *Technological development analyses*. After conducting product feature analyses, related technologies in the product features are classified and presented in the form of a fishbone diagram, and expert opinions are consulted to complete the classification of technologies.

(4) *Patent combination analyses*. Intellectual property analyses involve the discussion of patents and risk evaluations, such as where the patent should be registered, what the range should be, what the correlation is between the content of the patent and the application in the country in which the business is located, and patent issues in other countries.

The analysis is conducted through the search of patent information which uses common keywords in the industry or technologies, different patent classifications worldwide, and the names in International Patent Classification and of competitors. Afterwards, a patent information chart is created for the derived patent information and combined with time evolution factors. Patent combination analyses are completed with the use of technology distribution charts, technology function matrices, and competitor analyses.

(5) *Resource allocation*. Planning analyses are conducted to facilitate research and development decision-making; which, in other words, is the order of resource allocation for determining which research and development item to process. In this stage, expert opinion, the results of product technology matrices and patent analysis are consulted to decide which research and development activities are the most crucial.

Digital home case study

A home appliance magnate in China (hereafter referred to as M) is one of the world's top 500 makers of white home appliances, as well as being one of the top 100 electronic manufacturers in China. The manufacturer is a parent company to more than 240 corporate units and listed companies and has design centers, manufacturing bases,

Stages	Scenarios Future life scenarios		
Market scenarios	Scenario 1	Scenario 2	Scenario 3
Product features	Product 1-1	Product 2-1	Product 3-1
	Product 1-2	Product 2-2	Product 3-2
Technological development	Technology 1-1	Technology 2-1	Technology 3-1
	Technology 1-2	Technology 2-2	Technology 3-2
Patent combination			
Resource allocation	The most crucial		

Table I.
Market/product/ technology/ patent/ resource homography matrix

and trade companies in more than 30 countries, employing more than 50,000 people. This study was proposed by M's research and development department in an effort to enter the digital home market. Therefore, M proposed requirements for digital home products and outsourced the registration process to an intellectual property corporation, K. This study propounded a product planning model for the development of new products.

Digital home market scenario planning

(1) Evaluating the needs of digital home consumers. People spend the majority of their time at home and thus have diverse demands of their home surroundings. Smart home networks provide various services to satisfy the diverse needs of their users. Most consumers have the following home communications, information, and entertainment needs:

- *Data*. This primarily refers to data obtained and processed using computers. Most people are accustomed to having computers in the workplace, and families increasingly own multiple computers at home; similar to the use of ADSL and cable modem broadband internet access, which is another driving force behind the proliferation of home networks.
- *Entertainment*. There are two types of home entertainment networks. The first type refers to upgraded audiovisual entertainment networks, and the second type refers to online multimedia entertainment content, which has become more accessible with the popularity of broadband internet access.
- *Voice*. With the proliferation of broadband internet access, home applications of IP communication networks have also become more common. PSTN led to VoIP in landline telephone applications. VoIP is not restricted by cable communication networks and cell phones can also enjoy the same mobility, facilitating voice, data, and image transmissions at an affordable price. VoIP allows users to choose between various telecommunication services due to the relative ease of installing IP and the broadband convergence network.

(2) The current status of major competitors. Samsung, Panasonic, Philips, and LG are the four most advanced digital home industry companies today. This study compiled data on the digital home products produced by these companies and used this information as a reference for market planning.

The concept of a digital home is first analyzed with the six most common areas of the home (garage, kitchen, bedroom, living room, bathroom, and the general environment) on the horizontal axis. The digital home is then divided into six aspects, namely the central control system (including signal transmission and control networks), security monitoring and control, healthcare, home environment (convenience and comfort), information appliances (including audiovisual entertainment equipment), and green energy, and placed on the vertical axis. The resulting Table II can be used to gauge the products and technologies offered by competitors.

(3) Digital home market scenario planning. After surveying customer needs and obtaining information regarding the situation of the competitors, a brainstorming session was conducted, and a homography matrix was created. The chart lists two central control systems, eight security monitoring and control products, 12 healthcare products, six green energy products, 12 information appliance products, and five home environment products.

