STRATEGIC ANALYSIS OF THE ENVIRONMENT
A DSS FOR ASSESSING TECHNOLOGY ENVIRONMENTS

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Abstract: Assessing the external environment is an important component of organizations' survival and success. Unfortunately, a huge amount of information must be collected and processed in order to obtain a thorough and comprehensive representation of the environment. A decision support system can be very useful in helping decision makers to organize and analyze this information efficiently and effectively. This paper outlines a conceptual proposition helping to design such a system by presenting an ontology of the relevant information elements (actors, issues and needs) and a set of tools to analyze them. This paper also illustrates a prototype version of one of these tools which supports the analysis of the actors and issues perspectives.

1 INTRODUCTION

Assessing the environment of an organization can be defined as a search for information about events and relationships in a company's outside environment, the knowledge of which can help its top management to plan the company's future course of action (Aguilar 1967). Organizations scan their environment in order to understand the external forces of change that may affect their future position so that they can develop effective responses.

Researches from different disciplines recognize that understanding their own environments and consequently adapting their strategies to it is highly important to the organizations' survival and success.

From a systems theory perspective, companies are seen as complex social open systems (Boulding 1956), which are involved in a variety of exchanges with a larger system which is globally referred to as their environment. These exchanges are considered of primary importance as they are the source of the input resources required by the organization and the destination of its output (Katz and Kahn 1966).

The importance of obtaining a thorough perception of the environment has also been acknowledged by numerous prominent authors in strategic management, as shown in the following paragraphs. In particular, the alignment between the organization’s strategy and its environment is seen as essential for performance.

Indeed, one of the fundamental models that lies at the core of modern strategic management, the so-called Harvard normative model, makes its essential contribution by stating that organizations must craft their strategies based upon the prior identification of the present and future opportunities and threats in the environment and the match between these and the organization's unique strengths and weaknesses stemming from corporate resources and competencies (Learned, Christensen et al. 1965).

Many other renowned researchers are proponents of theories supporting the importance of monitoring the environment and achieving alignment with organizational strategy, structure, and performance (Dill 1958; Bourgeois 1980; Andrews 1987). Some further advise firms to proactively influence their environment to attain more favorable conditions (Porter 1980; Godet 2001).

Additional support can be found in the disruptive technologies literature. It suggests that established firms often fail to cope with a changing environment due to their focus on current customers. This hinders them from perceiving and dealing with change that does not initially affect their mainstream market but can later disrupt it (Christensen and Bower 1996).

A few empirical studies support the importance of environmental scanning and suggest a positive relationship with organizational performance (Choo 2001). For instance it has been found that higher-performing firms are characterized by more frequent scanning and by more careful tailoring of scanning

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to perceived strategic uncertainty (Daft, Sormunen et al. 1988) and that firms having advanced environment monitoring systems exhibited higher growth and profitability than firms that did not have such systems (Subramanian, Fernandes et al. 1993).

Research has shown that environmental analysis becomes even more essential in industries which are characterized by disruptive, uncertain and complex environments. These are commonly considered as the major drivers of environmental scanning (Daft, Sormunen et al. 1988; Boyd and Fulk 1996). Ironically, these characteristics that increase the value of scanning also make it more difficult and costly. Such environments usually characterize technologically intensive industries such as the mobile business, e-business and software industries.

Unfortunately, while the development of knowledge has produced many techniques to deal with parts of the problem, there is no easy methodology allowing for a systematic assessment of the environment (Andrews 1987, p. 39). Moreover, due to the huge amount of information to be collected and processed, decision makers should be assisted by decision support systems providing them the tools to systematically take advantage of the information at their disposal (Aguilar 1967).

The main objective of this paper is to provide conceptual foundations which aim to facilitate the development of an environmental decision support system. In particular, the paper provides an ontology indicating the relevant elements to monitor and their relationships. This ontology, presented in section 2, provides insights on how to structure the collected information. In addition, the paper provides a set of complementary analytic and visualization tools (see section 3) which allow users to analyze this information from different perspectives, thus providing a complete image of the environment.

