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Computer Assisted Affordable Technological Roadmapping

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Summary. Technological roadmapping (TR) emerged in the 70's as an interactive strategic planning process. Due to its relatively high costs, duration, mobilisation of human resources and know-how, its hitherto applications were attributed mainly to long-term strategy formation in large corporations and as a tool supporting policy making. This paper will show how to use modern information system technologies to provide affordable roadmapping for high technology SMEs. In particular, we will report on an implementation of roadmapping methods in .NET that may serve as a base for systematic thinking about the future when solving IT investment planning problems. We will also describe the application of on-line TR to the new product development and market placement problem (NPD-MP). Such problems are solved frequently in innovative companies that compete for the best market share with new products. A web-based analytic machine that supports roadmapping is able to generate optimal technological investment strategies, visualised as conditional multicriteria shortest paths in classical roadmapping diagrams. We will show that computer assisted roadmapping is a complex collaborative process that forces the use of new internet tools for managing, sharing and acquisition of knowledge. In this context, we use the integrated capacity offered by ontologies and semantic networks. TR makes also possible to extract formal and informal knowledge from heterogeneous information sources such as expert knowledge, web, records from past technology foresight projects.

Keywords: web-based roadmapping, ontologies, decision support systems, roadmapping

1.1 Introduction

Rapid technological change requires efficient, flexible and dynamic decision making from each market participant. This is a condition for success in business. Strategic planning in companies exploits OR-based methods to support the deci-sion-making process such as decision trees, influence diagrams [1], multi-criteria analysis [2], analysis of key technologies and factors, SWOT, and a more recent SWOTC (SWOT with Challenges) analysis [3], etc. These methods are often integrated with ERP systems. However, there is currently a lack of specialised decision-support systems dedicated to specific problems concerning technology transfer and commercialisation that are available on the business software market. The direct aim of such systems should be

- to acquire from heterogeneous sources, mainly web-based, collect and process knowledge about the environment (economic, ecological, social, scientific, technical, etc.) in which organisations that implement new technologies operate;
- to develop quantitative and qualitative models of these environmental factors, examine their interdependencies and identifying their dynamics on the basis of previous observations, with the application of optimization and game theory models;
- to classify the causative factors of processes taking place in the environment, which makes it possible to identify the environmental impact and consequences of future decisions to be made;
- to create a general vision of the future (forecasts, trends, scenarios) of the organisation and its environment, as well as information concerning the development of specific technologies and products.

The ultimate goal is to develop rules for decision making that optimize criteria relevant to the organisation that performs the strategic planning. Depending on how the decision problem is formulated, these rules may take the form of a strategic plan, a list of priorities or a business plan related to the particular technology or product.

Despite the development of decision-support methodologies, there is still a lack of technology transfer models suitable for implementation in ERP systems, and very little diversity in the models used in different technical fields. There is also a lack of standardization in the methods used. An extremely important but often overlooked issue is developing algorithms to modify a strategic or other decision-making plan that is dependent on specific future event scenarios for enterprises [4]. Nowadays, every innovative company operates in a highly competitive market, and the exploration of he future socio-economic and technological development is essential for brand building, acquisitions, and strategic market position. Complex and expensive TR and strategic planning processes allowed to fulfill the above presented goals andcontributed to the market success of many large enterprises, such as Apple, Microsoft, Motorola etc.

This paper addresses an important research area, namely the search for strategic decision support methods that due to new internet technologies, specifically the availability of free information on the web and its filtering and knowledge building would allow to reach that level of quality of strategic planning even for small companies that was previously restricted to major technological multinational companies. We will show that roadmapping is a methodology that allows for integration of a knowledge from different sources, including automatic and semi-automatic exploration of online resources, and expert knowledge. We claim that applying roadmapping-based intelligent decision support systems will strengthen the organisations in building their future.

An example of a situation in which an organisation should create a strategic plan is searching for new sources of financing for its investment projects and development. Decision makers should thoroughly consider taking certain steps, such as an IPO, acquiring a strategic investor, issuing bonds, a bank loan, mezzanine financing, venture capital funding, etc. For each of these alternatives and their permissible combinations, as well as specific environment scenarios, the impact of the decisions on the current and future situation of the organisation should be examined. Various factors must be taken into account, such as market capacity, competition analysis and characteristics of the technology under consideration (its lifetime, the possibility of generating commercial products, the impact of science on the development and resale of technology). Other factors include how technologies depend on legislative conditions, particularly those related to environmental protection, and how decisions affect social phenomena such as outsourcing, reduction or increase in employment, meeting existing or creating new needs. These issues are characterised by a high level of complexity, and most small and middle-sized enterprises (SME) do not have the capacity to analyse them thoroughly and systematically. For this reason, in the development of the computer-aided strategic decision-support systems we have reduced the analysis of external factors to the most important relations from the standpoint of the organisation and the particular decision problem in order to concentrate on a thorough study of those factors which most directly influence the decision to be made. Only the information that can be represented in a computer-aided decision support system either quantitatively or as qualitative but verifiable expert judgments and descriptions is processed by the system. Additionally, the decision support methodology for new product development and market placement problem (NPD-MP) presented in this paper makes use of information adopted from technological foresight [4]. The approach here presented has been implemented as a prototype decision support system in the .NET environment.

