A COMPARATIVE STUDY OF DIFFERENT KINDS OF TECHNOLOGY ROADMAPPING FORMATS AND INTRODUCING THE VISUALIZATION TECHNOLOGY ROADMAPPING

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Abstract

In today's high tech world, technology is an absolute need for all industries which they cannot escape from. The importance of technology in an environment of uncertainty and rapid change, force firms to apply somemethods to sustain their competitive advantage and core competence. Technology roadmapping (TRM) is one of these methods which its value for technology planning, technology selection and technological innovation has become widely recognized. This paper firstly describes different types of technology roadmapping formats along with a summary comparison of their advantages and disadvantages. Secondly, considering to various formats that were presented in relevant studies, a new technology roadmapping format called visualization was introduced. Finally, based on the experts' opinion that are familiar with these methods, the pictorial and graphical formats are more understandable and facile for use but more difficult to generate, time-consuming and costly. In contrast, textual methods are more facile to generate, but difficult for use.

Keywords: technology roadmap, management of technology, strategy, visualization

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Introduction

The world economy is going through a notable change and the place of technology in modern society is a critical matter(Daim, Basoglu, Dursun, Saritas, & Gerdsri, 2009).Technology is a major key resource for corporate profitability and growth, and has enormous significance in the well-being of industry economics, as well as competitiveness (Lin, Tang, Shyu, & Li, 2010). Both academics and practitioners are aware of the increasing interactive and critical importance of technology in the corporate strategic process(Walsh, 2004).In fact, the competency perspective of strategy places technology and technology management as the basis of a firm's search for competitive advantage as a necessary but not adequate condition for success (Prahalad & Hamel, 1990; Linton & Walsh, 2002). Therefore, effective technology management to organizational growth is greatly emphasized (Lin et al., 2010).

Currently, the roadmappingtechnique is applied in industry, government, and academia for providing a way to develop a technology strategy, identify gaps and opportunities in research development, and plan for resource allocation (Gerdsri & Kocaoglu, 2007).

Technology roadmap is one of the most widely used methods to support the strategic management of technology (Lee & Park, 2005). It is a comprehensive approach tostrategic planning which integrates science or technology development into product and business aspects (Bagheri Moghaddam & Sahafzadeh, 2010). Technology roadmaps can takevariousforms, but generally consist of multi-layered, time-based, graphical, and charts which enable technology developments to be aligned with market trends and drivers (Phaal, www.cgee.org.br). At first, TRM was developed by Motorola in the late 1970s to support integrated product technology planning and technology roadmaps have been used by a variety of companies, industries and countries for strategic and technology planning(Holmes & Ferrill, 2005; Phaal & Muller, 2009).

TRM enables R&D activities to be performed in a more systematic manner, by laying out clear plans about what technologies to develop when and how by forecasting future trends and identifying gaps between the firm's current technology levels and advanced levels it desires to achieve(Lee, Kang, Park, & Park, 2007).

This paper focuses on technology roadmapping formats. Roadmapping is a very flexible approach, and the various formats which it can support are reviewed in this study. Moreover, the different formats of technology roadmapping are compared and the visualization technology roadmapping is introduced.

Concept ofroadmap, technologyroadmap and technologyroadmapping

A "road map" is a layout of paths or routes that exists (or could exist) in some specific geographical space(Kostoff & Schaller, 2001).It exists in different forms according to the situations in which they are developed (Lee, Hyung-il, & Phaal, 2011).Roadmaps are defined as the views of a group of stakeholders as to how to get where they want to go to achieve their desired goals(Kajikawa, Usui, Hakata, Yasunaga, & Matsushima, 2008).Robert Galvin defined roadmap as "An extended look at the future of a chosen field of inquiry composed from the collective knowledge andimagination of the brightest drivers of the change" (Galvin, 1998).

Regarding to the concept of roadmap, technology roadmap can take diverse meanings: Rinne believes that, technology roadmaps provide a map of theunfolding evolution of technologies and the products that implement them (Rinne, 2004).James Winebrakedescribed technology roadmaps as a future based strategic planning device which outlines the goals, barriers, and strategies necessary for achieving a given vision of technological advancement and market penetrations (Amer & Daimo, 2010).