A prototype tool is presented in section 4 in order to give a preliminary idea of the usefulness of an environmental DSS. At the time of writing, this tool integrates only a subset of the proposed elements, but it will be extended in future work.

2 ENVIRONMENT ONTOLOGY

This section presents a conceptual framework intended to facilitate the collection and organization of the relevant information by indicating the elements to monitor and their relationships.

Although the relevant elements to observe essentially depend on the specific context under study, it is possible to describe a set of sufficiently abstract elements that should be assessed in any environment analysis. In a concrete case, these elements can be instantiated so as to match the particularities of the context under study.

In order to identify these elements, the literature was reviewed to identify and compare the elements proposed by the various existing approaches. In fact, there is a variety of complementary approaches which are focused on different environmental dimensions and have different scopes such as the competitor, competitive, business, technology and market intelligence, environment scanning, actors-issues models etc. (Choo 1999).

From the analysis of these approaches, three elements show up as highly relevant: the market, the actors and the issues. The market is the key element proposed by the business and market intelligence, but is at least mentioned by all other approaches. Analysis of the actors is advised by actor-issues methods, competitor, competitive and business intelligence. Finally, issues are the key proposal of actor-issues methods and environmental scanning. These elements are intertwined by a series of influence relationships as depicted in Figure 1

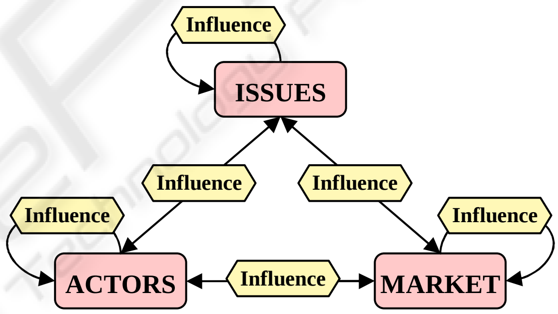

Figure 1: environmental ontology

The **market** or use perspective represents the demand side of the organization's environment. According to Kotler (Kotler 2003, p. 11), assessing the market basically implies investigating the end user needs and how they are translated into wants (desires to buy specific products to satisfy these needs) and demands (capacity and willingness to pay for these products). It is also important to understand how customers value the various elements of the value propositions (a sets of benefits embodied in a combination of products and services that satisfies certain needs) and choose the solution to adopt.

Research in marketing has shown that the market is not a homogeneous group, but that buyers tend to have individual needs, behaviors and preferences. A process of segmentation is commonly used to identify "*groups of customers that have similarities in characteristics or needs that are likely to exhibit similar purchase behavior*" (Smith 1956). It is vital to gather information about the customers (i.e. in terms of socio-demographic, psychographic and behavioral variables) that compose each segment.

Knowledge of customers' needs, wants, demands and segments allows firms to conceive more attractive value propositions and to gain substantial competitive advantage. Actually, some firms try to integrate their customers in the value proposition design (i.e. through mass customization).

The **actors** perspective represents the supply side of the environment. The relevant actors are those that have the power of directly or indirectly influence the organization's performance.

Among these actors, a prominent place is taken by the different players that contribute to satisfy the same end-user needs. As illustrated by Porter (Porter 1980), these players principally include not only the organization's existing direct competitors, but also the players in adjacent industries along the value system such as suppliers, distributors, new entrants and substitute product producers.

However, other influential players in diverse environmental areas must be taken into account. It is indeed suggested to consider all the actors which can influence the evolution of the environment (Godet 2001). In particular, it is worth considering players in the less immediate environment such as regulatory authorities and technology suppliers.

Finally, **issues** can be defined as open and debatable questions, events or other forthcoming developments whose realization can significantly influence the future conditions of the environment and, consequently, the ability of the organization to achieve its objectives (Ansoff 1980). Issues can arise in different environmental areas such as the market, technology, regulatory, economic and social areas.