1.2 The essence of Roadmapping

One method of supporting complex strategic decision-making processes is called roadmapping ([5], [6], [7], [8]). The essence of roadmapping is:

- breaking down the organisation's environment into layers corresponding to interrelated and desirably homogeneous groups of factors, objects and operations
- decomposing the dependencies and relationships within and between layers, where an attempt is made to rank the layers so that the factors of layer n are only associated with the factors of the (n-1)st and (n+1)st layer

- taking into account the time relationships between factors (causal relationships, probabilistic relationships, trends, scenarios, descriptions of dynamics, etc.)
- creating diagrams of dependency factors taking into account the different relationships and their gradation (called roadmaps due to the apparent similarity to the use of road network maps for selecting the shortest route; also similar to PERT diagrams within each layer the roadmapping concept is not fully reflected)
- identifying key decision points in the diagrams, solving optimization and decision-support problems associated with them.

Another special feature of roadmapping is the simultaneous use of formal and quantitative knowledge, as well as informal expertise and managerial knowledge. The approaches used here are familiar to foresight methodologies, such as Delphi surveys, expert panels, analysing associations (so-called "brainstorming"), etc. Through these methods, a wider and bolder look into the future is possible, as opposed to methods based solely on formal knowledge. This paper presents only a small selection of roadmapping application possibilities, na¬mely Technology Roadmapping, which focusses on decision problems associated with Information Technologies (IT) implementation and commercialization. There are further areas of application for this method in economic, political and social fields (cf. [9], [10]. These will be discussed briefly at the end of Section 5.

The concept of roadmapping is currently used in a variety of contexts. In this paper, roadmapping is an interactive, group instrument used for:

- finding the relationships between the individual elements of complex objects related to the technology transfer as well as analysing cause-effect relationships;
- Adapting strategic planning in technology issues;
- Decision support, through well-structured knowledge of the analysed problem.

Further on, we will present the system architecture which makes it possible to implement the above functions in organisations dealing with technology development and application research, technology transfer centres, as well as organisations creating and implementing new technologies. In other organisations, such as financial institutions, government agencies and research institutions, roadmapping can also be used for other tasks, which include forming R&D and innovative strategies.

Due to the diversity of scale and content of applications, no uniform methodological approach to roadmapping exists. There are many variants of this methodology, which differ by the number and type of layers, number of analysed factors, type of temporal and causal relationships under consideration, time horizon of decisions, etc. They depend on the problem area, the purpose of the analysis and target group. Therefore, the roadmapping process described below should be treated as a pattern of conduct/blueprint that allows us to create relational structures helpful in modelling and analysing the problem being solved. In this paper, the roadmapping process will therefore be understood as a scheme for implementing interactive decision-support methods for planning and predicting technological development.

Applying technological roadmapping in enterprises can take the following form:

1. modelling the evolution of technologies used by organisations, especially product and process technology;
2. forecasting demand for products and technologies;
3. planning and optimizing strategies that ensure the technological development of organisations.

In Problem (c), roadmapping is used to solve a multicriteria optimization problem. The choice of development strategy is implemented assuming the simultaneous optimization of several criteria such as profit as a function of time (the problem of trajectory optimization), the risk associated with the implementation of specific strategies, as well as the company's strategic position (including its market position). Different organisations can also apply specific additional criteria.

1.3 Formulating a technological strategic planning problem

A basic strategic problem that can be solved with computer-aided roadmapping techniques is New Product Development and Market Placement (NPD-MP, in short NPD). The company faces the challenge of developing a product that will be competitive in the market. Assuming the technological investment has been made, the following pre-criteria will determine the success of the product on the market:

- time t_0 to product launch (measured as a relative criterion, with respect to the start of implementation activities or to a known or estimated time of launch of similar products by competitors);
- average unit cost of the product $c(k)$ in the k-th forecasting period, $[tk, tk+\Delta t)$, not including the cost of depreciation of the technology; predicted market life,$T-t_0$, where T is the expected date of production completion;
- estimated demand $s(k)$ for the product by customers in the k-th period, $s(k) := \sum_i (\rho_i(k), \sigma_i(k))$,

where $\rho_i(k)$ is the price of the product on the i-th market, and$\sigma_i(k)$ is the estimated product market position index in the i-th market in the period $[tk, tk + \Delta t)$, which is dependent on factors such as the degree to which the product meets customer needs and the presence of competing products. A sum is made of all the markets where the product will be sold. Estimating the values of these criteria requires the implementation of product market research, competition analysis and analysis of the technologies currently available and expected in the planning period.

The concept of product used above is a simplification, as a ‘product’ can also be technology, and in certain cases it can be identified with the technology employed in its production. The product can also be understood here as a set of complementary products manufactured using the same technology, or as a result of the same investment process.