Scenarios	Garage	Kitchen	Bedroom	Demands Products Living room	Bathroom	Overall
Central control systems		S: 1 Pa: 1 L: 1		S: 2 Pa: 2 L: 2		
Security monitoring	L: 3	S: 4 L: 5		L: 6		S: 7, 8, 9, 10 Pa: 11, 12 L: 7, 13
Healthcare			Pa: 14	Ph: 15, 16, 17	Pa: 18 L: 19	S: 20, 21
Environmental protection and energy-saving		S: 22, 23			Pa: 24, 25	Pa: 26
Intelligent appliance		S: 27, 28 Pa: 29, 30, 31		S: 32 Pa: 33 L: 34		S: 35 Pa: 36 Ph: 37 L: 38, 39
Home environment			Ph: 40			S: 41 Pa: 42, 43 Ph: 44 L: 41, 45, 46, 47, 48

Notes: S – Samsung; Pa – Panasonic; Ph – Philips; L– LG; 1 – refrigerator monitor controller; 2 – remote control system; 3 – parking management machine; 4 – gas auto monitor controller; 5 – gas valve control; 6 – closed–circuit television; 7 – security protection system; 8 – emergency button; 9 – RFID Entrance Guard System; 10 – community remote monitor; 11 – intelligent entrance guard system; 12 – corner relief system; 13 – emergency call system; 14 – electric bed; 15 – body cycle; 16 – water font; 17 – soft therapy; 18 – chair mode shower system; 19 – intelligent toilet; 20 – telehomecare; 21 – physiological signal monitor; 22 – tertiary heat conduction microwave; 23 – energy-saving cook stove; 24 – heat pump water heater; 25 – vacuum and heat preservation bathtub; 26 – fuel cell generating system; 27 – wisdom washes and dries machine; 28 – navigation vacuum cleaner; 29 – kitchen guide system; 30 – food waste disposer; 31 – antiseptic and atomization dish washer; 32 – VoIP video phone; 33 – RFID mobile phone; 34 – DTV; 35 – electrical appliances auto controller; 36 – home theater; 37 – in touch system; 38 – intelligent control terminal; 39 – information appliance control; 40 – ambient window; 41 – light, background music, and air conditioner controller; 42 – comfortable environment controller; 43 – voice recognition and remote control system; 44 – light spectrum, and music spectrum; 45 – pyroscan; 46 – curtain control; 47 – scene gearing control; 48 – humidity sensor

Table II.
The product matrix of major competitors

The scenarios generated during the brainstorming session are listed in Table III. The list shows the products that were the primary focus of development for digital homes in the past five years; the number of product categories has reached a new record. This study also found that the development of digital homes is progressing in two different directions, one is the more advanced technological development of terminal products, and the other is the integrated control of terminal systems and home appliances through optical and audio means.

Table III.
Market scenario/product homography matrix

Scenarios	Garage	Kitchen	Bedroom	Demands Products Living room	Bathroom	General
Central control systems		Refrigerators monitors		Remote control systems		
Security monitoring and control	Garage access and waterproofing systems, car anti-theft systems, parking guidance systems	Gas water temperature monitoring systems				Security access control systems, emergency call systems, fire alarm detectors, community security monitoring and control systems
Healthcare			Smart mattresses, electric beds	Smart sofas for senior citizens, intelligent electronic first aid kits, smart assistants, diversified health measuring tapes, smart water coolers, wearable massagers	Smart toilets, shower seat systems	Virtual watches, remote care
Home environment			Smart wardrobes, smart lighting			Curtain control, integrated scene control, auto-detect temperature control systems
Information appliance		Smart washing machines with dryers, self-navigating vacuum cleaners, smart kitchens, food waste processors, energy-saving self-sterilizing dishwashers		Digital TV (DTV), VoIP video phones, RFID mobile phones		Error-detecting home appliances, air filtration and monitoring systems, intelligent control terminal, message control systems for home appliances
Green energy		Energy-saving microwaves, energy-saving cooking stoves			Wastewater treatment systems, energy-saving water heaters, green energy hot tubs	Family friendly power generation systems

Digital home product feature analyses

The latest consumer products are all digitalized and integrate multiple functions. Due to the integration and combination of home appliances, computers, communication devices, and other products, it is no longer possible to classify new products based on their earlier categories. Every minor change is another step in the creation of digital homes. New electronic products found in digital homes are characterized by the following features: information sharing, plug and play, wireless transmission, value-added images, data storage, and are compact in size (Jian, 2004).