Issues are an important element of environmental analysis. While the two other elements provide a good picture of the current conditions, they are not a sufficient basis for guiding decisions which deploy their effect in a relatively distant future. In changing environments, companies must continually look beyond the current environmental state and assess its future prospects. Due to the high uncertainty of future developments, this often leads to establishing a number of scenarios rather than a single forecast. In this respect, issues are a good mechanism to reflect on possible disruption of current conditions and trends, allowing the development of a broader set of scenarios. Particularly interesting issues are those that are open to dispute and upon which actors have diverging positions and means of influence.

Notice that these elements are consistent with the observations of Porter, which asserts that industries with rapidly changing and complex environments experience significant uncertainties about demand, strategy and technology (Porter 1980). The proposed elements cover the mentioned uncertainties: the market deals with demand uncertainties, actors cope with supply and its related strategic uncertainties, and issues cover environmental factors which include technology (Camponovo and Pigneur 2003).

These elements are inextricably intertwined and interact through **influence relationships**. While this concept is generic, relationships between a particular pairs of elements have an adapted meaning.

The market and actors are linked by a market relationship: by adopting certain value propositions as an expression of their needs, end users influence the type of products that are offered by the different actors and hence determine their relative power; conversely actors can often shape and even create user needs by offering innovative value propositions.

Market and issues are linked by an adoption relationship in the sense that the realization of issues can affect end user needs and, consequently, the solutions they adopt. Conversely, the adoption of certain solutions may affect positively or negatively the probabilities of realization of certain issues.

Actors and issues are linked by a position relationship. Actors can influence the realization of certain issues by strategically positioning themselves on them. On the other hand, the realization of issues constrains the strategic possibilities open to actors.

Finally influence relationships also exist between the instances of issues, actors and needs. Actors are linked by pressure relationships (Porter 1980), issues by dependency relationships (Arcade, Godet et al. 1999) and needs by a contribution relationships.

These relationships can create a complex network of indirect relationships between elements. For instance, the pressure relationships between actors can potentially change as a result of the realization of certain issues or shifts in user needs.

3 ANALYSIS TOOLS

This section presents a selection of methods and tools to collect analyze and visualize information about the different elements of the previous section.

Before illustrating these methods, it is useful to remind that there is a wide variety of information sources that may convey useful information. They have been categorized by the internal vs. external, personal vs. impersonal and verbal vs. written dimensions (El Sawy 1985). For instance, personal sources include external actors (i.e. competitors, customers, experts, suppliers, consultants etc.) as well as internal employees, staff and managers at all levels. Impersonal sources include internal reports and enterprise information systems, as well as external publications such as trade journals, research reports, the mass media and online sources (El Sawy 1985; Choo 1994).

3.1 Market

A good starting point in analyzing the market perspective is to exploit the wealth of internally available information. In fact, through customer interaction, an organization knows a lot about its market. In addition to the opinions of the various employees (e.g. sales force, staff, managers,...), enterprises commonly have sophisticate internal record systems (e.g. transaction histories, sales reports, customers databases) which can be exploited through a variety of data mining techniques. Seldom, companies also possess market intelligence systems and internal market research departments.

It is imperative to complement this internal point of view on the market with external information in order to avoid overemphasizing current visions, beliefs and assumptions about the market.

External secondary data consist in market reports, various business, governmental or academic studies and publications and published statistics (demographics, economics, industry...). This data has a lower cost and is readily available and should therefore be used first.

Primary data should then be used to gather complementary information and get fresh insight into original aspects of the market. Many research instruments can be used to collect primary data.

The traditional way of investigating end user needs is by directly asking users to elicit their needs. There is a variety of quantitative and qualitative methods including surveys, interviews, customer visits and focus groups (McQuarrie 1996). Alas, they are better suited for descriptive research than to discover actual user needs. Reasons are that users are hardly conscious of their real needs and are prone to reporting bias.

An alternative consists in focusing on the user's behavior. There is a multitude of methodologies from different research disciplines such as diffusion studies (studying the link between the characteristics of an innovation and its diffusion process), adoption studies (focusing on the individual user's decision to adopt a particular service), uses and gratification studies (studying the gratifications sought in adopting a new service), domestication studies (studying the societal consequence of domestication of everyday life technology), observational research (ethnography, participant, indirect observation, usability studies) and experimental methodologies (e.g. simulated shopping experience in a controlled environment) (Pedersen and Ling 2002; 2003).