The final decision to make the technological investment is dependent on the assessment of the economic parameters of the product throughout its life cycle. Discounted cash flow (Net Present Value) related to the implementation and operation of the new technology is usually taken into consideration as the final criterion:

$$NPV\,(I,t,d) = C\,(0) + \sum_{k=1}^{t} \frac{C(k)}{\prod\limits_{1\le j\le k} (1+d_j)} \tag{1.1}$$

where:

I – the technological investment characterized by cash flow (C(0),. . . ,C(t)) in subsequent accounting periods, C(0) is the initial investment;

t – the number of time units since the beginning of the technological investment until the planned completion of production $T, d = (d_1, ..., d_t)$ - the average expected discount rates in subsequent accounting periods (it should be added that the generally-used models with a constant discount rate in situations of highly volatile rates can result in serious financial errors). Cash flows C(k) over period k consist of revenues from sales generated by the investment C1(k):=N1(k)*p(k), remaining investment revenue, including revenue from the reinvestment of surplus cash C2(k), costs of investment C3(k), fixed production maintenance costs C4(k), as well as variable costs of production C5(k):=N2(k)*c(k) which depend on its size, i.e.

$$C(k) = N1(k) * p(k) + C2(k)–C3(k)–C4(k)–N2(k) * c(k),\ k = 1, ..., t \tag{1.2}$$

All these functions should be treated as random variables with distributions estimated from a sample as well as on the basis of market research and various heuristics. In practice, formulas (1) and (2) apply to expected values, and stochastic analysis reduces to variance analysis or other risk measures.

Note that in the criterion (1) we already take into account the values of pre-criteria k0, T-k0 ,c(t) and s(t). The latter is included in the sales forecast N1(t). However, criterion (1) can be further extended to include terms related to real options values (Trigeorgis (1996)) that can often be identified in IT management problems. That allows for a more adequate modelling of the strategic situation of the organisation implementing the new product or technology. When using the real options the demand s(t) can be considered a vector criterion scaled through the valuation of real options.

As mentioned above, technological measures of investment risk are further criteria used in the strategic planning process. The following can be used, alternatively or simultaneously:

- a variance or semivariance of NPV(i,t,d) (see (3.1) - (3.2));
- the probability of a loss of liquidity in the organisation during the investment, determined by analysing cash flow C(k);
- the probability of achieving the technological investment goals, which affects the deviation of NPV from the value determined by market analysis.

In addition, in supporting decisions related to technological planning, commercialization of technology and development of production, objectives and strategic criteria are taken into account. These include conformity of the investment with the strategic objectives of the company, conquering new markets, weakening competitors and achieving a competitive advantage. Other criteria can include degree of achievement of another strategic objective, which may be to gain strategic customers, etc. These indicators can be in the form of reference sets (cf. [2]).

The need to take into account multiple criteria simultaneously transforms the problem (1) - (2) into a multi-objective optimization problem. However, the assumption that in the problem of production planning criteria (1) or (2) are optimized as well as criteria related to risk, treated as a function of final time T, leading to the formulation of a discrete dynamic multi-objective optimization problem:

$$[J \ni I \rightarrow (NPV\,(I, t_1, .)\,, \,...\,, NPV\,(I, t_2, .))] \rightarrow max \tag{1.3}$$

where J is the set of allowable technology strategies (under consideration), t1 and t2 correspond to the minimum and maximum permissible deadlines for the settlement of the invest¬ment to be made. In problem (3), the discount rate is not a decision-making variable, but an external random variable whose values are estimated in the forecasting process. Note also that problem (3) is equivalent to the problem:

$$\left[J \ni I \rightarrow \left(NPV\,(I, t_1, .)\,, \, \frac{C(t_1+1)}{\prod\limits_{1 \le j \le t_1+1} \mathit{\Pi}\,(1+d_j)} \cdots, \, \frac{C(t_2)}{\prod\limits_{1 \le j \le t_2} (1+d_j)} \right) \right] \rightarrow max \tag{1.4}$$

where the precriteria are related to criteria in a more intuitive way. Finally, a multi-objective optimization problem associated with a choice of technological strategy can be written as

$$\begin{array}{c} [J \ni I \rightarrow (NPV\,(I, t_1, .)\,, \,...\,, NPV\,(I, t_2, .))] \rightarrow max \\ [J \ni I \rightarrow (R\,(I, t_1, .)\,, \,...\,, R\,(I, t_2, .))] \rightarrow min \\ [J \ni I \rightarrow (S\,(I, t_1, .)\,, \,...\,, S\,(I, t_2, .))] \rightarrow max \end{array} \tag{1.5}$$

where R is the measure of risk and S a valuation of the strategic position of a company concerned. Determining the precriteria values, the relationships between precriteria, as well as cash-flow values, and consequently, R and S as formal crite-ria in problem (5) is generally not an easy task. of. What is required is an examination of the relationship between technologies, products, sales markets, as well as market, economic and political environment forecasts, and the development and application of technological forecasting. All the elements and factors are interrelated, while in practical problems the number of relationships is very high, and their nature is usually heterogeneous: deterministic, stochastic and fuzzy. The data gathering and fusion processes are complex as well as qualitative preference information must be obtained from the decision maker in problem (5), from other decision makers in the same enterprise as well as from external experts.

Problem (5) is the main theoretical basis for roadmapping applications in NPD problems. Section 4 will present an examp¬le related to the manufacture of electronic components. In [3], an example of a roadmapping process applied for the NPD-MP problem of long-term liquid biofuels production planning was described.

1.4 Applying roadmapping to technology development planning

The analysis described above can be described algorithmically. Both formal and non-formal methods of acquiring knowledge about the environment of problem (5) are applied. This takes into account estimates of C(k), R, S, and the rules of technology strategy choice compromise in (5). In practice, roadmapping requires the quantitative and qualitative analysis of a large number of events in various fields, which need not be related directly to the development of the product itself. The analysis may cover an entire sphere of business activity. This methodology may be used to solve problems such as choosing a technology investment strategy that maximises future benefits (financial, knowledge, human resources), but where resources may be limited.