Technology roadmapping is a needs-driven technology planning process to help identify, select, and develop technology alternatives whichmeet a set of product demands (Blismas & Wakefiield, 2010). Institute for Manufacturing defined technology roadmapping (TRM) as "A high-level integrated planning tool which can be used to support the development and implementation of strategy and plans, as well as communication of the plan" (Phaal, Farrukh, & Probert, 2001a).It is a relatively new and powerful technique enabling the evolution of markets, products and technologies to be explored, as well as the linkages between the various perspectives(Pataki, Szalkai, & Bíró-Szigeti, 2010).

Usageand benefitsoftechnologyroadmap

Technology roadmap can be applied in many fields, such as physical and service product planning (Lee & Park, 2005), development of product family tree (Groenveld, 1997) and program planning (Lee & Park, 2005).Its application has gained popularity due to the increased recognition and awareness of the importance and primal role that technology and technology management has in the strategic process (Walsh, 2004).According to the study of Albright and Kappel, technology roadmaps in the corporate setting are used to define the plan for the evolution of a product, linking business strategy to the evolution of the product features (Albright & Kappel, 2003).

Although each organization applies TRM for its own set of reasons, the main objectives of technology roadmapping are widely seen to include the following:Identification of gaps;Prioritization of issues;Target setting/creating action plans; andCommunication across the organization (Gindy, Cerit, & Hodgson, 2006).

A new trend has emphasized the possibility of an extensive application of TRM, and different exploratory studies have been conducted to integrate TRM with other strategic processes such as TRM for R&D planning,TRM for disruptive technology, TRM for knowledge management, TRM for NPD, etc.(Lee S. , Kang, Park, & Park, 2007). Moreover, many other approaches having planning dimension, such as scenario planning are closely related to technology roadmaps (Lee & Park, 2005).

Some of the essential benefits of roadmapping to the user are:Establishment of a shared product-technology strategy,Improvement of time-to-market and time-to-money, therewith achieving a better competitive edge,supporting working in the process way (Groenveld, 1997).

At both the individual corporate and industry levels, it has several potential uses and resulting advantages:TRM can help develop a consensus about a set of needs and the technologies needed to satisfy those requirements(Garcia & Bray, 1998).It canrecognize the gap between a key technology needed to meet a product performance goal and present technologies and identify ways to leverage R&D investments through coordinating research activities either within a single firm or among alliance members (Lee et al., 2011).It provides a mechanism to help experts forecast technology developments in targeted areas(Garcia & Bray, 1998).It can provide a framework to help plan and coordinate technology developments both within a company or an entire industry (Asad, 2006).

Technologyroadmappingapproaches

The generic roadmap is a time-based chart, consisting ofseveral layers that typically include both commercial and technological perspectives(Phaal, Farrukh, & Probert, 2004).One of the reasons why organizations struggle with the application of roadmapping is that there are many particular forms of roadmap, which often have to be tailored to the specific needs of the company and its business context. It is essential to customize the roadmapping approach to suit the special circumstances for which it is intended (Bagheri Moghaddam & Sahafzadeh, 2010).

The popularity and efficacy of the roadmapping process has led to anextensive range of definitions and purposes of and for roadmaps (Walsh, 2004).Robert Phaal et al. examined a set of approximately 40 roadmaps and clustered them into the following eight broad areas, based on observed structure and content (Phaal, www.cgee.org.br).In addition,they identified eight types of roadmaps based on graphic formats and observed structure (Phaal et al., 2001b).See Fig1:

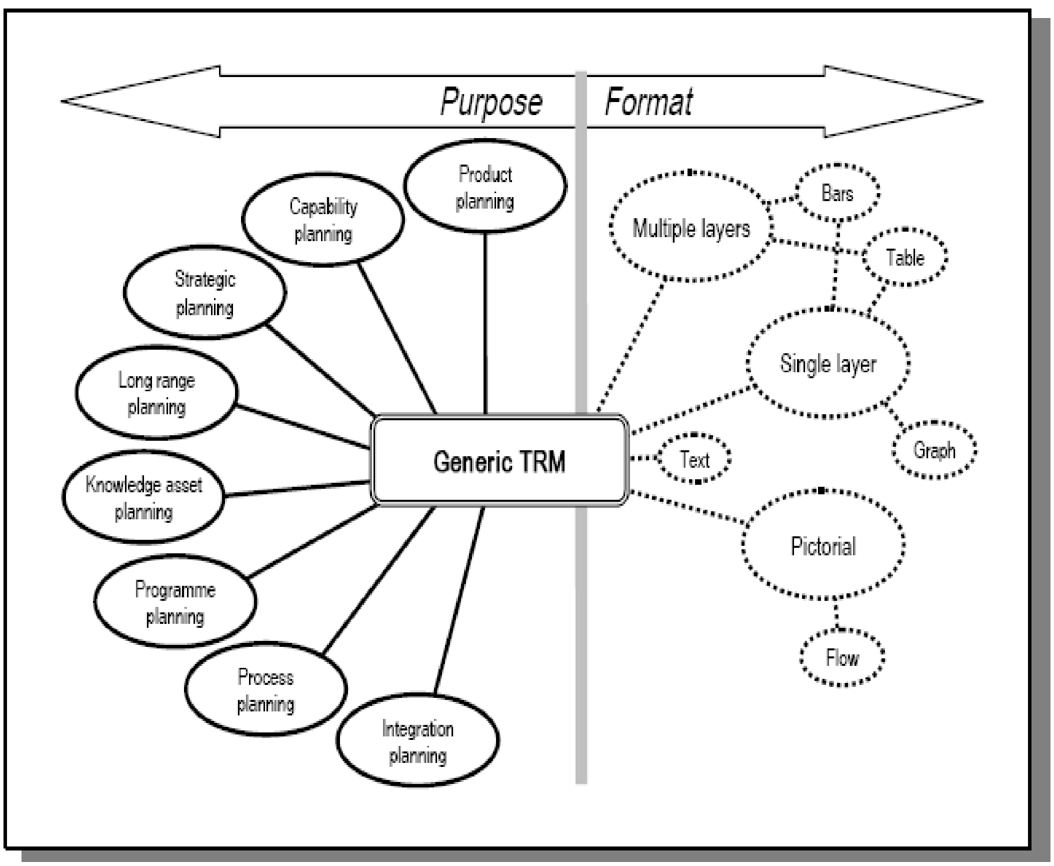

Figure 1: Characterizationof roadmaps: purpose and format (Phaal et al., 2004)

Technology roadmapping approaches-formats

a. Multiple layers

This is the most common TRM format which consists of several layers such as technology, product and market. The roadmap allows the evolution within each layer to be explored, along with the inter-layer dependencies, facilitating the integration of technology into products, services and business systems (Phaal, Farrukh, & Probert, 2001b).On the other hand, mapping this kind of roadmap is complicated and time consuming.

b. Bars

This format presents a set of bars for each layer or sub-layer.It has the advantage of simplifying and unifying the needed outputs, which facilitates communication, integration of roadmaps (Phaal et al., 2004). Versus, this roadmap is not flexible enough.

c. Tables

In some situations, the whole of roadmap or its internal layers are presented as tables.This kind of approach is specifically suited to situations where performance can be readily quantified (Phaal et al., 2001b).Although, this type does not need highexpertise, it is less flexible.

d. Graphs

Where product or technology performance can be quantified, a roadmap can be represented as a simple plot or graph- typically one for each sub-layer (Asad, 2006).This format is easy to use, but its mapping is complex.

e. Pictorial representations

Some roadmaps apply more creative pictorial representations to communicate technology integration and plans. Sometimes metaphors are applied to support the goals(Phaal et al., 2004). One of the main positive points of this format is that it is easy to use.However, on the negative side it is time consuming and needs high expertise to generate.