Companies must also understand the possible market evolution. There is a multitude of forecasting methods, such as various extrapolation techniques, probabilistic forecast, scenarios, expert opinion, delphi, buyers' intentions survey,... (Martino 2003).

An interesting approach is to assess the disruptiveness of emerging value propositions by comparing them to the ordinary ones on a number of dimensions (Rafii and Kampas 2002).

3.2 Actors

Understanding the roles of the different actors participating in a business system is essential because of their central role in shaping the future environment state by partly influencing some of the forces that govern its evolution.

For assessing the role of the key players, it is recommended to briefly but clearly describe their business models. This essentially implies describing the organization's value proposition, its target customers, its infrastructure (activities and partnership network) and its financial aspects (Osterwalder and Pigneur 2002).

Based on the business model of the different actors, it is also possible to assess the relationships and interactions among them. The well-known value chain framework (Porter and Millar 1985), which defines the value system as composed by a series of interconnected value-adding activities performed by the various enterprises along the supply chain, can be seen as the integration of the participants' business models. While this framework is adapted to manufacturing, there are extensions suited to service providers and brokering activities (Stabell and Fjeldstad 1998).

While these methods enable us to assess the relations between entities stemming from exchanges of value, there are important indirect relationships between actors that must be taken into account, too. These have been brilliantly illustrated by Michael Porter's five-forces framework (Porter 1980), which advocates the important effect on the firm by the pressure of existing competitors, suppliers, buyers, new entrants and substitute products producers. This framework can be extended to include other categories of players in the regulation (Rugman and Verbeke 2000) and technology areas.

3.3 Issues

Since the main goal of environment analysis is to anticipate the potential changes that occur in it, it is argued that the company must look beyond the current market state and assess the most important future prospects of its environment. This can be done by identifying and assessing the major issues and trends that may affect the environment.

While trends indicate the most likely evolution, issues determine possible departures from these trends towards alternative futures. Both elements must be obviously considered. Issues can be seen as forthcoming developments which are likely to have an important impact on the ability of the organization to achieve its objectives (Ansoff 1980).

Identification of the relevant issues is a difficult task and is mostly a matter of judgment. It often must rely on the opinion of a group of experts. A number of methods can help by fostering creativity (e.g. brainstorming, assumption reversal, and analogies), consensus (e.g. delphi, nominal groups) and collaboration (e.g. group support systems).

Godet proposes a systematic method for identifying, classifying and prioritizing issues. This method, called MICMAC, is based on the concept of influence and dependence between issues and classifies issues as dominant, relay, dominated and autonomous (Arcade, Godet et al. 1999).

An interesting category of tools are actor-issues methods. These basically consider the environment as a game between multiple actors that try to influence the factors (i.e. the issues) that govern its evolution either by mobilizing their resources to influence the issues outcome directly or indirectly by influencing (i.e. negotiating with) other actors.

There are a few actor-issue methods which stem from various disciplines and provide different information. The MACTOR method (Arcade, Godet et al. 1999) originates from a systemic perspective and provides an aggregate overview of the system under study through a number of computations on several input matrices. Allas and Georgiades (Allas and Georgiades 2001) developed a simpler model to support negotiators, which essentially consists in a set of graphs that provide strategic information. Other methods tackle the same problem based on game theory using expected utility calculations (Bueno de Mesquita and Stokman 1994).

4 A PROTOTYPE: MASAM

Based on the previous considerations, we conceived a prototype tool called MASAM based on previous actor-issues methods so as to integrate the actor and issue perspectives. It provides a preliminary insight on the usefulness of a more elaborate system. This prototype will be extended in forthcoming work to include the market perspective. In the meantime, this perspective can be regarded as a particular case of issues (e.g. social, demographic and economic issues affecting user needs, wants and demand) and actors (customers, consumer groups).