A general roadmapping process scheme for the NPD-MP problem (1)-(2) is shown in Figure 4.1 The decision problems and their place in the roadmapping process for product technolo¬gy are shown in Fig. 4.2. The diagrams constructed in the road-mapping process are a projection of alternative visions of pre¬sent and future linkages in the important areas for the activity of an organisation. The primary area - and also one of the layers in the roadmapping diagram - is a set of relationships related to technologies. During the analysis, causal relation¬ships between these areas are defined. The resulting roadmap is an essential element in creating a medium- and long-term organisational strategy. It primarily helps decision makers (technology administrators) to identify and select of the best alternatives. It should be stressed that any action taken during the roadmapping process involves forecasting, and analysing the dynamics is an essential component of roadmapping.

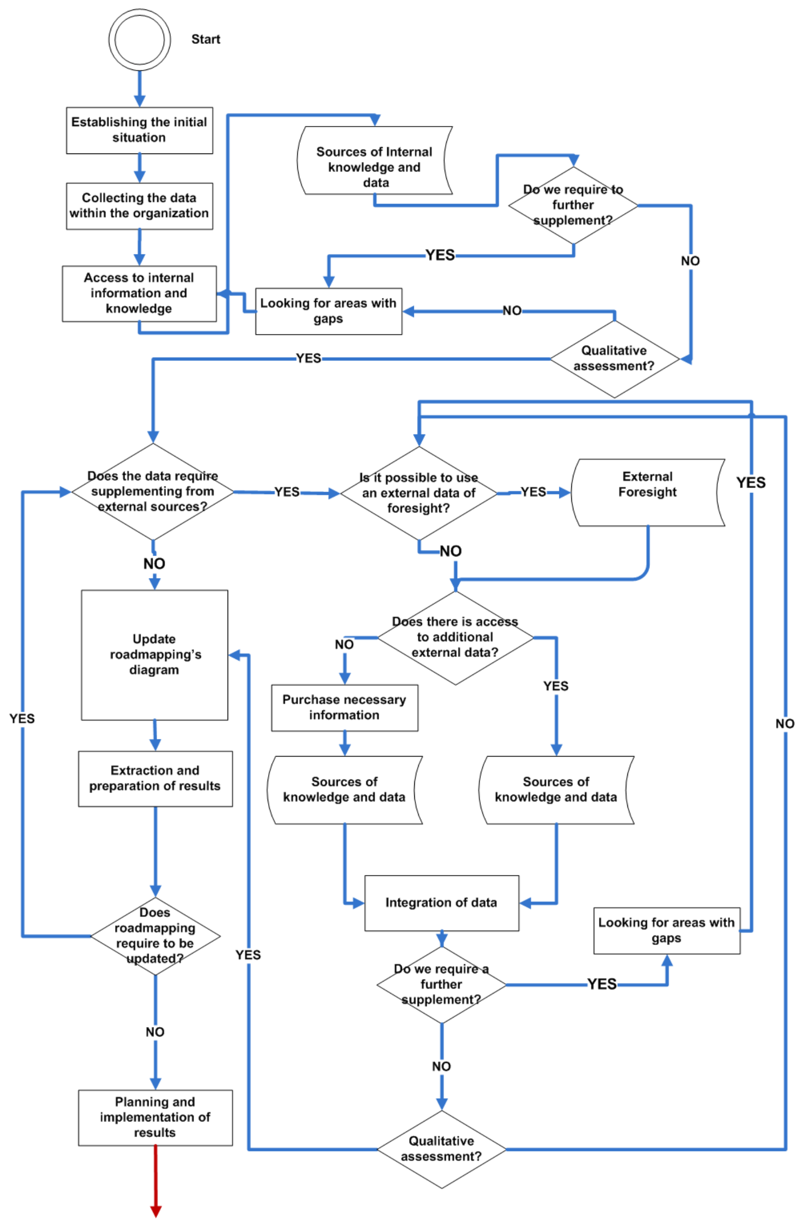

Fig. 1.1. A general roadmapping scheme

Different roadmapping applications require a different level of detail, when the relationships within certain layers or groups dominate quantitatively the external relationships between layers. What may be desirable is a hierarchical decom-position of the whole process by treating the roadmap as a hypergraph and analysing its individual levels. The culmination of the roadmapping process is an analytical report, which is based on a diagram analysis and contains recom-mendations for decision makers.

A sample diagram created for a manufacturer of notebook computers is shown in Fig.5.1. This example is not intended to provide a whole range of products and technologies, which computer manufacturers generally have, but is merely to illustrate the basic ways of building dependencies and identifying objects.

To analyse the NPD-MP problem, where the product is notebook computers, and the sponsor is a company is proposing to expand its production, five layers have been selected:

- technology
- products
- market and business environment factors
- development opportunities
- research related to IT and electronics.

The strategic business planning process proposed here runs in three phases:

Phase 1. Preliminary activities These activities involved preparing data necessary to initiate roadmapping. The scope of the project together with its boundaries and objectives was also defined. In the example below, roadmapping is used to select the manufacturer's strategic activities over a five-year horizon, including determining research areas, marketing strategy objectives, acquiring know-how, etc.