Studies have also indicated that the core concept of a digital home is the incorporation of multiple technologies and applications, such as televisions, desktop computers, mobile phones, handheld devices, audiovisual equipment, digital content, broadband internet access, home networking, and digital cameras. In addition, the key factors that contribute to the realization of the digital home is the proliferation of digital content, the advent of digital devices, and internet accessibility.

This study summarizes the key factors of a digitalized lifestyle as primarily comprising prevalence, convenience, efficiency, and optionality, but also involving the formation of the digital home, the connection of the home network, and home control. The establishment of a connected home environment through the use of cable or wireless internet connections, the connection to various data terminals, and the incorporation of voice, data, and multimedia control and management functions facilitate data transmission and connection between terminal equipment in the home environment. In terms of home control, mobile phones or the internet can be used to control, adjust, or monitor home equipment from a remote location. Examples include the control of microwaves, washing machines, air conditioners, lights, temperature, and humidity.

Table IV was derived by using an MRI survey of key indices to evaluate the quality of life in Japan, and the results were combined with digital home products, quality indicators, and expert opinions.

Digital home technological development analyses

The related classification technologies of six scenarios concerning the digital home central control systems, security monitoring and control, healthcare, home environment, green energy, and information appliances are described as shown in Table V.

Classification of functions	Description
Health	Promotes health or monitors health indices
Entertainment	Used for entertainment purposes
Safety	Promotes home and home appliance safety
Environmental protection	Emphasizes environmental protection and the conservation of resources
Energy-saving	Conserves energy resources
Ease of installation	Simplifies the installation of devices
Living convenience	Promotes a convenient lifestyle
Simple controls	Reduces the complexity of controls
System stability	Promotes digital home operational efficiency and reduces errors in digital home systems
Comfortable environment	Provides a comfortable home environment
Cost reduction	Reduces the cost of equipment and consumables

Table IV.
Classification of digital home product features

First layer	Second layer	Description
Central control systems	Control structures	Controls all home appliances through control systems or programs
	Authorization management	Ensures the security and stability of home network systems through the use of authentication systems
	Condition monitoring	Assesses electronic equipment by monitoring modules or establishing a monitoring procedure
	Network transmission	Facilitates communication between and control of home appliances through a network connection
	Remote control access	Facilitates remote control of home appliances
	Human machine interface	Displays the condition of home appliances and provides a platform for controlling and interacting with home appliances
	Others	Refers to other central control system devices
Security monitoring and control	Security monitoring and control	Monitors indoor and outdoor activity using monitoring systems
	Fault detection	Monitors home appliance use through the in-built detectors and modules of home appliances
	Environmental monitoring	Monitors possible risks, such as a coal gas or electric leakage
	Access authorization	Restricts home appliance use through the application of verification systems or components
	Remote control access	Controls home appliances remotely to reduce possible risks
	Access control systems	Automates input and output devices
	Others	Includes other security monitoring and control devices
Healthcare	Position monitoring	Locates items in the home, such as food and clothing
	Inventory control	Manages the inventory of consumables and communicates with the user through an interface
	Hospital bed control	Automates hospital bed control modules
	Remote control access	Controls healthcare modules remotely
	Others	Includes other healthcare devices
Home environment	Temperature control	Controls home environment temperatures
	Lighting control	Controls home lighting
	Shade control	Controls automatic shade modules
	Environmental monitoring	Includes other methods of environmental parameter monitoring
Information appliances	Control systems for home appliances	Controls home appliances
	Heating and cooling/ dehumidification	Includes air conditioners and dehumidifiers

Table V.
Classification of digital home technologies

(*continued*)

First layer	Second layer	Description
	Kitchenware/refrigerators	Includes kitchenware, such as refrigerators and ovens
	Cleaning devices	Includes cleaning devices, such as vacuum cleaners
	Bathrooms	Includes bathroom devices, such as SPA devices and toilets
	Audiovisual appliances	Includes audiovisual devices, such as TVs and stereo systems
	Data storage	Includes online data storage devices
	Others	Includes other information appliances
Green energy	Operation control	Includes green energy device control modules
	Water resource control	Includes water resource control devices
	Coal gas/energy control	Includes non-water or electric-powered control devices
	Power management	Includes power-control software
	Others	Includes other green energy devices

Table V.

Digital home patent combination analyses

(1) Digital home general patent combination analyses. This study found 1,227 US patents for digital homes. This study conducted patent analysis (including the patent matrices of digital home technologies/functions showed in Table VI) and found that the classification of technologies concentrated primarily on central control systems and information appliances. The numbers refer to the number of patent applications by type.