MASAM is a tool based on the multi actor-issue models proposed by Godet (Arcade, Godet et al. 1999) and Allas (Allas and Georgiades 2001). Actually, it integrates both models, corrects some of their flaws and adds new features as described in (Bendahan, Camponovo et al. 2003).

This tool is intended to assist decision makers in analyzing situations involving multiple actors that have divergent interests on multiple issues. It helps them to devise a suitable strategy which takes into account the interests and potential actions of other actors as well as the potential disruptive effects of the realization of certain issues on the environment. In particular, it can be used to support the selection of multiparty negotiation strategies or as part of a more ambitious scenario planning approach.

MASAM is a tool which is based on the collection of the opinion of a number of experts about the organization's environment (section 4.1). It fundamentally consists in a series of transformations that aggregate and analyze these opinions and generate valuable information that would be hardly obtainable from an unassisted analysis of the inputs (section 4.2). A visualization tool (section 4.3) has been developed specifically for MASAM (Monzani, Bendahan et al. 2004), allowing a graphical representation of this information, providing a means to easily and intuitively interpret it.

4.1 The inputs

MASAM is a tool which is based on the collection, aggregation and computation of the opinion of a number of experts about certain aspects of the organization's environment.

The first input is a list of the relevant actors and issues, as defined in sections 3.2 and 3.3. All actors which have a stake in the current situation and can influence its outcome, either by influencing issues directly or by influencing the other actors, should be considered. As well, it is worth including all issues which may disrupt the current environmental conditions, especially those upon which actors have sensibly diverging positions and means of influence.

The rest of the input consists in matrices that take into account the influence relationships between actor and issues or between pairs of actors. The concepts used to link these elements are called position, salience, clout and influence.

Position ($Pos_{a,i}$) represents the preferred outcome of an issue "i" to an actor "a". It is formalized as a linear continuum between two extreme values on which actors position themselves.

Salience ($Sal_{a,i}$) denotes the importance of an issue to an actor. It is measured by the relative utility that the actor loses if the outcome is not close to their position. Actors with high salience lose a lot of utility, while less salient actor are less affected.

Clout ($Clo_{a,i}$) represents the power that an actor has to influence an issue's outcome. The clout value can be seen as the actual part of control of the issue. It is supposed that the actors have, altogether, the power to influence the issue's outcome along the continuum on which the positions are set. If they cannot fully influence an issue, a fictive actor enacting the environmental trends may be used.

Finally, influence ($Inf_{a,b}$) represents the ability of an actor "a" to influence the decision of another actor "b". It corresponds to a relationship of power between the two actors, formalized as the part of control of one actor over the other. This means that actors do not have full control on themselves, but their actions are partly commanded by other actors that have means of pressure on them. The freedom that an actor has over its choice represents the actor's auto-determination coefficient.

The input matrixes can be filled with values of any scale. They are subsequently standardized so as to contain values ranging from 0 to 1.

The quality of the input is fundamental. For that reason, a careful choice of experts is essential to ensure input quality. In particular, it is suggested to select experts who are representative of the different actors' opinions. Furthermore, it is suggested to use some methods which can help fostering creativity (e.g. brainstorming), consensus (e.g. Delphi surveys) and collaboration (e.g. group support systems).

4.2 The transformations

MASAM proposes a set of transformations of the input data that provide valuable information for formulating strategic recommendations. The key ones are presented below with the corresponding equations: these allow users to assess indirect influence, analyze the issues' outcomes and disagreements, the actors' true power repartition and their proximity. Notice that MASAM extends the Godet's and Allas' methods and can thus also perform the same transformations proposed by them.