Phase 2. Roadmap diagram development As part of this phase, a diagram will be constructed by:

1. isolating of five classes of modelled objects: techno¬logy, products (which in this example initially leads to the analysis of 10 bipartite graphs)
2. studying the remaining structural links between layers
3. studying timelines and directions (trends) of their changes and how they develop

Phase 3. Result implementation and complementary activities In the IT and electronics industries, which are the main playground for the methods here proposed, technological progress is accelerating at a rapid pace, and the technology life cycle is short. In the example below, the time horizon is 5 years, which means a relatively very short life cycle for the individual products. Periodic updates are therefore necessary within the developed schedule. In

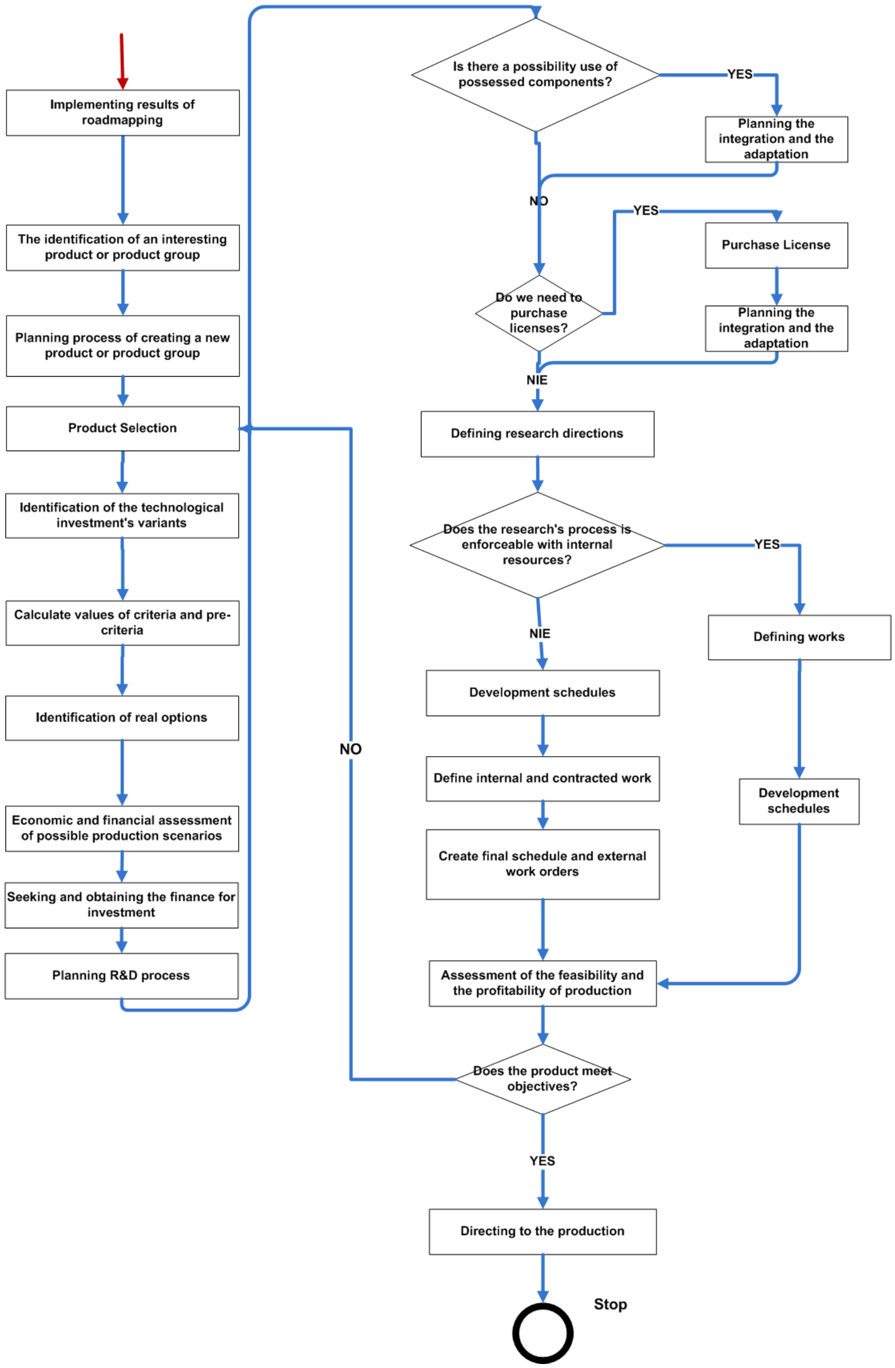

Fig. 1.2. The scheme of the decision-making process in an organisation using roadmapping methodology

this case, measures for upgrading and improving are proposed in the same periods of the year. The aim of these actions is to ensure that roadmapping results are of adequate quality and recommendations are accurate. Finally, the recommendations are presented to decision makers – the diagram is converted into specific actions to be taken in order to achieve the roadmapping objectives.

Roadmapping is a cyclical process and therefore it should allow for active monitoring of the reachability of goals in accordance with the whole procedure. This requires the operation of the system in a continuous production cycle as a part of an active environment.

1.5 An application of computer assisted roadmapping support system to it planning

Implementation of the functionality of DSS requires solutions to problems (4)-(5), which leads to the main outputs of the roadmapping process that appear as:

- diagram roadmaps,
- report with assessment scenarios and presentation of the best of them in accordance with users' preferences as well as
- key decision points and scenario bifurcations marked on the diagram.