The key requirements of functions in digital homes are living convenience, simple controls, and system stability. The considerations of cost reduction, safety, and ease of installation are also relatively important.

Features	Central control systems	Security monitoring and control	Scenarios Healthcare	Home environment	Information appliance	Green energy	Total
Living convenience	114	4	4	21	61	16	220
Safety	44	26	0	3	17	9	99
System stability	202	0	0	0	33	1	236
Ease of installation	62	0	0	0	15	1	78
Cost reduction	73	2	3	3	16	13	110
Entertainment	2	0	0	1	2	0	5
Health	1	0	1	0	0	0	2
Comfortable environment	10	0	1	5	18	3	37
Energy-saving	4	1	0	6	1	36	48
Environmental protection	26	0	0	1	11	1	39
Simple controls	289	0	0	0	63	1	353
Total	827	33	9	40	237	81	1,227

Table VI.
The patent matrices of digital home technologies/functions

Digital home technologies can be characterized as having simple controls, system stability, and providing living convenience through central control system technologies. In contrast, the central control system patent layout focuses on the ease of installation and installation costs. Another layout focus of the digital home is the promotion of living convenience and simple controls for information appliances.

(2) Central control system patent combination analyses. This study found 827 patents of central control technologies. The focus of central control systems is their control structure and network transmissions; central control systems primarily provide system stability and simple controls. Network transmission also focuses on achieving system stability and remote control to enable simple controls. Additionally, the development of a human-machine interface is crucial and focuses on achieving both living convenience and simple controls.

(3) Security monitoring and control patent combination analyses. This study found 33 patents of security monitoring and control, all of which are certified patents; however, there were no patents of home safety after 2007. Patents of security monitoring and control technologies were primarily of security monitoring and control, access control systems, and permission verification.

(4) Healthcare patent combination analyses. This study found only nine patents on healthcare, of which one was a certified patent, and the rest were public patents. Home care patent applications began in 1996 but were minimal. The highest number of patent applications was three in 2002.

(5) Home environment patent combination analyses. This study found 40 patents on home environment technologies. Home environment patent applications began in 1992 with two to five patent applications per year; the amount began decreasing in 2006. The collected data shows that the majority of the patents were on lighting control, but the highest demand is of living convenience and energy conservation.

(6) Information appliance patent combination analyses. This study found 237 patents of information appliance technologies, mostly on control systems for home appliance technologies, but the strongest demand is of simple controls and living convenience. Manufacturers focus on the production of control systems for home appliance technologies. They are racing to patent products with simple controls that enable living convenience, followed by those that provide system stability.

(7) Green energy patent combination analyses. This study found 81 patents on green energy technologies. Applications for green energy technology patent began in 1991, with the primary developmental stages between 2001 and 2006 at approximately ten patent applications per year. The number declined after 2006. Green energy technologies primarily focus on power management technologies, such as using power management to achieve energy conservation and living convenience.

(8) Competitor patent layout analyses. Samsung applied for 64 patents on smart homes, of which 21 were certified patents and 41 were public patents. Applications began in 1998 and peaked in 2006; the amount, however, decreased to single digits in 2007. Most patents were of layout technologies such as central control systems and information appliances, with 40 on central control systems, three on home environment, 19 on information appliances, and two on security monitoring and control.

Panasonic was the pioneer of the field and its patent applications began in 1990; the amount peaked in 2001. However, after the Korean brands LG and Samsung entered the market in 2002, the patent applications made by Matsushita declined drastically to zero in 2007 and 2009. Panasonic's patent applications were primarily for central control systems, information appliances and green energy systems only comprised one-fourth of the applications, and the remaining three-fourths consisted of central control system patents.

Philips dedicated much of its attention to smart home technologies in 2005, but slowed up after 2005. Philips is one of the leading companies of the lighting industry and thus dedicated more effort to lighting control. In addition to home environment technologies, Philips is also active in the central control system market.

LG applied for 64 patents on smart homes, of which 33 were certified patents and 31 were public patents. Patent applications began increasing in 2000 and peaked in 2004; the amount remained over ten in 2005 and 2006 before eventually declining in 2007. LG's patents were primarily for central control systems and information appliances, with 37 on central control systems, 25 on information appliances, one on a home environment system, and one on a home safety system.