Indirect influence of order n ($Inf(n)_{a,b}$) can be calculated using the following formula to take into account the fact that actors can not only influence other actors directly, but also indirectly through chains of influence passing through third parties. The user can specify the order of indirect influence, which defines the maximum length of these chains, according to the chances that parties have to bargain.

$$\mathrm{Inf}(n)_{a,b} = \mathrm{Inf}(n-1)_{a,b} + \sum_c \left(\mathrm{Inf}(n-1)_{a,c} \cdot \mathrm{Inf}(n-1)_{c,b}\right) \forall\, a = b$$

$$\mathrm{Inf}(n)_{a,b} = \sum_c \left(\mathrm{Inf}(n-1)_{a,c} \cdot \mathrm{Inf}(n-1)_{c,b}\ \forall b \neq c\right) \forall a \neq b$$

$$\mathrm{Inf}(0)_{a,b} = \mathrm{Inf}_{a,b}$$

The **issues analysis** allows the estimation of the expected outcome ($Outcome_i$) for all issues, which can be calculated using different hypothesis such as a pure vote based only on clout or integrating direct or indirect influences. By comparing the actors' positions with this outcome, it is possible to identify the divergence of actors ($Divergence_{a,i}$) so as to identify the actors that may want to challenge the outcome and how they want to change it.

$$\mathrm{Outcome}_i = \sum_a \left(\mathrm{Pos}_{a,i} \cdot \sum_b \left(\mathrm{Clo}_{b,i} \cdot \mathrm{Inf}(n)_{a,b}\right)\right)$$

$$\mathrm{Divergence}_{a,i} = \sum_a \left(\left|\mathrm{Pos}_{a,i} - \mathrm{Outcome}_i\right| \cdot \mathrm{Sal}_{a,i}\right)$$

The **actors analysis** enables to estimate the true repartition of power ($Power_a$) among actors considering their clout on the different issues, as their influence on other actors and the importance of the different issues. Actors are also compared to each other by looking at their general agreement on the different issues: a proximity coefficient can be calculated to illustrate potential conflicts and coalitions.

$$\mathrm{Power}_a = \left(\sum_i \mathrm{Inf}(N)_{a,b} \cdot \mathrm{Clo}_{b,i} \cdot \sum_c \left(\mathrm{Sal}_{c,i}\right)\right)$$

4.3 Output analysis

Thanks to the visualization tool, the user can obtain an intuitive representation of the output data which clearly brings to light the key elements. The most interesting graphs are illustrated thereafter using data taken from a study of the Public Wireless LAN industry in Switzerland. The study analyzed seven actors. Due to lack of space, this example is not described in this paper, but a description of the study as well as the visualization tool can be found in (Bendahan, Camponovo et al. 2003; Monzani, Bendahan et al. 2004).

The **influence graph** (Figure 2) summarizes the influence relationships between actors and their relative power. Each horizontal bar represents an actor. The height of this bar is proportional to the

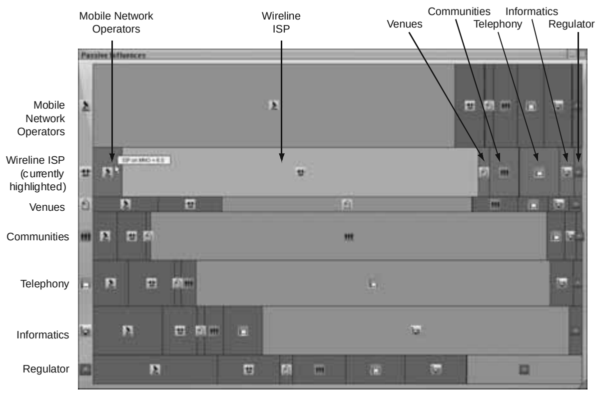

Figure 2: Influence graph

actor's true power, while its length shows who controls the subject actor. Actors that have a high surface are therefore the most influent actors. This graph can be helpful to view the different means of pressure that actors can use in their negotiations. In particular it can help to spot actors which can be influenced to gain their support as well as consider defensive strategies to prevent being influenced.

The **issues analysis graph** (Figure 3) shows the issues' expected outcome and the dissatisfaction of actors on these issues. Each issue is represented as a bar. The middle of the bar represents the issue's expected outcome. On this bar, the actors are placed according to their dissatisfaction, which depends on the actor's position and salience. This graph can help to identify the actors that are more likely to defend or challenge the expected outcome: the more an actor is far from the center, the more it is likely to exhibit a strong will to challenge the expected outcome. Actors can also spot their possible allies and enemies on the different issues.