The main advantage of implementing the technological roadmapping process as a web-based decision support system shows in Phase 2 above, after the grouping of objects. Focus groups using a collaborative internet environment distinguish then objects within layers and show the relationships between them and the objects in other layers. This is an interactive process, and the intermediate results are assessed, discussed and improved. In this phase, a report and roadmap are compi¬led together with recommendations for decision makers.

The roadmapping diagram shown in Fig. 5.1 includes cause-and-effect relationships for objects of individual layers. During the roadmapping process, two types of linkages are identified: within layers and between layers. For example, rela-tionships between objects in the layer "Products" depend chronologically on the introduction of individual products on the market, taking into account depreciation of the technology and marketing expenditure. In the example shown in Fig. 5.1, the following relationships within layers are defined:

- Scientific research - the development of scientific research (a consequence of timelines and research results, the evolution of the characteristics of research fields),
- Technology - the availability of technology as a result of research processes, the purchasing of a license and key components from external suppliers,
- Products - marketed products and their substitutes

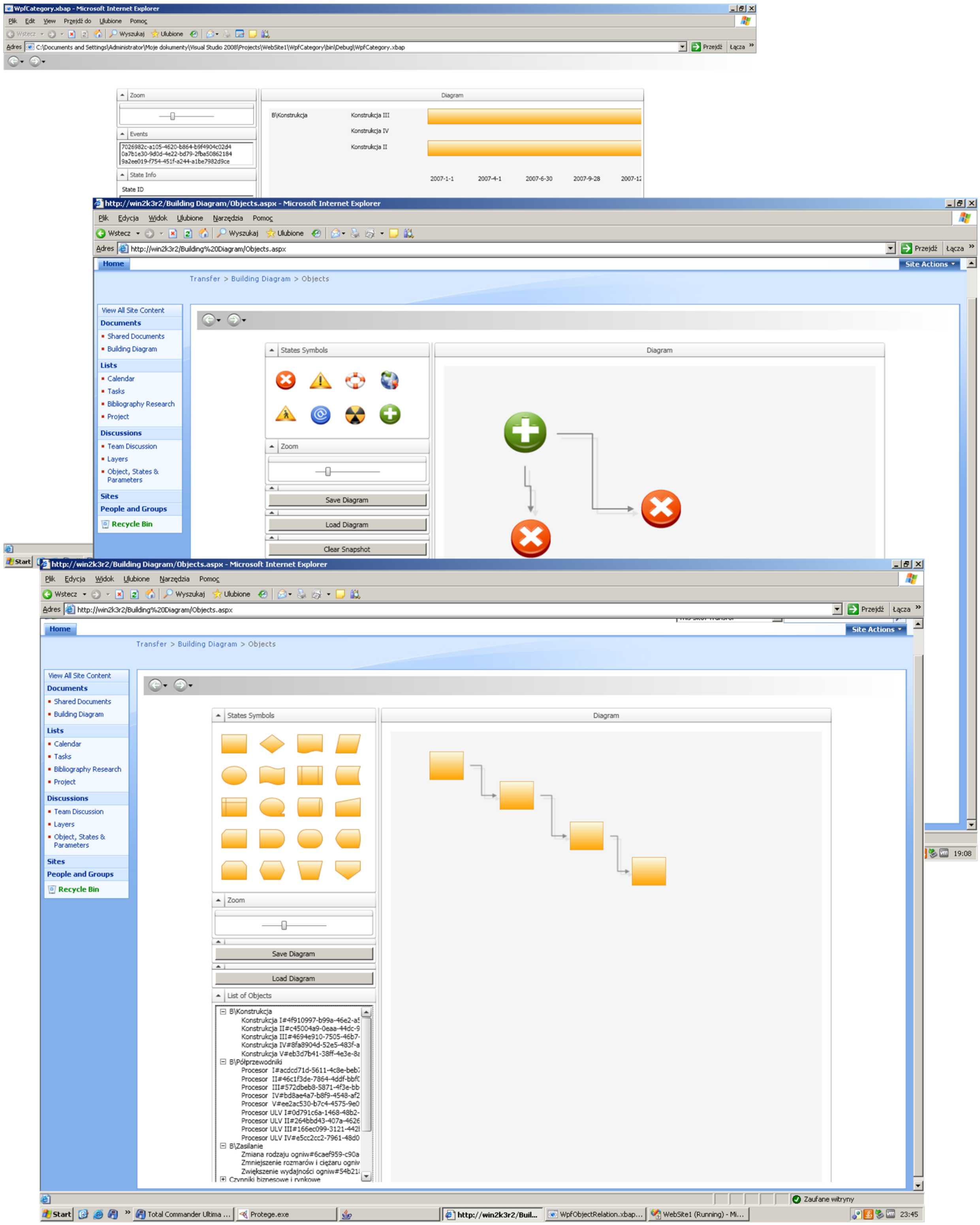

Fig. 1.1. Sample screenshots with an example of building roadmapping diagrams for notebook computers production

- Development opportunities - identification and evolution of developmental factors for the organisation,
- Business factors - identification and evolution of business and market factors.

The set of relationships between layers defines the various contexts for the objects of one layer. For example, the product can be analysed in terms of development opportunities as well as real time profit. In a similar way the Scientific Research layer can be viewed from the standpoint of the organisation's technological portfolio. In turn, the technology at the disposal of the organisation can be used to design and manufacture future products. Fig. 4 shows several relationships to illustrate this process. For example, relationship {1} in Fig.5.1 indicates the development of technology "Construction IV" enabling the creation of a class of casing used in the new product series. The layer "Technology" includes objects from the technological organisation portfolio. These objects are turned into real marketable products (see relationship 7).