f. Flow charts

Flow chart is aspecifictype of pictorial representation.This kind of roadmap is typically used to relate objectives, actions and outcomes (Phaal, www.cgee.org.br).Flexibility is one of the advantages of this format.

g. Single layer

This format is another type of format "a" which focuses on a single layer of the multiple layer roadmaps.While less complex, the disadvantage of this type is the linkages between the layers are not shown (Asad, 2006).

h. Text

Some roadmaps are completely or mostly text-based, describing the same issues which are included in more conventional graphical roadmaps (Phaal, www.cgee.org.br).Ease of generation of this format is the main positive side of text roadmaps.

A new technologyroadmappingformat: Visualization

Visualization has become a necessary tool for scientific researchersto understand their data and communicate their findings(Ma & Post, 1999). This technique can provide an efficient and relatively intuitive support for the evaluator to trace certain issues by simply exploring the visual representation (Baumeister & Freiberg, 2011).

Information visualization is a quickly developing and distinctive field with less than 20 years of history(www.techsource.ala.org, 2005). It is the visual representation of datasets(Wang & Jacobson, 2011). It has rapidly become a multidisciplinary research area that overlaps into a number of subject domains, comprising digital libraries, human-computer interaction, hypertext, the Web and the Internet, and information retrieval (www.techsource.ala.org, 2005).This method can support the perception of patterns and structural relations in data via data manipulation, data analysis, data representation, and data mining techniques(Baumeister & Freiberg, 2011).

The impact of visualization has been widespread and foundational, leading to new insights and more efficient decision making. Information visualization enables users to get the information they need, make sense of it, and reach decisions in a rather short time. Additionally, another key theme for information visualization involves ease of use(Gershon & G. Eickc, 1997).

On the other hand, beside the benefits of using visualization in a variety of fields, there are some disadvantages associated with visual depictions of information. Based on the study of Bresciani and Eppler(2008), visualization may be ambiguous due to its inherent conciseness and abstraction, as it conveys condensed concepts or information in a much more encoded way than an equivalent text. In addition, the interpretation of a visual form can depend on the familiarity of the observer and on his or her previous experience with it. Indeed, a priori positive or negative exposure to a graphic representation may determine expectations and attitude (Bresciani & Eppler, 2008).

Comparingandanalysing

In this part, different technology roadmapping formats are compared based on two criteria. Determined criteria are “ease of generate” and “ease of use".In order to analyzing these various formats, we used the opinions of industry experts that are familiar with technology roadmapping. These experts were asked to rate on a seven- point scaleanchored with “very low”, “low”, “relatively low”,“medium”,“relativelyhigh”,“high” and “very high”.Table 1 indicates the results obtained in this study.

Format / Criterion	Multiple layers	Bars	Tables	Graphs	Pictorial representation	Flow charts	Single layer	Text	visualization
ease of generate	Low	Medium	High	Low	Very low	Medium	Relatively high	High	Low
Ease of use	Relatively high	medium	Low	High	High	Relatively high	Very low	Low	High

Table 1: comparing different kinds of TRM formats

Conclusion

In recent years, many industrial firms have applied roadmapping as an effective technique for projecting future technology and for coordinating technology planning and strategy. They realized a number of benefits in deploying technology roadmapping (TRM) processes. On the other hand, the major role of technology for the survival of companies in today's competitive world is undeniable.

Since, TRMs take various formats, it is important to distinguish them accurately. So, the purpose of this paper is investigation and comparison of these TRM formats. Many studies have been done in the field of TRM that Phaal's researches are the most notable ones. After the survey of mentioned formats, a new format called visualization was recognized. Visualization is a method which its origins date back to the 18th century. The goal of this technique is to communicate technical information in a graphical, interactive, and understandable way(Draper, Livnat, & Riesenfeld, 2009).

At the end, considering to the results of interview with industry experts, TRM formats were compared. Based on the experts' opinion the pictorial and graphical formats are more understandable and facile for use but more difficult to generate, time-consuming and costly. In contrast, textual methods are more facile to generate, but difficult for use.

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