Whirlpool applied for 31 patents on smart homes, of which 11 were certified patents and 20 were public patents. Between 1996 and 2001, there was a lack of patent applications, but starting in 2006, the company has been applying for numerous patents. While many other home appliance companies greatly decreased their patent applications in 2007, Whirlpool's patent applications reached a new high. In addition to information appliances and central control systems, Whirlpool also has patents of green energy technologies, with more patents on green energy technologies than on power management and energy control technologies.

The digital home product planning strategies of M

The following conclusions were determined through market planning of digital home products, product feature analyses, technological development analyses, patent combination, and competitor analyses. These results can be used as a reference point for planning M's development direction for digital home products, and for decisions regarding the resource allocation of research and development projects.

(1) Decrease in patent applications among leading brands. After peaking in 2006, patent applications by many of the leading brands decreased significantly. Based on the analysis of the life cycle of technologies, the total number of patent applicants has also dropped, indicating inconsistent efforts to develop technology and suggesting a bottleneck period.

(2) A focus on central control systems and information appliances in the home appliance market. Leading home appliance brands such as Samsung, LG, Whirlpool, Matsushita, and Toshiba are the primary applicants of patents on central control systems and information appliances. In contrast, other brands applied for the majority of patents on home environment, green energy, security monitoring and control, and healthcare technologies. Leading home appliance brands focus primarily on central control systems and information appliances in the digital home sector.

(3) The strategies and characteristics of leading brands. The Korean brands Samsung and LG focus on central control systems and integrate digital home scenarios in their products. In contrast, Panasonic integrates green energy into its existing products, while Philips releases digital home scenario products based on their popular electronic and lighting technologies. Korean brands evidently focus on the most profitable, but also the most challenging, markets to control the central control system market.

(4) A new niche in the home appliance market. This study found that the digital home product development of all scenario products share two characteristics. The first is the promotion of energy-saving technologies and innovation, and the other is the integration of home appliances and central control systems to control product use. As shown in Table VII, healthcare has the most inconsistent number of patent applications and is the least targeted aspect of the digital home. Therefore, this is the research direction M should take. Products in the healthcare scenario include electric beds, smart toilets, and virtual watches. Based on analyses of the patent applications for these technologies, inventory control, position monitoring, and hospital bed control are currently the least focused on applications. This study therefore recommends additional research and development to generate more applications for patents of these three fields.

Conclusions and recommendations

(1) This study reviewed studies that combined technology roadmap and patent analysis and proposed a product planning model. This model incorporates the pulling force of the market and the pushing force of technologies to form a reference structure for product planning based on the five stages of scenario planning, functions analyses, technologies analyses, patent analysis, and resource allocation. Presenting this information as a chart and clearly defining the prerequisites of a product planning model can more accurately pinpoint the key factors of successful product development.

(2) The main requirements of digital homes are convenience, entertainment, energy conservation, security, comfort, cost reduction, and health. In terms of technological development, simplified terminal controls are currently the primary focus, but health and safety is expected to become the primary focus in the future.

(3) Leading home appliance brands primarily patent central control systems and information appliance technologies, and focus less on healthcare. More attention should be provided to the development of new healthcare products.

(4) In healthcare product technologies, the most promising patent applications are expected to be on inventory control, position monitoring, and hospital bed control. Therefore, more research and development resources should be allocated to these technologies.

(5) Businesses should consolidate their intangible assets, namely patents. They should also conduct reviews of existing patents to identify a niche and find opportunities for innovation to build a sustainable business model.

Table VII. Digital home market/product /technology/patent /resource homography matrix

	Future life scenarios					
Market scenarios	Central control systems	Security monitoring and control	Healthcare	Home environment	Information appliance	Green energy
Product features	Refrigerator monitors, remote control systems	Garage access and waterproofing systems, gas water temperature monitoring systems, security access control systems	Electric beds, smart toilets, virtual watches	Smart lighting, curtain control, temperature control systems	Digital TVs, intelligent control terminals, smart kitchens	Wastewater treatment systems, energy-saving microwaves, family friendly power generation systems
Technological development	Control structures	Security monitoring and control	Inventory control	Temperature control	Control systems for home appliances	Operation control
	Authorization management	Fault detection	Position monitoring	Lighting control	Heating and cooling/ dehumidification	Water resource control
	Condition monitoring	Environmental monitoring	Hospital bed control	Shade control	Kitchenware/ refrigerators	Coal gas/energy control
	Network transmission	Access authorization	Remote control access	Environmental monitoring	Cleaning devices	Power management
	Remote control access	Remote control access	Others		Bathrooms	Others
	Human machine interface	Access control systems			Audiovisual appliances	
	Others	Others			Data storage	
Patent combination	298	12	1	3	166	2
	20	3	1	31	19	13
	50	3	1	1	14	27
	191	5	3	5	7	35
	135	2	3		7	4
	125	5			9	
	8	3			1	
Resource allocation			Most crucial			