In the above roadmapping process, the identification of real options may also occur ([11], [12]). The difficulty in this case lies in the fact that options cannot generally be separated as objects in separate layers, but they can also correspond to relationships between objects in the same layer. These options can be connected using a single technological solution created for a specific product in a few other products in the same category for different market segments. For example, a 2.6 Ghz processor can be used in several different types of devices. An example of options separated in individual layers can be seen in relationships 2, 5 and 6 shown in Figure 5.2.

The creation of applications implementing the Roadmapping's functions requires developing a new approach to DSS. DSS architectures presented in this paper require new development tools, embedded in a web environment. To build the system we have used the available Microsoft technology: Sharepoint Services as collaboration software for the organisation as a programming framework, Microsoft SQL Server, Silverlight, WPF.

The quantity and variety of collected data, information and knowledge through the DSS system is large enough to give rise to the necessity of developing new basis for gathering and processing knowledge-bases. Several methods have been developed that are based on intensive use of ontological knowledge-bases . This leads directly to the use of Ontology and Semantic Web technology as the basis of the information carrier in the system [13]. The BPMN diagram for data, information and knowledge transfer in the present system is presented in Fig. 5.3. The above-mentioned ontological technologies are available as open source license. An example of the basic package used to create knowledge bases in our system is Jena API, which is developed in cooperation with HP Labs Semantic Web Programme. Use of this package provides access to such technologies as OWL, SPARQL and Pellet.

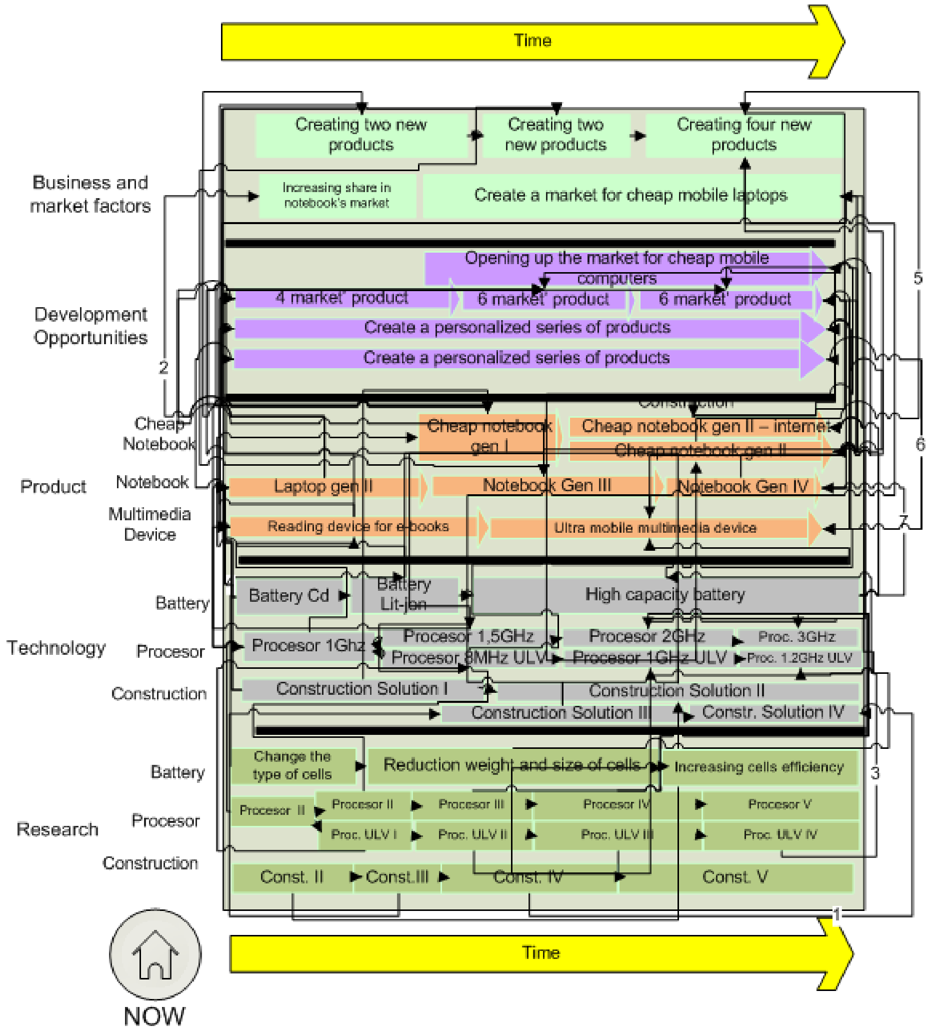

Fig. 1.2. A sample roadmap for a manufacturer of notebook computers

1.6 Final remarks

Pursuant to the system and roadmapping process requirements we have developed structures which allow for active sharing of data, information and knowledge in an on-line application that should be affordable even to small technological companies. When used repetitively in the same enterprise, TR is a process that can usually re-use previously gathered knowledge, experience and different procedures in a sequence of strategic decision-making problems and projects. In most cases the following items repeat on the construction stages of roadmaps: object-oriented structures, environment analysis, market