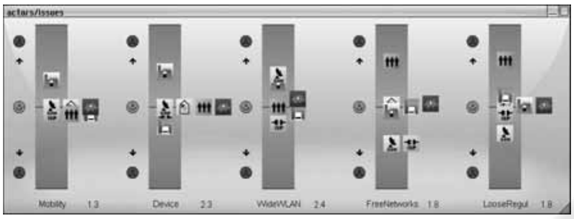

Figure 3: Issue analysis graph

The relative power of actors is approximately shown in the influence graph. However, a more precise vision of the repartition of power can be obtained from the **power repartition graph** (Figure 4) which shows how each issue is controlled. The principle of the graph is similar to the influence graphs: issues are represented as horizontal bars that are divided according to the repartition of clout of actors. The vertical sizes of the bars represent the issues' importance (average salience of actors).

Additional indications can be obtained from the brightness of the surfaces, which is proportional to the actor's salience. Actors with large and bright surfaces are very interesting negotiation parties, as they can be easily convinced to make concessions and have the power to influence the outcome.

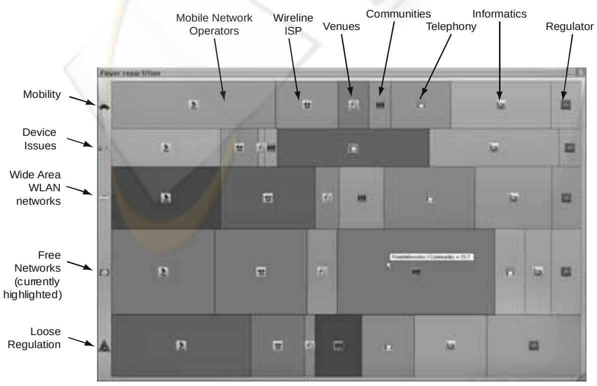

Figure 4: Power repartition graph

Finally, the **proximity map** (Figure 5) places the actors on a 2D graph giving an overview of the relative proximity of actors. Actors are positioned according to their proximity coefficient, showing how similar are their position on salient issues. This graph can be used to spot the likely alliances and conflicts: geographically compact groups of actors will more likely form alliances, while far away ones will more likely combat each other on a large number of issues.

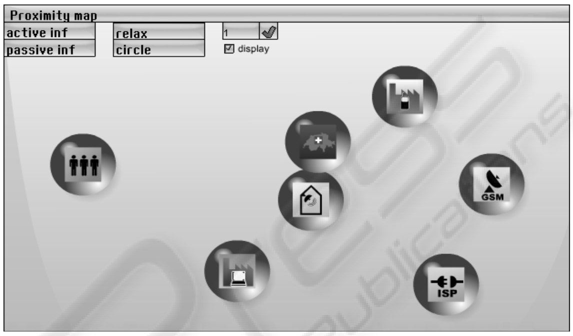

Figure 5: Proximity map

5 CONCLUSIONS

Environmental analysis is a hard task, because it requires a huge amount of information which is hard to identify and collect. Many different elements have to be assessed and integrated to give strategists a solid base upon which make their decision. For these reasons, a decision support system is very valuable.

This paper intends to facilitate environmental analysis by proposing an ontology of the relevant elements to consider (i.e. markets, actors and issues) and by suggesting a selection of tools to analyze and visualize the information in these different perspectives. In the longer term, we hope that these elements will support and stimulate the development of various decision support systems for assessing an organization's environment in a comprehensive and systematic manner.

The usefulness of such systems was illustrated by a prototype tool that proposes a partial analysis of the global situation by integrating the issues and actors perspectives. This tool is a first step towards the conception and development of an integrated system which assists the extensive analysis of the environment from the three mentioned perspectives.

Finally, we also envision to devise a modified scenario planning methodology which would take advantage of the results of this environmental analysis to possible to develop more grounded and coherent future scenarios (Godet 2001).

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