References

Australian Government of Department of Industry, Science and Resources Technology (2001), *Planning for Business Competitiveness: A Guide to Developing Competitiveness*, Occasional Paper No. 13, Emerging Industries Section, Department of Industry, Canberra, available at: www.technologyforge.net/enma/6020/6020Lectures/TechnologyRoadmapping/ENMA291TRReferences/TechnologyRoadmapping.pdf

Balachandra, R. and Friar, J.H. (1997), "Factors for success in R&D projects and new product innovation: a contextual framework", *IEEE Transactions on Engineering Management*, Vol. 44 No. 3, pp. 276-87.

Booz, Allen and Hamilton (1982), *New Product Management for the 1980s*, Booz, Allen and Hamilton, New York, NY, p. 17.

Cooper, R.G. (2000), "Doing it right – winning with new products", *Ivey Business Journal*, July/August.

Cooper, R.G. and Kleinschmidt, E.J. (1998), "Resources allocation in the new product development process", *Industrial Marketing Management*, Vol. 17, pp. 249-62.

Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (2002), "Optimizing the stage-gate process: what best-practice companies do – I", *Research Technology Management*, Vol. 45 No. 5, pp. 21-7.

Hollins, B. and Stuart, P. (1990), *Success Product Design*, Butterworth, London, pp. 3-16.

Imaz, M. and Benyon, D.R. (1999), "How stories capture interactions", in Johnson, C. and Sasse, A. (Eds), *Proceedings of Interact'99*, IOS Press, North Holland.

Jian, Z.S. (2004), *The Research of IC Design Industry Management*, Industrial Economics and Knowledge Center, Taipei.

Lee, S., Yoon, B., Lee, C. and Park, J. (2009), "Business planning based on technological capabilities: patent analysis for technology-driven roadmapping", *Technological Forecasting & Social Change*, Vol. 76 No. 6, pp. 769-86.

Song, X.M., Thieme, R.J. and Xie, J. (1998), "The impact of cross-functional joint involvement across product development stages: an exploratory study", *Journal of Product Innovation Management*, Vol. 15, pp. 289-303.

Willyard, C.H. and McClees, C.W. (1987), "Motorola's technology roadmap process", *Research Management*, Vol. 30 No. 5, pp. 13-19.

About the authors

Benjamin J.C. Yuan is a Professor in the Institute of Management of Technology at National Chiao Tung University, Taiwan, R.O.C. He graduated from the State University of New York at Buffalo with Master's and PhD degrees both from the Electrical Engineering Department in 1975 and 1978. His current research interests include technology forecasting and impact assessment, technology foresight and policy, innovation and R&D management, entrepreneurship and incubation management, core technology and competitive strategy, business plan and new venture, industrial economy, and technology development.

Chun Yi Liu is an Assistant Professor in the Department of Information Management, Yuanpei University, Taiwan, R.O.C. He graduated from the National Chiao Tung University with Master's and PhD degrees both from the Institute of Management of Technology in 1995 and 2009. He has been a Councillor of Tao-Yuan County Council in Taiwan. His current research interests include national technology policy, public policy and innovation management. Chun Yi Liu is the corresponding author and can be contacted at: tojo@ms38.hinet.net

Shun Chuan Ho is an Assistant Professor in the Department of Information Management, Yuanpei University, Taiwan, R.O.C.

Hector K.M. Kao has received his Master's degree from the Department of Business Administration at National Changhua University of Education, Taiwan. He is a PhD candidate at the Institute of Management of Technology at National Chiao Tung University, Taiwan. His current research interests include systematic innovation, business model and service management.

Po Chang Shen has received his Master's degree from the Institute of Management of Technology at National Chiao Tung University in 2010. He is a Product Manager at Advantech company, Taiwan, and his major field of interest is industrial grade panel PC's.