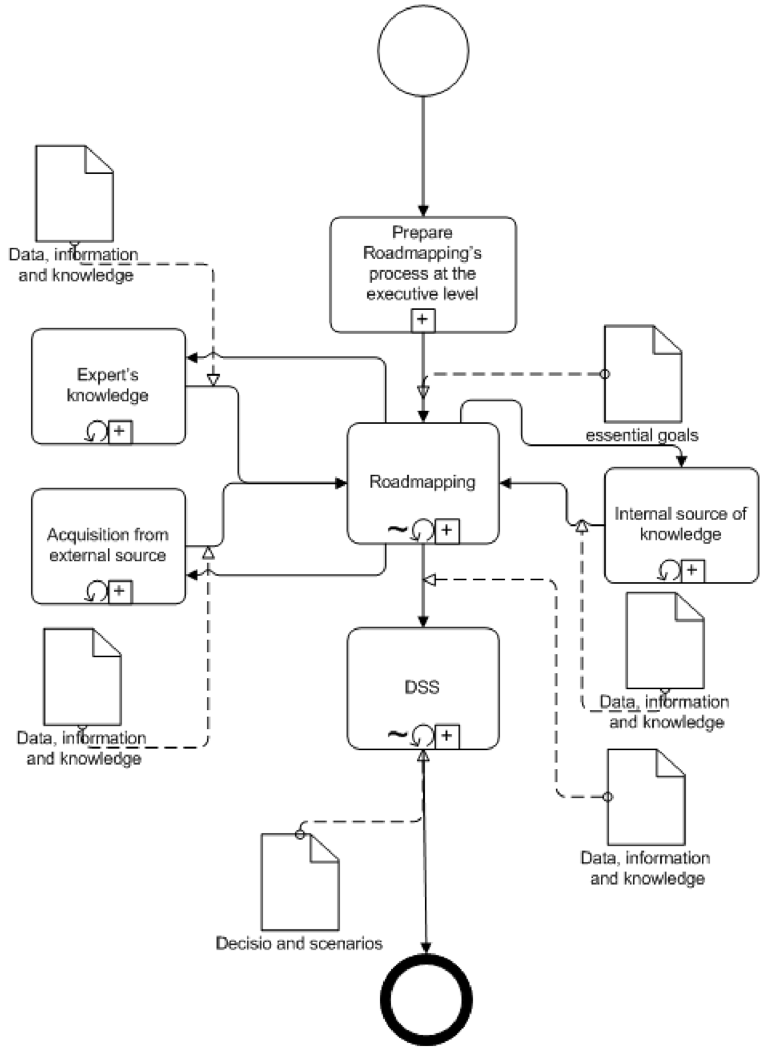

Fig. 1.3. A BPMN diagram of the roadmapping-based DSS

research. It becomes possible to use individual domain knowledge gained in various projects and at different organisations, in particular from technological foresight projects carried out at national level. Utilization of this knowledge to solve NPD-MP problems is important from the viewpoint of time, money and quality of outcomes. The above-proposed knowledge management approach uses the idea of creating a predefined structure consisting of dynamic components or all subsystems under consideration. DSS technologies based on ontologies provide appropriate tools for achieving these objectives. To sum up, roadmapping-based DSS can be useful in supporting the decision-making process in an enterprise and indicating several possible scenarios that give similar strategic results and optimize additional criteria such as cost (the cheapest solution), time (the earliest milestone for achieving the desired results). Prospects for improving the strategic position of the organisation can also be pointed out, e.g. spending on promoting environmentally-friendly activities, information on meeting ISO requirements, etc. Formulating precise optimization criteria may be difficult due to high levels of uncertainty, especially about financial results (profit) and qualitative assessment of the impact of implementing certain strategies. However, introducing additional risk-related criteria allows for a formal formulation of a dynamic multi-objective optimization problem and elimination of dominating solutions, which is often sufficient to make a decision on strategy alignment. A direct comparison of roadmapping uses and processes is given in [14], [15], [7], [6]. [8], [16]. Technology Roadmapping is a useful tool in virtually every organisation. The methodology constitutes an effective organisational framework and a new way of creating a knowledge base of the present and the future of technology and innovative ideas. Multiple points of view can be taken into account. The possibility of interactively generating scenarios in roadmapping-based DSS [4] means that an adequate model of the conditions affecting an analysed object is achieved more quickly. This model can easily be adapted to a particular area of application, taking into account quantitative factors - usually moments of random variables describing the state of an object and criteria optimization values - defining the quality of data used in the construction and subsequent exploitation of scenarios. The use of new tools based on internet technologies and on exploring the internet content can considerably increase the potential of TR as a powerful strategic DSS. The capability to networking a practically unlimited number of decision-ma¬kers in an enterprise and an immediate algorithmic verification of the consistency of their judgments allows to significantly improve the quality of the decision-making process. The knowledge gathered from the web, when coupled with internal information on company's resources processed in a separate ERP system is particularly important to solving the NPD-MP problem. In this paper, we have demonstrated that it is possible to adopt the roadmapping methodology to create flexible strategic DSS with analytic engines available in a cloud while the sensitive company data will be stored in the intranet. In addition, this approach allows the user to partially automate the process of creating business scenarios that stand behind stra¬tegic technological planning. This can be regarded as a first step towards the construction of future enterprise decision support-systems based on roadmapping techniques, which will minimize the time spent on interacting with experts, and will ensure an optimal processing of expert knowledge.

1.7 Acknowledgement

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